THURSTON COUNTY
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Thurston County

DRAINAGE DESIGN AND EROSION CONTROL MANUAL

July 2009 Edition, Adopted August 2009
Effective November 16, 2009

Thurston County Drainage Design and Erosion Control Manual

Volume I - Minimum Technical Requirements and Site Planning

Volume II - Construction Stormwater Pollution Prevention

Volume III – Hydrologic Analysis and Stormwater Conveyance

Volume IV – Source Control

Volume V – Stormwater BMPs

Prepared by
Thurston County Water Resources Division
Department of Resource Stewardship

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Additional Sources

Washington Department of Ecology Stormwater Management Manual for Western Washington, 2005
Pierce County Draft Stormwater Management and Site Development Manual, 2008
City of Tacoma Stormwater Management Manual, January 2009
City of Olympia Stormwater Management Manual, January 2005
Low Impact Development Technical Guidance Manual for Puget Sound, January 2005
Washington State Department of Transportation, Highway Runoff Manual (2009)

Chapter 1 - Introduction

The *Drainage Design and Erosion Control Manual* establishes requirements and provides guidance for managing the quantity and quality of stormwater runoff produced by development and redevelopment in Thurston County. This manual is a completely revised update to the 1994 Thurston County Drainage Design and Erosion Control Manual and is intended to comply with the National Pollutant Discharge Elimination System (NPDES) Phase II permit issued to Thurston County by the Department of Ecology and be equivalent to the *Stormwater Management Manual for Western Washington* (Ecology 2005).

The Thurston County Drainage Design and Erosion Control Manual applies to all unincorporated areas of Thurston County. Except that, within specific Urban Growth Areas (UGAs) associated with incorporated cities that have adopted a Drainage Manual equivalent to the *2005 Washington State Department of Ecology Stormwater Management Manual for Western Washington*, and for which an agreement between the City and Thurston County has been reached to use the City's Drainage Manual standards, the Drainage Manual of the incorporated city shall apply. The Manual establishes minimum requirements for projects of all sizes and types and the required submittals to demonstrate compliance with the minimum requirements.

The requirements of the manual also apply to cross-jurisdictional projects (e.g., utility, port, irrigation, drainage or flood control district, city, town, county, or other local, state, or federal government entity) located totally, or in part of, the County unless one of the following applies:

- Activity is exempted from submittal requirements (see Section 2.2)
- Development/redevelopment and stormwater activities are conducted in accordance with an approved stormwater management manual consistent with Thurston County's NPDES Phase II permit and the *2005 Washington State Department of Ecology Stormwater Management Manual for Western Washington*.

The Drainage Manual Administrator is authorized to request information or to impose controls beyond those specified in this Manual. In doing so, the Administrator shall act reasonably, exercising best professional judgment based on available information. Reasons that the Administrator may act include, but are not limited to, one of the following:

- To protect the health, safety, and welfare of the public
- To prevent water quality degradation and stream bank erosion

- To prevent flooding that may present a risk to life, safety, vital services, or property
- To implement regulatory mandates such at Total Maximum Daily Load (TMDL) requirements within a watershed
- Where the Administrator's direction is needed to correct errors and omissions, in order to clarify, augment or update Manual text. Where this is required, the Administrator will, in a timely and appropriate manner, revise the text and provide the revisions to Manual users. Users are advised to check the Thurston County website or contact the County for updated design and implementation guidelines.

The use of "onsite measures" (Low Impact Development) will be an integral part of the planning and design of all future development in Thurston County. The ultimate goal of stormwater management for new development and redevelopment will be to mimic the natural pre-development hydrologic conditions of the site as closely as possible with respect to infiltration, evapotranspiration, water quality, and quantity of surface water release from the site. To this end, the design for stormwater management systems for development shall be a sequential process described as follows:

1st Minimize disturbed areas and maximize open space and native vegetation retention.

2nd Limit impervious surface to the minimum necessary and implement source control measures to prevent contact of stormwater with pollutant generating sources.

3rd Use "onsite" measures such as dispersion, bio-retention (rain gardens), and small scale infiltration to the maximum extent practicable to reduce concentrated flows of stormwater.

4th Disconnect impervious surfaces to the maximum extent practicable to slow the runoff of stormwater from a site and increase the time of concentration. Examples include filter strips, porous paving, sheet flow of runoff to native vegetation, and bioretention.

5th For any remaining concentrated stormwater flows that exceed specific thresholds provide treatment and infiltrate to the maximum extent practicable and at least to the level of infiltration provided by the site in pre-development conditions.

6th Minimize release of surface water to protect stream channels and downstream properties by meeting design criteria established for peak flow rate and volume per drainage manual requirements.

7th Implement controls to manage stormwater runoff during construction to eliminate discharge of sediment-laden water offsite and maintain these controls until the site is stabilized.

8th Establish and implement a plan for the operations and maintenance of the stormwater facilities and provide ongoing maintenance, repair, and operations for those facilities to ensure continued protection of water quality and flow control.

The Best Management Practices (BMPs) described in this manual help meet the following water quality standards and protect beneficial uses of the receiving waters:

- **Chapter 173-200 WAC**, Water Quality Standards for Ground Waters of the State of Washington
- **Chapter 173-201A**, Water Quality Standards for Surface Waters of the State of Washington
- **Chapter 173-204**, Sediment Management Standards.

Stormwater management techniques applied in accordance with this manual are presumed to meet the technology-based treatment requirement of State law to provide all known available and reasonable methods of treatment, prevention and control (AKART; RCW 90.52.040 and RCW 90.48.010).

This technology-based treatment requirement does not excuse any discharge from the obligation to apply additional stormwater management practices as necessary to comply with the State water quality standards listed above.

The BMPs presented in this manual are approved by Thurston County and the Department of Ecology and are *presumed* to protect water quality and instream habitat – and meet the stated environmental objectives of the regulations described in this chapter. Project proponents always have the option of not following the stormwater management practices in this manual. However, if a project proponent chooses not to follow the practices in the manual then the project proponent will be required to individually *demonstrate* that the project will not adversely impact water quality by collecting and providing appropriate supporting data to show that the alternative approach is protective of water quality and satisfies state and federal water quality laws. Projects interested in pursuing the demonstrative approach should contact Thurston County early in the process.

Where requirements in this document are also covered in any other law, ordinance, resolution, rule, regulation, or similar requirement, the more restrictive shall govern.

This manual has been adopted by the Thurston County Board of Commissioners and is part of Thurston County Code. Failure to comply may trigger administrative or enforcement action, and result in project delays, fines, civil, or criminal penalties.

1.1 How This Manual is Organized

The manual is organized into five volumes, each addressing a specific aspect of stormwater management in Thurston County:

- **Volume I** introduces the entire *Drainage Design and Erosion Control Manual*, summarizes minimum requirements, describes submittal requirements, and contains detailed guidance for the selection of Best Management Practices (BMPs) for onsite measures Low Impact Development (LID), water quality treatment, and flow control.
- **Volume II** describes BMPs and submittal requirements for temporary stormwater management (erosion and sediment control) at construction sites.
- **Volume III** explains hydrologic analysis, modeling, BMP sizing techniques and requirements for conveyance design. Volume III also provides guidance on field and analytical methods to determine infiltration rates and site suitability criteria, to ensure that infiltration facilities are sited in a manner that protects groundwater.
- **Volume IV** describes source control BMPs, used to minimize pollution generated by pollution sources on developed sites.
- **Volume V** describes and provides detailed design guidance for BMPs to control stormwater flows and treat runoff that contains sediment or other pollutants from developed sites.

1.2 Volume I Overview

Chapters in this volume will determine the applicable requirements for your project, your submittal requirements, and provide guidance on selection of BMPs. It will also direct you to other volumes of the manual for topics relevant to specific hydrologic design methods and infiltration testing (Volume III), BMP design guidance (Volumes IV and V), and construction practices (Volume II).

- *Chapter 1: Introduction* describes the manual and where it applies, gives an overview of the stormwater management process, and lists related plans, permits, and manuals.

- *Chapter 2: Minimum Requirements for New Development and Redevelopment* describes minimum requirements for stormwater management for all new development and redevelopment projects. There are twelve minimum requirements, and their applicability to a project varies depending on the type and size of the proposed project.

- *Chapter 3: Stormwater Submittal Requirements* describes the submittal process required to meet Thurston County requirements. Submittal requirements vary depending on the project size and type and which minimum requirements apply to the project.

- *Chapter 4: Stormwater BMP Selection Process* explains how to select BMPs for long-term management of stormwater flows and quality. BMP selection for construction stormwater management and source control of pollution are not included in Volume I but can be found in Volume II and Volume IV respectively.

1.3 Related Plans, Permits, and Manuals

1.3.1 Phase II NPDES and State Waste Discharge Stormwater Permits for Municipalities

Depending on population, some cities, counties, and other agencies are subject to permitting under the U.S. Environmental Protection Agency (EPA) Phase II Stormwater Regulations (40 CFR Part 122). In western Washington, the Washington State Department of Ecology ("Ecology") has issued joint National Pollutant Discharge Elimination System (NPDES) and state waste discharge permits to regulate stormwater discharges from municipal separate storm sewer systems (MS4) operated by small cities and counties, including the urban parts of Thurston County.

The Phase II NPDES Municipal Stormwater Permit was issued on January 17, 2007, and modified on June 9, 2009. It is available on Ecology's website: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/PermitsPermittees.html.

Only those areas of unincorporated Thurston County that have population densities meeting the criteria of the NPDES Phase II program are covered by the permit. This is principally the area surrounding the incorporated cities of Lacey, Olympia, and Tumwater and includes portions of areas designated as urban growth areas as well as areas outside of the urban growth areas. The applicant should check with Thurston County to determine the current NPDES permit boundary if this information is necessary for the project.

1.3.2 NPDES and State Waste Discharge Baseline General Permit for Stormwater Discharges Associated With Industrial Activities (Industrial Stormwater Permit)

Businesses subject to the *Baseline General Permit for Stormwater Discharges Associated with Industrial Activities* must prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) in accordance with the terms of that permit. The current permit was reissued on October 15, 2008, became effective on November 15, 2008, and expired April 30, 2009. A new permit is currently being developed by Ecology. See the following website for more information: <http://www.ecy.wa.gov/programs/wq/stormwater/industrial/index.html>.

1.3.3 WSDOT Highway Runoff Manual (HRM)

The HRM addresses stormwater runoff issues for typical WSDOT roadway construction and maintenance activities. It has been granted equivalent status by Ecology and can, therefore, be adopted by other jurisdictions. It was last updated in 2008 and can be found at the following website: <http://www.wsdot.wa.gov/Environment/WaterQuality/Runoff/HighwayRunoffManual.htm>.

1.3.4 2005 Low Impact Development Technical Guidance Manual for Puget Sound (LID Manual)

The LID Manual is published by the Puget Sound Partnership and provides current guidance on LID techniques and design procedures in Washington State. The Ecology Manual recognizes the LID Manual and references it in its *Stormwater Management Manual for Western Washington*. The LID Manual is currently being updated and can be found at the following website: <http://www.psp.wa.gov/documents.php>.

1.3.5 The Puget Sound Conservation and Recovery Plan

The *Puget Sound Conservation and Recovery Plan (PSCRP)* directs every city and county in the Puget Sound Basin to develop and implement a comprehensive stormwater management program. It also emphasizes the use of Low Impact Development measures. (The PSCRP has replaced the Puget Sound Water Quality Management Plan.) Publication of this *Drainage Design and Erosion Control Manual* partially fulfills that requirement for Thurston County. For more information, see the Puget Sound Partnership website at: <http://www.psp.wa.gov/>.

1.3.6 Other State and Federal Permits

Your project may require additional permits, depending on location and type of development. These permits may include one or more of the following, which are described in detail in the Ecology *Stormwater Management Manual for Western Washington*:

- **Construction Stormwater Permit** (i.e., NPDES and State Waste Discharge General Permit for Stormwater Discharges Associated with Construction Activity): For construction sites with one or more acres of disturbed area with the potential to discharge stormwater to surface waters.
- **Endangered Species Act** (ESA): Potentially restricts construction and development activities that affect ESA-listed species or their habitat.
- **Section 401 Water Quality Certifications**: Certification required for projects that require a fill or dredge permit under Section 404 of the Clean Water Act.
- **Hydraulic Project Approvals**: Permit issued by Washington State Department of Fish and Wildlife (WDFW), required when project-related stormwater discharges would change the natural flow or bed of state waters or work is required below the ordinary high water level of a lake or stream.
- **Aquatic Lands Use Authorizations**: The Washington State Department of Natural Resources (WDNR), as the steward of public aquatic lands, may require a stormwater outfall to have a valid use authorization and to avoid or mitigate resource impacts.
- **Underground injection control program**: An Ecology program (WAC 173-218) which may require registration or restrictions for certain infiltration systems (see Volume V for more information).

Tom Cook Suggest Adding Bullet: "Water Rights Approval: Under the Water Resources Code a water right may be necessary for an irrigation pond."

1.3.7 Local Government Permits

Section 3.1.3

Your project will require some form of permit or land use review/acceptance from Thurston County depending on the location and type of project/development. Many of these permits also require a drainage review in accordance with the manual. These permits can include the following:

- Building Permit

- Construction Permit (Excavation, Grading, Clearing & Erosion Control)
- Short Plat Subdivision
- Large Lot Subdivision
- Long Subdivision
- Class IV Forest Practices Permit
- SEPA Approval
- Critical Areas Review
- Road Encroachment Permit
- Site Plan Review
- Binding Site Plan
- Design Review
- Contact Thurston County Permit Assistance Center for help in determining the permits that apply to your project: <www.co.thurston.wa.us/permitting>.

1.3.8 Requirements Identified through Watershed and Basin Planning or Total Maximum Daily Loads (TMDLs)

Many requirements in this manual can be superseded by adopting ordinances and rules to implement watershed or basin plan recommendations. In accordance with the Watershed Management Act (Chapter 90.82 RCW) or the basin planning option (Chapter 400-12 WAC), Thurston County has initiated its own basin planning processes to identify alternative requirements for sensitive watersheds.

Basin plans are thorough investigations of water problems and potential solutions for a specific drainage basin. The term "drainage basin" refers to all the land that drains to a common body of water. Basin plans address issues such as flooding, poor water quality, erosion, and the degradation of aquatic habitat. They involve gathering data about the topography of the land and the way water moves through the soil, and also assesses how drainage projects and other activities in one area of a watershed might affect other areas.

Basin plans are reviewed and approved by the elected officials of each participating agency. Basin plans in Thurston County are usually written jointly by the County and cities. The plan itself does not fund or authorize projects; however, Thurston County commissioners refer to the basin plans when deciding which stormwater construction projects to finance.

Information on Thurston County's basin planning process, including links to current County basin plans, can be found at the following website: <http://www.co.thurston.wa.us/stormwater/Basin%20Plans/Basin_Plans_home.htm>.

http://www.co.thurston.wa.us/stormwater/basin/basin-home.htm

1.4 Definitions—Generally

For the purposes of interpreting this Manual, unless it is plainly evident from the context that a different meaning is intended, certain words and terms are defined in this section as follows:

- The words "shall," "will," and "must" are always mandatory, while the word "should" is situation-specific and not mandatory, and "may" is situation-specific and permissive. For any project, the Administrator or designee is authorized to determine if situation-specific requirements are applicable.
- Words in the present tense include the future, the singular includes the plural and the plural includes the singular.
- The word "and" indicates that all connected items or provisions apply.
- The word "or" indicates that the connected items or provisions may apply singularly or in any combination.
- The term "either or" indicates that the connected items or provisions shall apply singularly but not in combination.
- Where terms are not specifically defined (see Glossary in Appendix I-A) in this Manual, the following sources, in order of their use, shall be referred to for a definition of the term:
    - Washington State Department of Ecology Stormwater Management Manual for Western Washington (2005)
    - Thurston County Code
    - Other Ecology Approved Equivalent Stormwater Manuals for jurisdictions located in Western Washington
    - Current industry standard text books, guidance documents, or reports

- If not defined in the above sources then words shall have their ordinary accepted meanings within the context with which they are used. Webster's Third New International Dictionary of the English Language, Unabridged, 1986 Edition, shall be considered in determining ordinarily accepted meanings.

Illustrations found in this Manual are not intended to supersede or replace written definitions, restrictions, or standards.

Chapter 2 - Minimum Requirements for New Development and Redevelopment

2.1 Overview

This chapter describes minimum requirements for stormwater management applicable to new development and redevelopment sites, and provides guidance on how to apply those requirements. The first section provides a list of projects which are exempt from the minimum requirements. If you are unsure whether your project is exempt or not, check with the Drainage Manual Administrator. The next section identifies which minimum requirements apply to your project, and the final section describes each of the minimum requirements in more detail.

After determining that your project is not exempt from the minimum requirements, you can use this chapter to determine the minimum requirements that apply to your project. At that point, you will need to know the following for your overall project and for each threshold discharge area within the project:

- Area of existing and new impervious surface
- Area of replaced impervious surface
- Area of pervious surface converted to impervious (i.e., landscape converted to pavement)
- Total disturbed area (logged, cleared, graded or otherwise disturbed as part of the project)
- Area converted from native vegetation to landscape or impervious
- Area converted from native vegetation to pasture.

The glossary defines each of the terms used above and should be referred to in calculating the applicable areas.

2.1.1 Roadway Frontage Improvements

If your property abuts a public roadway, roadway frontage improvements are typically required for all improvement and development projects. This can include roadway widening, right-of-way dedication, and/or upgrade to urban features. The abutting property is responsible for the management of stormwater drainage from the public right-of-way. This may include construction of treatment and flow control facilities or allowance for dispersion areas in accordance with this manual.

Any land disturbing activity or addition of impervious surfaces associated with frontage improvements shall be included in the area calculations for determining the Minimum Requirements. Plans and reports prepared in accordance with this manual shall include management of runoff from the roadway frontage abutting the project site. See the Thurston County Road Standards for more information on frontage improvements and road drainage requirements.

2.1.2 Cumulative Impact Mitigation Requirement

The determination of thresholds for a project site shall be based on the total increase or replacement of impervious surfaces, conversion of native vegetation to landscape area or pasture that have occurred within the previous 5 years. The County will consider the cumulative impacts of all permits issued within the previous 5 years from the date of project submittal by the applicant.

The purpose of this Cumulative Impact Mitigation Requirement is to adequately mitigate the stormwater from improvements on a project site that are submitted under separate permits. The separate submittals could have project areas that do not meet thresholds, but would meet the thresholds if the projects were combined as one project.

2.2 Exemptions

The following projects are exempt from the minimum requirements:

2.2.1 Forest Practices

Forest practices regulated under Title 222 WAC, except for Class IV General Forest practices that are conversions from timber land to other uses, are exempt from the minimum requirements.

2.2.2 Commercial Agriculture

Commercial agriculture practices are generally exempt. However, conversion from timberland to agriculture and construction of impervious surfaces are <u>NOT</u> generally exempt.

2.2.3 Oil and Gas Field Activities or Operations

Construction of the following is exempt:

- Drilling sites
- Waste management pits
- Access roads

- Transportation and treatment infrastructure (e.g., pipelines, natural gas treatment plants)
- Natural gas pipeline compressor stations
- Crude oil pumping stations.

Operators are encouraged to use BMPs to minimize erosion and control sediment during and after construction to protect surface water quality during storm events.

2.2.4 Road and Parking Lot Practices

The following road and parking lot maintenance practices are exempt but should use appropriate BMPs to minimize erosion and sediment transport:

- Pothole and square cut patching
- Road projects completely within the right-of-way which do not add impervious surface, such as overlaying existing asphalt or concrete pavement without expanding the area of coverage
- Shoulder grading
- Reshaping or regrading drainage systems to restore as-built conditions.
- Crack sealing or resurfacing with in-kind material without expanding the road prism
- Vegetation maintenance

The following road or parking lot maintenance practices are considered redevelopment, and therefore are not categorically exempt:

- **Removing and replacing a paved surface to base course or lower, or repairing the roadway base**. If impervious surfaces are not expanded, Minimum Requirements #1 through #5 apply. Where appropriate, for privately maintained roads, project proponents are encouraged to use permeable and porous pavements.
- **Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders**. These are considered new impervious surfaces and are subject to the minimum requirements that apply when the redevelopment project reaches identified thresholds.

- **Resurfacing by upgrading from dirt to gravel, asphalt, or concrete; upgrading from gravel to asphalt, or concrete; or upgrading from a bituminous surface treatment ("chip seal") to asphalt or concrete**. These are considered new impervious surfaces and are subject to the minimum requirements that apply when the redevelopment project meets or exceeds identified thresholds.

2.2.5 Underground Utility Projects

Underground utility projects that are linear in nature and replace the ground surface with in-kind material or materials with similar runoff characteristics are only subject to Minimum Requirement #2, Construction Stormwater Pollution Prevention.

All other development is subject to one or more of the Minimum Requirements.

2.2.6 Public Drainage Facilities

Drainage facilities conceived, designed, or constructed by or through an agent of the County shall be exempted from the submittal and permitting requirements of this Manual. The County shall meet the intent and specific requirements of this Manual on all projects relative to drainage or incorporating drainage components and shall maintain records adequate to reflect such compliance. These records shall be available upon request per the State Public Disclosure of Information Act, RCW 42.17.

The County shall incorporate the provisions of this Manual into the design calculations, drawings, and specifications of all projects released for public bid. These provisions shall also apply to projects constructed by County staff.

This exclusion from submittal and permitting requirements only applies to this Manual and does not relax any requirements of other applicable ordinances, regulations, or legislation except that superseded by this Manual.

2.3 Applying Minimum Requirements

If your project is not exempt, you must determine which Minimum Requirements apply to it. Use the flowcharts in Figures 2.1 and 2.2 to help determine which minimum requirements apply to your project.

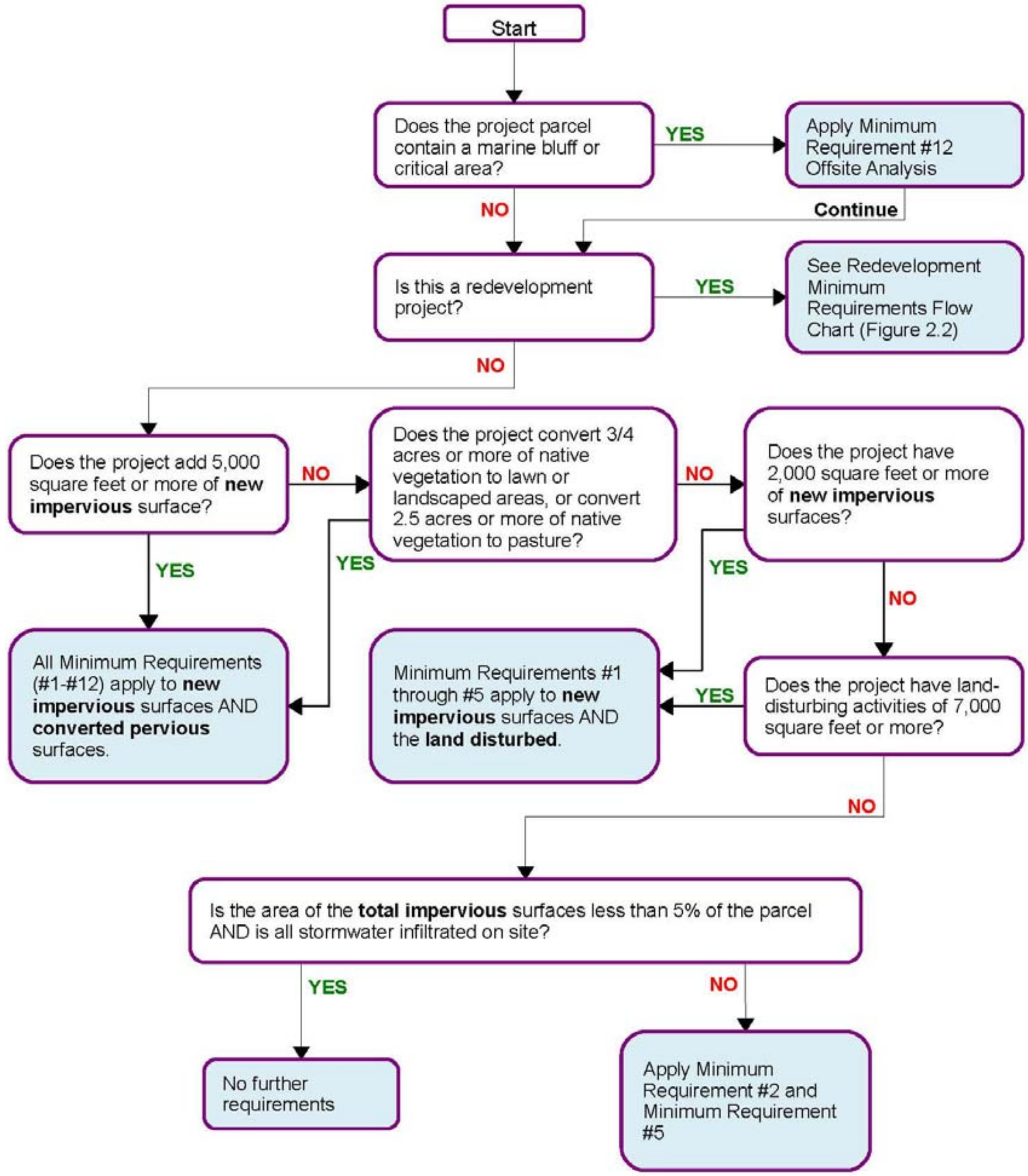
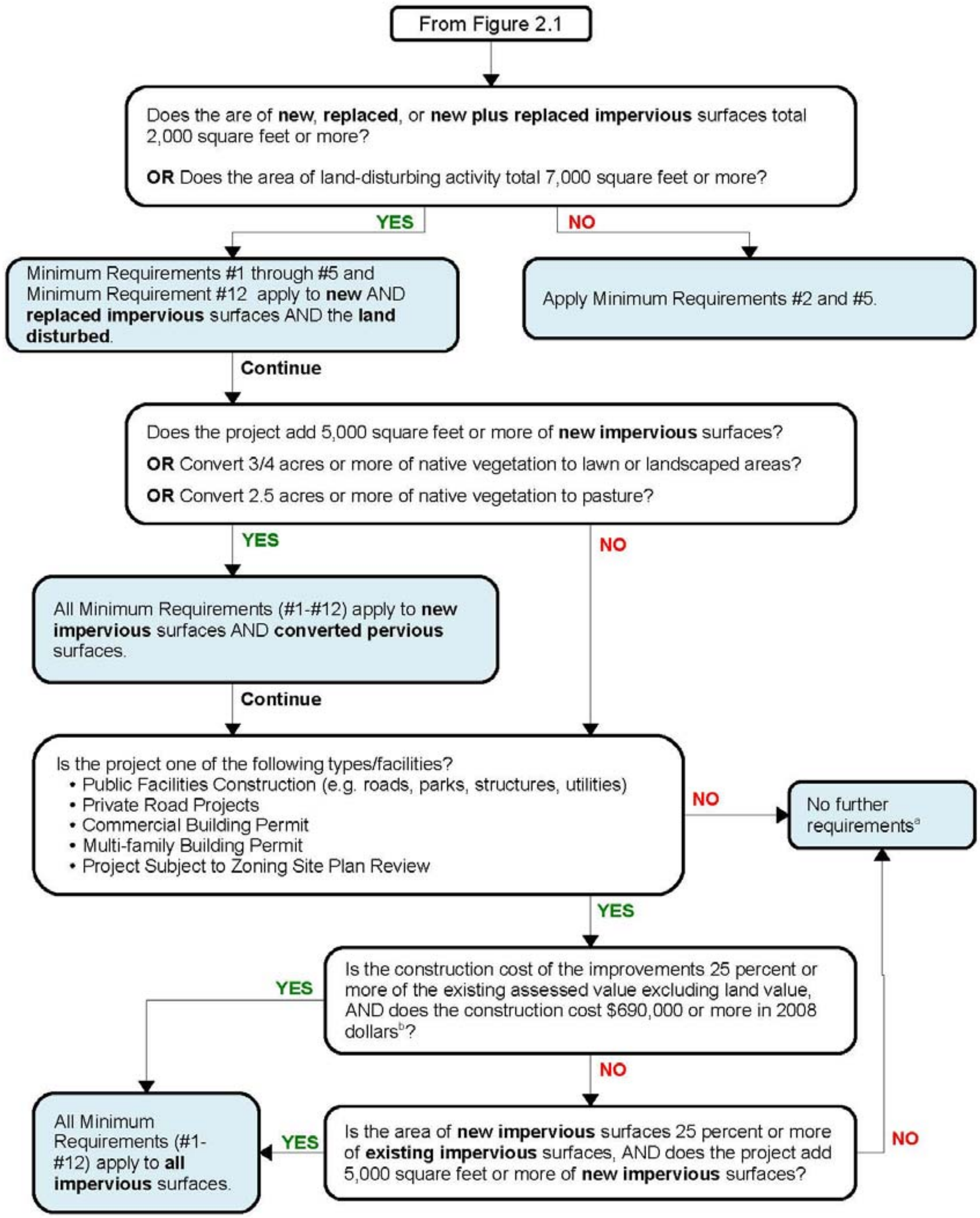


Figure 2.1 – Flow Chart for Determining Minimum Requirements for New Development

Figure 2.1. Flow Chart for Determining Requirements for New Development.



Notes:

[a] The County may require application of Minimum Requirements #1-#12 to all impervious surfaces if an existing water quality, flooding, or erosion problem is identified. See Section 2.2.

[b] Cost threshold will be escalated annually based on WSDOT Construction Cost Index. See Section 2.3.2.

Figure 2.2 – Flow Chart for Determining Minimum Requirements for Redevelopment

Figure 2.2. Flow Chart for Determining Requirements for Redevelopment.

Depending on the project size, site, and location, different requirements may apply. Not all minimum requirements apply to every project. The minimum requirements are:

1. Stormwater site planning
2. Construction stormwater pollution prevention
3. Source control of pollution
4. Preservation of natural drainage systems and outfalls
5. Onsite stormwater management
6. Runoff treatment
7. Flow control
8. Wetlands protection
9. Basin and watershed planning
10. Operation and maintenance
11. Financial liability
12. Offsite analysis and mitigation.

Not all minimum requirements apply to every project. This section describes thresholds that determine which minimum requirements apply. Minimum requirements are described in Section 2.4.

2.3.1 New Development

Figure 2.1 illustrates the process for determining the applicable minimum requirements for new development. In calculating project areas to determine thresholds, any required public roadway frontage improvements shall be included in the total for determining the thresholds.

All new development shall comply with Minimum Requirement #2, Construction Stormwater Pollution Prevention Plan, except if the total of all impervious surfaces (including existing) is less than 5 percent of the parcel AND all stormwater is infiltrated on site.

New development that does either of the following shall comply with Minimum Requirements #1 through #5 and Minimum Requirement #12 (offsite analysis and mitigation) for new and replaced impervious surfaces and the land disturbed:

- Creates or adds 2,000 square feet or greater of new, replaced, or new plus replaced impervious surface area

- Has land-disturbing activity of 7,000 square feet or greater.

New development that does any of the following shall comply with Minimum Requirements #1 through #12 for new impervious surfaces and the converted pervious surfaces:

- Creates or adds 5,000 square feet or more of new impervious surface area

- Converts 3/4 of an acre or more of native vegetation to lawn or landscaped areas

- Converts 2.5 acres or more of native vegetation to pasture.

2.3.2 Redevelopment

Figure 2.2 illustrates the process for determining the applicable minimum requirements for redevelopment.

All redevelopment shall comply with Minimum Requirement #2. All redevelopment that exceeds impervious area or land disturbance thresholds shall comply with additional minimum requirements, as follows:

- Redevelopment that does the following shall comply with Minimum Requirements #1 through #5 and #12 for the new and replaced impervious surfaces and the land disturbed:

  - The new, replaced, or total of *new plus replaced* impervious surfaces is 2,000 square feet or more, or

  - 7,000 square feet or more of land disturbing activities.

- Redevelopment that does any of the following shall comply with Minimum Requirements #1 through #12 for the new impervious surfaces and converted pervious areas:

  - Adds 5,000 square feet or more of new impervious surfaces

  - Converts 3/4 of an acre or more of native vegetation to lawn or landscaped areas

  - Converts 2.5 acres or more of native vegetation to pasture.

If runoff from new impervious surfaces and converted pervious surfaces is not separated from other surface runoff on the project site, stormwater treatment facilities must be sized for the entire flow directed to them. The Thurston County Drainage Manual Administrator may allow the minimum requirements to be met for an equivalent area within the same site and the same threshold discharge area. For roadway projects, the equivalent area does not have to be within the project limits, but must drain to the same receiving water. (For public roadway projects, use the most recent version of WSDOT's Highway Runoff Manual, for redevelopment guidance.)

Additional Requirements for Redevelopment Project Sites

In addition to the redevelopment requirements above, for any redevelopment project a complete retrofit (application of Minimum Requirements #1 through #12 to all impervious and pollution generation pervious surfaces) will be required if any of the following conditions apply:

- The proposed project will result in the addition of new impervious surface totaling 25 percent or more of existing impervious surface, providing that the area of the new impervious surface is at least 5000 square feet.
- The construction cost of proposed improvements is 25 percent or more of the assessed value excluding land value, providing that the construction cost of the addition or remodel is at least $690,000 in 2008 dollars (see note below).
- The County determines that an existing water quality, flooding, or erosion problem can be attributed to the developed site. The County shall base this determination on:
  - Results of basin planning for the basin where the project is located
  - Historic water quality data
  - Historic flooding, erosion, or habitat degradation in receiving waters.

Based on the information submitted to the County, the above determination of whether a complete retrofit will be required will be communicated to the applicant as early in the submittal process as feasible. If adequate information is presented, this could be at the time of the pre-submittal meeting, in the acceptance of the stormwater scoping report, or during preliminary review of the application.

NOTE: The $690,000 threshold figure is based on 2008 construction costs. The applicant shall calculate the current applicable figure based on using the current Washington State Department of Transportation (WSDOT) Construction Cost Index (CCI). The WSDOT CCI was 254 in 2008, and is updated annually. The calculation shall use the following formula:

$$Cost_{current} = Cost_{2008}\left(\frac{CCI_{current}}{CCI_{2008}}\right)$$

For road-related projects, runoff from all impervious surfaces (including existing, replaced and new pavement, shoulders, curbs, and sidewalks) shall meet all the Minimum Requirements if any of the following are met:

- The new impervious surfaces total 5,000 square feet or more and total 25 percent or more of the existing impervious surfaces within the project limits, or
- If the road project results in previously dispersed flows becoming concentrated (for example, because curb and gutter are to be installed), or
- The new impervious surfaces total 5, 000 square feet AND the estimated cost of the road project, excluding engineering, contingency, right-of-way acquisition and stormwater storage/treatment costs exceed $690,000 based on a 2008 Construction Cost Index (see adjustment method above).

The project limits for a roadway project shall be defined by the length of the project and the width of the right-of-way.

Financial Cap on Stormwater Mitigation

The total cost of stormwater improvements to mitigate existing impervious surfaces and pollution generating pervious surfaces shall be capped at a minimum expenditure of 30% of the total project costs excluding the cost of stormwater mitigation for existing surfaces.

For example, if the total project cost excluding stormwater mitigation costs is $1.0 million, and the cost to fully mitigate the existing impervious and pollution generating impervious areas is $500,000, then the applicant shall expend at least $300,000 toward mitigating existing impervious & pollution generating pervious making the total project cost including stormwater mitigation at least $1.3 million. The applicant shall consult with Thurston County regarding priorities for mitigation if the financial cap is in effect. The proposed stormwater mitigation improvements and cost data for stormwater mitigation and the total project cost shall be submitted with the scoping report and included in the Drainage Report for the project.

2.3.3 Basin Planning

Thurston County basin plans may have additional requirements for projects located within the basin. If your project is located within a basin subject to an adopted basin plan additional runoff treatment (minimum requirement #6), flow control (minimum requirement #7), or wetlands protection (minimum requirement #8) restrictions may apply. See Minimum Requirement #9 for more information.

2.4 Minimum Requirements

This section describes minimum requirements for stormwater management. See Section 2.3 of this Volume to determine which requirements apply. Volumes II through V of this manual describe BMPs and sizing criteria for use in meeting minimum requirements.

2.4.1 About Threshold Discharge Areas

Minimum Requirements #6 and #7 refer to *threshold discharge areas*. A threshold discharge area is an onsite area draining to one or more natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath). For a detailed description and example of mapping threshold discharge areas, see Section 4-2.5 of the *Highway Runoff Manual* (WSDOT 2008).

2.4.2 Minimum Requirement #1: Stormwater Site Planning

The main stormwater planning components of Minimum Requirement #1 are: (1) Construction Stormwater Pollution Prevention Planning, and (2) Permanent Stormwater Control Planning. Numerous documents are used to fulfill the objective of this requirement depending on the nature and location of the project.

The following types of submittals, as applicable to the project, when prepared as described in Chapter 3, will satisfy Minimum Requirement #1:

- Abbreviated Drainage Plan
- Engineered Abbreviated Drainage Plan
- Short Form Construction Stormwater Pollution Prevention Plan
- Drainage and Erosion Control Plan (includes a drainage report, drawings and specifications and a maintenance plan)

- Construction Stormwater Pollution Prevention Plan (includes temporary erosion and sediment control drawings and a narrative).

All non-exempt projects are required to prepare one or more of the above submittals for County review. Projects that require public roadway frontage improvements will be required to demonstrate how the roadway runoff is accommodated.

The County may require a project to prepare a “scoping report” and the applicant or County may request a “scoping meeting” early in the project to discuss the development site’s conceptual stormwater approach. This process may also be used to identify potential problems and to outline submittal requirements, scope, and content.

2.4.3 Minimum Requirement #2: Construction Stormwater Pollution Prevention Plan (SWPPP)

Projects in which the new, replaced, or new plus replaced impervious surfaces total 2,000 square feet or more, or disturb 7,000 square feet or more of land must prepare a Construction SWPPP (narrative and drawings) as part of the Drainage and Erosion Control Plan (see Section 2.4.1).

Each of the 12 elements must be considered and included in the Construction SWPPP, unless site conditions make an element unnecessary and exemption from that element is clearly justified in the SWPPP narrative.

Projects that add or replace less than 2,000 square feet of impervious surface or disturb less than 7,000 square feet of land are not required to prepare a Construction SWPPP, but must consider all of the 12 elements of a Construction SWPPP listed below, and develop controls for all elements that pertain to the project site. This can be demonstrated through the submittals required of all non-exempt projects as outlined in Chapter 3 (for example, an abbreviated or engineered abbreviated drainage plan).

These elements address general water quality protection strategies for limiting site impacts, preventing erosion and sedimentation, and managing activities and pollutant sources during construction.

The elements of a Construction SWPPP are:

1. Mark clearing limits/preserve vegetation

2. Establish construction access

3. Control flow rates

4. Install sediment controls

5. Stabilize soils

6. Protect slopes

7. Protect drain inlets

8. Stabilize channels and outlets

9. Control pollutants

10. Control dewatering

11. Maintain BMPs

12. Manage the project.

The SWPPP shall include a narrative and drawings, as described in Volume II. Volume II also has a template for a Short Form Construction SWPPP for projects that are eligible (see Chapter 3).

If the project is required to obtain coverage under Ecology's NPDES Stormwater Construction permit program for project sites greater than 1-acre the applicant shall provide a copy of the Notice of Intent and the SWPPP prepared for the NPDES Construction stormwater permit to Thurston County.

From October 1 through April 30, clearing, grading, and other soil disturbing activities will not be allowed unless it can be demonstrated that silt-laden runoff will be prevented from leaving the site through:

- Favorable site conditions such as vegetative coverage, no severe slopes, erosion-resistant soil types, and distance from receiving waters

- Limited activities and extent of disturbed areas

- Proposed erosion and sediment control measures.

The County may expand or restrict the seasonal limitation on site disturbance based on site inspections, local weather conditions, or other information. If, during the course of any construction activity or soil disturbance during the seasonal limitation period, silt-laden runoff leaving the construction site causes a violation of the surface water quality standard or if clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained, the County may take enforcement action, including but not limited to a notice of violation, administrative order, fine/penalty, stop-work order, or correction notice.

Activities and conditions exempt from seasonal controls are:

- Routine maintenance and repair of erosion and sediment control BMPs
- Routine public facility maintenance that doesn't expose bare soil
- Areas where there is 100 percent infiltration of stormwater within erosion and sediment control (ESC) facilities.

2.4.4 Minimum Requirement #3: Source Control of Pollution

All known, available and reasonable source control BMPs shall be applied to all projects. Source control BMPs shall be selected, designed, and maintained according to Volume IV, Chapter 3, of this manual.

Source control BMPs are used to prevent stormwater from contacting pollutants. They are a cost-effective means of reducing pollutants in stormwater and should be considered first in all projects, before applying treatment measures. Source control BMPs include operational and structural source control BMPs. See Volume IV for design details and the selection of source control BMPs. For construction sites, see Volume II.

Minimum Requirement #3 applies to all non-exempt projects that meet the thresholds described in Chapter 2. Source control of pollutants (sediment/erosion control and spill prevention) during construction applies to all projects per Minimum Requirement #2.

Depending on the project location, there may be an adopted basin plan (Minimum Requirement #9) or a TMDL plan (also known as a Water Cleanup Plan) with more stringent source control requirements for a specific basin. See Minimum Requirement #9 for more information.

Structural source control BMPs shall be shown on project drawings, and the design shall be documented in the Drainage Report. Any required maintenance or operations required for a structural source control BMP shall be included in the Maintenance Plan.

Operational source control BMPs shall be included in the Maintenance Plan for the project; or, if a Maintenance Plan is not required, the operational source control BMPs shall be included with other submittals and upon acceptance by the County shall be recorded with the County auditor for the subject property.

2.4.5 Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

Natural drainage patterns shall be maintained, and discharges from the project site shall occur at the natural location, to the maximum extent practicable.

Minimum Requirement #4 applies to all non-exempt projects that meet the thresholds described in Chapter 2, to the maximum extent practicable.

Preserving natural drainage systems provides multiple stormwater benefits and minimizes erosion and sediment problems. Runoff discharged from the project site must not cause a significant adverse impact to downstream receiving waters and downgradient properties.

When downstream drainage courses are inadequate, systems are undersized, or when (in the opinion of the Administrator or designee) property may be adversely affected by existing or proposed stormwater release rates, additional stormwater flow control measures may be required. Such determination by the Administrator or designee may be based upon information submitted by the applicant, existing information indicating problem areas, information received from or statements from property owners or residents near the project site, or current or past drainage problem litigation near the project. Additional information, calculations, or studies may be required of the applicant to assist the Administrator in making this determination.

If downstream conveyance system capacity is determined to be inadequate or undersized based on an evaluation of the entire contributing area at full build-out based on the current zoning, the applicant has the following options:

- Provide additional flow control, LID, or infiltration measures as required by the County to reduce stormwater discharge rates and/or volumes to pre-development conditions, or
- Correct or improve downstream drainage conditions so that the capacity is adequate to convey drainage from all contributing properties, or
- At such time as the County establishes a program for payment in lieu of improvements, the applicant may contribute to a dedicated fund to provide the downstream improvements required per the provisions of the program.

Any offsite improvements proposed by the applicant will require the applicant to obtain easements from the owners of any property where work occurs.

If flows for a given outfall are not channeled in the pre-development condition, runoff concentrated by the proposed project must be discharged overland through a dispersal system or to surface water through an energy dissipation BMP before leaving the project outfall. Typical dispersal systems include rock pads, dispersal trenches, level spreaders, and diffuser pipes. Typical energy dissipaters include rock pads and drop structures. These systems are better described in Volume III, "Conveyance."

In some instances, a diversion of flow from the existing (pre-development) discharge location may be beneficial to the downstream properties or receiving water bodies. Examples include situations where existing downstream flooding or channel erosion is occurring. If it is determined that a flow diversion may be warranted, the applicant should consult with Thurston County to confirm this conclusion and its application for the project.

As part of the project submittals, the applicant shall identify the location of natural drainage, topography, historic drainage information and any potential impacts. The discharge of stormwater from the project to adjacent properties may be subject to additional requirements (see Volume III, Conveyance).

2.4.6 Minimum Requirement #5: Onsite Stormwater Management

Projects shall employ onsite stormwater management BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible.

Minimum Requirement #5 applies to all projects that meet the thresholds described in Chapter 2. All projects, including those not meeting the thresholds of Chapter 2, should use onsite measures to the maximum extent practicable for the control of stormwater.

All projects required to comply with Minimum Requirement #5 shall employ all of the following Low Impact Development BMPs as applicable:

- Restore native vegetation (BMP LID.01)
- Post-Construction Soil Quality and Depth (BMP LID.02) – All disturbed areas of the project to be landscaped shall implement BMP LID.02 to restore soil quality and depth

- Downspout infiltration systems (BMP LID.04)
- Dispersion of roof and driveway runoff (BMP LID.05; LID.06; LID.07)
- Bioretention (BMP LID.08).

Where roof downspout controls are planned, the following three types shall be considered in descending order of preference:

- Downspout infiltration systems including bioretention (rain gardens)
- Downspout dispersion systems, only if infiltration is not feasible
- Collect and convey to the County or private stormwater system if other alternatives are not feasible.

The use of Low Impact Development BMPs is more effective in reducing disruptions to the site's natural hydrologic characteristics and preferable to more traditional BMPs such as detention ponds. In some cases, the application of onsite measures can reduce the effective impervious surface and/or effective pollution generating impervious surface within a threshold discharge area to the extent that additional flow control or water quality treatment (Minimum Requirements #6 and #7) is not required. An applicant may also consider using full dispersion where the impervious surface, landscape areas, and native vegetation retention as a percentage of the site meets certain thresholds (see BMP LID.11).

Chapter 4 provides guidance on BMP selection, including onsite stormwater management BMPs required by this minimum requirement. Design guidelines and sizing tables for the BMPs listed above are provided in Volume V.

Onsite measures and Low Impact Development BMPs shall be shown on the project drawings and design calculations shall be included in the Drainage Report. Maintenance and operations requirements for these BMPs shall be included in the Maintenance Plan for the project. For projects in which a Maintenance Plan is not required, the operations and maintenance criteria for onsite measures shall be shown on and described in the other submittal documents required for the project.

2.4.7 Minimum Requirement #6: Runoff Treatment

Projects must provide runoff treatment to reduce the water quality impacts of stormwater runoff from pollution-generating surfaces.

Minimum Requirement #6 applies to all non-exempt projects that meet the thresholds described in Chapter 2. Stormwater treatment facilities shall be constructed if the following criteria are met within a threshold discharge area (see Table 2.1):

- Total effective pollution-generating impervious surface (PGIS) is 5,000 square feet or more in a threshold discharge area, or
- Total pollution-generating pervious surfaces (PGPS) are 3/4 of an acre or more in a threshold discharge area, and from which there is a surface water discharge to a natural or man-made conveyance system from the site.

Table 2.1. Treatment Requirements by Threshold Discharge Area

	<¾ Acres of PGPS	≥¾ Acres PGPS	<5,000 sf PGIS	≥5,000 sf PGIS
Treatment Facilities		✔		✔
Onsite Stormwater BMPs	✔	✔	✔	✔

PGPS = pollution-generating pervious surfaces
PGIS = pollution-generating impervious surfaces
sf = square feet

The above thresholds apply to both a project's onsite and offsite improvements. Once the project triggers this minimum requirement, all new and replaced pollution generating impervious surfaces are required to receive water quality treatment.

With respect to the water quality treatment requirements, a "net" total of pollution generating impervious surfaces associated with a given project will not be considered when dealing with replaced impervious surfaces or impervious surfaces converted to pervious. For example, construction of new surfaces that do not generate pollution (i.e., replacing old surfaces that were pollution generating) does not balance the environmental impacts of newly created pollution generating surfaces. All new or replaced pollution generating surfaces that meet the thresholds for new development or redevelopment and create, add, and/or replace 5,000 square feet of pollution generating impervious surface shall provide water quality treatment.

If runoff from the total new PGIS and that portion of any replaced PGIS that requires treatment cannot be separated from the existing PGIS runoff, treatment facilities must be sized to treat all of the runoff.

Stormwater treatment facilities shall be selected using the process described in Chapter 4, designed in accordance with the design criteria in

Volume V, and maintained in accordance with the maintenance schedule in Appendix V-C and the requirements of Minimum Requirement #10.

Depending on the activities and likely pollutants at the project site, required BMPs may be basic, enhanced, phosphorus control, or oil control. Chapter 4, BMP Selection explains when each type is required.

- Volume III provides information on the water quality design storm and flow rate for treatment facility sizing.

Water quality treatment facilities shall be shown on the project drawings and include details and construction notes for their proper construction. Design calculations for each BMP shall be included in the Drainage Report along with any supporting documents (geotechnical reports, material specifications, soils testing, etc.). Maintenance and operations requirements for these BMPs shall be included in the Maintenance Plan for the project. If a justification for not providing treatment facilities for a threshold discharge area based on a reduction in effective impervious surfaces due to LID techniques, this justification shall be documented in the Drainage Report for acceptance by Thurston County.

2.4.8 Minimum Requirement #7: Flow Control

Projects must provide flow control to reduce the impacts of stormwater runoff from impervious surfaces and land cover conversions. This includes controlling the discharge and infiltration for a project site such that:

- Stormwater discharges from a threshold discharge area shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow and,

- For groundwater recharge, the average annual infiltration volume of stormwater from the project site after development shall match (or exceed) the pre-developed (forested condition, see below) average annual volume infiltrated

- The predevelopment condition to be matched shall be a forested land cover, unless reasonable historic information is available that indicates the site was prairie prior to settlement (modeled as "pasture" in the Western Washington Hydrology Model).

The above discharge requirement is waived for sites that will reliably infiltrate all runoff from impervious surfaces and converted pervious surfaces.

The requirement to match the average annual infiltration volume may be waived for the portion of a project site that can demonstrate that the average overall infiltration rate of the native soils at that portion of the site in the pre-developed condition have an infiltration rate of less than 0.5 inches per hour.

In calculating the average annual infiltration volume for purposes of meeting the minimum infiltration requirement, the applicant may include infiltration from dispersion areas, landscaped areas, biofiltration and bioretention facilities, drywells, and other infiltration facilities.

The Thurston County version of the Western Washington Hydrologic Model, Version 3, has been modified to include calculation of infiltration and whether the site meets the average annual infiltration criteria.

The following require construction of flow control facilities or use of land use management BMPs that will achieve the standard requirements (see Table 2.2):

- Projects in which the total of effective impervious surfaces is 10,000 square feet or more in a threshold discharge area.
- Projects that convert 3/4 of an acre or more of native vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture in a threshold discharge area, and from which there is a surface discharge in a conveyance system (natural or man-made) from the site.
- Projects that, through a combination of effective impervious surfaces and converted pervious surfaces, cause a 0.1 cubic feet per second increase in the 100-year recurrence interval flow frequency from a threshold discharge area, as estimated using the WWHM, MGSFlood, or other approved model.

That portion of any development project where the above thresholds are not exceeded in a threshold discharge area shall apply onsite stormwater management BMPs in accordance with Minimum Requirement #5.

Table 2.2. Flow Control Requirements by Threshold Discharge Area

	Flow Control Facilities	Onsite Stormwater Management BMPs
<3/4 acres conversion to lawn/landscape, or <2.5 acres to pasture		✔
≥3/4 acres conversion to lawn/landscape, or ≥2.5 acres to pasture	✔	✔
<10,000 square feet of effective impervious area		✔
≥10,000 square feet of effective impervious area	✔	✔
≥0.1 cubic feet per second increase in the 100-year flood frequency	✔	✔

If the discharge is to a stream that leads to a wetland, or to a wetland that has an outflow to a stream, both this flow control requirement and Minimum Requirement #8 apply.

Projects discharging directly to salt water bodies are exempt from flow control.

The requirements below apply to projects that discharge stormwater directly or indirectly through a conveyance system, into an exempt receiving water including a salt water body:

- The direct discharge must not result in the diversion of drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types "S", "F", or "Np" in the Permanent Water Typing System, or from any Category I, II, or III wetland; and

- Flow splitting devices or drainage BMPs shall be applied to route the natural runoff volumes from the project site to any downstream Type 5 stream or Category IV wetland:

  - Design of flow splitting devices or drainage BMPs will be based on continuous hydrologic modeling analysis. The design will assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50 percent of the 2-year to the 50-year peak flow.

  - Flow splitting devices or drainage BMPs that deliver flow to Category IV wetlands will also be designed using continuous simulation hydrologic modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by Thurston County; and

- The project site must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection, etc.) and extends to the ordinary high water line of the exempt receiving water; and

- The conveyance system between the project site and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) of the site, and the existing condition from non-project areas from which runoff is or will be collected; and

- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

For discharges to a conveyance system discharging to salt water see Minimum Requirement #12 for additional requirements. Flow control may be required if the conveyance system capacity is limited.

2.4.9 Minimum Requirement #8: Wetlands Protection

Discharges to wetlands (directly or indirectly through conveyance systems) shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.

Minimum Requirement #8 applies to all non-exempt projects that meet the thresholds of Chapter 2 and where stormwater discharges into a wetland, either directly or indirectly, through a conveyance system.

The thresholds identified in Minimum Requirement #6: Runoff Treatment and Minimum Requirement #7: Flow Control shall also apply for discharges to wetlands. In addition, a hydroperiod analysis must be performed and must show that the discharge will not adversely affect the wetland hydroperiod. The hydrologic analysis shall use the existing land cover condition to determine the existing hydrologic conditions, unless directed otherwise by the County or other regulatory agency.

The hydroperiod is the pattern of fluctuation of water depth and the frequency and duration of water levels on the site. This includes the duration and timing of drying in the summer. A hydrologic assessment is useful to measure or estimate elements of the hydroperiod under existing **preproject** and anticipated **postproject** conditions. This assessment involves reviewing and applying the best available science to assess potential impacts and deciding whether hydrological modeling is warranted. Wetland hydroperiod analysis is of concern when proposing to discharge stormwater into or detract stormwater from a natural wetland (not constructed). The purpose of the analysis is to determine whether the stormwater will change the natural hydroperiod beyond the limits allowed.

When this is an issue on a project, the applicant should retain the services of a wetlands professional to assist in the evaluation of the wetland impacts.

Refer to Ecology's *Stormwater Management Manual for Western Washington*, Appendix D of Volume I, for additional guidance on discharges to wetlands.

A wetland can be considered for hydrologic modification or stormwater treatment only in accordance with Thurston County Critical Areas Ordinance TCC 17.15.900.

Stormwater treatment and flow control facilities shall not be built within a natural vegetated buffer, except for:

- Where allowed by Thurston County Critical Areas Code, TCC 17.15.
- As allowed in wetlands approved for hydrologic modification or treatment as approved by Thurston County or other regulatory agency.

An adopted and implemented basin plan (Minimum Requirement #9), or a TMDL may be used to develop requirements for wetlands that are tailored to a specific basin.

2.4.10 Minimum Requirement #9: Basin and Watershed Planning

Projects may be subject to equivalent or more stringent minimum requirements for erosion control, source control, treatment, operations and maintenance (O&M), and alternative requirements for flow control and wetlands hydrologic control as identified in basin/watershed plans or Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) implementation plans for specific receiving waters.

Basin Plans

Basin/watershed plans shall evaluate and include, as necessary, retrofitting of urban stormwater BMPs for existing development or redevelopment to achieve watershed pollutant reduction and flow control goals consistent with requirements of the Clean Water Act. Standards developed from basin plans shall not modify any minimum requirement until the basin plan is both formally adopted and implemented by the local governments within the basin, and approved or concurred with by Ecology. Refer to Appendix I-A of Ecology's *Stormwater Management Manual for Western Washington* for examples of how basin planning can alter the minimum requirements.

In order for a basin plan to modify the minimum requirements, the following conditions must be met:

- The plan must be formally adopted by all jurisdictions with responsibilities under the plan
- All ordinances or regulations called for by the plan must be in effect.

As of May 2009, the following basins in Thurston County have adopted basin plans:

- Green Cove Creek Basin (North of Olympia, Cooper Point)
- Salmon Creek Basin (South of Tumwater, Vicinity I-5 and 93rd)
- Chambers/Ward/Hewitt Creek Basin (South of Olympia, Vicinity Yelm Highway & Rich Road)
- Indian/Moxlie Creek Basin (East side of City of Olympia and along South Bay Road)
- McCallister/Eaton Creek Basin (East of Lacey paralleling the Nisqually River)
- Percival Creek Basin (Southwest of Olympia from Black Lake to Capitol Lake)
- Woodland/Woodard Creek Basin (City of Lacey / north, south and east of Lacey).

Information on Thurston County's basin planning process and links to current basin plans may be found on Thurston County's web site:

<http://www.co.thurston.wa.us/stormwater/Basin%20Plans/Basin_Plans_home.htm>.

2.4.11 Minimum Requirement #10: Operation and Maintenance

A Maintenance Plan that is consistent with the provisions in this manual shall be provided for all proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified.

For private facilities, a project-specific agreement to maintain stormwater facilities and implement a pollution source control plan consistent with the provisions in Appendix I-E, for a single family residence, residential subdivision or commercial/industrial project, shall be executed by the party (or parties) responsible for maintenance of stormwater facilities and BMPs. The agreement shall normally be signed by the property owner and recorded with the Thurston County Auditor's Office prior to final project acceptance by Thurston County. A draft copy of the agreement shall be included with the submittal of the Maintenance Plan for County review and acceptance. The maintenance agreement shall run with the land and be transferred automatically to all subsequent owners. Publicly owned facilities are not required to execute an agreement.

If the project is a subdivision, the Proponent shall form a Property Owners' Association. The document creating the Property Owners' Association shall, at a minimum, make provision for the following:

- Members of the Property Owners' Association shall be responsible for maintenance of storm drainage facilities as described in the Maintenance Plan

- Inclusion by reference of the Maintenance Plan prepared by the Project Engineer in accordance with Chapter 4 of this volume

- Power to assess fees to maintain storm drainage facilities

- Sanctions in the event that Thurston County has to take action to maintain facilities. The following or substantially similar words shall appear in the document creating the Property Owner's Association:

  In the event Project Proponent (or successors or the Property Owners' Association), in the judgment of Thurston County, fails to maintain drainage facilities within the plat, or if the Proponent or successors willfully or accidentally reduces the capacity of the drainage system or renders any part of the drainage system unusable, the Proponent or successors agree to the following remedy: After 30 days notice by registered mail to the Proponent or successors, Thurston County may correct the problem or maintain facilities as necessary to restore the full design capacity of the drainage system. Thurston County will bill the Proponent or successors for all costs associated with the engineering and construction of the remedial work. Thurston County may charge interest as allowed by law from the date of completion of construction. Thurston County will place a lien on the property and/or on lots in the Property Owners' Association for payments in arrears. Costs or fees incurred by Thurston County, should legal action be required to collect such payments, shall be borne by the Proponent or successors.

- A Maintenance Covenant stating the Property Owners' Association's specific maintenance responsibilities shall be recorded on the plat and recorded against each lot in the subdivision. The covenant shall include the following or substantially similar language:

  MAINTENANCE COVENANT

  Easements are hereby granted for the installation, inspection, and maintenance of utilities and drainage facilities as delineated on the plat for subdivision______________ including unrestricted access for Thurston County staff to any and all stormwater system features for the purpose of routine inspections and/or performing maintenance, repair and/or retrofit as may become necessary. No encroachment will be placed within the easements shown on the plat which may damage or interfere with the installation, inspection, and maintenance of utilities. Maintenance and expense thereof of the utilities and drainage facilities shall be the responsibility of the Property Owners' Association as established by covenant recorded under Auditor's file number _____________.

Sanctions for Failure to Maintain

Inadequate maintenance is a common cause of failure for stormwater control facilities. Volume V, Appendix C, provides detailed maintenance guidelines and standards for each BMP presented in this manual. The applicable checklists from Volume V shall be included in the Maintenance Plan for the project.

At private facilities, a copy of the Maintenance Plan shall be retained onsite or be reasonably accessible from the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the Maintenance Plan shall be retained in the appropriate department. A log of maintenance activity shall be kept and be available for inspection by the County. An annual report on maintenance activities during the previous year is required to be submitted annually no later than August 31st Chapter 3 describes Maintenance Plan submittal requirements, which are included as part of the Drainage and Erosion Control Plan for the project.

2.4.12 Minimum Requirement #11: Financial Liability

To ensure compliance with these standards, performance bonding or other appropriate financial instruments shall be required for all projects.

Financial Guarantees

In accordance with Thurston County Code Title 15.05.040, the project proponent/owner shall provide financial guarantees to insure that:

- The project will operate according to the design approved by the project engineer, and
- Operation of erosion control facilities will provide protection against siltation of surface water, erosion, and damage to adjacent properties.

The project proponent/owner shall provide a financial guarantee to the Administrator to ensure satisfactory maintenance of drainage facilities for a minimum of 2 years from final plat acceptance or acceptance of the project, whichever is later, in accordance with the Maintenance Plan submitted as part of the Drainage and Erosion Control Plan. The financial guarantee shall continue in effect until the drainage facilities are fully established, functioning per design and determined not to have substantial maintenance problems, or, if for a residential subdivision project, until no less than 80 percent of the lots have been developed and received certificates of occupancy (build-out). Upon acceptance of the project by Thurston County and after minimum time requirements and other conditions have been met, including minimum build-out for residential subdivisions, the project proponent shall request in writing that the financial guarantee be released. Said request shall document that the requirements for financial guarantee release have been met.

If the stormwater system is dependent on a property owners' association (POA) for maintenance, then the applicant shall present evidence of a POA being established and active before the financial guarantee is released. The holder of the financial guarantee shall establish a mechanism prior to sale of all or part of the project that ensures that the financial agreement holder has the legal right and ability to perform required stormwater system maintenance while the financial guarantee is in effect. Proof of same shall be provided to the Administrator prior to acceptance of the financial guarantee.

The mechanism may include a replacement of the financial guarantee by an identical guarantee from a third party (such as a POA) who takes responsibility for stormwater system maintenance. The original financial guarantee shall not be released until the replacement guarantee is accepted by the Administrator and legally recorded.

The amount of the guarantee shall be 25 percent of the construction cost of the drainage facilities. The applicant shall submit an itemized work sheet for the cost of facilities, acceptable to the Administrator before the financial guarantee amount is fixed. The bond quantities worksheet provided in Appendix I-D shall be used to prepare the cost estimate.

With County acceptance, and to the extent allowed by law, all project guarantees may be replaced by a single guarantee, provided that the total amount guaranteed shall at no time be less than the sum of the separate guarantees replaced. Furthermore, such guarantees shall clearly delineate those separate guarantees which they are intended to replace.

Subject to County acceptance, financial guarantees may be any of the following:

- Cash deposit escrow account
- Assignment of interest in a bank account
- Irrevocable letter of credit from a financial institution
- A bond.

All financial guarantees shall run continuously until released by the County.

2.4.13 Minimum Requirement #12: Offsite Analysis and Mitigation

Minimum Requirement #12 applies to those projects meeting the thresholds outlined in Chapter 2. The Project Engineer or applicant (for abbreviated plans) shall submit an offsite analysis that assesses the potential offsite impacts of the project's stormwater discharges.

All projects shall perform a *qualitative analysis* downstream from the site to the receiving water even if 100 percent infiltration is proposed. The analysis shall meet the requirements in Chapter 3.

A *quantitative* analysis may be required for any project deemed to need additional downstream information or where the Project Engineer or the Administrator or designee determine that a quantitative analysis is necessary to evaluate the offsite impacts or the capacity of the conveyance system.

This quantitative analysis shall determine conveyance system performance for the appropriate design events (see Volume III), both with and without the proposed development and based on full development of the contributing basin based on land use zoning. The Administrator or designee shall have the discretion to specify the distance and level of detail to be provided by the Project Engineer. The Administrator or designee shall consider factors such as the relative size of the new development, availability of other hydrologic work for the drainage area, and results of the qualitative analysis in making this determination.

The Administrator or designee may impose stricter discharge, infiltration or detention standards, or require offsite mitigation work to an existing conveyance system if the discharge from the Project is reasonably expected to result in any of the following:

- Flooding
- Loss of aquatic habitat due either to high or low flows
- Property damage
- Water quality problems
- Erosion
- An unacceptable interruption of vital services
- Exceeding the capacity of a downstream conveyance system based on full basin development.

If the Project Engineer (or Administrator or designee) determines that greater treatment, infiltration or storage volumes, lower release rates, or downstream improvements are needed, he or she shall specify project design criteria or other means to relieve the downstream problems, providing that such a solution will not violate minimum standards established in this Drainage Design and Erosion Control Manual. The Administrator or designee shall have the final decision as to the scope and depth of the analysis.

Other means might include increases in downstream flow capacity or offsite detention and infiltration facilities. Plans and financing for these alternatives will be subject to the acceptance of the Administrator or designee.

The Offsite Analysis shall also include how the runoff from any public roadway frontage abutting the property is managed (qualitative at minimum, quantitative if meets above conditions). The project shall incorporate any runoff from public roadway frontage into the drainage system for the project.

2.5 Deeds and Easements

The following deeds and easements shall be used to convey property or rights to Thurston County:

- Statutory warranty deed (individual, partnership, or corporate): conveys real property to Thurston County

- Storm sewer easement: conveys to Thurston County the right to have and maintain a storm sewer system across a specific parcel of property

- Stormwater Maintenance Agreement: delineates responsibilities of party responsible for stormwater system maintenance and grants to Thurston County the right to have access to stormwater facilities for purposes of inspection, maintenance, or repair if the party responsible for maintenance fails to take required actions in accordance with the maintenance agreement.

- Slope and utility easement: conveys the right to have fill material or a cut slope and utilities on private property

- Quitclaim deed: conveys maintained but undocumented right-of-way to Thurston County

- Drainage Easement: conveys to Thurston County the right to access, use, and maintain a specific area of a parcel of property for purposes of storm drainage. This may include stormwater facilities for water quality treatment or flow control, dispersion, conveyance, or other purposes.

Prior to final project acceptance by Thurston County, all easements, dedicated tracts, buffers, or similar features associated with the stormwater facilities of a development, including a subdivision, shall be shown on the face of the plat or project site plan. In addition, written legal documents shall be prepared and recorded against all parcels to which the easement or dedication applies. Easements or tracts providing access to stormwater facilities shall be delineated in the field with permanent markers to prevent encroachment.

2.6 Acceptance of New Stormwater Facilities

The developer of a stormwater facility is responsible for construction and maintenance of the facility, which must be in compliance with this manual.

2.6.1 Public Ownership

The County does not accept maintenance responsibility for private stormwater facilities constructed by private developers.

2.6.2 Private Ownership – Subdivision Projects

If the project is a subdivision or short subdivision, the project proponent/owner shall form a property owners' association. The document creating the association shall provide for the following, at a minimum:

- The Property Owners' Association shall be responsible for maintenance of storm drainage facilities
- Inclusion by reference of the Maintenance Plan prepared by the project engineer in accordance with this manual
- Power to assess fees to maintain storm drainage facilities
- Responsibility for payment of financial sanctions/repayments should the County have to conduct repairs due to hazardous conditions.

The maintenance covenant and statement of sanctions described under Minimum Requirement #10, Section 2.4.11 will be included in the document establishing the Property Owners' Association and shall be recorded with the Thurston County Auditor for the plat and recorded against each lot within the subdivision or short division.

2.6.3 Private Ownership – Other Projects

If the project is other than a subdivision, short subdivision, or large lot division, the applicant will describe the organization or persons that will own and maintain the facility and provide evidence that maintenance activities will be performed and are adequately financed.

2.7 Adjustments

Adjustments to the Minimum Requirements may be granted prior to permit acceptance and construction. The Administrator may grant an adjustment subject to a written finding of fact that documents the following:

- The adjustment provides substantially equivalent environmental protection
- The objectives of safety, function, environmental protection and facility maintenance, based upon sound engineering, are met.

2.8 Exceptions

Exceptions to the Minimum Requirements or the design standards, submittal requirements, or any other standards provided in the Manual may be allowed at the discretion of the Administrator provided that the applicant will substantially meet flow control and water quality goals established by or implicit in these standards. The Administrator may grant an exception subject to a written finding of fact that documents the following:

- There are special physical circumstances or conditions peculiar to the land, such as size, shape, topography, or location, such that the strict application of these provisions would deprive the property owner of rights commonly enjoyed by other properties similarly situated; OR

- The site is being redeveloped and certain site investigations or installed stormwater facilities would require that existing structures be removed or damaged; OR

- The site is being redeveloped and the changes are either very small or configured in such a way that in the Administrator's or designee's opinion some requirements of the manual cannot practically be met; OR

- The project is to be completed within an existing right-of-way which is of inadequate size to install required facilities and which cannot be expanded due to encroaching structures or setbacks;

AND

- That the granting of the exception will not be detrimental to the public health and welfare, nor injurious to other properties in the vicinity and/or downstream, and to the quality of waters of the state; AND

- The exception is the least possible exception that could be granted to comply with the intent of the Manual; AND

- A fee-in-lieu, based on the avoided cost or value of the exception, may be collected by the County subject to specific requirements regarding fee-in-lieu set by Thurston County at such time as a fee-in-lieu program is established.

2.9 Supplemental Guidelines

The adjustment and exception variance provisions are important elements of the plan review and enforcement programs. They are intended to maintain a necessary flexible working relationship between the applicant and the County. The Administrator will consider these requests judiciously, keeping in mind both the need of the applicant to maximize cost-effectiveness and the need to protect offsite properties and resources from damage.

2.10 Interpretations and Appeals

Any person who disagrees with any decision of the Administrator or Thurston County regarding application of this Manual may request an interpretation. The request for an interpretation shall be submitted in writing to the Administrator or designee as defined herein. The Administrator or designee shall respond to that person in a timely manner.

Appeals from an Administrative decision may be taken to the Hearings Examiner by any aggrieved person or by an officer, department, board, or commission of the jurisdiction affected by any order, requirement, permit, decision, or determination made by the Administrator or designee in the administration or enforcement of this manual or any subsequent amendment thereto. The appeals procedure shall be identical to the appeal procedures of the Thurston County zoning code which requires the appeal to be in writing and made within 14 days of the administrative decision being appealed. A fee is required to be paid for an appeal.

2.11 Severability

If any provisions of this Manual or their application to any person or property are amended or held to be invalid, the remainder of the provisions in this Manual in their application to other persons or circumstances shall not be affected.

Chapter 3 - Stormwater Submittal Requirements

3.1 Introduction

Completion of submittals described in this chapter documents compliance with Minimum Requirement #1 (Stormwater Site Planning) and Minimum Requirement #2 (Construction SWPPP), as described in Chapter 2. The following submittals, and their applicability to different types and sizes of projects, are described in this Chapter:

- Abbreviated Drainage Plan
- Engineered Abbreviated Drainage Plan
- Short Form Construction Stormwater Pollution Prevention Plan
- Drainage and Erosion Control Plan (includes a Drainage and Erosion Control Report, drawings and specifications and a Maintenance Plan)
- Construction Stormwater Pollution Prevention Plan (includes temporary erosion and sediment control drawings and a narrative).

All non-exempt projects are required to prepare one or more of the above submittals for County review and acceptance.

The County may require a project to prepare a “scoping report” and the applicant or County may request a “scoping meeting” early in the project to discuss the development site’s conceptual stormwater approach. This process may also be used to identify potential problems and to outline submittal requirements, scope, and content.

This chapter describes the submittal process for drainage review of projects submitted to Thurston County for permits. However, the site characterization and stormwater planning process should begin before submittal preparation.

3.1.1 Site Characterization

Site planning and design are integrated with stormwater management requirements. The manner in which a site is developed will impact the extent and cost of stormwater treatment and flow control. This section provides techniques that should be implemented to reduce both the impacts of projects on receiving waters and the overall cost of the stormwater management system.

Take an inventory of the site prior to design activities and identify the following:

Soils Analysis

Use of many of the BMPs described in this Manual requires a detailed understanding of site soils. A preliminary soils analysis of the overall site to identify the locations of different soil types, the layering of soils, existence of hardpan, etc. should be conducted prior to major site planning. The objective of site planning should be to locate new impervious surfaces over soils that are less permeable and locate proposed stormwater facilities over soils that are more permeable to promote infiltration.

A preliminary assessment of infiltration rates of soils throughout the site should be considered early in the process for establishing potential BMP locations. More detailed infiltration evaluation as described in Volume III can occur once preliminary locations of infiltration facilities are established. Establishing an estimated overall site infiltration rate will also determine whether the minimum infiltration volume requirement of Minimum Requirement #7 will apply to the project.

A few strategically located test pits or borings are generally adequate for this preliminary soils assessment.

Critical Areas (e.g., wetlands, streams, or stream buffers)

Sites that have streams, wetlands, high groundwater, steep slopes, geologic hazard areas, well head protection areas or a number of other features are considered critical areas. Many have been assigned buffer zones that restrict activities that can occur within them. These critical areas and associated buffers must be indicated on site plans and methods to protect them must be instituted from the start of development.

Natural Drainage Systems and Outfalls

Minimum Requirement #4 stipulates that natural drainage patterns shall be maintained, and discharges from the project site shall occur at the natural location, to the maximum extent practicable (see Chapter 2). By identifying natural drainage patterns at the start of the project, the designer can ensure that drainage routes are protected and that (where possible) the site is designed to minimize the conveyance facilities required to transport stormwater to natural drainage locations. Preserving natural drainage also decreases the likelihood of flooding or other problems downstream.

Significant Trees and Native Vegetation

By designing the site to protect significant trees and native vegetation, the designer will have more opportunities to use LID BMPs such as infiltration and dispersion for stormwater management. Native vegetation areas suitable for dispersion and where trees can be retained without risk of toppling should be mapped and included in the site plan.

Steep Slopes

Unless preventive measures are taken, stormwater runoff from development will cause additional erosion problems or even landslides on steep slopes. Many stormwater BMPs do not work well in areas with steep slopes, and their use is limited in those locations. Identify through topographic mapping and site visits the location of slopes greater than 10 to 15 percent and show these on the site maps. Special studies may be required for facilities located within setback distances to steep slopes. Marine bluffs are a special case of steep slopes for properties located along the marine waterfront. Thurston County Code, Title 17, includes specific requirements related to properties along marine bluffs.

Existing Topography

How does the undeveloped site deal with stormwater? If most stormwater currently infiltrates rather than running off the site, the finished site should use infiltration as the main method of stormwater management. This lessens the need for constructing new drainage channels or installing pipe, lessens the likelihood of downstream flooding, and protects downstream water quality.

If the topography provides large areas of surface storage through many small dips and hollows, consider providing onsite storage. If the existing topography already drains to a natural channel, designing the drainage system to follow this means less grading and less likelihood of erosion, if existing channel vegetation is preserved.

Design practices that consider and adapt to a site's characteristics, like the features listed above, are sometimes referred to as Low Impact Development. LID techniques are intended to more closely mimic predevelopment watershed hydrologic functions than traditional development practices.

LID techniques are emphasized throughout this manual. These techniques include reducing impervious surfaces (described in BMP LID.03), preserving native vegetation (BMP LID.01), and protecting soils (BMP LID.02). They require advance planning, but will likely reduce costs associated with grading, stormwater treatment, flow control, stormwater conveyance, paving materials, curbs, and landscaping (if native vegetation is preserved). The County's NPDES Phase II permit also requires LID measures be given preferential consideration.

Preliminary sources of topographic information such as USGS maps and the Thurston County Geodata system can be used for preliminary evaluation of a site; however, topographic surveying by licensed surveyors and site visits to verify conditions by the project engineer or designer should be conducted to support design and before construction.

3.1.2 Site Design – Smart Design and Low Impact Development

As presented in Chapter 1, and as required by Minimum Requirement #5, to effectively protect critical areas and receiving waters while taking advantage of a site's overland and subsurface flow, infiltration, storage, and evapotranspiration characteristics, the applicant shall consider first the following Low Impact Development strategies:

- **Minimize effective impervious area (EIA):** By avoiding the use of curbs (where permitted), designing reverse slope sidewalks, and allowing impervious surfaces to drain overland to pervious areas, a site can be designed to avoid concentrating runoff allowing for a higher time of concentration and greater infiltration. Ecology allows a flow credit for reverse slope sidewalks that drain onto native soils (see BMP LID.03). When impervious surfaces drain onto lawn or gravel prior to being collected in the site stormwater system, peak flows and volumes of stormwater from the site are reduced, thereby reducing stormwater management costs.

- **Onsite stormwater management:** Many parts of Thurston County have soils with high infiltration rates. By designing your site so that small areas drain to localized facilities, such as bioretention facilities (BMP LID.08), you may be able to manage your runoff entirely onsite, using areas not much larger than those needed for traditional landscaping. This practice also assures compliance with Minimum Requirement #5.

- **Alternative paving surfaces**: For areas of private developments with low traffic volume and where allowed by Thurston County road standards for private roads, alternative paving surfaces (BMP LID.09) such as porous concrete or asphalt can be highly effective at reducing or eliminating stormwater runoff and associated stormwater treatment, flow control, and conveyance costs. Even with very low infiltration rates of underlying soils, alternative paving surfaces are highly effective at controlling stormwater runoff. Alternative paving surfaces are not allowed within the public right-of-way or for private roadways which may be dedicated to the County.

3.2 Submittal Review and Acceptance Process

This is a conceptual overview of a typical submittal review and acceptance process, shown in Figure 3.1. For the latest information on submittal requirements and the acceptance process, contact the Permit Assistance Center or see Thurston County's permit website at: <http://www.co.thurston.wa.us/permitting/>.

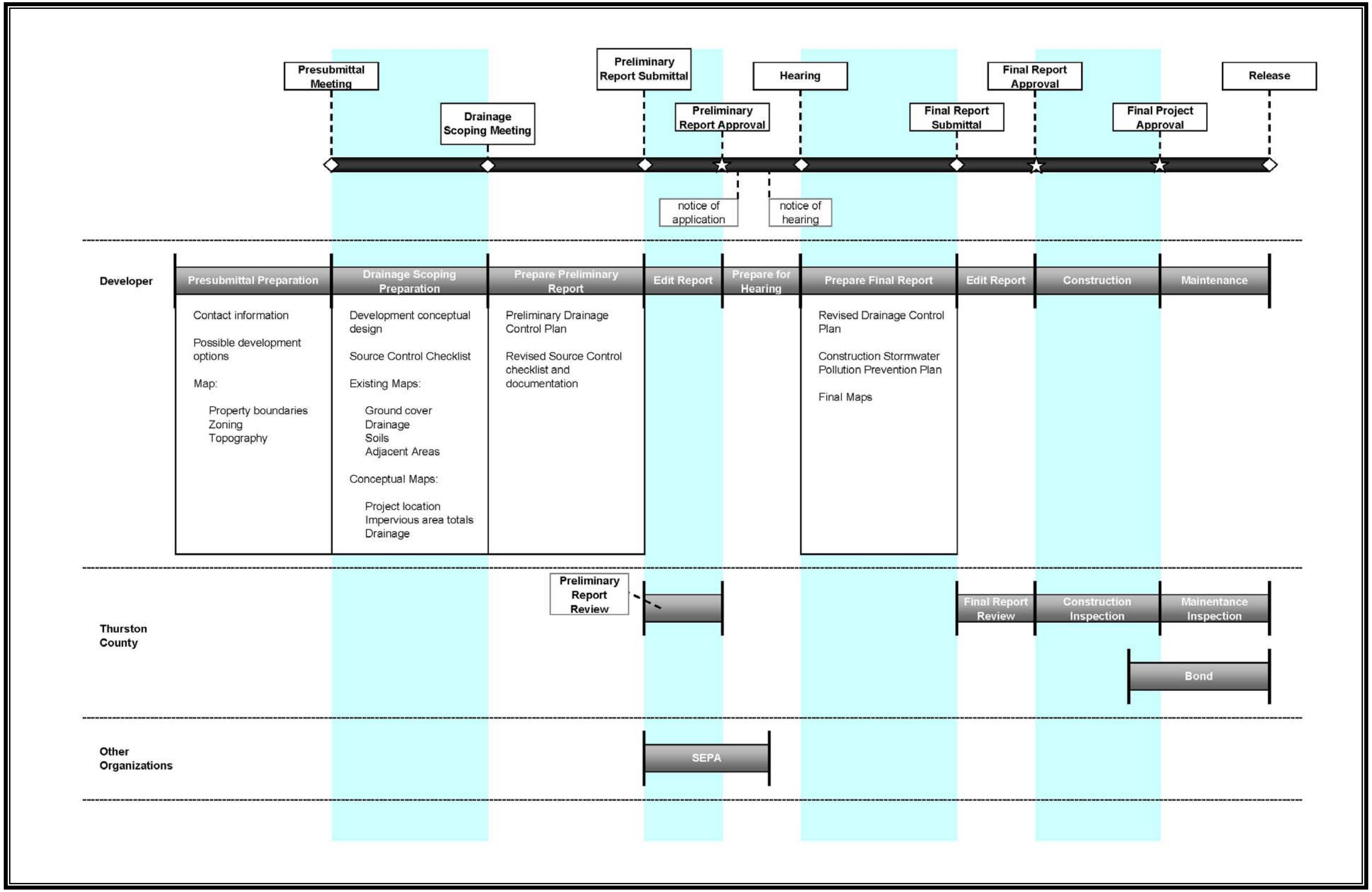


Figure 3.1. Submittal Review and Approval Process.

3.2.1 Presubmittal Meeting

A presubmittal meeting is an informal meeting between a project applicant and County and local government staff who will review the proposal. The applicant may have advisors present (e.g., realtor, surveyor, and engineer). Since this is an informal meeting and no decisions will be made, public comment is limited to the applicant and their advisors.

The project applicant must provide contact information, possible development options, and a map showing the property boundaries, topography, and zoning.

Sometimes, a presubmittal meeting is a required first step in a land use or subdivision process. The meeting is also a good way to obtain important information before beginning your project. For more information about the presubmittal meeting, see Thurston County's permit website at: <http://www.co.thurston.wa.us/permitting/>.

A presubmittal meeting is not required for single family residential projects, short plats, or large lot subdivision projects. However, it is still an option on these projects and may be appropriate on more complex projects to avoid delays in application review and acceptance.

3.2.2 Drainage Scoping Report/Meeting

For any project exceeding the thresholds of Chapter 2 for which Minimum Requirements #6 (Runoff Treatment) and/or #7 (Flow Control) apply, a Drainage Scoping Report shall be submitted. Based on the review of the Drainage Scoping Report, or at the request of the applicant, a drainage scoping meeting may be scheduled to assist the applicant in complying with stormwater requirements.

The Drainage Scoping Report shall include the following:

- A letter of transmittal requesting a Drainage Scoping Report review and including applicant, property owner, and parcel information required to identify the property and its location
- A written description of the project including overall stormwater management strategy proposed for the site
- Maps of the sites existing conditions showing ground cover, existing drainage, topography, soils, and adjacent areas
- A general vicinity map showing surrounding properties including topography, downstream, and upstream areas of the project

- Results of preliminary geotechnical investigations, test pits, etc. as well as Natural Resources Conservation Service (NRCS) soils mapping information

- A completed conceptual site plan, including a scale drawing with topography of the site and showing conceptual lot and building locations, impervious area totals, proposed drainage facilities, zoning information including any limits on impervous surfaces, tree retention requirements, landscape buffers, etc.

- If the project is a redevelopment project, a preliminary estimate of project construction costs should be submitted.

- The applicant shall also submit a completed source control checklist (see Volume IV, Source Control).

Upon review of the Drainage Scoping Report, Thurston County will prepare a response letter accepting the report and providing any additional information, studies, recommendations, suggestions, or additional requirements that might apply to the project that should be included in the submittal documents. If the County determines that a drainage scoping meeting is required, this will be included in the response letter.

3.2.3 Preliminary Report Submittal

Based on comments received from the Drainage Scoping Report review and drainage scoping meeting, the applicant then produces a preliminary Drainage and Erosion Control Plan including a preliminary drainage report, drainage plan, and a revised source control checklist for inclusion in the permit or land use application package.

3.2.4 Final Report Submittal

After receiving preliminary acceptance of the project (Preliminary Plat Approval, Site Plan Review Approval, etc.) the applicant shall submit a final Drainage and Erosion Control Plan including a complete, Drainage Report, Maintenance Plan, Construction SWPPP, and final construction drawings for the project for County review.

Drainage and Erosion Control Plans submitted to the County will be routed to the Administrator or designee for review concurrently with other project plans (e.g., vegetation removal and clearing, final grading, landscaping, water and sewer, community onsite sanitary waste disposal system, roads, utilities plans). Incomplete Drainage and Erosion Control Plans will be returned to the applicant without being reviewed.

Until the Administrator or designee accepts the submittal and confirms that erosion control devices are in place as per the plan, the County will not:

- Grant any development, building, or other related permit except as needed to install erosion and sediment control facilities
- Allow project clearing, earthwork, demolition, site work, or construction to begin
- Allow construction of footings for structures.

3.2.5 Final Report Acceptance

After the applicant completes changes to the final report required by the County, the County shall issue a Final Report Acceptance, allowing construction to begin.

3.2.6 Final Project Acceptance

The following must be completed before the County will accept plats, grant certificates of occupancy, release financial securities related to drainage and erosion control, or accept final construction.

For those filing Drainage and Erosion Control Plans:

- Drainage and Erosion Control Plan accepted by the County
- Stormwater Facilities Maintenance Plan accepted by County
- Construction Inspection Report and as-built drawings in electronic format (PDF or CAD)
- Special requirements on the cover sheet of a plat, such as BMP volumes or other design criteria, and a general easement for protection and maintenance
- Filing of covenants on lots, the Property Owners' Association articles of incorporation and CC&R's, maintenance agreements, easements, agreements with adjacent property owners, conservation easements, and similar documents as required in the Drainage and Erosion Control Plan and Thurston County Code.
- Conditions of acceptance fulfilled
- Site permanently stabilized and restored, and temporary erosion control measures removed.

For Abbreviated Drainage Plan or Engineered Abbreviated Drainage Plan projects:

- All conditions of the Abbreviated or Engineered Abbreviated +Drainage Plan must be met, except that replanting may be delayed with the concurrence of the County.
- An 8½ x 11" version of the Abbreviated or Engineered Abbreviated Drainage Plan showing the location of drainage structures, conveyances, drywells, and dispersion areas shall be created and recorded with the Thurston County Auditor for the subject property.

Abbreviated Drainage Plans must be submitted with the application for permit or preliminary project acceptance.

3.3 Submittal Format

Submittals shall be in accordance with submittal requirements of the Thurston County Code and Development Services appropriate for the project type. At least one copy of all submitted documents shall be in electronic (Adobe PDF) format. Where required, full size plans shall be 22" x 34" and all information and text shall be of sufficient size to be readable when reduced to 11" x 17" size. Where plot plans are required, such as for abbreviated plan submittals, they shall be 11" x 17'. Examples are available from the County.

3.4 Submittal Types

Submittals required for drainage review depend on the project's type, size, location, and proposed treatment. Figure 3.2 summarizes required submittals, depending on whether the project is 1) eligible for an Abbreviated Drainage Plan; 2) located within or near a critical area; and 3) subject to Minimum Requirement #2, Construction Stormwater Pollution Prevention Plan (SWPPP). Consult relevant sections of this manual to determine whether these categories apply to the proposed project.

In terms of submittals, there are four categories of Thurston County projects:

1. Projects exempt from submittal requirements
2. Projects eligible for an Abbreviated Drainage Plan
3. Projects requiring an Engineered Abbreviated Drainage Plan
4. Projects requiring a complete Drainage and Erosion Control Plan.

Projects that may submit an Abbreviated Drainage Plan or an Engineered Abbreviated Drainage Plan may have additional submittal requirements (e.g., a Short Form Construction SWPPP and Source Control Plan) if they are subject to Minimum Requirement #2 or #3. These submittals are briefly described below.

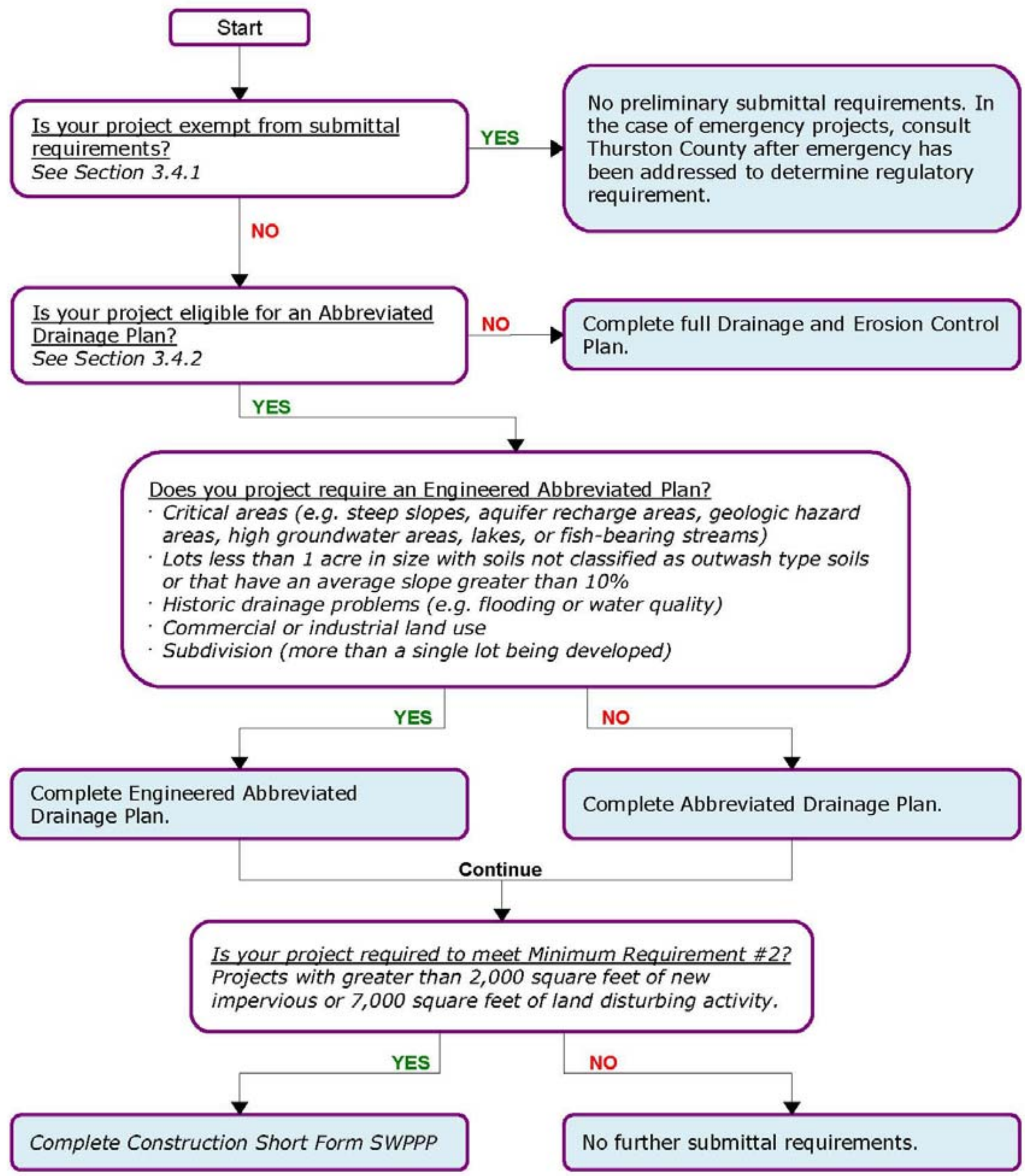


Figure 3.2 – Flow Chart for Determining Submittal Requirements

Figure 3.2. Flow Chart for Determining Submittal Requirements.

3.4.1 Projects Exempt from Submittal Requirements

In addition to those projects that are categorically exempt from the requirements of this manual (see Section 2.2) the following projects are exempt from the submittal requirements but shall be designed and constructed consistent with the requirements of this manual:

- Emergency projects which if not performed immediately would substantially endanger life or property are exempt from submittal requirements. Contact Thurston County to determine which regulatory requirements must still be met after the emergency situation has been addressed.

- Public works road projects completely within the right-of-way which do not add impervious surface and for which previously dispersed flows are not concentrated (i.e., adding curb and gutter).

- Public works road widening projects including minor right-of-way acquisitions and for which no change in the type of conveyance system (i.e., from open channel to piped system) is proposed and for which previously dispersed flows are not concentrated (i.e., adding curb and gutter).

- Projects for which impervious area to be added or modified results in total impervious surface of less than 5 percent of the parcel—providing that there is no increase in runoff or sediment discharge to adjoining property or to waters of the United States. If the property abuts a public roadway frontage, the area of the roadway frontage contributing drainage to the site shall be included in the impervious area computation and runoff from the roadway shall accounted for.

3.4.2 Abbreviated Drainage Plan

Abbreviated Drainage Plans are streamlined submittals allowed for projects on land zoned residential, agriculture, or forestry, where none of the special conditions requiring an Engineered Abbreviated Plan apply and the project meets one or a combination of the following criteria:

- Project on a single lot where less than 2,000 square feet of new impervious surface is created and less than 7,000 square feet of land is disturbed.

- Project on a single lot where greater than 85 percent of the lot area can be classified as Type A/B (outwash) soils and where less than 5,000 square feet of new impervious surface is created.

- Project subject to a building permit on a single lot of any size, *if* the lot is within a development that has a previously accepted and currently functioning stormwater system that includes the future development of that lot.

- Project converting less than 3/4 of an acre from native vegetation to lawn or landscaped areas

- Project converting less than 2.5 acres from native vegetation to pasture or timberland to commercial agriculture with no increase in impervious surface.

- Project on a parcel of greater than 1 acre outside the NPDES Phase II permit boundary where 85% of the parcel area can be classified as Type A/B (outwash) soils on which new, replaced, and existing impervious surfaces including any public roadway frontages are less than 10 percent of the site, *and* total non-native pervious plus impervious surfaces are less than 35 percent of the site, *and* no substantial (>0.1 cfs) increase in runoff or sediment discharges to adjoining property or to waters of the United States occurs as a result of the project.

- Project on a parcel of greater than 2.5 acres outside the NPDES Phase II permit boundary with any soil type on which new, replaced, and existing impervious surfaces are less than 10 percent of the site, *and* total non-native pervious plus impervious surfaces are less than 35 percent of the site, *and* no substantial (>0.1 cfs) increase in runoff or sediment discharges to adjoining property or to waters of the United States occurs as a result of the project

- Grading project requiring a permit, where total grading is less than 500 cubic yards with less than 2,000 square feet of impervious surface added and less than 7,000 square feet of land disturbing activity occurs and no change to existing drainage occurs.

In computing the area thresholds above, if the project site abuts a public roadway and roadway frontage improvements are required, the impervious and disturbed areas associated with the frontage improvements shall be included in the area calculations. In calculating existing impervious area the area to the centerline of the public road fronting the property shall be included.

Additional submittals (such as a Construction SWPPP or Source Control Plan) may be required to comply with Minimum Requirements #2 and #3 or for projects with critical areas as described below.

3.4.3 Engineered Abbreviated Drainage Plan

An Engineered Abbreviated Drainage Plan is a streamlined submittal similar to an Abbreviated Drainage Plan that must be prepared by a civil engineer licensed in the State of Washington and includes additional design, calculations and specifications beyond those required by an Abbreviated Drainage Plan (see Section 3.7). An Engineered Abbreviated Drainage Plan is allowed for the following project types:

- Project that meets the general requirements for an Abbreviated Drainage Plan, but has any of the following special conditions:
  - Any critical areas as defined by Thurston County Code, Title 17 (e.g., wetlands, aquifer recharge areas, geologic hazard areas, high groundwater areas, special management areas, flood hazard areas, shoreline protection areas, lakes, streams, etc.) exist within 200 feet of the boundaries of the disturbed area of the project site
  - Any project located within 200 feet of a Marine Bluff Hazard Area as defined by Thurston County Code, Title 17. (Note: Any project located within the Marine Bluff Hazard Area shall prepare a full Drainage and Erosion Control Report in accordance with Title 17, TCC)
  - For lots less than 1 acre in size with soils not classified as predominately Type A/B (outwash) soils, or where the average slope across the parcel is greater than 10 percent or any slope 15 percent or greater with 10 foot or greater height exists.
  - Project is located in an area that has historically had drainage problems including flooding and/or water quality problems
  - Proposed or existing land use is commercial, industrial, or multi-family residential.
  - Subdivision (more than a single lot being developed).
- Other Single Family Residential or Duplex projects on a single lot not meeting criteria for an Abbreviated Drainage Plan and not located within a Marine Bluff Hazard Area.
- Grading projects requiring a permit, where total grading is less than 5,000 cubic yards with less than 5,000 square feet of impervious surface added and less than ¾ of an acre of native

vegetation converted to lawn or landscape and no change to existing drainage occurs.

Engineered Abbreviated Drainage Plans shall be stamped by and prepared by, or under the direct supervision of, a civil engineer licensed in the State of Washington. All minimum requirements applicable to the project as described in Chapter 2 shall be addressed by the Engineered Abbreviated Drainage Plan.

3.4.4 Drainage and Erosion Control Plan

Applicants with projects not eligible for an Abbreviated Drainage Plan or Engineered Abbreviated Drainage Plan shall submit a Drainage and Erosion Control Plan. All such plans shall be stamped by and prepared by, or under the direct supervision of, a civil engineer licensed to practice in the State of Washington (hereinafter referred to as the "Project Engineer").

3.5 Abbreviated Drainage Plan

This section summarizes the minimum requirements of an Abbreviated Drainage Plan. The Administrator or designee may increase plan submission and runoff control requirements for projects expected to have a significant impact on sensitive natural resources, or projects that could exacerbate existing flooding or water quality problems.

An Abbreviated Drainage Plan consists of a written project summary, a plot plan, and any other requirements set by the Administrator or designee. Abbreviated Drainage Plans need not be stamped with the seal of a licensed Professional Engineer.

For projects which are required to address more than Minimum Requirement #2 (Construction SWPPP), the Abbreviated Drainage Plan shall address all Minimum Requirements applicable to the project.

3.5.1 Plot Plan

The plot plan submitted for the Abbreviated Drainage Plan shall be sufficiently clear to see the footprint of structures and other features described below. Drawings shall be 11 inches by 17 inches in size. Lines shall be drawn with a straight edge and features shall be to scale.

The plot plan shall contain the following information:

- Name, address, and telephone of the applicant, project proponent and property owner (may be the same person).

- Name, address, and telephone of the person preparing the plot plan

- Parcel number(s)
- Scale and north arrow
- Legend, if symbols are used
- Vicinity map of sufficient clarity to locate the property and the receiving water body
- Property boundaries, dimensions, and area
- Contour lines from the best available source (specify datum used)
- Adjoining street names
- Existing and proposed structures and other impervious surfaces such as driveways, patios, green houses, barns, etc. Include the area of each impervious surface.
- Location of waste treatment systems
- Utility easements
- Established buffers, significant trees, and natural vegetation easements
- Natural drainage channels, wetlands, canyons, gullies, water bodies, etc.
- Clearing limits and total area being cleared
- Areas to be graded, filled, excavated, or otherwise disturbed
- Location of known wells, underground storage tanks, septic tanks
- The location and type of erosion and sediment control measures.

The plan shall be kept on the project site during construction and made available to the County's inspectors on demand. Any changes to the plot plan shall be submitted to Thurston County for review and acceptance prior to performing the work in the field. All changes from the original plot plan shall be recorded and a record drawing (as-built) prepared showing the final constructed improvements. This as-built shall be submitted to Thurston County prior to final project acceptance.

3.5.2 Conditions

The Administrator or designee will attach conditions to the project as necessary to control erosion and runoff. These conditions shall include but not be limited to:

- An evaluation of the need for downspout infiltration systems (BMP LID.04), downspout dispersion systems (BMP LID.05), bioretention facilities (BMP LID.08), or other onsite facilities for disposal of runoff from roofs and other impervious surfaces. Size of facilities shall be determined through application of requirements specified in Volume V.

- Routing for storm drainage as necessary and appropriate for the size of project.

- Erosion control devices (e.g., construction entrances, filter fabric fences, stockpile protection, buffers for Critical Areas, and other measures).

- Easements and setbacks as required to ensure maintenance access, buffers, proper drainage, dispersion area protection, or other functions cited in this manual

- Management of tributary runoff from private or public roadway frontages abutting the project site.

3.6 Short Form Construction SWPPP

A Short Form Construction SWPPP is provided for projects with a disturbed area of less than 1 acre that are eligible for the Abbreviated Drainage Plan or Engineered Abbreviated Drainage Plan and are required to meet Minimum Requirement #2, i.e., projects with greater than 2,000 square feet of new impervious or 7,000 square feet of land disturbing activity.

The template for the short form Construction SWPPP, which includes an abbreviated erosion and sediment control plan, is provided in Volume II.

3.7 Engineered Abbreviated Drainage Plan

The Engineered Abbreviated Plan must consider the following in accordance with the hydrologic design criteria of Volume III for flow control, water quality treatment, and conveyance system design:

- Provision of adequate slope of surfaces toward drains

- Sizing of catch basins, drains, swales, ditches, pipes, and other conveyance facilities
- Bedding or anchoring of pipes
- Safe routing of runoff away from, over, or through critical areas including marine bluffs, geologic hazard areas, landslide hazard areas, wetlands, etc.
- Design of infiltration systems including drywells, bioretention areas, infiltration ponds, or trenches
- Design of flow control and runoff treatment facilities for stormwater released from the site, as required.
- Design of dispersion areas required to disperse concentrated or other runoff in accordance with the applicable BMP
- Other factors pertinent to safely convey runoff.

In addition to the requirements for submittal of an Abbreviated Drainage Plan, the Engineered Abbreviated Plan shall include narrative, calculations, drawings of facilities and specifications sufficient for construction.

The plan shall address all minimum requirements applicable to the project based on the criteria of Chapter 2.

For a project within a marine bluff hazard area or landslide hazard area Thurston County Code, Title 17, 17.15.630, has additional requirements that shall be addressed by the applicant.

3.8 Drainage and Erosion Control Plan

Drainage and Erosion Control Plans shall contain the following:

- A Drainage Report (described below)
- A Construction SWPPP (as described in Volume II)
- Drawings and Specifications
- A Maintenance Plan.

3.8.1 Drainage Report

The report shall be bound and 8-1/2 x 11 inches with map pockets for plan sheets (22” x 34” maximum size) and 11” x 17” drawings folded to

8-1/2 x 11 inch size unless the County approves another submittal format. The complete drainage report including appendices and drawings shall also be converted to PDF format and included in the submittal.

The report shall contain the following:

- **Cover Sheet**: Include the project name, applicant, owner and project pronponent's name, address, and telephone number, project engineer's name, address and phone number, date of submittal, contact's name, address, and telephone number, and the name, address and phone number of the contractor, if known.

- **Table of Contents**: Show the page number for each section of the report and appendices.

- **Project Engineer's Certification**: The Drainage Report must be developed by a professional engineer licensed to practice in the State of Washington. For projects where a PE is required, all plans and specifications, calculations, certifications, "as-built" drawings, and all other submittals which will become part of the permanent record of the project must be dated and bear the project engineer's official seal and signature.

  The Drainage Report shall contain a page with the project engineer's seal with the following statement:

  "I hereby state that this Drainage and Erosion Control Plan/Construction SWPPP for (insert name of project) has been prepared by me or under my supervision and meets the requirements of the Thurston County Drainage Design and Erosion Control Manual and the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that Thurston County does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities prepared by me."

- **Facility Summary Form** (see example in Appendix I-D)

- **Bond Quantities Worksheet** (use Thurston County's format, Appendix I-B)

- **Drainage Report Narrative** (10 sections, described below)

- **Construction SWPPP** (12 sections, summarized in Volume II, can be bound separately or together with the Drainage Report).

Drainage Report Section 1 – Proposed Project Description

The Drainage Report shall include the following information. Where appropriate, features should be shown on the drawings.

Permit

Describe the type of permit being applied for. Describe other permits required (e.g., hydraulic permits, 404 permit, marine bluff, etc.).

Project Location

Determine precise location of the construction site, adjacent roads and receiving waters:

- Indicate locations on Vicinity Map.
- Describe project including locations in Project Description.

Property Boundaries and Zoning

Determine the legal property boundaries and zoning requirements for the site:

- Indicate Legal Property Boundaries and Zoning on Site Map.
- Discuss zoning requirements in Existing Site Conditions.

Project Description

Provide a brief description of the development project, including the anticipated timing of the project.

Timing of the Project

An important consideration in selecting BMPs is the timing and duration of the project. Projects that will proceed during the wet season and projects that will last through several seasons must take all necessary precautions to remain in compliance with the water quality standards.

- Provide a timeline for the project based on applicant's best estimate of project start date.
- Describe and show design considerations based on project timing
- Include 12 elements of Construction SWPPP in timeline as applicable.

Drainage Report Section 2 – Existing Site Conditions

This section describes the existing conditions and what is required to be shown on the existing conditions scale drawing of the site to be included in a map pocket or an 11” x 17” drawing.

Topography

Prepare a topographic drawing of the site to show existing contour elevations at intervals of 1 to 5 feet, depending upon the slope of the terrain (see Section 3.8.3 for drawing protocols). Evaluate topography for erosion potential. The primary topographic considerations are slope steepness and slope length. The longer and steeper the slope, the greater the erosion potential. Erosion potential should be determined by a qualified engineer, soil professional, or certified erosion control specialist. Site topography shall be based on field survey by a licensed professional surveyor for any area of the project disturbed or where structures, roadways, or stormwater facilities will be located including dispersion areas.

- Show Topography on Site Map
- Discuss site topography in Existing Site Conditions.

Ground Cover

Label existing vegetation on the drawing. Show features such as tree clusters, grassy areas, and unique or sensitive vegetation. Indicate existing denuded or exposed soil areas. Where available, provide the most recent aerial photograph of the site.

Ground cover is the most important factor in erosion prevention. Existing vegetation that can be saved will prevent erosion better than constructed BMPs. Trees and other vegetation protect the soil structure. If the existing vegetation cannot be saved, consider practices like phasing construction, temporary seeding, and mulching. Phasing of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

- Show vegetation on Site Map
- Include aerial photograph in Drainage Report
- Discuss vegetation in Existing Site Conditions.

Drainage

Locate and clearly mark existing drainage ditches, closed depressions, and storm drain systems on the site map. Identify the point(s) of exit of drainage from the property. The drawings should distinguish between natural and constructed drainage. Identify offsite drainage contributing to the project site, and characterize the quantity and quality of offsite water. Document existing erosion or flooding problems. Identify closed depressions, areas where stormwater appears to infiltrate, and potential sites for temporary stormwater retention and detention.

- Show existing Drainage on Site Map
- Discuss Drainage in Existing Site Conditions.

Soils

Identify and label soil type(s) and erodibility (slight, moderate, severe, very severe or an index value from the NRCS manual) on the drawing. Soils information usually can be obtained from a county soil survey. If a soil survey is not available, a request can be made to a district Natural Resource Conservation Service Office. Show the location of any test pits or borings conducted for the project. Include description of the soils and the boring or test pit logs in the Drainage Report. Estimate the overall pre-development infiltration rate for the site based on preliminary soils data.

- Show soils information on Site Map and location of any borings or test pits
- Discuss in Soils section of drainage report
- Include boring or test pit logs in drainage report.

Critical Areas

Delineate critical areas adjacent to or within the site on the drawing. Show features such as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas. Delineate setbacks and buffer limits for these features on the drawings.

Other related jurisdictional boundaries such as Shorelines Management and the Federal Emergency Management Agency (FEMA) base floodplain should also be shown on the drawings. Critical areas per Thurston County Code 17.15.100 may include but not be limited to critical aquifer recharge areas, geologic hazard areas, important habitats, flood and channel migration hazard areas, and wetlands. Critical areas and their buffers shall be delineated on drawings and clearly flagged in the field. Fencing may be more useful than flagging to assure that equipment operators stay out of critical areas. Only unavoidable work should take place within critical areas and their buffers. Such unavoidable work will require special BMPs, permit restrictions, and mitigation plans.

- Show critical areas on Site Map
- Discuss critical areas in Critical Areas section.

Adjacent Areas

Identify existing buildings, roads, and facilities adjacent to and on the project site on the drawings. Identify existing utility locations on the drawings. An analysis of adjacent properties should focus on areas upslope and downslope from the construction project. Water bodies that will receive direct runoff from the site are a major concern. Evaluate the types, values, sensitivities of and risks to downstream resources, such as private property, stormwater facilities, public infrastructure, or aquatic systems.

- Show adjacent areas on Site Map
- Discuss adjacent areas in Adjacent Areas.

Precipitation Records

Refer to Volume III to determine the required rainfall records and the method of analysis for design of BMPs.

- Include rainfall data needed for sizing.

Reports and Studies

Include references to relevant reports such as basin plans, flood studies, groundwater studies, wetland designation, sensitive area designation, environmental impact statements, lake restoration plans, and water quality reports. When such reports impose additional conditions on the applicant, state these conditions.

Drainage Report Section 3 - Geotechnical Report

A geotechnical report may be required for grading or, where infiltration BMPs are proposed, a geotechnical report must be prepared in accordance with Section 3.3.2 of Volume III. Section 3 of the drainage report shall summarize soil types, geotechnical recommendations, infiltration testing methods and locations, and design infiltration rates. The entire report shall be included as an appendix.

If an infiltration or detention facility is near the top of a slope that is greater than 15 percent or otherwise regulated by Thurston County, then a geotechnical report addressing effects of seepage and the potential for slope failure during any precipitation event through the 100-year, 24-hour event may be required as part of the Drainage and Erosion Control Plan.

Any assessment of the infiltration receptor and/or mounding analysis shall be included in the geotechnical report or in another report and included in the Drainage Report.

This section should address all suitability criteria for infiltration facilities as described in Volume III.

Drainage Report Section 4 – Wells and Septic Systems

The Project Engineer shall make a diligent search to identify wells and septic systems "of record", on the site, and on adjacent property within the setback distance for stormwater retention/detention facilities identified in Volume V, Appendix E. The Project Engineer shall inquire with Thurston County Environmental Health and neighboring property owners as necessary to obtain the location of wells and septic systems that are not "of record." Wells and septic systems thus found, both active and abandoned, shall also be called out on the plans or as-builts (if found during construction).

The Project Engineer shall also identify whether the project site is located within the designated Well Head Protection Area (WHPA) of any public (Group A) water system. Thurston County Code, Title 17 and this Drainage Manual imposes additional requirements for projects within a designated WHPA.

The proper abandonment of wells is a matter regulated by state law (WAC 173-160). If a well on the site has not been properly sealed, the applicant shall be responsible for contacting Thurston County Environmental Health and Ecology. Ecology’s procedure shall be followed for sealing the well. Proof of proper abandonment (e.g., copies of the well log and invoice from a firm qualified to perform such work) shall be supplied to the County at or prior to final project acceptance. Indicate if no wells or septic systems were found.

Drainage Report Section 5 – Fuel Tanks

The Project Engineer shall report after making a diligent search of records and project site the existence of fuel tanks, in-use or abandoned. Fuel tanks shall be shown on the plans or as-builts (if found during construction). If fuel tanks will be abandoned, contact Thurston County Environmental Health for specific instructions. If no fuel tanks were found, indicate so.

Drainage Report Section 6 – Analysis of the 100-Year Flood

If the project contains or abuts a stream, show the 100-year flood hazard zone on the plans. If the zone has not been established (or the Administrator or designee determines that it is in error), the County may require the applicant to establish the 100-year flood plain for the proposed Project to be submitted with the Drainage and Erosion Control Plan. Analysis will be for the 100-year flood for build out at maximum density allowed by zoning (making reasonable assumptions regarding future stormwater management). The Project Engineer shall use the applicable program (HEC-HMS/RAS) for backwater analysis or another on acceptance of the Administrator or designee.

Drainage Report Section 7 – Aesthetic Considerations for Facilities

Describe the effort made to make the facilities aesthetically pleasing, how facilities will provide usable open space, and how the facilities will fit into the landscaping plan for the property.

Drainage facilities shall be made attractive features of the urban environment. Engineers are encouraged to be creative in shaping and landscaping facilities and to consider aesthetics when choosing design alternatives (e.g., parking lot paving, conveyance systems, detention facilities, weirs, check structures). See Volume V and Appendix V-E for aesthetic and landscaping criteria.

The applicant shall provide an informational sign for all aboveground stormwater facilities located within the development tract. Signs shall be constructed and worded as specified for each BMP and in Appendix V-E or as directed by the Administrator.

Drainage Report Section 8 – Facility Sizing and Offsite Analysis

Impervious and Pervious Area Tabulations

Include a tabulation of the pervious and impervious surfaces by threshold discharge area, including the following (see Appendix I-A Glossary for definitions):

- Existing impervious surfaces
- Converted pervious surfaces
- Replaced impervious surface
- New impervious surface
- Disturbed areas (area subject to “land disturbing activities”)
- Undisturbed pervious surfaces
- Existing significant trees and native vegetation.

Basins and sub-basins shall be labeled on the work map(s) and descriptors assigned that match the basin and sub-basin descriptors included in any hydrologic modeling. The work maps shall be included in the Drainage Report in a map pocket.

Proposed BMP Design

Describe which onsite and LID BMPs have been incorporated into the design and include design calculations where applicable. If LID design practices have not been used, explain why not.

If natural drainage patterns have not been preserved, explain why not and how hydrologic impacts to receiving waters will be mitigated.

Discuss vegetation establishment and soils management plans for all BMPs.

Provide calculations in an appendix documenting that conveyance facilities are sized in accordance with the standards in Volume III and runoff treatment and flow control facilities are designed to meet the design standards in Volumes III and V:

- All calculations shall be keyed to features shown on the work map.
- If hydrologic modeling is required, the Project Engineer shall state methods, assumptions, model parameters, data sources, and all other relevant information to the analysis. The input parameters to the model including basin characteristics, soil types, areas, etc. shall be tabulated within the drainage report and shall match the input parameters shown in any model output reports included as an appendix.
- If model parameters are used that are outside the recommended ranges discussed in Volume III or if parameters are different than those discussed in Volume III, justify parameters. Include an electronic copy of the computer model data file and the site plan in AutoCAD format.
- Include copies of all calculations for capacity of channels, culverts, drains, gutters, etc. If used, include nomographs and tables indicating how they were used. Show headwater and tailwater analysis for culverts when necessary. Provide details on references and sources of information used.
- Describe capacities, design flows, and velocities in each link.
- Describe required materials or specifications for the design (e.g., rock lining for channels when velocity is exceeded; high density

polyethylene pipe needed for steep slope). Regardless of whether the calculations are made using computer software or by hand, all relevant work shall be submitted for review. Complete calculations, including hydrologic modeling analyses where required, must be included with the report. It is recommended that these be placed in appendices and be referenced where appropriate. At Thurston County's request, submit electronic data for computer work including associated data files and settings.

Offsite Analysis

At a minimum, the qualitative analysis shall include the following:

- Site map showing project limits, existing and proposed storm drains (including pipe diameter, length, materials and slopes where available), existing and proposed ditches (including slope, width, bank slope, and bed materials), downstream drainage path to receiving water, and other contributing areas and up-stream and other offsite drainage entering or passing through the site.

- Review of available information, including but not limited to basin plans, record drawings, FEMA maps, drainage studies, critical areas maps, and Thurston County maintenance records.

- Field visit conducted by Project Engineer. The Project Engineer shall verify drainage basins, inspect onsite and offsite drainage systems, identify and document (with photographs and notations on site map) drainage problems (erosion, flooding, capacity problems, channel scour or incision).

If a quantitative analysis is required by the Administrator or designee (see Chapter 2, Minimum Requirement #12), the quantitative downstream analysis will include modeling the hydraulics of the proposed project and all other sources of runoff tributary to the receiving water body for the appropriate Design Event. The Project Engineer shall include an analysis of the impact of the 24-hour, 100-year event (in addition to "Design Event" analysis) for each component of the system including pond spillway.

Describe the proposed approach for managing run-on from upstream properties including whether run-on will be diverted around the project or incorporated into the site's stormwater system. The offsite analysis upstream of the property will include all properties located topographically uphill from the project that do, or may, contribute flow through the project site.

Describe how runoff from any public road frontage is managed. If runoff from the road is not collected in a roadway ditch or other public conveyance system then the project shall incorporate any roadway runoff into the drainage plans for the site.

Summarize measures that will be used to protect properties and waterways downstream from the development site from erosion due to increases in the velocity and peak volumetric flow rate of stormwater runoff from the project site. Describe how flow from the project site will be discharged to adjacent properties per the requirements of Volume III (i.e., easement, dispersion, spreader, etc.).

Drainage Report Section 9 — Covenants, Dedications, Easements

Describe legal instruments needed to guarantee preservation of drainage system and access for maintenance purposes. (Attach copies.) Describe the organization which will be responsible for operation and maintenance of storm drainage facilities.

Drainage Report Section 10 – Property Owners Association Articles of Incorporation

Attach a copy of the Articles of Incorporation, if applicable.

3.8.2 Construction SWPPP Elements

The elements of a Construction SWPPP (below) are addressed in the Drainage and Erosion Control Report following the 10 Drainage Report Sections:

1. Mark clearing limits/preserve vegetation
2. Establish construction access
3. Control flow rates
4. Install sediment controls
5. Stabilize soils
6. Protect slopes
7. Protect drain inlets
8. Stabilize channels and outlets
9. Control pollutants
10. Control dewatering

11. Maintain BMPs

12. Manage the project.

SWPPP elements are described in detail in Volume II.

3.8.3 Drawings and Specifications

It is the responsibility of the Project Engineer to ensure that engineering plans supporting the Drainage and Erosion Control Plan shall be sufficiently clear to construct the Project in proper sequence, using specified methods and materials, with sufficient dimensions to fulfill intent of drainage laws and ordinances and these design guidelines.

Required Drawing Size

Required sheet size is 22 x 34 inches and text and details shall be of such size as to be legible at ½ size (11” x 17”). Submittals shall include full size drawings, half size (11” x 17”) drawings, as well as PDF files, and if requested by the County AutoCAD drawing files.

Required Drawing Protocol

All drawings shall generally comply with the requirements of the Thurston County Road standards, Chapter 3, “Plan Format” and Thurston County CAD standards. These are available from Thurston County Department of Public Works. Where those standards conflict with the standards of this manual this manual shall govern.

Number of Sheets - Content

Plans will include sheets adequate to clearly display the following:

Vicinity Map

Show Project boundaries, sub-basin boundaries, and offsite area tributary to the project. Show contours, major drainage features (such as channels and detention facilities and floodways), and flow path to receiving waters. Identify existing buildings, roads, and facilities adjacent to or within the project site on the drawings. Identify existing and proposed utility locations, and construction clearing limits on the drawings.

Site Map

On a topographic map, show existing conditions and the proposed Project including (as applicable) but not limited to:

- Existing topography for the site and at least 50 feet beyond site boundaries

- Finished grades
- Existing structures within 100 feet of project boundaries
- Utilities
- Easements both existing and proposed
- Environmentally sensitive areas (e.g., gullies, ravines, swales, wetlands, steep slopes, estuaries, springs, wetlands, creeks, lakes, etc). For natural drainage features, show direction of flow.
- 100-year flood plain boundary (if applicable)
- Existing and proposed wells onsite and on adjacent properties (both "of record" and not "of record") within setbacks as specified in Appendix V-E
- Existing and proposed fuel tanks
- Existing and proposed onsite sanitary systems within setbacks as specified in Appendix V-E
- Proposed structures including roads, parking surfaces
- Lot dimensions and areas
- Proposed drainage facilities and sufficient cross sections and details to build
- Standard stormwater plan notes. Example notes are found in Appendix G of this volume (Volume I). Provide only those notes that apply.

Topography must be field verified for all areas where site improvements are to be constructed including drainage easements and conveyance systems. Contour intervals on site plan shall be as follows:

- 0 to 15 percent slope: 2 foot contour intervals
- 16 to 40 percent slope: 5 foot contour intervals
- Greater than 40 percent slope: 10 foot contour intervals.

Drainage Plan

Show the following information:

Plans or worksheets of open channel systems shall show water surface elevation for the design storm, invert elevations at breaks in grade, design discharge, design velocity, and any other data that facilitates plan review including:

- Schedule of catch basins with the following information:
    - Catch Basin/Manhole Identifier
    - Street Name
    - Cross Street
    - Stationing
    - Street side
    - Catch Basin diameter or size
    - Invert in/out
    - Pipe Diameter in/out.
- Detention/Infiltration/Wet Ponds to include:
    - Catch points for cuts and fills
    - Max design water level, water quality water level, overflow level
    - Clear path of overflow to downstream collection point
    - Outfalls and energy dissipation at outfalls
    - Inlet and outlet pipe invert elevations, slopes and pipe lengths.
- Drainage Details and Notes
    - Details of all BMPs
    - Construction notes and specifications for all BMPs
    - Cross-sections (ponds, swales, roadways, etc.).

Other Required Plans/Drawings

Include copies of other required plans such as:

- Soil Management Plan

- Landscape Plan
- Road profiles & roadway sections.
- Utility plans (sewer, water, septic).

Work Map (or maps) (bound into Drainage Report)

On a topographic map at the same scale and contour interval as the site map, show:

- Unit areas contributing to a reach of swale or to a catchbasin including offsite area. Identify areas contributing to retention/detention facilities. Show the following on the work map (or on a schedule) for unit areas: area, percent impervious, average slope, and estimated ultimate infiltration rate.
- Conveyance data, identifier (for reference to model output), length, slope, inverts up and down
- Overland flow paths and distances
- Soil types
- Locations of soil pits and infiltration tests
- Spot water surface elevations discharges and velocities for the Design Event.

The SWPPP drawing shall show:

- Construction entrance detail
- Silt fences and traps
- Mulching and vegetation plan
- Clearing and grubbing limits
- Existing and finished grade
- Standard erosion control plan notes. Example notes are found in the individual BMP design guidelines in Volume II.

Plans and Specifications

The most recent editions of Standard Specifications and Standard Plans (see Appendix I-A, Glossary) shall be the standards for all design and construction of drainage facilities not explicitly described herein. In the event of a conflict between the Standard Specifications, Standard Plans, and this Drainage Design and Erosion Control Manual, this manual shall prevail.

3.8.4 Maintenance Plan

The Maintenance Plan will be prepared as a standalone document, including all necessary figures, maps and drawings. The Maintenance Plan should be bound separately and submitted for review and acceptance by Thurston County at the time of submittal of the Final Drainage and Erosion Control Plan for the project. Acceptance of the Maintenance Plan by Thurston County is required prior to final project acceptance.

Contents of Plan

The Project Engineer will prepare a Maintenance Plan including the following:

- A statement of where the Maintenance Plan will be kept and that it must be made available for inspection by Thurston County upon request
- A copy of the Maintenance Agreement (Commercial/Industrial or Residential) executed by the property owner and accepted as to form by Thurston County
- A maintenance activity log in a format that includes sufficient space to list maintenance activities completed as a result of inspections
- Facility Summary Forms prepared for each stormwater facility as part of final permitting
- A written description of each flow control and treatment facility and an over view of the stormwater system for the site explaining the principles of operations and general maintenance requirements and providing such information from the Drainage Report as might be necessary to the future maintenance of the stormwater facilities. This might include the design capacity of conveyance facilities, slope of pipes and swales, size and dimensions of infiltration and/or detention facilities and calculated release rates for various storm events.
- A drawing showing all stormwater facilities, drainage easements, access easements, etc., with a key referencing the applicable maintenance checklists required to be used in performing routine inspection and maintenance for the facility

- Engineering drawings of the stormwater facilities including details and specifications shall be included. Drawings may be 11” x 17” or 22” x 34” and included in a map pocket.

- All applicable maintenance checklists for facilities included in the project. The applicant shall only include those checklists that apply to the project.

- Vegetation Management Plan

- Identification of the responsible maintenance organization

- A description of the required maintenance frequency for each facility

- A description of required recordkeeping and reports and frequency of submittal of reports to Thurston County

- An estimate of the average annual cost of maintenance will be included. The annual cost shall include the annualized cost of major maintenance items such as sediment removal from ponds, etc.

- A pollution source control plan per Volume IV.

See Appendix V-C and Appendix I-E for additional guidance.

Identify Organization Responsible for Maintenance

It is Thurston County’s policy that the property owner(s) shall maintain storm drainage facilities, or in the case of a subdivision, the Property Owners’ Association shall maintain drainage facilities. The Maintenance Plan shall be prepared to Thurston County’s specifications and held by the property owner or for a subdivision, included by reference in the articles of incorporation of the Property Owners Association.

Vegetation Management Plan

A vegetation management plan shall be included in the Stormwater Facilities Maintenance Plan for the project and shall include recommended plantings for each stormwater facility and specifications for maintenance and replacement plantings. The effectiveness of many stormwater facilities will depend on the species planted in them and their proper maintenance. Consult Appendix V-E regarding proper species for the design condition and for their requirements for maintenance.

Pollution Source Control

Pollution source control is the application of pollution prevention practices on a developed site to reduce contamination of stormwater runoff **at its source.** Best management practices (BMPs) and resource management systems are designed to reduce the amount of contaminants used or discharged to the environment.

The Maintenance Plan shall contain language regarding pollution source control that is specifically developed for the type of site covered by the plan. The pollution source control section of the plan shall incorporate the relevant information found in Volume IV of this manual, unless otherwise accepted by the Administrator or designee.

Annual Report Required

The owner shall submit an annual report to Thurston County by August 31st of each calendar year to include, at a minimum, the following:

- Name, address, and telephone number of the businesses, persons, or firms responsible for plan implementation, and the person completing the report
- Time period covered by the report
- A chronological summary of activities conducted to implement the programs required by the Maintenance Plan. A photocopy of the applicable section of the log book, with any additional explanation needed, shall normally suffice. For any activities conducted by paid parties, include a copy of the invoice for services.
- An outline of planned activities for the next year.

The annual report shall be submitted to the Water Resources Unit of the Thurston County Department of Resource Stewardship.

3.8.5 Project Completion Criteria

Inspection Report – Drainage and Erosion Control Plans

For Drainage and Erosion Control Plans, in addition to inspection performed by Thurston County, the applicant must retain a licensed Civil Engineer to inspect or oversee inspection of the project as directed by the Drainage and Erosion Control Plan and/or the Administrator or designee. (See inspection reporting requirements, Appendix I-C.) The Engineer must file with Thurston County a construction inspection report as shown in Appendix I-C before the project is made final. The report will consist of a completed form and sufficient additional text to describe all factors relating to the construction and operation of the system to meet treatment, erosion control, detention/retention, flow control, and conveyance requirements.

The Engineer or his/her designee shall keep records of inspections of drainage and erosion control facilities. Records of inspection shall be submitted to the County upon request at any time during the course of the project.

As-Built Submittal – Drainage and Erosion Control Plans

For Drainage and Erosion Control Plans, the Project Engineer shall submit as-built drawings bearing the Project Engineer's seal showing all final locations and elevations, materials, and changes substantially different from the design. Final elevations, locations, slopes, grades, roadway alignments, etc. shall be based on a field survey conducted by a licensed professional surveyor and shall be stamped by the surveyor as a record of the final constructed location and elevation of facilities shown. The volume of any ponds, vaults, tanks, etc. included in the design shall be calculated based on the as-built survey and this information shall be noted on the as-built drawing. Changes from the approved plans shall be clearly identified using clouding, bold text or other methods to clearly identify those items that were changed during construction. Note that changes from the accepted plan will be reviewed by the County and may be subject to action by the Administrator or designee.

Phased Projects Submittals – Drainage and Erosion Control Plans

A plan showing the overall project, clearly delineating phase boundaries, and estimating dates of construction, shall be part of any initial submittal. Phased projects shall be completed in accordance with accepted plans and in accordance with standard phased development requirements for Thurston County. The thresholds of Chapter 2 shall apply to the entire development including all phases.

3.9 Additional Submittal Information

3.9.1 Qualifications of Project Engineers

The Project Engineer responsible for completion of Drainage and Erosion Control Plans and Engineered Abbreviated Drainage Plans shall be a Civil Engineer with a current State of Washington Professional Engineer's license. All plans and specifications, calculations, construction inspection reports, and all other submittals which will become part of the permanent record of the Project must bear the Project Engineer's official seal.

3.9.2 Review and Acceptance Does Not Confer Responsibility

Thurston County will review all drainage related submittals for general compliance with specific criteria. Acceptance by the County does not relieve the applicant or Project Engineer of responsibility for ensuring that all facilities are safe and that calculations, plans, specifications, construction, and as-built drawings comply with normal engineering standards, this manual, and applicable federal, state, and local laws and codes.

3.9.3 Time Limitations of Acceptance for Plans

Drainage and Erosion Control Plans and Abbreviated Drainage Plans shall expire when acceptance for the permitted activity (e.g., preliminary plat, clearing, grading, building permit) expires. After expiration, a new Drainage and Erosion Control Plan must be completed subject to conditions and requirements applicable at that time.

3.9.4 Aesthetic Considerations

Drainage facilities shall be made attractive features of the urban environment. Engineers are encouraged to be creative in shaping and landscaping facilities and to consider aesthetics when choosing design alternatives (e.g., parking lot paving, conveyance systems, detention facilities, weirs, check structures). See Volume V and Appendix V-E for aesthetic and landscaping criteria.

The applicant shall provide an informational sign for all aboveground stormwater facilities located within the development tract. The sign for storm ponds shall be constructed and worded as specified in Appendix V-E. Other stormwater facilities including swales, rain gardens, dispersion areas, etc. shall also include signage and fencing identifying the area as a stormwater facility and not to disturb. Individual BMPs also include requirements for signage and fencing.

3.9.5 Drainage Plans for Environmentally Sensitive Areas

Development in an Environmentally Sensitive Area

Where buffer zones have been established by the County to restrict development near an environmentally sensitive area or critical area, the applicant shall obtain and implement the requirements of those regulations in addition to any requirements of this manual.

Acceptance of Dedication of Buffers

Buffers for natural drainage features can provide water quality benefits. Consult the jurisdiction regarding their policy on acceptance of buffers.

3.9.6 Easements and Access

Easements for Natural Channels and Stormwater Facilities

All man-made drainage facilities, conveyances, and all natural channels (including swales, stream channels, lake shores, wetlands, potholes, estuaries, gullies, ravines, etc.) shall be located within easements. Easements shall contain the natural features and facilities and shall allow jurisdiction access to them for purposes of inspection, maintenance, flood control, water quality monitoring, and other activities permitted by law.

Easements for Access

Specific access requirements for ponds are included in Volume V, Appendix V-E. Generally a minimum 15-foot wide access easement shall be provided to drainage facilities from a public street or right-of-way and shall provide a 12-foot minimum width drivable path surfaced with lattice block pavement, crushed rock, or other acceptable surface to allow year-round equipment access to the facility. The easement shall include easement boundary markers which shall be fiberglass utility markers with a reflective easement tag, located at each corner of the easement, at angle points and at least every 100 feet along the length of the easement. Contact Thurston County Water Resources for additional information on easement marker requirements.

Easements for Conveyance Systems

Easement requirements for conveyance systems are described in Volume III, Section 3.6.2.

Chapter 4 - Stormwater BMP Selection Process

This chapter aids in the selection of appropriate LID, infiltration, flow control, and runoff treatment BMPs to meet Minimum Requirements #5 (Onsite measures), #6 (Runoff Treatment), and #7 (Flow Control). This chapter is organized as follows:

- **Section 4.1**: Types of BMPs and satisfying minimum requirements
- **Section 4.2**: Step-by-step process for determining the level of treatment and flow control and selecting BMPs
- **Section 4.3**: Supplemental information for selecting and applying oil control BMPs
- **Section 4.4**: Supplemental information for selecting and applying phosphorus treatment BMPs
- **Section 4.5**: Supplemental information for selecting and applying enhanced treatment BMPs
- **Section 4.6**: Supplemental information for selecting and applying basic treatment BMPs
- **Section 4.7**: Additional treatment facility selection factors, including pollutants of concern and BMPs for specific land uses.

4.1 Introduction

Stormwater BMPs described in this chapter focus on reducing or mitigating the hydrologic and water quality impacts of development. These BMPs address the following minimum requirements:

Minimum Requirement #5: Onsite Stormwater Management

- *Onsite* BMPs are measures to protect soils and control roof drainage and other runoff to prevent stormwater from leaving the site as much as possible.
- *LID* BMPs are site design and stormwater management techniques that seek to minimize the stormwater impacts of development by mimicking natural hydrologic processes.

Minimum Requirement #6: Runoff Treatment

- *Basic treatment* BMPs remove sediment from the water column to prevent sedimentation of receiving waters and the adverse effects of sedimentation on fish and amphibians. Sediments can also carry other pollutants, and sediment removal reduces the level of these other pollutants in the runoff.

- *Enhanced treatment* BMPs provide a greater degree of removal of dissolved metals (that are toxic to salmon and other endangered species) than “basic” runoff treatment BMPs.

- *Phosphorus treatment* BMPs include larger wet pond facilities, media filtration BMPs, and treatment trains intended to reduce total phosphorus concentrations in nutrient-sensitive lakes.

- *Oil control* BMPs remove non-polar, hydrophobic substances (oil and grease) from stormwater by trapping the floating material with baffles or other physical barriers. They are required for high use sites.

Minimum Requirement #7: Flow Control

- *Flow control* BMPs are infiltration and/or detention BMPs that control the hydrologic impacts of stormwater by matching predevelopment peak flows, flow durations, and levels of infiltration.

- Applying LID and onsite BMPs within a threshold discharge area may also be used as part of flow control efforts.

Selection of construction-phase stormwater pollution prevention BMPs to meet Minimum Requirement #2 is described in Volume II. Selection of post-construction source control BMPs to meet Minimum Requirement #3 is described in Volume IV.

4.2 Step-by-Step BMP Selection Process

Selecting appropriate BMPs for a project site requires knowledge of:

- The receiving water(s) of the project site’s discharge

- Whether Thurston County, Ecology, or the EPA have identified the receiving water as subject to phosphorus control requirements

- Site conditions that may require oil control or enhanced runoff treatment.

Figure 4.1 illustrates the BMP selection process. The steps of this process are described in detail below.

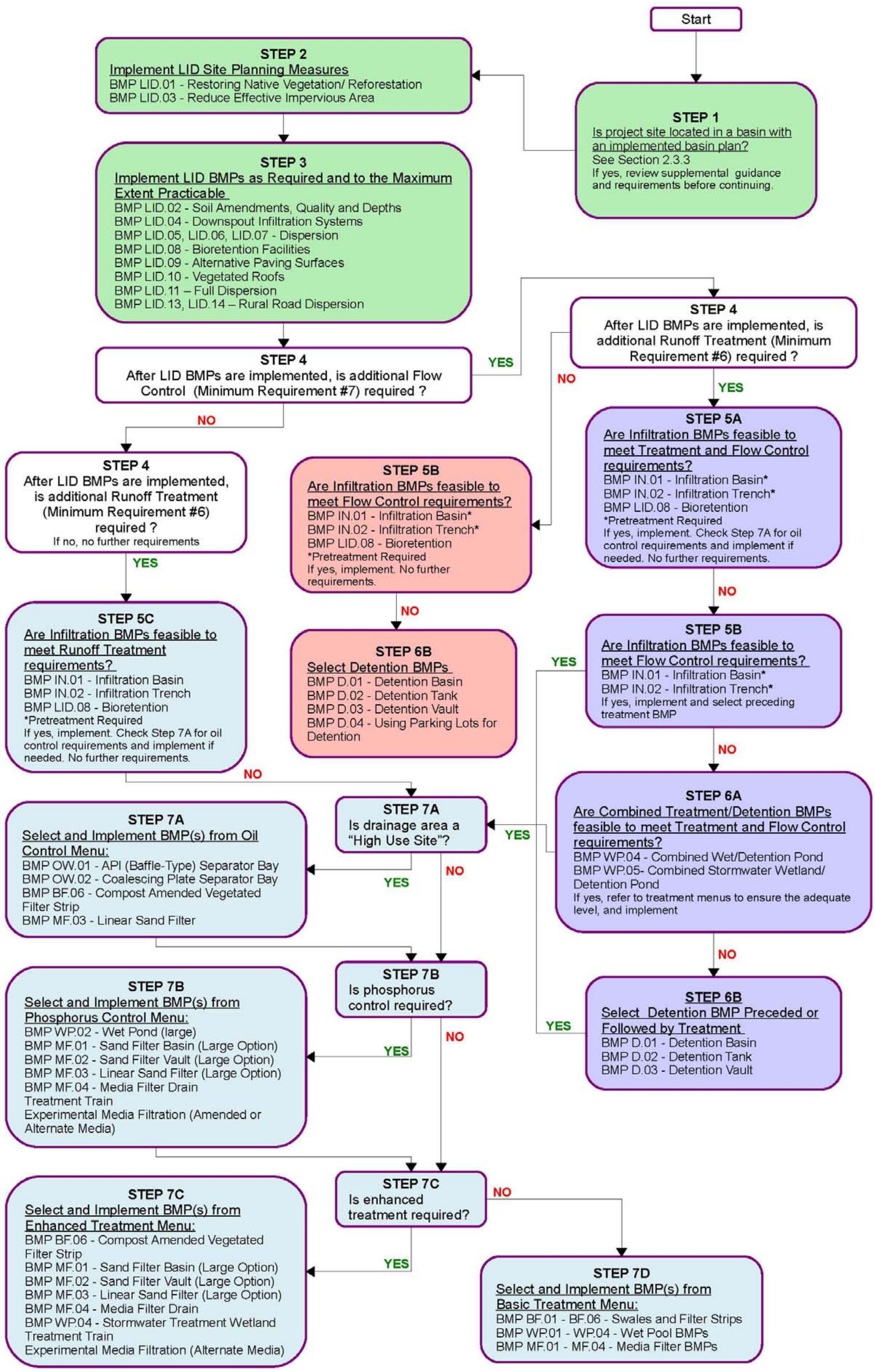


Figure 4.1. Stormwater BMP Selection Process Flow Chart

Notes:

*BMPs LID.02, LID.04, LID.05, LID.06 and IN.01 are required for all projects subject to Minimum Requirement #5 - On-Site

Figure 4.1. Stormwater BMP Selection Process Flow Chart.

4.2.1 Step 1: Determine if the Project Site is in a Basin with an Implemented Basin Plan

Does Your Project Drain to a Basin with an Implemented Basin Plan?

If so, see the applicable basin plan or the Thurston County basin planning website to determine if there are applicable requirements or restrictions for runoff treatment, flow control, and infiltration. You must meet the more stringent of either of the controls described in this section or those in the basin plan. See the Thurston County basin planning website for more information: <http://www.co.thurston.wa.us/stormwater/BasinPlans/Basin_Plans_home.htm>.

4.2.2 Step 2: Implement LID Site Planning Measures

Thoughtful site design can significantly reduce both the cost and land area required for stormwater management and the hydrologic and water quality impacts of your project. Volume V provides ideas for smart design and LID measures to consider and, where feasible, implement at the earliest planning stages. Site planning LID BMPs include:

- **BMP LID.01**: Restore Native Vegetation
- **BMP LID.03**: Reduce Effective Impervious Areas Associated with Roads, Shared Accesses, Alleys, Sidewalks, Driveways, and Parking Areas.
- **BMP LID.11**: Full Dispersion

4.2.3 Step 3: Implement LID BMPs as Required and to the Maximum Extent Practicable

To meet Minimum Requirement #5: Onsite Stormwater Management, new and redevelopment projects must meet the requirements of the following onsite BMPs:

- **BMP LID.02**: Post-Construction Soil Quality and Depth.

Downspout controls, which includes:

- **BMP LID.04**: Downspout Infiltration Systems
- **BMP LID.05**: Downspout Dispersion Systems.

Alternately, rooftop runoff may be managed using one of the following BMPs:

- **BMP LID.08**: Bioretention Facilities
- **BMP LID.10**: Vegetated Roofs

Although some combination of the above BMPs is required to comply with Minimum Requirement #5, Thurston County encourages developers to incorporate LID BMPs to the maximum extent practicable. The following BMPs can be especially effective:

- **BMP LID.08**: Bioretention Facilities

  Many parts of Thurston County have soils with high infiltration rates. By designing your site so that small areas drain to localized facilities (e.g., bioretention facilities), you may be able to manage most of your runoff onsite, using areas not much larger than those needed for traditional landscaping.

- **BMP LID.09**: Alternative Paving Surfaces

  Where permissible by Thurston County or local jurisdiction road standards (or with approval), alternative paving surfaces such as porous concrete or asphalt can be used, and are highly effective at reducing or eliminating stormwater runoff and associated stormwater treatment, flow control, and conveyance costs. Even with nominal infiltration rates of underlying soils, alternative paving surfaces are highly effective at treating and controlling stormwater runoff, since there is effectively a 1:1 ratio of contributing area to storage/infiltration facility (run-on of stormwater to alternative paving surfaces is not allowed by Thurston County).

- **BMP LID.06**: Sheet Flow Dispersion

  Sheet flow dispersion is an effective way to reduce the stormwater runoff from moderately sloping impervious surfaces such as driveways, sport courts, patios, or bare soil where concentration of flows can be avoided.

- **BMP LID.07**: Concentrated Flow Dispersion

  Where sheet flow dispersion cannot be achieved, concentrated flow dispersion should be considered.

For roadway projects in the rural area of Thurston County (outside UGA and NPDES boundaries), additional BMPs that allow greater flexibility for dispersion include:

- **BMP LID.12**: Rural Roads Natural Dispersion

  For rural roads where adequate native vegetation is available within the right-of-way or adjacent to the right-of-way, concentrated and sheet flows can be dispersed using this BMP.

- **BMP LID.13**: Rural Roads Engineered Dispersion

  For rural roads where native vegetation is inadequate or not available within the right-of-way or adjacent to the right-of-way, but sufficient area is available to create an engineered dispersion area, concentrated and sheet flows can be dispersed to the engineered dispersion area using this BMP.

For projects on large parcels or where development can be concentrated in a small area of a parcel and limits on impervious surfaces, landscape areas and native vegetation retention can be met, the applicant may choose to apply the following BMP:

- **BMP LID.11**: Full Dispersion

  Full dispersion is allowed for projects where a combination of limits on impervious surface and landscape area and minimum native vegetation retention is provided such that stormwater flows can be dispersed and infiltrated to an extent that flow control and water quality treatment facilities are not required or are greatly reduced in size. The dispersion techniques of this BMP provide greater flexibility than dispersion BMPs for sites not meeting the criteria for full dispersion.

4.2.4 Step 4: Determine Applicability of Minimum Requirements #6 and #7

After implementing LID BMPs, see the Minimum Requirements (Chapter 2 of this volume) to determine whether additional flow control (Minimum Requirement #7) or runoff treatment (Minimum Requirement #6) BMPs are required. The implementation of LID BMPs will help reduce the amount of flow control runoff treatment facilities required.

Are Both Flow Control and Runoff Treatment Required?

If YES, proceed to Step 5A.

If NO, proceed to next question.

Is Flow Control Required?

If YES, proceed to Step 5B.

If NO, proceed to next question.

Is Runoff Treatment Required?

If YES, proceed to Step 5C.

If NO, there are no further requirements.

4.2.5 Step 5: Select infiltration BMP

Step 5A: Determine Feasibility and Select Infiltration BMP for Both Flow Control and Runoff Treatment

Can an infiltration facility meet your project's flow control requirements, and do your site and soils meet the site suitability and runoff treatment criteria in Section 2.3 of Volume III?

If YES, select from the following BMPs to provide both flow control and runoff treatment. Also, check Step 7A to determine if oil control is needed prior to infiltration. If so, select an oil control BMP from the list and implement. However, do not continue to Step 7B. If after implementing one of the following BMPs the discharge to surface water exceeds flow control thresholds, proceed to Step 6B and implement detention BMP to meet flow control requirements:

- **BMP IN.01**: Infiltration Basins
- **BMP IN.02**: Infiltration Trenches
- **BMP LID.08**: Bioretention Facilities.

If NO, proceed to Step 5B.

Step 5B: Determine Feasibility and Select Infiltration BMP for Flow Control

Can an infiltration facility meet your project's flow control requirements and does your site meet the site suitability criteria in Section 2.3 of Volume III (pretreatment required)?

If YES, select from the following BMPs to provide flow control:

- **BMP IN.01**: Infiltration Basins
- **BMP IN.02**: Infiltration Trenches
- **BMP IN.04**: Bio-Infiltration Swale.

If after implementing one of the above BMPs there is a discharge to surface water that exceeds flow control requirements, proceed to Step 6B and implement detention BMP to meet flow control requirements.

Proceed to Step 7 if runoff treatment is still required to select runoff treatment BMP(s) located upstream of the infiltration BMP. If not, BMP selection is complete.

If NO *and runoff treatment is still required*, proceed to Step 6A.

If NO *and no runoff treatment is required*, proceed to Step 6B.

Step 5C: Determine Feasibility and Select Infiltration BMP for Runoff Treatment

Do your site and soils meet the site suitability and runoff treatment criteria in Section 2.3 of Volume III?

If YES, select from the following BMPs:

- **BMP IN.01**: Infiltration Basins
- **BMP IN.02**: Infiltration Trenches
- **BMP IN.04**: Bio-Infiltration Swale
- **BMP LID.08**: Bioretention Facilities.

Also, check Step7A to determine if oil control is needed prior to infiltration. If so, select an oil control BMP from the list and implement. However, do not continue to Step 7B.

If NO, proceed to Step 7.

4.2.6 Step 6: Select Detention BMP

Step 6A: Determine Feasibility and Select Combined Treatment/Flow Control BMP

Is a combined treatment/flow control BMP feasible?

If YES, select from the following BMPs:

- **BMP WP.04**: Combined wet/detention pond
- **BMP WP.05**: Combined stormwater wetland/detention pond.

Proceed to Step 7 to evaluate the need for additional oil control BMPs, and to verify that the combined BMP selected above meets the necessary treatment level.

If NO, proceed to Step 6B.

Step 6B: Select Detention BMP

Select from the following BMPs:

- **BMP D.01**: Detention Ponds
- **BMP D.02**: Detention Tanks
- **BMP D.03**: Detention Vaults
- **BMP D.04**: Use of Parking Lots for Detention.

If *runoff treatment (Minimum Requirement #6) is required* for your project, proceed to Step 7.

If *no runoff treatment is required*, BMP selection is complete.

4.2.7 Step 7: Select Runoff Treatment BMP

Step 7A: Determine Feasibility and Select Oil Control BMP

Is your project a "high use site"?

"High use" sites include:

- An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area (see Section 4.4 for guidance on estimating traffic counts)
- An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil
- An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.)
- A road intersection with a measured average daily traffic (ADT) count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Section 4.4 has supplemental information on oil control, including land uses that are likely to have areas that fall within the definition of "high use sites".

If YES, select one of the following BMPs and proceed to Step 7B:

- **BMP OW.01**: API (Baffle type) Separator Bay
- **BMP OW.02**: Coalescing Plate (CP) Separator Bay
- **BMP OW.03**: Oil Containment Booms. (not allowed for private development)

Alternately, the following BMPs can be used to meet oil control requirements and other treatment levels. If these BMPs are selected, steps 7B, 7C, and 7D must be completed to ensure that they meet the appropriate level of treatment:

- **BMP MF.03**: Linear Sand Filter (if amended to provide phosphorus treatment)
- **BMP WP.03**: Wet vaults (if designed to include a baffle)
- **BMP BF.06**: Compost-Amended Vegetated Filter Strip.

If NO, proceed to Step 7B.

Step 7B: Phosphorus Control BMP

The following Thurston County lakes are reported under Section 305(b) of the Clean Water Act and designated as not supporting beneficial uses due to phosphorus.

- Black Lake
- Capitol Lake
- Clear Lake
- Lawrence Lake
- Long Lake
- Pattison Lake (south arm).

Projects within any of these lakes' basins will be required to provide phosphorus treatment, unless a TMDL or County-approved lake management plan specifically identified phosphorus treatment as unnecessary.

If there is no lake management plan or TMDL for one of the above water bodies, and your project has the potential to contribute phosphorus to it (e.g., landscaped areas that will be fertilized, bare soils that could be transported offsite), phosphorus treatment is required.

If phosphorus treatment is required, select and apply a phosphorous treatment facility from the list below:

- **BMP LID.08:** Bioretention Facility
- **BMP MF.04**: Media Filter Drain
- **BMP MF.01**: Sand Filter Basin (if amended to provide phosphorus treatment)
- **BMP MF.03**: Linear Sand Filter (if amended to provide phosphorus treatment)
- **BMP MF.02**: Sand Filter Vault (if amended to provide phosphorus treatment)
- **BMP WP.02**: Wet ponds (if designed to be a large wet pond)
- **BMP WP.03**: Wet vaults (if designed to be a large wet vault)
- **BMP WP.04**: Combined detention/wet pool facilities (if designed with a large wet pool).

Note: Project sites subject to the Phosphorus Treatment requirement could also be subject to the Enhanced Treatment requirement (see Step 11). In that event, apply a facility or a treatment train that is listed both above and under Step 7C. Infiltration treatment also provides phosphorous treatment.

Proceed to Step 7C.

Step 7C: Enhanced Treatment BMP

Does your project discharge to fish-bearing streams, lakes, or to waters or conveyance systems tributary to fish-bearing streams or lakes?

If NO, proceed to Step 7D.

If YES, proceed to next question.

Does your project drain directly (or, indirectly through a municipal storm sewer system) to a salt water body?

If YES, proceed to Step 7D.

If NO:

Does your project include any of the following?

- Infiltration facility within a designated Well Head Protection Area for a public water supply serving over 1,000 connections.
- Industrial project sites,
- Commercial project sites,
- Multi-family project sites, and
- High Annual Average Daily Traffic (AADT) roads as follows:
  - Within Urban Growth Management Areas:
    - Fully controlled and partially controlled limited access highways with AADT counts of 15,000 or more
    - All other roads with an AADT of 7,500 or greater
  - Outside of Urban Growth Management Areas:
    - Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger
    - Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).

However, areas of the project sites listed above that are identified as subject to Basic Treatment requirements (see Section 4.6) are also not subject to Enhanced Treatment requirements. For developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprises 50 percent or more of the total runoff within a threshold discharge area.

If YES, select enhanced treatment BMPs for your site or for those areas subject to enhanced treatment BMPs.

- **BMP LID.08**: Bioretention Facilities
- **BMP BF.06**: Compost-Amended Vegetated Filter Strip
- **BMP WP.01**: Stormwater treatment wetland
- **BMP MF.04**: Media Filter Drain

- **BMP MF.01**: Sand Filter Basin (if amended to provide enhanced treatment)
- **BMP MF.03**: Linear Sand Filter (if amended to provide enhanced treatment)
- **BMP MF.02**: Sand Filter Vault (if amended to provide enhanced treatment).

Step 7D: Basic Treatment BMP

The following are options for basic treatment BMPs:

- **BMP BF.01**: Basic Biofiltration Swale
- **BMP BF.02**: Wet Biofiltration Swale
- **BMP BF.03**: Continuous Inflow Biofiltration Swale
- **BMP BF.04**: Basic Filter Strip
- **BMP BF.05**: Narrow area filter strip
- **BMP WP.01**: Stormwater treatment wetland
- **BMP WP.02**: Wet ponds
- **BMP WP.03**: Wet vaults
- **BMP WP.04**: Combined detention/wet pool facilities
- **Any BMP providing enhanced treatment**.

This completes the treatment facility selection process.

4.3 Oil Control BMPs: Supplemental Information

4.3.1 Applicability

The traffic count (to determine whether a site is considered "high use") can be estimated using information from *Trip Generation*, published by the Institute of Transportation Engineers, or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.

The following urban land uses are likely to have areas that fall within the definition of "high use sites" or have sufficient quantities of free oil present that can be treated by an API or CP-type oil and water separator:

- Industrial Machinery and Equipment, and Railroad Equipment Maintenance
- Log Storage and Sorting Yards
- Aircraft Maintenance Areas
- Railroad Yards
- Fueling Stations
- Vehicle Maintenance and Repair
- Construction Businesses (paving, heavy equipment storage and maintenance, storage of petroleum products).

Oil control facilities should also be used on other sites that generate high concentrations of oil. All-day parking areas are not intended to be defined as high use sites and should not require the oil control options listed in this menu**.** Gasoline stations, with or without small food stores, will likely exceed the high use site threshold. The petroleum storage and transfer criterion is intended to address regular transfer operations such as gasoline service stations, not occasional filling of heating oil tanks.

4.3.2 Application on the Project Site

Oil control facilities are to be placed upstream of other facilities, as close to the source of oil generation as possible. For high use sites located within a larger commercial center, only the impervious surface associated with the high use portion of the site is subject to treatment requirements. If common parking for multiple businesses is provided, treatment shall be applied to the number of parking stalls required for the high use business only. However, if the treatment collection area also receives runoff from other areas, the treatment facility must be sized to treat all water passing through it.

High use roadway intersections shall treat lanes where vehicles accumulate during the signal cycle, including left and right turn lanes and through lanes, from the beginning of the left turn pocket. If no left turn pocket exists, the treatable area shall begin at a distance equal to three car lengths from the stop line. If runoff from the intersection drains to more than two collection areas that do not combine within the intersection, treatment may be limited to any two of the collection areas.

4.3.3 Performance Goal

The facility choices in the Oil Control Menu are intended to achieve the goals of no ongoing or recurring visible sheen, and to have a 24-hour average Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/l, and a maximum of 15 mg/l for a discrete sample (grab sample).

Note: Use the method for NWTPH-Dx in Ecology Publication No. ECY 97-602, Analytical Methods for Petroleum Hydrocarbons to determine oil concentrations. If the concentration of gasoline is of interest, the method for NWTPH-Gx should be used to analyze grab samples.

4.3.4 Oil Control Menu

Options

Oil control options include facilities that are small, treat runoff from a limited area, and require frequent maintenance. The options also include facilities that treat runoff from larger areas and generally have less frequent maintenance needs.

- **BMP OW.01**: API-Type Oil/Water Separator
- **BMP OW.02**: Coalescing Plate Oil/Water Separator
- **BMP MF.03**: Linear Sand Filter
- **BMP BF.06**: Compost-Amended Vegetated Filter Strip.
- **BMP WP.03**: Wet vaults (if designed to include a baffle).

Note: The linear sand filter is also used in the Basic, Enhanced, and Phosphorus Treatment menus. If used to satisfy one of those treatment requirements, the same facility shall not also be used to satisfy the oil control requirement, unless enhanced maintenance is assured. This is to prevent clogging of the filter by oil so that it will function for both suspended solids and phosphorus removal. Quarterly cleaning is required unless otherwise specified by the designer.

4.4 Phosphorus Treatment: Supplemental Information

4.4.1 Where Applied

The Phosphorus Treatment Menu (below) applies to projects within watersheds determined by local governments, the Department of Ecology, or the USEPA to be sensitive to phosphorus, and that are being managed to control phosphorus inputs from stormwater. This menu applies to stormwater conveyed to the lake by surface flow and to stormwater infiltrated within one-quarter mile of the lake in soils that do not meet soil suitability criteria described in Volume III, Chapter 3.

4.4.2 Performance Goal

The Phosphorus Menu facility choices are intended to achieve a goal of 50 percent total phosphorus removal for a range of influent concentrations of 0.1 – 0.5 mg/l total phosphorus. The choices are also intended to achieve the Basic Treatment performance goal. The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (offline treatment facilities), or can be passed through the facility (online treatment facilities) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of treatment facilities that engage a bypass at flow rates higher than the water quality design flow rate. Note that wet pool facilities are always designed to be online.

4.4.3 Phosphorus Treatment Menu

Any one of the following options may be chosen to satisfy the phosphorus treatment requirement.

- Infiltration with appropriate pretreatment:
  - **Infiltration treatment**: If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (see Chapter 3 of Volume III and Volume V), a presettling basin or a basic treatment facility can serve for pretreatment.
  - **Infiltration preceded by Basic Treatment**: If infiltration is through soils that do not meet the soil suitability criteria for infiltration treatment, treatment must be provided by a basic treatment facility unless the soil and site fit the description in the next option below.
  - **Infiltration preceded by Phosphorus Treatment**: If the soils do not meet the soil suitability criteria *and* the infiltration site is within 1/4 mile of a phosphorus-sensitive receiving water, or a tributary to that water, treatment must be provided by one of the other treatment facility options listed below.
- **BMP MF.01** or **MF.02**: Large Sand Filter
- **BMP MF.01** or **MF.02**: Amended Sand Filter

  Note: Processed steel fiber and crushed calcitic limestone are the only sand filter amendments for which Ecology has data that documents increased dissolved metals removal. Though Ecology is interested in obtaining additional data on the effectiveness of these amendments, Ecology is allowing local governments to exercise their judgment on the extent to which to allow their use. The use of processed steel fiber has been reported to cause a number of maintenance problems as it oxidizes over time and decreases the design filtration rate.

- **BMP WP.02**: Large Wet Pond
- Media Filter targeted for phosphorus removal (Drainage Manual Administrator acceptance required)
- Two-Facility Treatment Trains see Table 4.1.

Table 4.1. Treatment Trains for Phosphorus Removal

First Basic Treatment Facility	Second Treatment Facility
BMP BF.01 Biofiltration Swale	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP BF.04 Filter Strip	BMP MF.03 Linear Sand Filter (no presettling needed)
BMP MF.03 Linear Sand Filter	BMP BF.04 Filter Strip
BMP WP.02 Basic Wet Pond	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP WP.03 Wet Vault	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP WP.01 Stormwater Treatment Wetland	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault
BMP WP.04 Basic Combined Detention and Wet Pool	BMP MF.01 Sand Filter Basin or BMP MF.02 Sand Filter Vault

4.5 Enhanced Treatment: Supplemental Information

4.5.1 Performance Goal

The Enhanced Menu facility choices (below) are intended to provide a higher rate of removal of dissolved metals than Basic Treatment facilities. Due to the sparse data available on dissolved metals removal in stormwater treatment facilities, a specific numeric removal efficiency goal could not be established at the time of publication. Instead, Ecology relied on available nationwide and local data, and knowledge of the pollutant removal mechanisms of treatment facilities to develop the list of options below.

The choices are also intended to achieve the Basic Treatment performance goal. This performance goal assumes that the facility is treating stormwater with dissolved Copper typically ranging from 0.003 to 0.02 mg/l, and dissolved Zinc ranging from 0.02 to 0.3 mg/l.

The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of treatment facilities that engage a bypass at flow rates higher than the water quality design flow rate as long as the reduction in dissolved metals loading exceeds that achieved with initiating bypass at the water quality design flow rate. Note that wet pool facilities are always designed to be on-line.

4.5.2 Enhanced Treatment Menu

Any one of the following options may be chosen to satisfy the enhanced treatment requirement:

Note: If phosphorous treatment is also required, select a facility or facility train that meets both Enhanced and Phosphorous treatment.

- Infiltration with appropriate pretreatment (see Volume III and Volume V)
    - *Infiltration treatment:* If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (see Volume III and Volume V), a presettling basin or a basic treatment facility can serve for pretreatment.
    - *Infiltration preceded by Basic Treatment:* If infiltration is through soils that do not meet the soil suitability criteria for infiltration treatment, treatment must be provided by a basic treatment facility unless the soil and site fit the description in the next option below.
    - *Infiltration preceded by Enhanced Treatment:* If the soils do not meet the soil suitability criteria **and** the infiltration site is within a designated well head protection area or within 1/4 mile of a fish-bearing stream, a tributary to a fish-bearing stream, or a lake, treatment must be provided by one of the other treatment facility options listed below.
- **BMP MF.01** or **BMP MF.02**: Large Sand Filter
- **BMP MF.01** or **BMP MF.02**: Amended Sand Filter (sand filter amendment requires Drainage Manual Administrator acceptance from Thurston County)
- **BMP WP.01**: Stormwater Treatment Wetland

- **BMP BF.06**: Compost-amended Filter Strip
- Two Facility Treatment Trains – see Table 4.2

Table 4.2. Treatment Trains for Dissolved Metals Removal

First Basic Treatment Facility	Second Treatment Facility
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Filter Strip	Linear Sand Filter with no pre-settling cell needed
Linear Sand Filter	Filter Strip
Basic Wet Pond	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Wet Vault	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Basic Combined Detention/Wet Pool	Basic Sand Filter or Sand Filter Vault or Media Filter [1]
Basic Sand Filter or Sand Filter Vault with a presettling cell if the filter isn't preceded by a detention facility	Media Filter [1]

[1] The media must be of a nature that has the capability to remove dissolved metals effectively based on at least limited data. Ecology includes Stormfilter's ™ leaf compost and zeolite media in this category.

- **BMP LID.08**: Bioretention Facility

  Note: Any stormwater runoff that infiltrates through the imported soil mix will have received the equivalent of Enhanced Treatment. Where bioretention/rain gardens are intended to fully meet treatment requirements, they must be designed, using an approved continuous runoff model, to infiltrate 91 percent of the influent runoff file.

- **BMP MF.04**: Media Filter Drain

4.6 Basic Treatment: Supplemental Information

4.6.1 Applicability

The Basic Treatment Menu (below) is applied to:

- Project sites that discharge to the ground, *unless*:
  - o The soil suitability criteria for infiltration treatment are met (see Chapter 3 of Volume III and Volume V), or

  - The project uses infiltration strictly for flow control – not treatment – and the discharge is within 1/4 mile of a phosphorus sensitive lake (use the Phosphorus Treatment Menu), or within 1/4 mile of a fish-bearing stream, or a lake (use the Enhanced Treatment Menu).

  - Facility is located within a designated Well Head Protection Area for a public water supply with 1,000 connections or greater (use the Enhanced Treatment Menu).

- Residential projects not otherwise needing phosphorus control as designated by the EPA, Ecology, or a local government.

- Project sites discharging directly to salt water or basic receiving waters

- Project sites that drain to streams that are not fish-bearing, or to waters not tributary to fish-bearing streams

- Landscaped areas of industrial, commercial, and multi-family project sites, and parking lots of industrial and commercial project sites, dedicated solely to parking of employees' private vehicles that do not involve any other pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals). For developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the areas subject to the Basic Treatment requirement comprises 50 percent or more of the total runoff within a threshold discharge area.

4.6.2 Performance Goal

The Basic Treatment Menu facility choices (below) are intended to remove 80 percent of TSS for influent concentrations that are greater than 100 mg/l, but less than 200 mg/l. For influent concentrations greater than 200 mg/l, a higher treatment goal may be appropriate. For influent concentrations less than 100 mg/l, the facilities are intended to achieve an effluent goal of 20 mg/l TSS.

The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable. The goal also applies on an average annual basis to the entire annual discharge volume (treated plus bypassed). The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net TSS reduction is maintained. Ecology encourages the design and operation of treatment facilities that engage a bypass at flow rates higher than the water quality design flow rate as long as the reduction in TSS loading exceeds that achieved with initiating bypass at the water quality design flow rate. Wet pool facilities are always designed to be online. The performance goal assumes that the facility is treating stormwater with a typical particle size distribution. For a description of a typical particle size distribution, please refer to the stormwater monitoring protocol in “Guidance for Evaluating Emerging Stormwater Treatment Technologies, Technology Assessment Protocol - Ecology (TAPE)” on the Ecology website: <http://www.ecy.wa.gov/biblio/0210037.html>.

4.6.3 Basic Treatment Menu

Any one of the following options may be chosen to satisfy the basic treatment requirement:

- Infiltration (with adequate soils)
- Sand filters
- Biofiltration swales
- Filter strips
- Basic wet pond
- Wet vault
- Stormwater treatment wetland
- Combined detention and wet pool facilities
- Bioretention facilities

  Note: For bioretention facilities, any stormwater runoff that infiltrates through the imported soil mix will have received the equivalent of Enhanced Treatment. Where bioretention/rain gardens are intended to fully meet treatment requirements, they must be designed, using an approved continuous runoff model, to infiltrate 91 percent of the influent runoff file.

- Media Filter Drain
- Alternative Technologies when accepted at the “General Use Level” under Ecology’s TAPE program: (for example: CONTECH Stormwater Management StormFilter with ZPG™ media – A canister-type filter with zeolite/perlite/granular activated carbon).

Note: A wet vault may be used for commercial, industrial, or road projects if there are space limitations. Thurston County discourages the use of wet vaults for residential projects. Combined detention/wet vaults are allowed. Any use of a wet vault for basic treatment requires specific authorization and acceptance by Thurston County based on site circumstances.

4.7 Other Treatment Facility Selection Factors

Selection of a treatment facility should be based on physical site factors and pollutants of concern. Requirements for using Enhanced Treatment or Phosphorus Treatment represent facility selection based on pollutants of concern. Even if the site is not subject to those requirements, try to choose a facility that has been shown to remove the types of pollutants generated on the site. The types of physical site factors that influence facility selection are summarized below.

4.7.1 Soil Type

The permeability of soil under a treatment facility has a profound influence on the facility's effectiveness. This is particularly true for infiltration treatment facilities that are best sited in sandy to loamy sand soils, and not generally appropriate for sites that have final infiltration rates of less than 0.5 inches per hour. Wet pond facilities situated on coarser soils will need a synthetic liner or soil amendment to reduce the infiltration rate and provide treatment. Maintaining a permanent pool in the first cell is necessary to avoid resuspension of settled solids. Biofiltration swales in coarse soils can also be amended to reduce the infiltration rate.

4.7.2 High Sediment Input

High TSS loads can clog infiltration soil, sand filters and coalescing plate oil & water separators. Pretreatment with a presettling basin, wet vault, or another basic treatment facility would typically be necessary.

4.7.3 Other Physical Factors

Slope

Steep slopes restrict the use of several BMPs. For example, biofiltration swales are usually situated on sites with slopes of less than 6 percent, although greater slopes can be considered. Infiltration BMPs are not suitable when the slope exceeds 15 percent.

High Water Table

Unless there is sufficient horizontal hydraulic receptor capacity, the water table acts as an effective barrier to exfiltration and can sharply reduce the efficiency of an infiltration system. If the seasonal high water table extends to within 5 feet of the bottom of an infiltration BMP, the site is seldom suitable.

Depth to Bedrock/ Hardpan/Till

The downward exfiltration of stormwater is also impeded if a bedrock or till layer lies too close to the surface. If the impervious layer lies within 5 feet below the bottom of the infiltration BMP, the site is seldom suitable. Similarly, pond BMPs are often not feasible if bedrock lies within the area that must be excavated.

Proximity to Foundations and Wells

Since infiltration BMPs convey runoff back into the soil, some sites may experience problems with local seepage. This can be a real problem if the BMP is located too close to a building foundation. Another risk is ground water pollution; hence the requirement to site infiltration systems more than 100 feet away from drinking water wells.

Maximum Depth

Wet ponds are also subject to a maximum depth limit for the "permanent pool" volume. Deep ponds (greater than 8 feet) may stratify during summer and create low oxygen conditions near the bottom resulting in re-release of phosphorus and other pollutants back into the water.

Appendix I-A
Glossary

303(d) waterbody	A list of lakes, rivers, and streams designated as impaired or threatened by a pollutant for which one or more TMDLs are needed. "Impaired" means the water is not meeting water quality standards.
319	The section of the federal Clean Water Act that addresses nonpoint pollution.
Applicant	The person who has applied for a development permit or approval.
Aquifer	A geologic strata containing water that can be withdrawn and used for human purposes.
Arterial	Road or street primarily for through traffic. A major arterial connects an Interstate Highway to cities and counties. A minor arterial connects major arterials to collectors. A collector connects an arterial to a neighborhood. A collector is not an arterial. A local access road connects individual homes to a collector.
As-built drawings	Engineering plans which have been revised to reflect all changes to the plans which occurred during construction.
Basin	Any area draining to a point of interest.
Basin plan	A plan that assesses, evaluates, and proposes solutions to existing and potential future impacts to the beneficial uses of, and the physical, chemical, and biological properties of waters of the state within a basin. Basins typically range in size from 1 to 50 square miles.
Best Management Practice (BMP)	The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State.
Bond	A surety bond, cash deposit or escrow account, assignment of savings, irrevocable letter of credit or other means acceptable to or required by the manager to guarantee that work is completed in compliance with the project's drainage plan and in compliance with all local government requirements.
Buffer	The zone contiguous with a sensitive area that is required for the continued maintenance, function, and structural stability of the sensitive area. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, overflow during high water events, protection from disturbance by humans and domestic animals, maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of slope stability, attenuation of surface water flows from stormwater runoff and precipitation, and erosion control.

Catch basin	A chamber or well, usually built at the curb line of a street, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.
Cation Exchange Capacity (CEC)	The amount of exchangeable cations that a soil can adsorb at pH 7.0.
Channel	A feature that conveys surface water and is open to the air.
Channel, natural	Streams, creeks, or swales that convey surface/ground water and have existed long enough to establish a stable route and/or biological community.
Check dam	Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.
Clearing	The destruction and removal of vegetation by manual, mechanical, or chemical methods.
Closed depression	An area which is low-lying and either has no, or such a limited, surface water outlet that during storm events the area acts as a retention basin.
Commercial agriculture	Those activities conducted on lands defined in RCW 84.34.020(2), and activities involved in the production of crops or livestock for wholesale trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five (5) years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.
Compost	Organic residue or a mixture of organic residues and soil, that has undergone biological decomposition until it has become relatively stable humus. Reference note: The Department of Ecology Interim Guidelines for Compost Quality (1994) defines compost as “the product of composting; it has undergone an initial, rapid stage of decomposition and is in the process of humification (curing).” Compost used should meet specifications for grade A or AA compost in Ecology publication 94-038.
Converted pervious surface	Areas of native vegetation that have been converted to lawn or landscape.
Conveyance system	The drainage facilities, both natural and man-made, which collect, contain, and provide for the flow of surface and stormwater from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.

Critical areas	At a minimum, areas which include wetlands, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, including unstable slopes, and associated areas and ecosystems. Critical areas are those areas as defined by Thurston County Code, Title 17.
Critical drainage area	An area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in an ordinance.
Culvert	Pipe or concrete box structure that drains open channels, swales or ditches under a roadway or embankment. Typically with no catchbasins or manholes along its length.
Curb and gutter barrier	An element of a roadway that prevents sheet flow of runoff from the roadway surface at the road edge and concentrates the flow for conveyance through a gutter to either a point of discharge or a catch basin structure and/or piping system. This includes rolled curbs, inverted crown roadway, asphalt wedge curbs and concrete curb and gutters.
Design storm	A prescribed hyetograph and total precipitation amount (for a specific duration recurrence frequency) used to estimate runoff for a hypothetical storm of interest or concern for the purposes of analyzing existing drainage, designing new drainage facilities or assessing other impacts of a proposed project on the flow of surface water. (A hyetograph is a graph of percentages of total precipitation for a series of time steps representing the total time during which the precipitation occurs.)
Detention facility	An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a slower rate than it is collected by the drainage facility system. There is little or no infiltration of stored stormwater.
Discharge	Runoff leaving a new development or redevelopment via overland flow, built conveyance systems, or infiltration facilities. A hydraulic rate of flow, specifically fluid flow; a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.
Dispersion	Release of surface and stormwater runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodible underlying granular soils.
Drainage easement	A legal encumbrance that is placed against a property's title to reserve specified privileges for the users and beneficiaries of the drainage facilities contained within the boundaries of the easement.
Dry season	The season in which little rainfall occurs. In Western Washington, from May 1 through September 30.

Earth material	Any rock, natural soil or fill and/or any combination thereof. Earth material shall not be considered topsoil used for landscape purposes. Topsoil used for landscaped purposes shall comply with ASTM D 5268 specifications. Engineered soil/landscape systems are also defined independently.
Ecology	Washington Department of Ecology. The agency responsible for implementing the stormwater control required by the Clean Water Act.
Embankment	A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.
Erosion	The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Also, detachment and movement of soil or rock fragments by water, wind, ice, or gravity.
ESA	Endangered Species Act
Effective impervious surface	Those impervious surfaces that are connected via sheet flow or discrete conveyance to a drainage system. Impervious surfaces on residential development sites are considered ineffective if the runoff is dispersed through at least one hundred feet of native vegetation in accordance with BMP LID.11 – "Full Dispersion," as described in Volume V.
Energy dissipator	Any means by which the total energy of flowing water is reduced. In stormwater design, they are usually mechanisms that reduce velocity prior to, or at, discharge from an outfall in order to prevent erosion. They include rock splash pads, drop manholes, concrete stilling basins or baffles, and check dams.
Eutrophic	A condition in a waterbody where nutrient over-enrichment has led to excessive growth of aquatic plants, especially algae.
Excavation	The mechanical removal of earth material.
Fish bearing stream	A stream is generally considered fish-bearing in Western Washington if it is 2 feet or grater in width and has a gradient of 20 percent or less. Intermittent streams may also be fish-bearing for those times during which the stream is flowing. Includes lakes or ponds connected to a known fish-bearing water by a stream channel of similar dimensions as above.
Flow control facility	A drainage facility designed to mitigate the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control facilities are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.
Flow duration	The aggregate time that peak flows are at or above a particular flow rate of interest. For example, the amount of time that peak flows are at or above 50% of the 2-year peak flow rate for a period of record.
Flow frequency	The inverse of the probability that the flow will be equaled or exceeded in any given year (the exceedance probability). For example, if the exceedance probability is 0.01 or 1 in 100, that flow is referred to as the 100-year flow.

Frequency of storm (design storm frequency)	The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur; thus a 10-year storm can be expected to occur on the average once every 10 years. Sewers designed to handle flows that occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.
Ground water	Water in a saturated zone or stratum beneath the land surface or a surface waterbody.
Groundwater table	The free surface of the ground water, that surface subject to atmospheric pressure under the ground, generally rising and falling with the season, the rate of withdrawal, the rate of restoration, and other conditions. It is seldom static.
Habitat	The specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be protected from harmful biological, chemical, and physical alterations.
Hardpan	A cemented or compacted and often clay-like layer of soil that is impenetrable by roots. Also known as glacial till.
Highway	A main public road connecting towns and cities.
Hydrologic cycle	The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.
Hydrologic soil groups	A soil characteristic classification system defined by the U.S. Soil Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based upon infiltration rate and other properties. Type A: Low runoff potential. Soils having high infiltration rates, even when thoroughly wetted, and consisting chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission. Type B: Moderately low runoff potential. Soils having moderate infiltration rates when thoroughly wetted, and consisting chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. Type C: Moderately high runoff potential. Soils having slow infiltration rates when thoroughly wetted, and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. These soils have a slow rate of water transmission. Type D: High runoff potential. Soils having very slow infiltration rates when thoroughly wetted, and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan, till, or clay layer at or near the surface, soils with a compacted subgrade at or near the surface, and shallow soils or nearly impervious material. These soils have a very slow rate of water transmission.

Hydrology	The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.
Hydroperiod	A seasonal occurrence of flooding and/or soil saturation; it encompasses depth, frequency, duration, and seasonal pattern of inundation.
Illicit discharge	All non-stormwater discharges to stormwater drainage systems that cause or contribute to a violation of state water quality, sediment quality or ground water quality standards, including but not limited to sanitary sewer connections, industrial process water, interior floor drains, car washing, and greywater systems.
Impervious surface	A hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces which similarly impede the natural infiltration of stormwater. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of determining whether the thresholds for application of minimum requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling.
Impoundment	A natural or man-made containment for surface water.
Industrial activities	Material handling, transportation, or storage; manufacturing; maintenance; treatment; or disposal. Areas with industrial activities include plant yards, access roads and rail lines used by carriers of raw materials, manufactured products, waste material, or by-products; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater.
Infiltration	The downward movement of water from the surface to the subsoil.
Infiltration rate	The rate, usually expressed in inches/hour, at which water moves downward (percolates) through the soil profile. Short-term infiltration rates may be inferred from soil analysis or texture or derived from field measurements. Long-term infiltration rates are affected by variability in soils and subsurface conditions at the site, the effectiveness of pretreatment or influent control, and the degree of long-term maintenance of the infiltration facility.

Interflow	That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface for example, in a roadside ditch, wetland, spring or seep. Interflow is a function of the soil system depth, permeability, and water-holding capacity.
Land disturbing activity	Any activity that results in movement of earth, or a change in the existing soil cover (both vegetative and nonvegetative) and/or the existing soil topography. Land disturbing activities include, but are not limited to clearing, grading, filling, and excavation. Compaction that is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices are not considered land-disturbing activity.
Maximum extent practicable	The NPDES permit requires permittees to reduce the discharge of pollutants to the maximum extent practicable (MEP). Permittees who choose to use the site planning process, and BMP selection and design criteria in the 2005 Stormwater Management Manual for Western Washington, or an equivalent manual approved by Ecology, may cite this choice as their sole documentation to meet this requirement. When used in conjunction with application of BMPs such as LID it means those measures that are feasible taking into consideration all factors such as site conditions, soils, type of project, cost, maintenance, human health and the environment.
Maintenance	Repair and maintenance includes activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing and results in no significant adverse hydrologic impact. It includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems. Those usual activities may include replacement of dysfunctioning facilities, including cases where environmental permits require replacing an existing structure with a different type structure, as long as the functioning characteristics of the original structure are not changed. One example is the replacement of a collapsed, fish blocking, round culvert with a new box culvert under the same span, or width, of roadway.
Municipal Separate Storm Sewer System (MS4)	A system where stormwater and wastewater flows are conveyed through separate systems of pipes. (As opposed to a combined sewer system.) MS4 systems exceeding certain population levels must obtain an NPDES permit for stormwater discharges.
Native vegetation	Vegetation comprised of plant species, other than noxious weeds, that are indigenous to the coastal region of the Pacific Northwest and which reasonably could have been expected to naturally occur on the site. Examples include trees such as Douglas Fir, western hemlock, western red cedar, alder, big-leaf maple, and vine maple; shrubs such as willow, elderberry, salmonberry, and salal; and herbaceous plants such as sword fern, foam flower, and fireweed.

Natural location	Means the location of those channels, swales, and other non-manmade conveyance systems as defined by the first documented topographic contours existing for the subject property, either from maps or photographs, or such other means as appropriate. In the case of outwash soils with relatively flat terrain, no natural location of surface discharge may exist.
New Development	Land disturbing activities, including Class IV -general forest practices that are conversions from timber land to other uses; structural development, including construction or installation of a building or other structure; creation of impervious surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in Chapter 58.17 RCW. Projects meeting the definition of redevelopment shall not be considered new development.
Non-point source (NPS) pollutants	Pollution that comes from many different, hard-to-trace sources with no obvious point of discharge, unlike wastewater treatment plant discharges, for example. NPS pollutants come from roadways, fertilizers on lawns, rooftops, agricultural and forestry practices, and many other diffuse sources.
NPDES	The National Pollutant Discharge Elimination System as established by the Federal Clean Water Act. Under NPDES regulations, point source dischargers must obtain permits.
NPDES Phase II Boundary	The boundary of those areas of Thurston County which have sufficient population density based on the criteria established for the NPDES program managed by Ecology to be subject to the requirements of the NPDES Phase II permit. The boundary is subject to revision based on census data or regulatory changes. A map of the NPDES Phase II Boundary is available for review at the offices of the Thurston County Water Resources Unit of the Department of Resource Stewardship.
Off-line facilities	Water quality treatment facilities to which stormwater runoff is restricted to some maximum flow rate or volume by a flow-splitter.
Off-site	Any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.
On-line facilities	Water quality treatment facilities which receive all of the stormwater runoff from a drainage area. Flows above the water quality design flow rate or volume are passed through at a lower percent removal efficiency.
On-site	The entire property that includes the proposed development.
On-site Stormwater Management BMPs	Site development techniques that serve to infiltrate, disperse, and retain stormwater runoff on-site.
Outfall	Every point at which the stormwater conveyance system discharges from the project site into a receiving waterbody, such as a stream, river, wetland, salt water body or lake or a conveyance channel or ditch that eventually discharges to a surface water body such as a lake, stream or wetland.
Outwash soils	Soils formed from highly permeable sands and gravels.

Peak flow rate	The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event, such as a 25-year, 24-hour event.
Permeable soils	Soil materials with a sufficiently rapid infiltration rate so as to greatly reduce or eliminate surface and stormwater runoff. These soils are generally classified as SCS hydrologic soil types A and B.
Person	Any individual, partnership, corporation, association, organization, cooperative, public or municipal corporation, agency of the state, or local government unit, however designated.
Pervious surface	A surface which allows water to pass through it.
Phase 1 stormwater permit	The part of the NPDES program that deals with large cities, >100,000 population, or heavily urbanized areas.
Phase 2 stormwater permit	The part of the NPDES program that deals with small cities, generally between 10,000 and 100,000 in population.
Point discharge	The release of collected and/or concentrated surface and stormwater runoff from a pipe, culvert, or channel.
Pollution-generating impervious surface (PGIS)	Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to: vehicular use; industrial activities (as further defined in this glossary); or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall. Erodible or leachable materials, wastes, or chemicals are those substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff. Examples include erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and garbage dumpster leakage. Metal roofs are also considered to be PGIS unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating). A surface, whether paved or not, shall be considered subject to vehicular use if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways,parking lots, unfenced fire lanes, vehicular equipment storage yards, and airport runways. The following are not considered regularly-used surfaces: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles, fenced fire lanes, and infrequently used maintenance access roads.
Pollution-generating pervious surface (PGPS)	Any non-impervious surface subject to use of pesticides and fertilizers or loss of soil. Typical PGPS include lawns, landscaped areas, golf courses, parks, cemeteries, and sports fields.

Pre-developed condition	The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The predeveloped condition shall be assumed to be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.
Pretreatment	The removal of material such as solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, settling, oil/water separation, or application of a Basic Treatment BMP prior to infiltration.
Project engineer	The professional civil engineer licensed in the State of Washington who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.
Project proponent	The person with overall responsibility for directing the project as a representative of the owner (may be the owner, architect, developer or project engineer).
Project site	That portion of a property, properties, or right of way subject to land disturbing activities, new impervious surfaces, or replaced impervious surfaces.
Property Owner's Association	A non-profit corporation established for the purposes of enforcing subdivision covenants, conditions and restrictions and for operating, maintaining and repairing private facilities associated with the subdivision such as roads, stormwater facilities, open space, water and sewer systems, as applicable. As used in this manual, it is synonymous with Home Owner's Association, Lot Owner's Association, Condominium Association, etc.
Receiving waters	Bodies of water or surface water systems to which surface runoff is discharged via a point source of stormwater or via sheet flow.
Redevelopment	On a site that is already developed, the creation or addition of impervious surfaces; the expansion of a building footprint or addition or replacement of a structure; structural development including construction, installation or expansion of a building or other structure; replacement of impervious surface that is not part of a routine maintenance activity; and land disturbing activities.
Regional detention facility	A detention facility sited to detain stormwater runoff from a number of new developments or areas within a catchment, subbasin, or basin.
Replaced impervious surface	For structures, the removal and replacement of any exterior impervious surfaces or foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement.
Retention	The process of collecting and holding surface and stormwater runoff with no surface outflow.
Runoff	Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water. As applied in this manual, it also means the portion of rainfall or other precipitation that becomes surface flow and interflow.

Salmonid	A member of the fish family Salmonidae. Chinook, coho, chum, sockeye and pink salmon; cutthroat, brook, brown, rainbow, and steelhead trout; Dolly Varden, kokanee, and char are examples of salmonid species.
Site	The area defined by the legal boundaries of a parcel or parcels of land that is (are) subject to new development or redevelopment. For road projects, the length of the project site and the right-of-way boundaries define the site.
Soil group, hydrologic	A classification of soils by the Soil Conservation Service into four runoff potential groups. The groups range from A soils, which are very permeable and produce little or no runoff, to D soils, which are not very permeable and produce much more runoff.
Source control	Control of pollution by preventing it from entering stormwater such as covering materials, rather than treating it after it enters stormwater.
Stormwater facility	A constructed component of a stormwater drainage system, designed or constructed to perform a particular function, or multiple functions. Stormwater facilities include, but are not limited to, pipes, swales, ditches, culverts, street gutters, detention ponds, retention ponds, constructed wetlands, infiltration devices, catch basins, oil/water separators, and biofiltration swales. An engineered or natural dispersion area that is dedicated to strormwater use is also considered a stormwater facility for purposes of this manual.
Surface and stormwater	Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow ground water.
SWPPP	Storm Water Pollution Prevention Plan
TESC	Temporary erosion and sediment control.
Threshold Discharge Area	An onsite area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath).
Tightline	A continuous length of pipe that conveys water from one point to another (typically down a steep slope) with no inlets or collection points in between.
Till	A layer of poorly sorted soil deposited by glacial action that generally has very low infiltration rates.
Time of concentration	The time period necessary for surface runoff to reach the outlet of a subbasin from the hydraulically most remote point in the tributary drainage area.
Topsoil	Topsoil shall be per ASTM D5268 standard specification, and water permeability shall be 0.6 inches per hour or greater. Organic matter shall have not more than 10 percent of nutrients in mineralized water soluble forms. Topsoil shall not have phytotoxic characteristics.

Total Maximum Daily Load (TMDL)	A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL (also known as a Water Cleanup Plan) is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The calculation must also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic like support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.
Total Suspended Solids (TSS)	Suspended solids are organic or inorganic particles that are suspended in and carried by the water. The term includes sand, mud, and clay particles (and associated pollutants) as well as solids in stormwater. TSS refers to the solids that can be captured on a standard glass filter.
Tract	A legally created parcel of property designated for special nonresidential and noncommercial uses.
Water Resource Inventory Area (WRIA)	Ecology and other state natural resources agencies have divided the state into 62 Water Resource Inventory Areas or WRIAs to delineate the state's major watersheds.
Water table	The upper surface or top of the saturated portion of the soil or bedrock layer indicates the uppermost extent of ground water.
Waters of the state	Surface waters of the state include lakes, rivers, ponds, streams, inland waters, saltwaters, wetlands, and all other surface waters and water courses within the jurisdiction of the state of Washington.
Wet season	The season in which most of the rainfall occurs. In Western Washington, from October 1 through April 30.
WSDOT	Washington State Department of Transportation
WSDOT Standard Plans	The most current version of the Washington State Department of Transportation's Standard Plans.
WSDOT Standard Specifications	The most current version of the Standard Specifications for Road, Bridge and Municipal Construction prepared and promulgated by the Washington State Department of Transportation and any revisions thereof.

Appendix I-B
Bond Quantities Worksheet

BOND QUANTITIES WORKSHEET

Instructions

Financial assurance may be required for your project for one of several purposes including, but not limited to:

- Bonding for Site Improvements: As part of a land division to secure completion of required site improvements (Thurston County Code, Title 18, Section 18.24,"Agreement and Bond for Improvements").
- Maintenance Bond: To secure successful operation and maintenance of site stormwater facilities (Thurston County Code, Title 15, Section 15.05.040, "Financial Guarantee required").
- Performance Bond: To guarantee the performance of, or to correct permitted work in accordance with Thurston County Road Standards Section 2.16, "Securities". This can include roadway, stormwater, landscaping or other work that is part of the approved project.
- Other purposes as allowed by Thurston County Code and/or Washington State Law.

The attached Bond Quantities Worksheet is provided to the applicant for use in preparing cost estimates associated with establishment of a financial assurance for a project. For items not used in your project, leave the line blank or cross out the item. Unit prices should be based on actual construction costs and/or price quotes from providers. Unit prices inconsistent with current prices require the applicant to provide supporting data and/or justification. Unit prices and quantities are subject to the acceptance of the Administrator or designee.

The Bond Quantities Worksheet covers the following work items:

1. Erosion & Sediment Control
2. General Items (site work)
3. Road Improvements
4. Roadway Surfacing
5. Drainage

Additional project elements including sewer, water supply, franchise utility service (phone, power, cable, etc.) are not included in the worksheet; however, estimates for these items may be required depending on the type of financial assurance being provided or as required by the utility service providers.

Note: All unit prices shall include labor, equipment, materials, overhead and profit.

SITE IMPROVEMENT BOND QUANTITY WORKSHEET				
Item	**Quantity**	**Unit**	**Unit Price**	**Amount**
EROSION/SEDIMENT CONTROL				
Backfill & compaction-embankment		CY		
Check dams, 4” minus rock		Each		
Crushed surfacing 1-1/4” minus		CY		
Ditching		CY		
Excavation-bulk		CY		
Fence, silt		LF		
Fence, Temporary (Orange Construction)		LF		
Hydroseeding		SY		
Jute Mesh		SY		
Mulch, by hand, straw, 3” deep		SY		
Mulch, by machine, straw, 2” deep		SY		
Piping, temporary, CPP, 6”		LF		
Piping, temporary, CPP, 8”		LF		
Piping, temporary, CPP, 12”		LF		
Plastic covering, 6 mm, sandbagged		SY		
Rip Rap, machine placed; slopes		CY		
Rock Construction Entrance, 50’x15’x1’		Each		
Rock Construction Entrance, 100’x15’x1’		Each		
Sediment pond riser assembly		Each		
Sed. Trap, 5’ high, riprapped spillway		Each		
Seeding, by hand		SY		
Sodding, 1” deep, level ground		SY		
Sodding, 1” deep, sloped ground		SY		
TESC Supervisor		HR		
Water truck, dust control		HR		
Wheel Wash		Each		
Street Sweeper		HR		
WRITE-IN-ITEMS				
EROSION & SEDIMENT CONTROL SUBTOTAL:				
CONTINGENCY & MOBILIZATION (30%):				
EROSION & SEDIMENT CONTROL TOTAL:				
Item	**Quantity**	**Unit**	**Unit Price**	**Amount**

SITE IMPROVEMENT BOND QUANTITY WORKSHEET				
GENERAL ITEMS				
Backfill & Compaction-embankment		CY		
Backfill & Compaction-trench		CY		
Clear/Remove Brush, by hand		SY		
Clearing/Grubbing/Tree Removal		Acre		
Excavation-bulk		CY		
Excavation-trench		CY		
Fencing, cedar, 6’ high		LF		
Fencing, chain link, vinyl coated, 6’ high		LF		
Fencing, chain link, gate, vinyl coated, 20’		Each		
Fencing, split rail, 3’ high		LF		
Fill & compact – common borrow		CY		
Fill & compact – gravel base		CY		
Fill & compact – screened topsoil		CY		
Soil Amendment – scarification, placement		SY		
Gabion, 12” deep, stoned-filled mesh		SY		
Gabion, 18” deep, stone-filled mesh		SY		
Gabion, 36” deep, stone-filled mesh		SY		
Grading, fine, by hand		SY		
Grading, fine, with grader		SY		
Monuments, 3’ long		Each		
Sensitive Areas Sign		Each		
Stormwater Facility Sign		Each		
Soil Amendment		SY		
Sodding, 1” deep		SY		
Surveying, line & grade		Day		
Surveying, lot location/lines		Acre		
Traffic control crew (2 flaggers)		HR		
Traffic control signs		Day		
Trail, 4” chipped wood		SY		
Trail, 4” crushed cinder		SY		
Trail, 4” top course		SY		
Wall, retaining, concrete		SF		
Wall, retaining, segmental block		SF		
Wall, rockery		SF		
Well, monitoring or piezometer		Each		

SITE IMPROVEMENT BOND QUANTITY WORKSHEET				
Item	**Quantity**	**Unit**	**Unit Price**	**Amount**
WRITE-IN-ITEMS				
GENERAL ITEMS SUBTOTAL:				
CONTINGENCY & MOBILIZATION (30%):				
GENERAL ITEMS TOTAL:				
ROAD IMPROVEMENT				
AC grinding, removal & disposal		SY		
Barricade, type I		LF		
Barricade, type III (Permanent)		LF		
Curb and Gutter, rolled		LF		
Curb and Gutter, vertical		LF		
Curb and Gutter, demolition and disposal		LF		
Curb, extruded asphalt		LF		
Curb, extruded concrete		LF		
Sawcut, asphalt, 3” depth		LF		
Sawcut, concrete, per 1” depth		LF		
Sealant, asphalt		LF		
Shoulder, AC, (see AC road unit price)		SY		
Shoulder, gravel, 4” thick		SY		
Sidewalk, 4” thick		SY		
Sidewalk, 4” thick, demolition and disposal		SY		
Sidewalk, 5” thick		SY		
Sidewalk, 5” thick, demolition and disposal		SY		
Sign, handicap		Each		

SITE IMPROVEMENT BOND QUANTITY WORKSHEET				
Item	**Quantity**	**Unit**	**Unit Price**	**Amount**
Striping, thermoplastic, (for crosswalk)		SF		
Striping, 4” reflectorized line)		LF		
Sign, Traffic (stop, yield, speed, etc.)		Each		
Sign, Street (including post & installation)		Each		
ROAD SURFACING (11”Rock=2” CSTC, 9” Gravel Base)				
AC Overlay, 1.5” AC		SY		
AC Overlay, 2” AC		SY		
AC Road, 2.4” ACP, 9” rock		SY		
AC Road, 3” ACP, 9” rock		SY		
AC Road, 4” ACP, 9” rock		SY		
Asphalt Treated Base, 4” thick		SY		
Gravel Road, 9” rock		SY		
PCC Road, 5”, no base		SY		
PCC Road, 6”, no base		SY		
Thickened Edge		LF		
WRITE-IN-ITEMS				
ROAD IMPVMT & SURFACING SUBTOTAL:				
CONTINGENCY & MOBILIZATION (30%):				
ROAD IMPVMT & SURFACING TOTAL:				

SITE IMPROVEMENT BOND QUANTITY WORKSHEET				
Item	**Quantity**	**Unit**	**Unit Price**	**Amount**
DRAINAGE (CPP=Corrugated Plastic Pipe, N12 or equivalent)				
Access Road, (Pond)		SY		
Bollards – fixed		Each		
Bollards – removable		Each		
*(CB's include frame & grate/lid)				
CB Type I		Each		
CB Type IL		Each		
CB Type II, 48" dia,		Each		
for additional depth over 4'		FT		
CB Type II, 54" dia		Each		
For additional depth over 4'		FT		
CB Type II, 60" dia		Each		
For additional depth over 4'		FT		
CB Type II, 72" dia		Each		
For additional depth over 4'		FT		
Through-curb inlet Framework		Each		
Cleanout, PVC, 4"		Each		
Cleanout, PVC, 6"		Each		
Cleanout, PVC, 8"		Each		
Storm Drain Pipe, PVC, 4"		LF		
Storm Drain Pipe, PVC, 6"		LF		
Storm Drain Pipe, PVC, 8"		LF		
Storm Drain Pipe, PVC, 12"		LF		
Storm Drain Pipe, CPP, 8"		LF		
Storm Drain Pipe, CPP, 12"		LF		
Storm Drain Pipe, CPP, 15"		LF		
Storm Drain Pipe, CPP, 18"		LF		
Storm Drain Pipe, CPP, 24"		LF		
Storm Drain Pipe, Concrete, 8"		LF		
Storm Drain Pipe, Concrete, 12"		LF		
Storm Drain Pipe, Concrete, 15"		LF		
Storm Drain Pipe, Concrete, 18"		LF		
Storm Drain Pipe, Concrete, 24"		LF		
Storm Drain Pipe, Concrete, 30"		LF		

SITE IMPROVEMENT BOND QUANTITY WORKSHEET				
Item	**Quantity**	**Unit**	**Unit Price**	**Amount**
Storm Drain Pipe, Concrete, 36”		LF		
Storm Drain Pipe, Concrete, 42”		LF		
Storm Drain Pipe, Concrete, 48”		LF		
Storm Drain Pipe, __________, ___”		LF		
Storm Drain Pipe, __________, ___”		LF		
Storm Drain Pipe, __________, ___”		LF		
Storm Drain Pipe, ___________, ___”		LF		
Ditching		CY		
Flow Dispersal Trench		LF		
French Drains		LF		
Geotextile		SY		
Infiltration Pond Testing (post-construction)		LS		
Detention Tank System		LS		
Detention Vault System		LS		
Vault/Tank Access Riser		Each		
Pond Excavation & Embankment		CY		
Swale Excavation & Embankment		LF		
Pond Overflow Spillway		Each		
Restrictor/Oil Separator, 12”		Each		
Restrictor/Oil Separator, 15”		Each		
Restrictor/Oil Separator, 18”		Each		
Riprap, placed		CY		
Trash rack, 12”		Each		
Trash rack, 15”		Each		
Trash rack, 18”		Each		
Trash rack, 24”		Each		
Trash rack, ____”		Each		
Storm Facility Landscaping, Fencing & Signage		LS		
WRITE-IN-ITEMS				

SITE IMPROVEMENT BOND QUANTITY WORKSHEET				
Item	**Quantity**	**Unit**	**Unit Price**	**Amount**
DRAINAGE SUBTOTAL:				
CONTINGENCY & MOBILIZATION (30%):				
DRAINAGE TOTAL:				

Appendix I-C
Engineer's Construction Inspection Report Form

ENGINEER'S CONSTRUCTION INSPECTION REPORT FORM

Project Name: ____

Project Number: ____

Location (address, or other): ____

____

____

____

Stormwater Ponds (detention, infiltration, wetponds, etc.):

1. Type: ____

2(a). After pond construction, have infiltration tests and/or soil logs been completed? ________

____

____

2(b). Indicate test results and compare with design criteria (pre-construction soils information). Do the post-construction values indicate a need to modify system design? Explain. __________________

____

____

____

3. Outlet Type ______________________________

4. Field verify orifices, weirs, overflow at correct elevation: (Y/N) ___________________

Comments: ____

5. Field verify orifices, weirs, etc. of correct size per design plans: (Y/N) ______________

Comments: ____

6. Emergency Spillway at correct elevation, slope, width, adequately armored, etc. (Y/N)

Comments: ____

____

7. As-built of pond volume verified based on field survey: (Y/N) _______________________

As-built volume at Max water elevation: ____________________Cubic Feet

8. Pond side slopes per design: ____________________

9. Pond landscaping completed per design: ____

____

10. Pond inlet pipes and swales adequately armored:__________________________________

____

11. Pond outlet pipe is adequately armored to prevent erosion: ___________________

____

12. Amended soils placed per design (if applicable): ___________________________

____

Water Quality Treatment Facility:

1. Facility dimensions (width, length, depth, slope, etc.) per plans based on field survey:

Comments: ____

____

____

2. Level spreaders constructed per plan and field verified: (Y/N) _______________________

3. Amended soils meet specifications and placed per plans and specifications:

(Y/N) ________, Depth of amended soil: ________ inches. Comments: _____________________

____

4. Swale bottom sodded and sideslopes seeded per design seed mix: (Y/N):______________

Comments: ____

____

5. Plantings installed per planting plan (quantity, type and quality): (Y/N): ______________

____

6. Grass established and growing (swale bottom & slopes) ______________________________

____

Conveyances

1. Channels properly graded, sloped, planted, etc. _________________________________

____

____

2. Storm sewers are at proper grade, inlets as designed, trenches as designed, pipe bedding properly prepared, backfilling procedures correct, materials as specified, etc. _________________

____

____

Dispersion & Post-Construction Soil Quality/Depth:

1. Have all required disturbed areas had amended soils placed of the type and amount required: (explain)
____

____

____

2. Are areas designated for stormwater dispersion undisturbed and protected from encroachment by signage and fencing as required: ____

____

3. Have disturbed areas of native vegetation required to remain undisturbed been replanted and restored per Best Management Practices: ____

____

____

4. Are level spreaders and rock dispersion pads in place and functioning correctly: ____________

____

____

5. Inspect dispersion areas and verify that no short circuiting, channeling, etc. is occurring to prevent sheet flow treatment of stormwater: ____

____

Roof Leaders:

1. Do roof leaders drain to infiltration trenches, drywells or rain gardens as shown on the plans (if applicable). ____

2. If roof drain dispersion is used, do splash blocks direct roof runoff to amended soils, do contributing areas of different roof drains meet convergence criteria and is there adequate dispersion length through native vegetation or amended soils as required by Best Management Practices? __________

____

____

____

Erosion Control:

1. Describe erosion temporary erosion and sediment control measures used during project construction: ____

____

____

2. Describe temporary erosion and sediment controls remaining in place pending full site stabilization: ____

____

____

____

3. What final site stabilization still needs to occur prior to removing final temporary erosion and sediment control facilities: ____

____

____

____

4. During construction were there any discharges of sediment laden waters to water bodies, wetlands or to adjacent properties? If so, what measures were taken to mitigate impacts: ________________

____

____

____

5. Are permanent erosion control measures in place and as designed? ___________________

____

____

Signature and Seal:

I or someone under my direct supervision have adequately inspected the project during construction and to the best of my knowledge the project was built according to the approved plans and specifications except as noted above.

Signature/Date: ____

Appendix I-D
Facility Summary Form

THURSTON COUNTY
FACILITY SUMMARY FORM

Complete one (1) for each facility on the project site including flow control and water quality treatment facilities (BMPs) such as, but not limited to: detention ponds, vaults, or tanks; infiltration ponds, trenches, swales, or vaults; bioretention facilities (rain gardens, bioretention swales/slopes); biofiltration BMPs (filter strip, biofiltration swale); oil/water separators; wet ponds; constructed wetlands; dispersion areas & flow spreaders; StormFilters™ & other proprietary devices; sand filters; etc. Attach 8 1/2 x 11 sketch showing location of facility. Applicant may prepare one copy of pages 1 to 4 for the project and then attach multiple copies of pages 5 & 6 for each separate facility.

Facility Name or Identifier (e.g., Pond A):____

Total Number of Facilities Associated with Project: ______________________________
(For which a Facility Summary Form is being prepared)

Name of Road or Street to Access Facility*:* ______________________________________

Name of Nearest Major Cross Street: ____

Hearings Examiner Case Number: ____

Thurston County Project No./Bldg Permit No.: __________________________________

Parcel Number(s): ____

To be completed by Utility Staff:

Utility Facility Number ________________________

Project Number (num) ________________________

Parcel Number Status, (num, 1ch) ________
(0, Known; 1, Public; 2 Unknown; 3, Unassigned)

Basin and Subbasin: (num, 6ch) _________ __________ __________
(2ch for basin, 2ch for subbasin, 2ch future)

Part 1 - Project Name and Proponent

Project Name: ____

Project Owner: ____

Project Contact: ____

Address: ____

Phone: ____

Project Proponent: (if different) ____

Address: ____

Phone: ____

Project Engineer: ____

Firm: __________________________________ **Phone:** _____________________

Part 2 - Project Location

Section ________________

Township ________________

Range ________________

Names and Addresses of Adjacent Property Owners: (attach add'l sheet if required)

____

____

____

____

Part 3 - Type of Permit Application

Type of permit (e.g., Building, Plat, etc.): _______________________________________

Other Permits (circle)

WDFW HPA	**COE 404**	**COE Wetlands**
DOE Dam Safety	**FEMA Floodplain**	**Shoreline Mgmt**
Rockery/Retaining Wall	**Encroachment**	**Grading**
NPDES Construction Storm	**NPDES Industrial**	**Forest Practices/Clearing**

Other ____________________________________

Other Agencies (Federal, State, Local, etc.) that have had or will review this Drainage and Erosion Control Plan:

Part 4 - Proposed Project Description

What stream/lake/saltwater basin is this project in (e.g., Salmon, Green Cove, Woodland):

____

Project Area, acres (total area of all parcels) _____________

Project Area Disturbed, acres (total of all areas disturbed by project) _____________
(Include all area cleared, graded, etc. as part of this project)

Onsite Impervious Surfaces: *(excluding offsite public / private street frontage).*

Existing Impervious Surface, acres: ___________________

Replaced Impervious Surface, acres: ___________________

Existing Impervious Converted to Landscape, acres: ___________________

New Impervious Surface, acres: ___________________

Total Impervious, acres (existing, new, and replaced): ___________________

Zoning: ____________________________________

Onsite:

Residential Subdivision:

Number of Lots: __________

Lot size (average), acres: __________

Building Permit/Commercial Plat:

Building(s) Footprint, acres: __________

Concrete Paving, acres: __________

Gravel Surface, acres: __________

Lattice Block or Porous Paving, acres: __________

New Public Roads (including gravel shoulder), acres: __________

New Private Roads (including gravel shoulder), acres: __________

Frontage Improvements (including gravel shoulder), acres: _____________

Existing road frontage to center of right-of-way, acres: ________________

<u>Part 5 - Pre-Developed Project Site Characteristics</u>

Stream through site, y/n: __________

Name: ____

DNR Type: _____________________________

Type of feature this facility discharges to (i.e., lake, stream, intermittent stream, pothole, roadside ditch, sheet flow to adjacent private property, etc:
____

Swales, Ravines, y/n: __________

Steep slopes, (steeper than 15%) y/n: __________

Erosion hazard, y/n: __________
(soil types classified "highly erodible" by NRCS soil survey)

100 yr. Floodplain, y/n: __________

Lakes or Wetlands, y/n: __________

Seeps/Springs, y/n: __________

High Groundwater Table, y/n: __________
(depth to seasonal high groundwater table less than 5-feet)

Wellhead Protection or Aquifer Sensitive Area, y/n: __________

Other: ____

Part 6 - Facility Description

Facility Type: ____

Facility Description: ____

____

____

Total Area Tributary to Facility Including Offsite (acres): __________

Total Onsite Area Tributary to Facility (acres): __________

Design Impervious Area Tributary to Facility (acres): __________

Design Landscaped Area Tributary to Facility (acres): __________

Design Native Vegetation Area Tributary to Facility (acres): ____________

Design Total Tributary Area to Facility (acres): __________

Water Quality Design Volume: ________________________

Water Quality Design Flow: __________________________

100 Year return interval, 24-hr Design Flow: _________________________

Part 7 - Release to Groundwater (if applicable)

Design Infiltration Rate ________________ in/hr

Average Annual Infiltration per WWHM _______________________

Designed for 100% Infiltration Y/N: ____________

Designed for Infiltration Treatment Y/N: ___________

Part 8 - Release to Surface Water (if applicable)

Discharge Structure: (check all that apply)

Single orifice _________	**Elev. __________**	**Dia. __________**
Multiple orifice _________	**Elev. 1 __________**	**Dia. __________**
	Elev. 2 __________	**Dia. __________**
	Elev. 3 __________	**Dia. __________**

Weir _________ Elev. ________ Type ________________

Overflow Weir __________ Elev. _______ Dia/Width: ___________

Spillway _________ Elev. _________ Max Elev. _________

Pump(s) ________ Model/Type: ________________ Rating: ________

Other ____

Discharge to surface water:

Return Period	**Pre Developed:**	**Post Developed:**
2 year:	____________	_____________
5 year:	____________	_____________
10 year:	____________	_____________
25 year:	____________	_____________
50 year:	____________	_____________
100 year:	____________	_____________

Pond Information:

Design Max surface water elevation: __________ ft (msl)

Design Maximum pond depth: __________ ft

Pond Volume at Max design water level:____________________ cubic feet

Overflow water elevation: __________ ft (msl)

Sediment storage volume: __________ft (depth below outlet)

Appendix I-E
Maintenance Agreement Forms

After recording return to:

Thurston County
2000 Lakeridge Drive SW
Olympia, WA 98502

Thurston County Project No.______________________

**"COMMERCIAL/INDUSTRIAL"
AGREEMENT TO MAINTAIN
STORMWATER FACILITIES AND TO IMPLEMENT A
POLLUTION SOURCE CONTROL PLAN**

For purposes of this agreement and for indexing by the Auditor as required by R.C.W. Ch. 65.04, the parties of this agreement are _____________________________, **Grantor**, and Thurston County, **Grantee**.

LEGAL DESCRIPTION OF PROPERTY: (Abbreviated legal description if complete legal will not fit here and reference to where complete legal can be found.)

Assessor Parcel No.(s)

(COMMERCIAL/INDUSTRIAL VERSION)

AGREEMENT TO MAINTAIN
STORMWATER FACILITIES AND TO IMPLEMENT A
POLLUTION SOURCE CONTROL PLAN
BY AND BETWEEN THURSTON COUNTY, AND
__________[*INSERT LEGAL NAME OF OWNER*]_______________, AND
ITS HEIRS, SUCCESSORS, OR ASSIGNS
(HEREINAFTER "OWNER")

The upkeep and maintenance of stormwater facilities and the implementation of pollution source control best management practices (BMPs) are essential to the protection of water resources in Thurston County. All property owners are expected to conduct business in a manner that promotes environmental protection. This Agreement contains specific provisions with respect to maintenance of stormwater facilities and use of pollution source control BMPs. The authority to require maintenance and pollution source control is provided by Thurston County Code.

LEGAL DESCRIPTION:

[INSERT LEGAL DESCRIPTION HERE OR REFERENCE ATTACHED EXHIBIT]

RECITALS

WHEREAS, OWNER is the owner of certain real property in Thurston County, Washington, described as set forth in the legal description contained herein and referred to in this agreement as the "Property".

and

WHEREAS, In connection with the OWNER'S proposed development of the Property, Thurston County has required and OWNER has agreed to construct stormwater facilities and to implement a pollution source control plan. The stormwater facilities and pollution source control plan were prepared by ________________________________ for the OWNER'S property and is on file with Thurston County.

and

WHEREAS, OWNER has constructed improvements, including but not limited to, buildings, pavement, and stormwater facilities on the Property, in order to further the goals of Thurston County to ensure the protection and enhancement of Thurston County's water resources, THURSTON COUNTY and OWNER hereby enter into this Agreement. The responsibilities of each party to this Agreement are identified below.

OWNER SHALL:

(1) Implement the stormwater facility maintenance program included herein as Attachment "A".

(2) Implement the pollution source control program included herein as Attachment "B".

(3) Maintain a record (in the form of a log book) of steps taken to implement the programs referenced in (1) and (2) above. The log book shall be available for inspection by THURSTON COUNTY at ____________________________ during normal business hours. The log book shall catalog the action taken, who took it, when it was done, how it was done, and any problems encountered or follow-on actions recommended. Maintenance items ("problems") listed in Attachment "A" shall be inspected as specified in the attached instructions or more frequently if necessary. OWNER is encouraged to photocopy the individual checklists in Attachment "A" and use them to complete its monthly inspections. These completed checklists would then, in combination, comprise the log book.

(4) Submit an annual report to THURSTON COUNTY regarding implementation of the programs referenced in (1) and (2) above. The report must be submitted on or before August 31 of each calendar year and shall contain, at a minimum, the following:

(a) Name, address, and telephone number of the business, the person, or the firm responsible for plan implementation, and the person completing the report.

(b) Time period covered by the report.

(c) A chronological summary of activities conducted to implement the programs referenced in (1) and (2) above. A photocopy of the applicable sections of the log book, with any additional explanation needed, shall normally suffice. For any activities conducted by paid parties not affiliated with OWNER, include a copy of the invoice for services.

(d) An outline of planned activities for the next year.

(5) Prevent any unauthorized modifications to the drainage system and prevent it from being dismantled, revised, altered or removed except as necessary for maintenance, repair or replacement. Any such actions will be covered under item 4 above and shall be approved of by THURSTON COUNTY. Modifications to the stormwater quantity control and stormwater quality system must be approved in advance by THURSTON COUNTY and may require the submittal of revised design drawings, supporting calculations, modifications to maintenance requirements, and applications for permits.

THURSTON COUNTY WILL, AS RESOURCES ALLOW:

(1) Provide technical assistance to OWNER in support of its operation and maintenance activities conducted pursuant to its maintenance and source control programs. Said assistance shall be provided upon request, as County time and resources permit and at no charge to OWNER.

(2) Review the annual report and conduct occasional site visits to discuss performance and problems with OWNER.

(3) Review this agreement with OWNER and modify it as necessary.

REMEDIES:

(1) If THURSTON COUNTY determines that maintenance or repair work is required to be done to the stormwater facility existing on the OWNER'S property, THURSTON COUNTY shall give OWNER, and the person or agent in control of said property if different, notice of the specific maintenance and/or

repair required. THURSTON COUNTY shall set a reasonable time in which such work is to be completed by the persons who were given notice. If the above required maintenance and/or repair is not completed within the time set by THURSTON COUNTY, written notice will be sent to the persons who were given notice stating THURSTON COUNTY'S intention to perform such maintenance and bill the owner for all incurred expenses. THURSTON COUNTY may also adjust stormwater utility charges if required maintenance is not performed.

(2) If at any time THURSTON COUNTY determines that the existing system creates any imminent threat to public health, welfare or water quality THURSTON COUNTY may take immediate measures to remedy said threat. No notice to the persons listed in Remedies (1), above, shall be required under such circumstances. All other responsibilities shall remain in effect.

(3) OWNER grants unrestricted authority to THURSTON COUNTY for access to any and all stormwater system features for the purpose of routine inspections and/or performing maintenance, repair and/or retrofit as may become necessary under Remedies (1) and/or (2).

(4) OWNER shall assume all responsibility for the cost of any maintenance and for repairs to the stormwater facility. Such responsibility shall include reimbursement to THURSTON COUNTY within 30 days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate for liquidated judgments. If legal action ensues, any costs or fees incurred by THURSTON COUNTY will be borne by the parties responsible for said reimbursements.

(5) OWNER hereby grants to the THURSTON COUNTY a lien against the above-described property in an amount equal to the cost incurred by THURSTON COUNTY to perform the maintenance or repair work described herein.

This Agreement is intended to protect the value and desirability of the real property described above and to benefit all the citizens of the County. It shall run with the land and be binding on all parties having or acquiring from OWNER or their successors any right, title, or interest in the property or any part thereof, as well as their title, or interest in the property or any part thereof, as well as their heirs, successors, and assigns. They shall inure to the benefit of each present or future successor in interest of said property or any part thereof, or interest therein, and to the benefit of all citizens of THURSTON COUNTY.

Dated at _______________, Washington, this ______ day of _________________, ______.

OWNER

By: ________________________________

____
Title

STATE OF WASHINGTON)
) ss
COUNTY OF THURSTON)

On this day and year above personally appeared before me, ________________________________ __________________________ known to be the ___________________ of _____________________ ________________________ , the company that executed the forgoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said company, for the uses and purposes therein mentioned, and on oath stated that he is authorized to execute the said instrument.

Given under my hand and official seal this ______ day of _____________, _______.

____
Notary Public in and for the State of
Washington, residing in ________________________
My commission expires _________________________

Dated at _________________, Washington, this __________ day of _________________, _________

APPROVED as to form only:

____
Thurston County Prosecuting Attorney

____
Date

ACCEPTED BY:

____
for THURSTON COUNTY

____
Date

After recording return to:

Thurston County
2000 Lakeridge Drive SW
Olympia, WA 98502

Thurston County Project No.______________________

**RESIDENTIAL SUBDIVISION
AGREEMENT TO MAINTAIN
STORMWATER FACILITIES AND TO IMPLEMENT A
POLLUTION SOURCE CONTROL PLAN**

For purposes of this agreement and for indexing by the Auditor as required by R.C.W. Ch. 65.04, the parties of this agreement are ____________________________, **Grantor**, and Thurston County, **Grantee**.

LEGAL DESCRIPTION OF PROPERTY: (Abbreviated legal description if complete legal will not fit here and reference to where complete legal can be found.)

Assessor Parcel No.(s)

(RESIDENTIAL SUBDIVISION VERSION)

AGREEMENT TO MAINTAIN
STORMWATER FACILITIES AND TO IMPLEMENT A
POLLUTION SOURCE CONTROL PLAN
BY AND BETWEEN THURSTON COUNTY, AND
_____________[*INSERT LEGAL NAME OF OWNER*]________________, AND
ITS HEIRS, SUCCESSORS, OR ASSIGNS
(HEREINAFTER "OWNER")

The upkeep and maintenance of stormwater facilities and the implementation of pollution source control best management practices (BMPs) are essential to the protection of water resources in Thurston County. All property owners are expected to conduct business in a manner that promotes environmental protection. This Agreement contains specific provisions with respect to maintenance of stormwater facilities and use of pollution source control BMPs. The authority to require maintenance and pollution source control is provided by Thurston County Code.

LEGAL DESCRIPTION:

[INSERT LEGAL DESCRIPTION HERE OR REFERENCE ATTACHED EXHIBIT]

RECITALS

WHEREAS, OWNER is the owner of certain real property in Thurston County, Washington, described as set forth in the legal description contained herein and referred to in this agreement as the "Property".

and

WHEREAS, In connection with the OWNER'S proposed development of the Property, Thurston County has required and OWNER has agreed to construct stormwater facilities and to implement a pollution source control plan. The stormwater facilities and pollution source control plan were prepared by ________________________________ for the OWNER'S property and is on file with Thurston County.

and

WHEREAS, OWNER has constructed improvements, including but not limited to, buildings, pavement, and stormwater facilities on the Property, in order to further the goals of Thurston County to ensure the protection and enhancement of Thurston County's water resources, THURSTON COUNTY and OWNER hereby enter into this Agreement. The responsibilities of each party to this Agreement are identified below.

OWNER SHALL:

(1) Implement the stormwater facility maintenance program included herein as Attachment "A".

(2) Implement the pollution source control program included herein as Attachment "B".

(3) Maintain a record (in the form of a log book) of steps taken to implement the programs referenced in (1) and (2) above. The log book shall be available for inspection by THURSTON COUNTY at ____________________________ during normal business hours. The log book shall catalog the action taken, who took it, when it was done, how it was done, and any problems encountered or follow-on actions recommended. Maintenance items ("problems") listed in Attachment "A" shall be inspected as specified in the attached instructions or more frequently if necessary. OWNER is encouraged to photocopy the individual checklists in Attachment "A" and use them to complete its monthly inspections. These completed checklists would then, in combination, comprise the log book.

(4) Submit an annual report to THURSTON COUNTY regarding implementation of the programs referenced in (1) and (2) above. The report must be submitted on or before August 31 of each calendar year and shall contain, at a minimum, the following:

(a) Name, address, and telephone number of the business, the person, or the firm responsible for plan implementation, and the person completing the report.

(b) Time period covered by the report.

(c) A chronological summary of activities conducted to implement the programs referenced in (1) and (2) above. A photocopy of the applicable sections of the log book, with any additional explanation needed, shall normally suffice. For any activities conducted by paid parties not affiliated with OWNER, include a copy of the invoice for services.

(e) An outline of planned activities for the next year.

(5) Prevent any unauthorized modifications to the drainage system and prevent it from being dismantled, revised, altered or removed except as necessary for maintenance, repair or replacement. Any such actions will be covered under item 4 above and shall be approved of by THURSTON COUNTY. Modifications to the stormwater quantity control and stormwater quality system must be approved in advance by THURSTON COUNTY and may require the submittal of revised design drawings, supporting calculations, modifications to maintenance requirements, and applications for permits.

THURSTON COUNTY WILL, AS RESOURCES ALLOW:

(1) Provide technical assistance to OWNER in support of its operation and maintenance activities conducted pursuant to its maintenance and source control programs. Said assistance shall be provided upon request, as County time and resources permit and at no charge to OWNER.

(2) Review the annual report and conduct occasional site visits to discuss performance and problems with OWNER.

(3) Review this agreement with OWNER and modify it as necessary.

REMEDIES:

(1) If THURSTON COUNTY determines that maintenance or repair work is required to be done to the stormwater facility existing on the OWNER'S property, THURSTON COUNTY shall give OWNER,

and the person or agent in control of said property if different, notice of the specific maintenance and/or repair required. THURSTON COUNTY shall set a reasonable time in which such work is to be completed by the persons who were given notice. If the above required maintenance and/or repair is not completed within the time set by THURSTON COUNTY, written notice will be sent to the persons who were given notice stating THURSTON COUNTY'S intention to perform such maintenance and bill the owner for all incurred expenses. THURSTON COUNTY may also adjust stormwater utility charges if required maintenance is not performed.

(2) If at any time THURSTON COUNTY determines that the existing system creates any imminent threat to public health, welfare or water quality THURSTON COUNTY may take immediate measures to remedy said threat. No notice to the persons listed in Remedies (1), above, shall be required under such circumstances. All other responsibilities shall remain in effect.

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(5) OWNER hereby grants to the THURSTON COUNTY a lien against the above-described property in an amount equal to the cost incurred by THURSTON COUNTY to perform the maintenance or repair work described herein.

This Agreement is intended to protect the value and desirability of the real property described above and to benefit all the citizens of the County. It shall run with the land and be binding on all parties having or acquiring from OWNER or their successors any right, title, or interest in the property or any part thereof, as well as their title, or interest in the property or any part thereof, as well as their heirs, successors, and assigns. They shall inure to the benefit of each present or future successor in interest of said property or any part thereof, or interest therein, and to the benefit of all citizens of THURSTON COUNTY.

Dated at _______________, Washington, this ______ day of _________________, ______.

OWNER

By: ________________________________

____
Title

STATE OF WASHINGTON)
) ss
COUNTY OF THURSTON)

On this day and year above personally appeared before me, ______________________________ ______________________ known to be the ________________ of __________________ ____________________ , the company that executed the forgoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said company, for the uses and purposes therein mentioned, and on oath stated that he is authorized to execute the said instrument.

Given under my hand and official seal this _____ day of ___________, ______.

____
Notary Public in and for the State of
Washington, residing in ____________________
My commission expires _____________________

Dated at ______________, Washington, this ________ day of ______________, ________

APPROVED as to form only:

____
Thurston County Prosecuting Attorney

____
Date

ACCEPTED BY:

____
for THURSTON COUNTY

____
Date

After recording return to:

Thurston County
2000 Lakeridge Drive SW
Olympia, WA 98502

Thurston County Project No.____________________

"RESIDENTIAL"
AGREEMENT TO MAINTAIN
STORMWATER FACILITIES AND TO IMPLEMENT A
POLLUTION SOURCE CONTROL PLAN

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LEGAL DESCRIPTION OF PROPERTY: (Abbreviated legal description if complete legal will not fit here and reference to where complete legal can be found.)

Assessor Parcel No.(s)

(RESIDENTIAL VERSION)

AGREEMENT TO MAINTAIN
STORMWATER FACILITIES AND TO IMPLEMENT A
POLLUTION SOURCE CONTROL PLAN
BY AND BETWEEN THURSTON COUNTY, AND
_____________[*INSERT LEGAL NAME OF OWNER*]_______________, AND
ITS HEIRS, SUCCESSORS, OR ASSIGNS
(HEREINAFTER "OWNER")

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LEGAL DESCRIPTION:

[INSERT LEGAL DESCRIPTION HERE OR REFERENCE ATTACHED EXHIBIT]

RECITALS

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(4) Submit an annual report to THURSTON COUNTY regarding implementation of the programs referenced in (1) and (2) above. The report must be submitted on or before August 31 of each calendar year and shall contain, at a minimum, the following:

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(b) Time period covered by the report.

(c) A chronological summary of activities conducted to implement the programs referenced in (1) and (2) above. A photocopy of the applicable sections of the log book, with any additional explanation needed, shall normally suffice. For any activities conducted by paid parties not affiliated with OWNER, include a copy of the invoice for services.

(f) An outline of planned activities for the next year.

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(2) Review the annual report and conduct occasional site visits to discuss performance and problems with OWNER.

(3) Review this agreement with OWNER and modify it as necessary.

REMEDIES:

(1) If THURSTON COUNTY determines that maintenance or repair work is required to be done to the stormwater facility existing on the OWNER'S property, THURSTON COUNTY shall give OWNER, and the person or agent in control of said property if different, notice of the specific maintenance and/or

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Dated at _______________, Washington, this ______ day of _________________, ______.

OWNER

By: _________________________________ By: ___________________________

Address: _____________________________ Address: ___________________________

_____________________________ ___________________________

STATE OF WASHINGTON)
) ss
COUNTY OF THURSTON)

On this day and year above personally appeared before me, ______________________________ __________________________ known to be the individual(s) described, and who executed the foregoing instrument and acknowledge that they signed the same as their free and voluntary act and deed for the uses and purposes therein mentioned.

Given under my hand and official seal this ______ day of _____________, _______.

____
Notary Public in and for the State of
Washington, residing in ________________________
My commission expires _________________________

Dated at _________________, Washington, this __________ day of _________________, _________

APPROVED as to form only:	ACCEPTED BY:
_________________________________	_____________________________________
Thurston County Prosecuting Attorney	for THURSTON COUNTY
______________________	______________________
Date	Date
APPROVED as to form only:	ACCEPTED BY:
_________________________________	_____________________________________
Thurston County Prosecuting Attorney	for THURSTON COUNTY
______________________	______________________
Date	Date

Appendix I-F
Soils Report Forms

SOIL EVALUATION REPORT FORMS

INSTRUCTIONS

A geotechnical report and/or soils report is required for the majority of development projects. Specific requirements are described throughout the Drainage Design and Erosion Control Manual. Specific instances when a geotechnical report and/or soil report is required include:

- All projects for which a Drainage and Erosion Control Plan is required.
- To establish field-saturated percolation rates for stormwater facilities and the overall site.
- For characterizing the infiltration receptor when an infiltration facility is proposed for the project.
- For establishing parameters for the performance of a groundwater mounding analysis, if required.
- To support the design of structures, retaining walls and other site features associated with securing a building permit.
- To support the construction of roads, parking areas, etc. as part of the overall project design process.
- For sites with slopes greater than 15% to determine suitability for locating facilities and/or determining whether a landslide hazard exists and addressing the effects of seepage and potential for slope failure.
- As required for grading work per Thurston County Code Chapter 14.31, *International Building Code Appendix J, Grading*.

When completing a geotechnical/soils report, the forms in this Appendix shall be included in the report as follows:

- Form 1: General Site Information: One copy of this completed form will be included at the front of the report.
- Form 2: Soil Log Evaluation: One copy of Form 2 shall be completed and included for each soil location where testing has been done.

Where inadequate space is provided, reference attached supplemental documents or prepare separate report in format that includes each of the headings of Form 1

PREPARER: PLEASE READ ALL INSTRUCTIONS FIRST.

STAFF USE ONLY

SOIL EVALUATION REPORT
FORM 1: GENERAL SITE INFORMATION

PROJECT TITLE:	SHEET OF
PROJECT NO.:	DATE:
PREPARED BY:	

1. SITE ADDRESS OR LEGAL DESCRIPTION:
2. PROJECT DESCRIPTION:
3. SITE DESCRIPTION:
4. SUMMARY OF SOILS WORK PERFORMED:
5. ADDITIONAL SOILS WORK RECOMMENDED:
6. FINDINGS (Including pre-development site percolation rate):
7. RECOMMENDATIONS:

I hereby certify that I prepared this report and conducted or supervised the performance of related work. I certify that I am qualified to do this work. I represent my work to be complete and accurate within the bounds of uncertainty inherent to the practice of soil science and to be suitable for its intended use.

SIGNED: ________________________________

DATE: __________________

SOIL EVALUATION REPORT INSTRUCTIONS FOR COMPLETING FORM 1

Form 1 is the "cover page" for all projects that require a soil evaluation report. One copy of Form 1 must accompany all soil evaluation reports. Certain information may be omitted for soil evaluations completed for small projects (e.g., single-family residences, duplexes). The following instructions should give you the guidance needed to complete the form:

1. Provide project name and address or legal description. Attach a legible map on 8 ½" by 11" paper showing site and major landmarks (e.g., roadways and surface waters) within approximately one-quarter mile radius around site.

2. Provide acreage, parcel dimensions, type of development proposed, and approximate proposed coverage of impervious surfaces.

3. Describe site topography, geomorphology, terrain, and natural cover. Distinguish among areas of the site with significantly different characteristics.

4. Provide description and purpose of soils work done. List methods used to expose, sample, and test soils. Give number of test holes logged. Describe field and lab tests performed. Attach a scaled map of good accuracy on 8 ½" by 11" paper showing locations of soil logs. Except small projects, using soil log results, divide map area into sub-areas according to hydrologic group (A through D).

5. Describe soils work still needed. For example, more work may be needed to obtain accurate percolation or infiltration rates for stormwater facilities not yet constructed.

6. Describe results of soil logs and tests and compare with expected soils from NRCS Soils maps. **As appropriate for the project, give your best estimate of the (a) overall predeveloped site infiltration rate, (b) the saturated infiltration rate for the above-ground stormwater facility, or (c) the saturated percolation rate for the below ground stormwater trench or drywell.** Discuss soils factors related to erosion control, infiltration, percolation, and placement of buildings, as these vary on the site.

7. Describe the recommended general approach for managing stormwater on the site. For example, if stormwater can be infiltrated or percolated, indicate where and at what depth. If erosion, soil stability, or high ground water are problems, can these problems be avoided or mitigated?

Sign the form and affix relevant professional seal (e.g., P.E. ARCPACS, R.G.). The form becomes the cover page to one or more copies of Form 2, which has soil logs for each test hole evaluated.

PREPARER:	PLEASE READ ALL INSTRUCTIONS FIRST.

STAFF USE ONLY

SOIL EVALUATION REPORT
FORM 2: SOIL LOG INFORMATION

PROJECT TITLE: SHEET OF
PROJECT NO.: DATE:
PREPARED BY:

SOIL LOG:

LOCATION:

1. TYPE OF TEST DONE:	2. NRCS SOIL SERIES:	3. LAND FORM:
4. DEPOSITIOIN HISTORY:	5. HYDROLOGIC SOIL GROUP:	6. DEPTH TO SEASONAL HW:
7. CURRENT WATER DEPTH:	8. DEPTH TO IMPERV LAYER:	9. MISC:

POTENTIAL FOR:	EROSION	RUNOFF	PONDING

11. SOIL STRATA DESCRIPTION:

HORZ	DEPTH	COLOR	TEXTURE	%CL	%ORG	%CF	STR	MOT	IND	CEM	ROD	<X>	FSP

12. SITE PERCOLATION RATE:

13. FINDINGS & RECOMMENDATIONS:

SOIL EVALUATION REPORT INSTRUCTIONS FOR COMPLETING FORM 2

Form 2 is the detailed record of soil information obtained on the development site. One copy of Form 2 must be completed for each soil location where testing has been done. For tests other than soil logs for which the scientist wants to submit numerical results, please attach a separate sheet and briefly describe the results under "Findings and recommendations." The summary information that heads the sheet should be self-explanatory. Regarding location, reference the location to features that are permanent and static, such as roads or property lines.

1. State briefly tests that were done. Indicate whether tests were field, laboratory, or other.

2. Determine the soil series from the maps provided in the NRCS *Soil Survey of Thurston County*. Then, indicate what soil series was mapped as a result of the testing done.

3. Indicate land form (e.g., till plain)

4. Indicate depositional history (e.g., alluvial plain).

5. Indicate NRCS hydrologic soil group (e.g., letter designation A through D).

6. Indicate seasonal high water table depth based upon the presence of mottling, gleying, or other evidence. Indicate how you determined this value under "Findings…" section. If information available is inadequate, state value to be "greater than" bottom of hole depth.

7. Indicate current water table depth based upon observation. If saturated conditions are not observed, state value to be "greater than" bottom of hole depth.

8. Indicate depth to impervious layer (e.g., basal till). If information is inadequate, state value to be "greater than" bottom of hole depth.

9. Space for other miscellaneous observations regarding setting of site (e.g., concave, convex, swale, hillslope).

10. Indicate susceptibility of area to erosion, runoff, and ponding problems. The susceptibility should be rated based upon relevant physical characteristics and development operations planned for the area, such as shape of the area (e.g., concave, convex, flat) removal or addition of fill, time of year, existing and planned vegetative cover, degree of soil compaction, etc. For erosion, the K-factor for the soils series in question might help in assessing erodibility.

11. The profile description provides the minimum information on the physical attributes of the soil. Additional factors may be assessed at the option of the scientist, but data on these factors should be tabulated separately and summarized briefly in the "Findings and recommendations" section.

FORM 2 INSTRUCTIONS (CONTINUED)

All information provided for the profile shall utilize standard NRCS nomenclature and abbreviations. The following are the factors to be addressed, with brief examples of acceptable responses. Further information on most of these is provided in the NRCS *Soil Survey of Thurston County.*

a. Hor(izon): a layer of soil with distinct characteristics, labeled A, AB, B, C, Ccw, etc..
b. Depth: Starting at "0" (surface), depth and interval of horizon.
c. Color: Munsell code for hue, value, and chroma, such as 10 YR 3/4. Indicate whether color is wet or dry.
d. Textur(al class): Class that best describes relative percentages of sand, silt, and clay in horizon, such as sandy loam (SL).
e. %Cl(ay): Clay percentage is very useful as a guide to determining the drainage capability of a soil.
f. %Org(anic) M(atter): Organic matter percentage by volume is related to the infiltration as well as pollutant removal capability of soils.
g. %C(oarse)F(ragments): Coarse fragments percentage is relevant to drainage and other site management factors.
h. Str(ucture): Describes size and shape of soil "clods."
i. Mot(tling): Where present, describe using three-letter abbreviations to indicate abundance, size, and contrast, such as CFS (common, fine, distinct).
j. Ind(uration): Physical compaction of a layer such as a glacial till. Where present, describe as weak, mod(erate), or str(ong).
k. Cem(entation): Aggregation of soil particles due to chemical processes. Describe as in induration.
l. Roo(ts): Where present, describe using two-letter abbreviation to indicate abundance and size, such as CF (common, fine).
m. Generalized range of infiltration rates using NRCS Soil Survey <X>;
n. F(ield) S(aturated) P(ercolation rate): Using all available information, estimate field saturated percolation rate. This rate should be a <u>single number</u>, and may vary from that range (see previous column) published in the NRCS Soil Survey due to horizon-specific factors.

12. Provide overall site (location) field saturated percolation rate. Rate should reflect effects of the entire soil column. If soil test location is proposed for siting of an infiltration facility, use methods of Volume III and apply applicable correction factors to establish long-term, saturated infiltration rate for facility design.

13. Discuss results of tests done on soil. Indicate features of soil that most affect stormwater management <u>at this location.</u> Provide recommendations to the Project Engineer on soil-related factors such as problems and controls, and for additional work needed (if necessary).

Appendix I-G
Standard Stormwater Notes

1. All workmanship and materials shall be in accordance with the Thurston County Drainage Design and Erosion Control Manual, other County standards and the most current copy of the State of Washington Standard Specifications for Road, Bridge and Municipal Construction (WSDOT/APWA) in that order.

2. Temporary erosion/water pollution measures shall be required in accordance with the Standard Specifications and the Drainage Design and Erosion Control Manual.

3. Applicant shall comply with all other permits and other requirements of the governing authority or agency.

4. A preconstruction meeting shall be held prior to the start of construction or staking of the site.

5. All storm mains and retention/detention areas shall be staked for grade and alignment by an engineering or survey firm licensed to perform such work.

6. Storm drain pipe shall be as specified in the Drainage Design and Erosion Control Manual.

7. Special structures, oil/water separators, and outlet controls shall be installed per plans and manufacturer's recommendations.

8. Provide traffic control plan(s) as required in accordance with MUTCD.

9. Call underground locate line 1-800-424-5555 minimum 48 hours prior to any excavations.

10. All surveying and staking shall be performed by an engineering or surveying firm capable of performing such work. The engineer or surveyor directing such work shall be licensed by the State of Washington.

11. The minimum staking of storm sewer systems shall be as follows:

    A. Stake location of all catch basins/manholes and other fixtures for grade and alignment.

    B. Stake location, size, and depth of retention/detention facility.

C. Stake finished grade of all stormwater features, including but not limited to catch basin/manhole rim elevations, overflow structures, weirs, and invert elevations of all pipes in catch basins, manholes, and those pipes that daylight.

12. Pipe materials used for stormwater conveyance shall be as acceptable by Thurston County. Pipe size, slope, cover, etc., shall be as specified in Volume III of the Drainage Design and Erosion Control Manual.

13. All driveway culverts shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled and sections to match the side slope.

14. If drainage outlets (stub-outs) are to be provided for each individual lot, the stub-outs shall conform to the following:

    A. Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an acceptable storm water conveyance system or to an acceptable outfall location.

    B. Outlets on each lot shall be located with a 5-foot-high, 2"x4" stake marked "storm" or "drain." The stub-out shall visibly extend above surface level and be secured to the stake.

    C. Pipe material shall be as acceptable to Thurston County.

    D. Drainage easements are required for drainage systems designed to convey flows through individual lots.

    E. The developer and/or contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to the utilities (e.g., power, gas, telephone, television).

    F. All individual stub-outs shall be privately owned and maintained by the lot home owner.

13. The storm drainage system shall be constructed according to accepted plans on file with the County. Any material deviation

from the plans will require written acceptance from the Drainage Manual Administrator.

14. A copy of the accepted storm water plans must be on the job site whenever construction is in progress.

15. All disturbed areas shall be seeded and mulched or similarly stabilized to the satisfaction of Thurston County. For sites where grass has been planted through hydroseeding, the performance bond will not be released until the grass has been thoroughly established (90% establishment), unless otherwise approved by the County.

16. All building downspouts on commercial sites shall be connected to the storm drainage system, unless otherwise acceptable to the County.

17. All erosion control and stormwater facilities shall be regularly inspected and maintained by the contractor during the construction phase of the development project.

18. The contractor shall be responsible for providing adequate safeguards, safety devices, protective equipment, flaggers, and any other needed actions to protect the life, health, and safety of the public, and to protect property in connection with the performance of work covered by the contract. Any work within the traveled right-of-way that may interrupt normal traffic flow shall require at least one flagger for each lane of traffic affected. All sections of the current WSDOT Standard Specifications for Traffic Control shall apply.

19. It shall be the sole responsibility of the contractor to obtain street use and other related or required permits prior to any construction activity in the County right-of-way. It shall also be the responsibility of the contractor to obtain all required permits prior to any construction.

20. No final cut or fill slope shall exceed two (2) horizontal to one (1) vertical without stabilization by rockery or by a structural retaining wall.

21. The project engineer shall verify the locations, widths, thicknesses, and elevations of all existing pavements and structures, including utilities and other frontage improvements, that are to interface with new work, provide all trimming, cutting, saw cutting, grading, leveling, sloping, coating, and other work, including materials as necessary to cause the interface with existing works to be proper,

without conflict, acceptable to the engineer and Thurston County, complete in place, and ready to use.

22. Compaction of all fill areas shall be per current APWA specifications. Fill shall be provided in 6 inch maximum lifts and shall be compacted to 95 percent of its maximum relative density.

Thurston County Drainage Design and Erosion Control Manual

Volume II
Construction Stormwater Pollution Prevention

Prepared by
Thurston County Water Resources Division,
Department of Resource Stewardship

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Chapter 1 - Introduction to Construction Stormwater Pollution Prevention

1.1 Purpose of this Volume

This volume of the *Drainage Design and Erosion Control Manual* explains how to prevent adverse stormwater impacts from construction activities on downstream resources and onsite stormwater facilities.

Information in this Volume applies to your project if you are required to address Minimum Requirement # 2 (See Volume I). This includes any project with more than 2,000 square feet of impervious surface that disturbs greater than 7,000 sf of land, or converts greater than 3/4 acre from native vegetation to pasture. If your project has greater than 1-acre of land disturbing activity and discharges to surface water, you may also be required to obtain an NPDES Stormwater Permit from the Department of Ecology. Projects not meeting the above thresholds must still prepare an Abbreviated Drainage Plan that shall include appropriate elements from this Volume to minimize downstream impacts of your project.

Construction may take place over multiple seasons or years. Therefore, all management practices and control facilities used during construction shall be designed and sized to ensure protection during the anticipated construction period, including the appropriate selection of design storms.

IMPORTANT: Linear construction projects such as roadway construction and utility installations are special cases, and present their own unique set of stormwater protection challenges. If you are completing a linear project, use the current edition of the WSDOT *Highway Runoff Manual* instead of this manual unless otherwise indicated.

1.2 How This Volume is Organized

Volume II is organized into three chapters that address key considerations and mechanics of construction stormwater BMPs:

- **Chapter 1** describes the 12 elements that must be considered when preparing a Stormwater Pollution Prevention Plan. It also includes additional regulatory requirements that may apply to construction sites and their stormwater discharges. This includes the Department of Ecology's (Ecology) National Pollutant Discharge Elimination System (NPDES) discharge permit and Washington's Water Quality Standards pertaining to construction stormwater and how they apply to field situations.

- **Chapter 2** explains additional requirements for construction erosion control, including seasonal limitations and required components of the SWPPP.

- **Chapter 3** describes best management practices (BMPs) for construction stormwater control and site management, including source control for construction-related activities, runoff, conveyance, and treatment. You can use various combinations of these BMPs in the Construction SWPPP to satisfy each of the 12 elements described in Section 1.3. Design and facility sizing information is included within the applicable BMP sections.

1.3 12 Elements of Construction Stormwater Pollution Prevention

The project proponent or designated project engineer shall develop a Stormwater Pollution Prevention Plan (SWPPP). The goal of an SWPPP is to avoid immediate and long-term environmental loss and degradation caused by poorly managed construction sites. Additional information on erosion and sedimentation processes and factors influencing erosion potential may be found in the latest edition of the *Stormwater Management Manual for Western Washington*.

The following 12 elements address water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources. Each element must be considered when developing the Construction SWPPP, unless site conditions make it unnecessary. If an element is unnecessary, the Construction SWPPP must justify the omission.

The 12 elements of a Construction SWPPP are:

1. Mark clearing limits
2. Establish construction access
3. Control flow rates
4. Install sediment controls
5. Stabilize soils
6. Protect slopes
7. Protect drain inlets
8. Stabilize channels and outlets
9. Control pollutants
10. Control dewatering
11. Maintain BMPs
12. Manage the project

Chapter 2 describes each element and its associated BMPs.

The Ecology has determined that a local manual can be used where local requirements for construction sites are at least as stringent as Ecology's. However, for sites also subject to Ecology's NPDES Construction General Permit requirements, applicants are responsible for ensuring that no additional requirements apply to comply with Ecology's regulations.

1.4 Water Quality Standards

Stormwater discharges from construction activity are subject to applicable state water quality standards. These discharges must not cause or contribute to violations of Washington State's surface water quality standards (Chapter 173-201A WAC), sediment management standards (Chapter 173-204 WAC), ground water quality standards (Chapter 173-200 WAC), and human health based criteria in the National Toxics Rule (Federal Register, Vol. 57, No. 246, Dec. 22, 1992, pages 60848-60923).

A Site Development Permit does not authorize violation of these standards. Thurston County expects that the selection and implementation of appropriate BMPs outlined in this volume will result in compliance with water quality standards. Proper implementation and maintenance of BMPs is critical to adequately control adverse water quality impacts from construction activity. If observations reveal that installed BMPs do not adequately maintain flow and water quality standards, additional BMPs must be installed.

1.5 Other Applicable Regulations and Permits

In addition to Thurston County regulations, other regulations and permits may require the implementation of BMPs to control pollutants in construction site stormwater runoff. These include but are not limited to the following (principal permitting agency in parentheses):

- Construction General Permit under NPDES (Ecology)
- Total Maximum Daily Load (TMDLs) or Water Clean Up Plans (Ecology)
- Endangered Species Act – ESA (NOAA Fisheries or U.S. Fish & Wildlife)
- Hydraulic Project Approval Permits (WA Dept. of Fish & Wildlife)
- General provisions from the WSDOT (WA Dept. of Transportation)
- Contaminated site remediation agreements.

See Volume I, section 1.3 for more information about these regulations and permits.

1.5.1 Enforcement Guidelines

The purpose of compliance monitoring is to ensure protection of water resources and stormwater infrastructure, not punish violators. Therefore, the initial and primary enforcement tool shall be a correction notice, compliance order, or similar action. If the situation is not corrected, all construction work will be halted (with a stop work order if necessary) until appropriate erosion prevention and sediment control BMPs are in place, and runoff meets applicable discharge and water quality standards.

If a timely and adequate response does not occur, or in cases of severe repeated violations, the County shall, at their discretion, issue infraction notices or citations carrying monetary penalties.

The following discharge standard applies:

- Runoff leaving the construction site shall be free of settleable solids, as measured with an Imhoff Cone, turbidity meter or transparency tube and in accordance with Standard Methods for the Examination of Water and Wastewater, most recent addition, American Water Works Association. "Free of settleable solids" shall be defined as measuring less than 2.5 mg/L/hr, for storms up to the water quality design event. Generally, if turbidity is visible in runoff, it does not meet this standard.

The following surface water standard applies:

- For storms up to the water quality design event, turbidity downstream of a construction site may not increase more than 5 NTU, if upstream turbidity is 50 NTU less, and may not increase more than 10 percent, if upstream turbidity is over 50 NTU. To the extent practicable, samples shall be taken far enough downstream so that the construction site discharge has been well-mixed with surface water.

Whenever inspection or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.

Chapter 2 - Developing and Implementing a Construction Stormwater Pollution Prevention Plan

This chapter describes the important components and process necessary for developing and implementing a Construction Stormwater Pollution Prevention Plan (SWPPP).

Section 2.1 provides general guidelines for plan format and content, and ideas for creating an effective plan.

Section 2.2 lists the components to be submitted with the SWPPP.

Section 2.3 describes a step-by-step procedure for developing a Construction SWPPP, from data collection to finished product, to meet the 12 required elements.

Section 2.4 lists drawing protocols for the SWPPP.

See Chapter 3 for design standards and specifications for BMPs referred to in this chapter.

2.1 General Guidelines

2.1.1 What is a Construction Stormwater Pollution Prevention Plan?

A Construction SWPPP consists of a Temporary Erosion and Sediment Control (TESC) Plan and a narrative that addresses the 12 required elements described in section 1.3 above. The TESC is a set of plan sheets showing BMP locations and other features such as topography and sensitive areas, and includes construction details for BMPs, construction notes and specifications.

The narrative supplements the TESC and includes a description of the project, a description of how each of the 12 elements is addressed, and design calculations for specific BMPs including calculation of runoff volumes and flows for the design storm. See Section 2.2 for detailed submittal requirements for the TESC and narrative.

A Construction SWPPP is required for projects that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet (see Volume I, Chapter 3, for threshold limits for various plan submittals). For projects not meeting the above threshold, and those that qualify for the Abbreviated Drainage Plan, a Short Form Construction SWPPP may be acceptable for erosion and sediment control purposes (see Appendix II-C).

A copy of the TESC drawings must always be kept on the construction site and the Construction SWPPP must be located either on the construction site or within reasonable access of construction and inspection personnel. As site work progresses, the plan must be modified to reflect changing site conditions.

The owner or lessee of the land being developed is responsible for preparing and submitting the Construction SWPPP to the County. The owner or lessee may designate someone (i.e., an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but remains responsible for preparing and submitting the plan.

2.1.2 What is an "Adequate" Plan?

When required, the Construction SWPPP must contain sufficient information to satisfy the County that sediment, erosion and pollution problems have been adequately addressed for the proposed project.

On construction sites that discharge to surface water, the primary concern in the preparation of the Construction SWPPP is compliance with Washington State Water Quality Standards. Each of the 12 elements (Section 2.3.2) must be included in the Construction SWPPP, unless an element is determined to not be applicable to the project and the exemption is justified in the narrative.

On construction sites that infiltrate all stormwater runoff, the primary concern in the preparation of the Construction SWPPP is the protection of the infiltration facilities from fine sediments during the construction phase and protection of ground water from other pollutants.

2.1.3 BMP Standards and Specifications

Chapter 3 contains standards and specifications for the BMPs referred to in this chapter. Wherever any BMPs are used on a site, reference the specific title and number of the BMP in the narrative and mark it on construction drawings.

The standards and specifications in Chapter 3 of this volume are not intended to limit any innovative or creative effort to effectively control erosion and sedimentation. If the BMPs in this chapter are not adequate to meet regulatory requirements, experimental management practices can be considered. Minor modifications to standard practices may also be employed. However, such practices must be pre-approved by the County before being used. All experimental management practices and modified standard practices are required to meet or exceed the performance of the BMPs listed in Chapter 3.

2.1.4 General Principles

The Construction SWPPP shall first consider the use of onsite practices to provide erosion and sediment control. Onsite practices include design and construction practices that focus on preserving vegetation and native soils, minimizing impervious surfaces, and selecting construction materials and BMPs that mimic the natural hydrology of a site as much as possible.

NOTE: Projects incorporating onsite measures are not exempt from flow control and runoff treatment requirements and must be in compliance with applicable standards in this manual. For guidance on modeling hydrologic performance of onsite BMPs, see Volume III.

Minimize Clearing and Grading

Keep grading to a minimum by incorporating natural topographic depressions into the project and limiting the amount of cut and fill on those portions of the site with permeable soils. At a minimum, the following standards shall be used:

- Preserve native soils and vegetation by retaining the duff layer, native topsoil, and natural vegetation in an undisturbed state to the maximum extent possible
- Limit clearing to road, utility, building pad, lawn areas, and the minimum amount of extra land necessary to maneuver machinery (e.g., a 10-foot perimeter around a building). All other land outside these areas shall be protected with construction fencing to prevent intrusion and compaction by construction equipment or other types of vehicles.
- Keep distances for overland flow short to promote sheet flow and minimize concentration of runoff.
- Grading shall not increase angle or length of steep, continuous slopes.
- Minimize the amount and time that graded areas are left exposed by completing construction and erosion control in one section of the site before beginning operation on the next.
- Limit secondary excavations and heavy equipment use by shaping final lot grades and topographic features at the site development stage.
- Reuse native topsoil elsewhere on the site to amend areas with sparse or nutrient-deficient topsoil.

- Do *not* relocate topsoil or other material to critical areas where they can cover critical root zones, suffocate vegetation, or erode into adjacent streams.
- Stockpile materials in areas designated for clearing and grading (such as parking areas and future roadways).
- To prevent erosion, cover small stockpiles with weed barrier material that sheds moisture but allows air transmission. Large stockpiles may need to be seeded and/or mulched.

Incorporate Erosion Control Techniques

Onsite best management practices to control erosion and sediment include the following:

- Use effective revegetation methods to reduce erosion, including:
  - Establish vegetation quickly, particularly during seasons that have the most rainfall.
  - Use native plant species adapted to the local environment.
  - Plant during seasons that provide the best opportunity for survival of vegetation (usually late fall, winter, or early spring months).
  - Control excess surface water runoff to prevent erosion.
  - Use proper seedbed preparation.
  - Fertilize as needed and mulch to protect germinating plants.
  - Protect areas designated for revegetation from soils compaction by restricting heavy equipment.
  - Provide proper soil amendments where necessary (see Section 3.1.8).
- Protect native topsoil during the construction phase. Native topsoil has a high organic content and native seed sources, which are excellent for reestablishing permanent vegetation.
- Limit clearing and grading during heavy rainfall seasons. Construction activities should begin during the season of lowest precipitation and end when conditions are favorable for the establishment of vegetation.

- Incorporate natural drainage features whenever possible, using adequate buffers and protecting areas where flow enters the drainage system.
- Direct runoff to areas of permeable soils or natural depressions to promote infiltration.
- Reduce runoff velocities to prevent channel erosion.
- Prevent offsite tracking of sediment.
- Reduce the number and width of construction access roads. Locate access roads where future roads and utility corridors will be placed.
- Perform preconstruction, routine, and post-construction inspections:
    - Conduct a preconstruction inspection to determine that adequate barriers have been placed around vegetation retention areas and structural controls are properly implemented.
    - Conduct routine inspections to verify that structural controls are being maintained and operating effectively throughout construction.
    - Conduct a final inspection to verify that revegetation areas are stabilized and that stormwater management systems are in place and functioning properly.

Select Appropriate BMPs

In addition to the general erosion and sediment control BMPs for construction, onsite stormwater management principles to use in preparing your Construction SWPPP include:

- Prevent pollutant release. Select source control BMPs as a first line of defense. Prevent erosion rather than treat turbid runoff.
- Select BMPs depending on site characteristics (topography, drainage, soil type, ground cover, and critical areas) and the construction plan.
- Divert runoff away from exposed areas wherever possible. Keep clean water clean.
- Select appropriate BMPs for the control of non-sediment pollutants.

- Be realistic about the limitations of controls that you specify and the operation and maintenance of those controls. Anticipate what can go wrong, how to prevent it, and how to fix it.
- Monitor all construction BMPs for effectiveness and have a plan to address any failures, including lack of vegetative establishment.

Besides the general principles, onsite BMPs included in Volume V that apply to construction include:

- BMP C101: Preserving Natural Vegetation (this Volume). Identify and mark existing vegetation to preserve before grading or excavation takes place on the site.
- BMP C252: Preservation of Upper Soil Structure (Native Topsoil).

2.2 Construction SWPPP Submittal Components

The Construction SWPPP is intended to be a stand alone document that supplements other project documentation. The Construction SWPPP shall contain the components listed below. Some of these components may be derived from the Drainage and Erosion Control Report, Drainage Plans (drawings), Engineered Abbreviated Drainage Plan, or Abbreviated Drainage Plan prepared for the project.

- Cover sheet
- Project engineer's certification (where required)
- Table of contents
- Construction SWPPP Narrative
- Construction SWPPP TESC Drawings including:
    - Coversheet and project information
    - TESC Plan
    - TESC Details
    - TESC Notes and Specifications
- Inspection forms and inspection record.

Note that a Short Form Construction SWPPP can be submitted for projects that require only an Abbreviated Drainage Plan. See Appendix II-C for a template.

2.3 Step-By-Step Procedure

There are three basic steps in producing a Construction SWPPP:

- **Step 1**: Document existing site conditions
- **Step 2**: Select and design BMPs
- **Step 3**: Development and Implementation of Construction SWPPP.

Step 1 is intended for projects that meet or exceed the Construction SWPPP threshold limits of Minimum Requirement #2 (see Volume I, Chapter 2). For some single-family home construction projects, an Abbreviated Drainage Plan may be acceptable for erosion and sediment control purposes (see also Volume I, Chapter 3).

2.3.1 Step 1 – Document Existing Site Conditions

Evaluate existing site conditions and gather information that will help develop the most effective Construction SWPPP. The applicant shall show the information gathered on the TESC drawings and detail it in the narrative. Give special consideration to those areas that have critical erosion hazards or erosion potential when evaluating existing site conditions.

Existing Site Components

- **Project Location**: Determine precise location of the construction site, adjacent roads and receiving waters:
  - Indicate locations on a **Vicinity Map** for inclusion in the narrative and on TESC drawings.
  - Describe project including locations in **Project Description.**
- **Property Boundaries and Zoning**: Determine the legal property boundaries and zoning requirements for the site.
  - Indicate Legal Property Boundaries and Zoning on the TESC drawings**.**
  - Discuss zoning requirements in **Existing Site Conditions** section of the narrative.
- **Topography**: Prepare a topographic drawing of the site to show existing contour elevations at intervals of 1 to 5 feet depending upon the slope of the terrain (see Section 2.5 for drawing protocols). Evaluate topography for erosion potential. The primary topographic considerations are slope steepness and slope length. Because of the effect of runoff, the longer and steeper the

slope, the greater the erosion potential. Erosion potential should be determined by a qualified engineer, soil professional, or certified erosion control specialist.

- Show existing topography on the TESC drawings**.**
- Discuss topographic considerations in the **Existing Site Conditions** section of the narrative.

- **Ground Cover:** Label existing vegetation on the TESC drawing. Show features such as tree clusters, grassy areas, and unique or sensitive vegetation. Unique vegetation may include existing trees above a given diameter. Investigate requirements for tree preservation. (At a minimum, the applicant shall comply with provisions for native vegetation preservation and/or replacement as set forth in applicable Thurston County Code including critical areas, zoning, grading and forest practices.) Also indicate existing denuded or exposed soil areas.

  Ground cover is the most important factor in erosion prevention. Existing vegetation that can be saved will usually prevent erosion better than constructed BMPs. Trees and other vegetation protect the soil structure. If the existing vegetation cannot be saved, consider practices like phasing construction, temporary seeding, and mulching. Phasing of construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

  - Show existing vegetation on TESC drawings.
  - Discuss vegetation in the **Existing Site Conditions** section of the narrative**.**

- **Drainage**: Locate and clearly mark existing drainage swales and patterns on the TESC drawings, including existing storm drain pipe systems. The drawings should distinguish between natural and manmade drainage. Use natural drainage paths (e.g., overland flow, swales and depressions) to convey runoff through the site to avoid constructing an artificial drainage system. Man-made ditches and waterways will become part of the erosion problem if not properly stabilized. Ensure that increased runoff from the site will not erode or flood the existing natural drainage system. Consider possible sites for temporary stormwater retention and detention. Direct construction away from areas of saturated soil - areas where ground water may be encountered - and critical areas where drainage will concentrate. Preserve natural drainage patterns on the site.

  - Show existing Drainage on TESC drawings**.**

- Discuss Drainage in **Existing Site Conditions** section of the narrative.

- **Soils**: Identify and label soil type(s) and erodibility (slight, moderate, severe, very severe or an index value from the NRCS manual) on the drawing. Soils information can be obtained from a county soil survey (if one exists). If a soil survey is not available, a request can be made to a district Natural Resource Conservation Service Office.

  Soils must be characterized for permeability, water holding capacity, percent organic matter, and effective depth by a qualified soil professional or engineer. Express these qualities in averaged or nominal terms for the subject site or project. This information is typically available in the published SCS Soil Survey of Thurston County.

  - A sieve analysis of the soils
  - Permeability (in/hr)
  - Available water-holding capacity (in/in)
  - The percent of organic matter.

  Evaluate soil properties such as surface and subsurface runoff characteristics, depth to impermeable layer, depth to seasonal ground water table, permeability, shrink-swell potential, texture, settleability, and erodibility. Develop the Construction SWPPP based on known soil characteristics. Properly protect infiltration sites from clay and silt disturbed during construction activities, which reduce infiltration capacities.

  - Show soils information on TESC Plan Sheet and include soil descriptions on the TESC Notes sheet**.**
  - Discuss in **Soils** in the narrative.

- **Critical Areas**: Delineate critical areas adjacent to or within the site on the drawing. Show features such as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas. Delineate set backs and buffer limits for these features on the TESC drawings. Other related jurisdictional boundaries, such as Shorelines Management and the Federal Emergency Management Agency (FEMA) base floodplain shall also be shown on the TESC drawings. Critical areas per TCC 17.15, may include aquifer recharge areas, geologic hazard areas, floodplains, streams, and wetlands.

  Critical areas within or adjacent to a development that does not meet the Thresholds of Volume I are required to submit an

Abbreviated Engineered Drainage Plan. The existence of critical areas near the project exerts a strong influence on land development decisions. Critical areas and their buffers shall be delineated on drawings and clearly flagged in the field. Fencing may be more useful than flagging to assure that equipment operators stay out of critical areas. Only unavoidable work should take place within critical areas or their buffers, and will require special BMPs, permit restrictions, and mitigation plans.

- Show critical areas on the TESC Plan**.**
- Discuss critical area in the **Critical Areas** section of the narrative**.**

- **Adjacent Areas**: Identify existing buildings, roads, and facilities adjacent to or within the project site on the TESC drawings. Identify existing and proposed utility locations, construction clearing limits and erosion and sediment control BMPs on the drawings. An analysis of adjacent properties should focus on areas upslope and downslope from the construction project. Water bodies that will receive direct runoff from the site are a major concern. Evaluate the types, values, sensitivities of and risks to downstream resources, such as private property, stormwater facilities, public infrastructure, or aquatic systems. Select erosion and sediment controls accordingly.

  - Show adjacent areas on the TESC Plan**.**
  - Discuss adjacent areas in the **Adjacent Areas** section of the narrative.

- **Precipitation Records and Stormwater Design Flows**: see Volume III to determine the required rainfall records and the method of analysis for design of BMPs.

  - Include stormwater design flows for sediment control BMPs on the TESC Plan. Show basins for which the design flows are applicable.

  - Discuss rainfall data and stormwater design flows and volumes in the Narrative.

- **Timing of the Project**: An important consideration in selecting BMPs is the timing and duration of the project. Projects that will proceed during the wet season and projects that will last through several seasons must take all necessary precautions to remain in compliance with the water quality standards.

- Describe design considerations based on timing in the **Narrative**.
- Prepare a construction schedule and include in the TESC drawings and the narrative.
- Include 12 elements in timeline as applicable.

2.3.2 Step 2 – Select and Design BMPs

After collecting and analyzing the data to determine the site limitations, BMPs can be selected and designed. **Each of the 12 elements below must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary.** Justification for exempting an element must be clearly explained in the narrative of the SWPPP.

Onsite stormwater management general principles and BMPs should be given primary consideration when designing a SWPPP. Onsite elements were already discussed under Section 2.1.4 – General Principles. In certain cases, the County may require written justification on why onsite techniques are not deemed practicable.

Element #1: Preserve Vegetation/Mark Clearing Limits

- Prior to beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area. These shall be clearly marked, both in the field and on the plans, to prevent damage and offsite impacts.

- Clearly visible plastic, metal, or stake wire fence may be used to mark the clearing limits.

- The duff layer, native top soil, and natural vegetation shall be retained in an undisturbed state to the maximum degree practicable. If it is not practicable to retain the duff layer in place, stockpile it onsite cover it to prevent erosion, and replace it immediately upon completion of the ground disturbing activities.

- Suggested BMPs:

  - BMP C101: Preserving Natural Vegetation (Onsite)
  - BMP C252: Preservation of Native Topsoil (Onsite)
  - BMP C102: Buffer Zones
  - BMP C103: High Visibility Plastic Fence.

Element #2: Establish Construction Access

- Construction vehicle access and exit shall be limited to one route, if possible, or two for linear projects such as roadways where more than one access is necessary for large equipment maneuvering.

- Access points shall be stabilized with a pad of quarry spalls or crushed rock, or equivalent BMP prior to traffic leaving the construction site to minimize the tracking of sediment onto public roads.

- Wheel wash or tire baths should be located on site, if the stabilized construction entrance is not effective in preventing sediment from being tracked on public roads.

- If sediment is tracked off site, public roads shall be cleaned thoroughly at the end of each day, or more frequently during wet weather, if necessary to prevent sediment from entering waters of the state. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area. Street washing will be allowed only after sediment is removed in this manner.

- Street wash wastewater shall be controlled by pumping back on site to an approved infiltration facility, or otherwise must be prevented from discharging into systems tributary to state surface waters. Other options include discharge to the sanitary sewer, or discharge to an approved offsite treatment system. For discharges to the sanitary sewer, permits must be obtained from the local jurisdiction providing the sewer.

- Suggested BMPs:
  - BMP C105: Stabilized Construction Entrance
  - BMP C106: Wheel Wash
  - BMP C107: Construction Road/Parking Area Stabilization.

Element #3: Control Flow Rates

- Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site.

- Downstream analysis is necessary if changes in offsite flows could impair or alter conveyance systems, streambanks, bed sediment, or aquatic habitat. See Volume I, Chapter 3, for potential offsite analysis requirements and guidelines.

- Where necessary to comply with Minimum Requirement #7, stormwater retention/detention facilities shall be constructed as one of the first steps in grading. Detention facilities shall be functional prior to construction of site improvements (e.g., impervious surfaces).

- The County may require pond designs that provide additional or different stormwater flow control if necessary to address local conditions or to protect properties and waterways downstream from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site.

- If permanent infiltration ponds are used for flow control during construction, protect them from siltation during the construction phase.

- Suggested BMPs:
    - BMP C240: Sediment Trap
    - BMP C241: Temporary Sediment Pond
    - Refer to Volume III for site suitability and sizing for infiltration facilities

Element #4: Install Sediment Controls

- Prior to leaving a construction site or prior to discharge to an infiltration facility, stormwater runoff from disturbed areas shall pass through a sediment pond or other appropriate sediment removal BMP. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard of Element #3, the first bullet. Full stabilization means concrete or asphalt paving; quarry spalls used as ditch lining; or the use of rolled erosion products, a bonded fiber matrix product, or vegetative cover in a manner that will fully prevent soil erosion. The County shall inspect and approve areas fully stabilized by means other than pavement or quarry spalls.

- Sediment ponds, vegetated buffer strips, sediment barriers or filters, dikes, and other BMPs intended to trap sediment on site shall be constructed as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.

- Earthen structures such as dams, dikes, and diversions shall be seeded and mulched according to the timing indicated in Element #5.

- BMPs intended to trap sediment on site must be located in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages, often during non-storm events, in response to rain event changes in stream elevation or wetted area.

- Suggested BMPs:

  - BMP C233: Silt Fence
  - BMP C234: Vegetated Strip
  - BMP C235: Straw Wattles
  - BMP C240: Sediment Trap
  - BMP C241: Temporary Sediment Pond
  - BMP C250: Construction Stormwater Chemical Treatment
  - BMP C251: Construction Stormwater Filtration.

Element #5: Stabilize Soils

- All exposed and unworked soils shall be stabilized by application of effective BMPs that protect the soil from the erosive forces of raindrop impact, flowing water, and wind.

- From October 1 through April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days. This condition applies to all soils on site, whether at final grade or not. These time limits may be adjusted by the County if it can be shown that the average time between storm events justifies a different standard.

- Soils shall be stabilized at the end of the shift before a holiday or weekend if the weather forecast calls for precipitation.

- Applicable practices include, but are not limited to, temporary and permanent seeding, sodding, mulching, plastic covering, erosion control fabrics and matting, soil application of polyacrylamide (PAM), the early application of gravel base on areas to be paved, and dust control.

- Soil stabilization measures should be appropriate for the time of year, site conditions, estimated duration of use, and potential water quality impacts that stabilization agents may have on downstream waters or ground water.

- Soil stockpiles must be stabilized from erosion, protected with sediment trapping measures, and when possible, be located away from storm drain inlets, waterways and drainage channels.

- Linear construction activities, including right-of-way and easement clearing, roadway development, pipelines, and trenching for utilities, shall be conducted to meet the soil stabilization requirement. Contractors shall install the bedding materials, roadbeds, structures, pipelines, or utilities and re-stabilize the disturbed soils so that:
  - From October 1 through April 30 no soils shall remain exposed and unworked for more than 2 days, and
  - From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days.
- Suggested BMPs:
  - BMP C120: Temporary and Permanent Seeding
  - BMP C121: Mulching
  - BMP C122: Nets and Blankets
  - BMP C123: Plastic Covering
  - BMP C124: Sodding
  - BMP C125: Topsoiling
  - BMP C126: Polyacrylamide for Soil Erosion Protection
  - BMP C130: Surface Roughening
  - BMP C131: Gradient Terraces
  - BMP C140: Dust Control
  - BMP C180: Small Project Construction Stormwater Pollution Prevention.

Element #6: Protect Slopes

- Design and construct cut and fill slopes in a manner that will minimize erosion.
- Consider soil type and its potential for erosion.
- Reduce slope runoff velocities by reducing the length of continuous slope with terracing and diversions, reducing slope steepness, and roughening slope surface.
- Offsite stormwater (run-on) shall be diverted away from slopes and disturbed areas with interceptor dikes and/or swales. Offsite stormwater must be managed separately from stormwater generated on the site.
- At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion.

- Temporary pipe slope drains shall handle the peak flow from a 10-year, 24-hour event assuming a Type 1A rainfall distribution. Alternatively, the 10-year and 25-year, 1 hour flow rates indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. If a 15-minute (or less) time step is used, no correction factor is required. The hydrologic analysis shall use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis shall use the temporary or permanent project land cover condition, whichever will produce the highest flow rates.

- Permanent pipe slope drains shall be sized for the 100-year, 24-hour event.

- Provide drainage to remove ground water intersecting the slope surface of exposed soil areas.

- Excavated material shall be placed on the uphill side of trenches, consistent with safety and space considerations.

- Check dams shall be placed at regular intervals within channels that are cut down a slope.

- Stabilize soils on slopes, as specified in Element #5.

- Suggested BMPs:

  - BMP C120: Temporary and Permanent Seeding
  - BMP C130: Surface Roughening
  - BMP C131: Gradient Terraces
  - BMP C200: Interceptor Dike and Swale
  - BMP C201: Grass-Lined Channels
  - BMP C204: Pipe Slope Drains
  - BMP C205: Subsurface Drains
  - BMP C206: Level Spreader
  - BMP C207: Check Dams
  - BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam).

Element #7: Protect Drain Inlets

- All storm drain inlets made operable during construction shall be protected so that stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment.

- All approach roads shall be kept clean. Sediment and street wash water shall not be allowed to enter storm drains without prior and adequate treatment unless treatment is provided before the storm drain discharges to waters of the state.

- Inspect inlets weekly at a minimum and daily during storm events. Clean inlet protection devices, or remove and replace when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

- Suggested BMPs:
  - BMP C220: Storm Drain Inlet Protection.

Element #8: Stabilize Channels and Outlets

- All temporary onsite conveyance channels shall be designed, constructed and stabilized to prevent erosion from the expected peak 10 minute velocity of flow from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour time step flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. If a 15-minute (or less) time step is used, no correction factor is required. The hydrologic analysis shall use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis shall use the temporary or permanent project land cover condition, whichever will produce the highest flow rates.

- Stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes, and downstream reaches shall be provided at the outlets of all conveyance systems.

- Suggested BMPs:
  - BMP C202: Channel Lining
  - BMP C209: Outlet Protection.

Element #9: Control Pollutants

- All pollutants, including waste materials and demolition debris, that occur onsite shall be handled and disposed of in a manner that does not cause contamination of stormwater. Woody debris may be chipped, ground or chopped and spread on site.

- Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and other materials that have the potential to pose a threat to human health or the environment. Onsite fueling tanks shall include secondary containment.

- Maintenance and repair of heavy equipment and vehicles involving oil changes, hydraulic system drain down, solvent and de-greasing cleaning operations, fuel tank drain down and removal, and other activities which may result in discharge or spillage of pollutants to the ground or into stormwater runoff must be conducted using spill prevention measures, such as drip pans. Contaminated surfaces shall be cleaned immediately following any discharge or spill incident. Emergency repairs may be performed onsite using temporary plastic placed beneath and, if raining, over the vehicle.

- Wheel wash or tire bath wastewater shall be discharged to a separate onsite treatment system or to the sanitary sewer.

- Application of agricultural chemicals, including fertilizers and pesticides, shall be conducted in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Manufacturers' recommendations for application rates and procedures shall be followed.

- BMPs shall be used to prevent or treat contamination of stormwater runoff by pH modifying sources. These acidic or basic sources include, but are not limited to, bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, and concrete pumping and mixer washout waters. Stormwater discharges shall not cause or contribute to a violation of the water quality standard for pH in the receiving water.

- Construction sites shall adjust the pH of stormwater if necessary to prevent violations of water quality standards. Projects must obtain written approval from the Department of Ecology prior to using chemical treatment other than CO_2 or dry ice to adjust pH.

- Suggested BMPs:

  - BMP C151: Concrete Handling
  - BMP C152: Sawcutting and Surfacing Pollution Prevention
  - See Volume IV – Source Control BMPs.

Element #10: Control De-Watering

- Foundation, vault, and trench de-watering water, which have similar characteristics to stormwater runoff at the site, shall be discharged into a controlled conveyance system prior to discharge to a sediment trap or sediment pond. Channels must be stabilized, as specified in Element #8.

- Clean, non-turbid de-watering water, such as well-point ground water, can be discharged to systems tributary to state surface waters, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of receiving waters. These clean waters should not be routed through stormwater sediment ponds.

- Highly turbid or contaminated dewatering water from construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam, shall be handled separately from stormwater.

- Other disposal options, depending on site constraints, may include:

  - Infiltration

  - Transport offsite in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters

  - Ecology-approved onsite chemical treatment or other suitable treatment technologies

  - Sanitary sewer discharge with local sewer district approval, if there is no other option

  - Use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

Element #11: Maintain BMPs

- All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function. Maintenance and repair shall be conducted in accordance with BMP specifications.

- All temporary erosion and sediment control BMPs shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil resulting from removal of BMPs or vegetation shall be permanently stabilized.

Element #12: Manage the Project

- Phasing of Construction:

  Development projects shall be phased where feasible in order to prevent soil erosion and, to the maximum extent practicable, the transport of sediment from the site during construction. Revegetation of exposed areas and maintenance of that vegetation shall be an integral part of the clearing activities for any phase.

  Clearing and grading activities for developments shall be permitted only if conducted pursuant to an approved site development plan (e.g., subdivision approval) that establishes permitted areas of clearing, grading, cutting, and filling. When establishing these permitted clearing and grading areas, consider minimizing removal of existing trees and minimizing disturbance/compaction of native soils except as needed for building purposes. These permitted clearing and grading areas and any other areas required to preserve critical or sensitive areas, buffers, native growth protection easements, or tree retention areas as may be required by the County, shall be delineated on the site plans and the development site.

- Seasonal Work Limitations:

  From October 1 through April 30, clearing, grading, and other soil disturbing activities will not be permitted unless it is shown to the satisfaction of the County that silt-laden runoff will be prevented from leaving the site through a combination of the following:

  - Site conditions including existing vegetative coverage, slope, soil type, and proximity to receiving waters; and
  - Limitations on activities and the extent of disturbed areas; and
  - Proposed erosion and sediment control measures.

  Based on the information provided and/or local weather conditions, the County may expand or restrict the seasonal limitation on site disturbance. The County shall take enforcement action – such as a notice of violation, administrative order, penalty, or stop-work order under the following circumstances:

  - If, during the course of any construction activity or soil disturbance during the seasonal limitation period, sediment leaves the construction site causing a violation of the surface water quality standard; or
  - If clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained.

The following activities are exempt from the seasonal clearing and grading limitations:

- Routine maintenance and necessary repair of erosion and sediment control BMPs;
- Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil; and
- Activities where there is 100 percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

- Coordination with Utilities and Other Contractors:

  The primary project proponent shall evaluate, with input from utilities and other contractors, the stormwater management requirements for the entire project, including the utilities, when preparing the Construction SWPPP.

- Inspection and Monitoring:

  All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Site inspections shall be conducted at least weekly and immediately following any substantial rainfall event by a person who is knowledgeable in the principles and practices of erosion and sediment control. The person must have the skills to: 1) assess the site conditions and construction activities that could impact the quality of stormwater, and 2) assess the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.

  For construction sites that will disturb 1 acre or more and that discharge stormwater to surface waters of the state, a Certified Erosion and Sediment Control Lead shall be identified in the Construction SWPPP and shall be onsite or on-call at all times. Certification may be obtained through an approved training program that meets the erosion and sediment control training standards established by Ecology.

  Whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.

- Maintaining an Updated Construction SWPPP:

  The Construction SWPPP shall be retained onsite or within reasonable access to the site.

  The SWPPP shall be modified whenever there is a change in the design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on the discharge of pollutants to waters of the state.

  The SWPPP shall be modified if, during inspections or investigations conducted by the owner/operator, Thurston County or a state regulatory authority, it is determined that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. The SWPPP shall be modified as necessary to include additional or modified BMPs designed to correct problems identified. Revisions to the SWPPP shall be completed within seven (7) days following the inspection.

2.3.3 Step 3 – Development and Implementation of the Construction SWPPP

The Construction SWPPP must include all of the components specified in Construction SWPPP Submittal Requirements (Section 2.2). Refer to the checklist (Appendix II-C).

A plan showing the overall project, clearly delineating phase boundaries, and estimating dates of construction, shall be part of any initial submittal. Phased projects shall be completed in accordance with approved plans and in accordance with phased development requirements placed upon the development by the County. Phasing of projects does not reduce drainage and erosion control requirements.

Submit three copies of the plan, bound, and 8.5 x 11 inches in size, with the exception of required engineered drawing sheets which shall meet the criteria established within this general Section 3.4.1. Where possible, sheets shall be folded or rolled as small as possible, but not smaller than 8.5 x 11 inches.

Number all pages.

Detailed Components of SWPPP Narrative

Cover Sheet: The Construction SWPPP narrative will include a cover sheet that includes:

- Project name

- Applicant, and owner’s name, address, and telephone number
- Project engineer's name, address and telephone number
- Date of submittal
- Contact's name, address, and telephone number
- Contractor’s name, address and telephone number.

Table of Contents: Show the page number for each section of the report. Show page numbers of appendices.

Project Engineer's Certification: For smaller projects, the SWPPP need not be developed by a professional engineer. However, for more complex projects where a Drainage Control Plan is also required or where the SWPPP involves engineering calculations, the SWPPP must be developed by a professional engineer licensed to practice in the State of Washington. For projects where a PE is required, all plans and specifications, calculations, certifications, “as-built” drawings, and all other submittals which will become part of the permanent record of the project must be dated and bear the project engineer's official seal and signature.

The Construction SWPPP shall contain a page with the project engineer's seal with the following statement:

> *"I hereby state that this Construction SWPPP for ____ (name of project) has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that Thurston County does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities prepared by me."*

Inspection Report: All projects required to have a Construction SWPPP must conform to the inspection guidelines stated in Element 12: Manage Project. In summary, site inspections shall be conducted by a person who is knowledgeable in the principles and practices of ESC. For construction sites that will disturb 1 acre or more and that discharge stormwater to surface waters of the state, a Certified Erosion and Sediment Control Lead (CESCL) shall be identified in the Construction SWPPP and Construction SWPPP and shall be onsite or on-call at all times.

In addition, for complex projects where a Drainage Control Plan is required or where the SWPPP involves engineering calculations, the applicant shall have a professional engineer file with the County an

Engineer's Inspection Report Form as shown in Appendix I-C before the project is accepted by the County as complete. The report will consist of a completed form and sufficient additional text to describe all factors relating to the construction and operation of the system to meet treatment, erosion control, detention/retention, flow control, and conveyance requirements.

2.4 Construction SWPPP TESC Drawing Protocols

Where applicable, TESC drawings for the SWPPP shall conform to the following drawing protocols:

2.4.1 Required Drawing Protocol

- All sheets will have a north arrow, scale, a benchmark reference, the section, township, and range. Each set of drawings shall have a legend to define map symbols.
- All lettering shall be one-tenth of an inch or greater. Existing spot elevations will be no smaller than one-twentieth of an inch or greater than one-tenth of an inch.
- All submittals shall be stamped, signed, and dated by a licensed professional engineer prior to review by the County.

2.4.2 General Drawing Requirements

All drawings shall contain the following:

- Road alignments with 100-foot stationing, preferably increasing to the north or east and reading from left to right; stationing at points of curve, tangent, and intersection, with ties to section or quarter corners or other established and monumented survey control points to include at the intersection of any proposed road or roads and any existing county road or state highway. All lettering shall be right reading.
- Bearing on all centerlines.
- Curve data including radius, delta, and arc length on all horizontal lines.
- Right-of-way, easement, tract lines, and dimensions for all existing and proposed facilities, including proposed roads and intersecting roads. The plans shall show properly dimensioned lot lines and lot numbers, and locate and dimension all tract and easement areas.

- All topographic features within project limits and a sufficient area beyond (50-ft minimum), to resolve questions of setback, slope, drainage, access onto abutting property, and road continuations.

- Existing contours and drainage basins and the direction of flow for the different drainage areas. Contour intervals on the site plan shall be at a minimum as follows:

Slope (%)	Contour Interval (feet)
0 – 15	2
16 – 40	5
>40	10

- Topography must be field verified for drainage easements and conveyance systems. Contours shall extend a minimum of 50 feet beyond property lines and extend sufficiently to depict existing conditions. If survey is restricted to the project site due to lack of legal access, contours shall be provided by other means; i.e., Thurston County Geodata, USGS, etc.

- All ditch flow lines, all drainage structures with invert elevations, utility locations, fences, structures, existing curbing and approaches, pertinent trees and shrubbery, and other appurtenances which would affect the construction of the project.

- Identification of all existing public roads and adjoining subdivisions when it is pertinent to the scope of the project.

- Scale: 1 inch = 20 feet or 1 inch = 50 feet (1 inch = 100 feet may be used with prior county approval) for public facilities and roads to be dedicated to the County.

- Scale: 1 inch = 50 feet for plats, 1 inch = 20 feet, 30 feet, or 40 feet for all others.

- North arrow shall point to the top or to the left of the sheet.

- Existing features will be ghosted or shaded.

- A legend.

2.4.3 Cover Sheet

- Any drawing sets submitted for review and acceptance by the County containing three or more sheets shall have a cover sheet.
- The cover sheet shall be sheet one of the drawing set and contain the following information:
  - A simple vicinity map, with north arrow oriented to the top of the sheet, showing project site, existing public road system and any other pertinent information. Minimum scale shall be 4 inches = 1 mile.
  - An overall site plan or location map showing the project site(s). Road and stormwater drainage system network including its connection to an existing public road or state highway. This does not have to be to scale.
  - The applicant,and project engineer's, firm, name, address, and telephone numbers, current owner, and parcel numbers.
  - An index table of drawings.
  - Title block descriptive of project.

2.4.4 General Drawing Site and/or Grading Plan Sheets

- In addition to the general drawing requirements the site and/or grading plan sheets shall show the following:
  - Proposed storm drainage and easements, tracts, drainage facilities, all buffer and screening areas, offsite and onsite existing drainage courses, delineated wetlands, and associated buffers.
  - Soil logs and soil log locations.
  - Wells – existing and proposed.
  - Topographic information including contour lines of the property in its existing condition. County or U.S. Geological Survey (USGS) topographic mapping must be field verified and supplemented with additional field topographic information when necessary to provide an accurate depiction of the property.

- o Proposed grades.
- o Property lines, parcel numbers and ownership.
- o Contour intervals shall be as follows:

– 0 percent	< 15 percent	2-foot contour interval
– 15 percent	- 40 percent slope	5-foot contour interval
– 40 percent	+ slope	10-foot contour interval.

2.4.5 Plan and Profile Sheet

Show the following:

- Original ground line at 100-foot stations and at significant ground breaks and topographic features, with accuracy to within 0.1 feet on unpaved surface and 0.01 feet on paved surfaces.
- Typical roadway/storm drainage cross-sections when applicable.
- Existing and proposed drainage features, indicating direction of flow, size, and kind of each drainage channel, pipe and structure. The status of existing drainage structures must be clarified as either, “existing-abandon" or “existing-remove.”
- Final surface and storm drain profile with stationing the same as the site/grading plan sheets. Preferably reading from left to right, to show stationing of points of curve, tangent, and intersection of vertical curves, with elevations to 0.01 feet.
- Surface grade and vertical curve data; roads to be measured at centerline.
- Datum and all bench mark information shall use established U.S.C. and G.S. control or county bench marks when there is an existing bench mark within one-half mile of the project.
- Vertical scale 1 inch = 5 feet. Clarifying details may be drawn to a convenient scale. Use 1 inch = 10 feet for vertical scale when horizontal scale is at 1 inch = 100 feet.
- When roads end at a property line, the existing ground profile shall be continued a minimum of 200 feet to show the proposed vertical alignment is reasonable.
- When intersecting road profile grades have a difference of 1 percent or less, a vertical curve is not required. All other vertical grade intersections will require a minimum 50-foot vertical curve.

- Storm drainage text to be shown in profile only to avoid duplication of text. Number of structure will be shown in the plan and profile views. The following information shall be shown in the profile view:
  - Type of structure
  - Structure number
  - Stationing/offsets (coordinates to be shown in the plan view)
  - Rim elevation
  - Invert elevations (in)
  - Invert elevations (out)
  - Pipe length, pipe size, material and slope (percent).

2.4.6 Detail Sheets

- All applicable standard notes.
- A minimum of two cross-sections of each retention/detention pond showing original property lines, slope catch points, and all other pertinent information to adequately construct the pond.
- Standard open conveyance system cross-sections, if applicable.
- Right-of-way cross-sections as required by the County.
- Construction recommendations from a soils report, if applicable.

2.4.7 Required Drawing Size

Drawings shall be 24x36 inches or 22x34 inches. Original sheets shall be Mylar or photo Mylar.

2.4.8 Plans and Specifications

The most recently adopted editions of standard specifications and standard plans (see Glossary in Volume I, Appendix I-A) shall be the standards for all design and construction of drainage facilities not explicitly described herein. In the event of a conflict between the standard specifications, standard plans, and the manual, this manual shall prevail. When required by the County, standard specifications and general provisions for construction must be submitted with any road construction plans.

Chapter 3 - Standards and Specifications for Best Management Practices

Best Management Practices (BMPs) are activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices that, prevent or reduce the release of pollutants to the waters of Washington State. This chapter contains standards and specifications for temporary BMPs for use during the construction phase of a project.

Section 3.1 contains the standards and specifications for source control BMPs.

Section 3.2 contains the standards and specifications for runoff conveyance and treatment BMPs.

Standards for each BMP are divided into four sections:

1. Purpose
2. Conditions of Use
3. Design and Installation Specifications
4. Maintenance Standards

Note that "Conditions of Use" always refers to site conditions. As site conditions change, BMPs must change to remain in compliance.

Information on streambank stabilization is available in the *Integrated Streambank Protection Guidelines*, Washington State Department of Fish and Wildlife, 2003.

3.1 Source Control BMPs

3.1.1 BMP C101: Preserving Natural Vegetation

Purpose

To reduce erosion. Limiting site disturbance is the single most effective method for reducing erosion. For example, conifers hold up to 50 percent of all rain that falls on them during a storm, with the size of the storm playing a large factor. As much as 30 percent of rain, on average, may never reach the ground but is taken up by the tree or evaporates. The rain held in the tree is released slowly to the ground after the storm. Preserving natural vegetation is an important LID technique. It can help protect water quality and preserve the natural hydrology of a site by maintaining the infiltration capacity of soils, reducing impervious surfaces, and reducing fertilizer and irrigation requirements required to establish new vegetation.

Conditions of Use

- Preserve natural vegetation on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.

- Where established native plants or ground cover are present, or where underlying soils have good infiltrative properties (Natural Resource Conservation Service Hydrologic Group A or B) they should be preserved to the extent possible.

- At a minimum, the applicant shall comply with provisions for native vegetation preservation and/or replacement as set forth in applicable Thurston County Code including critical areas, zoning, grading and forest practices.

Design and Installation Specifications

Natural vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.

The preservation of individual plants is more difficult because heavy equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor, and the work involved.

- Fence or clearly mark areas around trees to be saved. It is preferable to keep ground disturbance at least outside the tree's dripline.

Take the following steps to protect vegetation during construction:

- Map natural resource protection areas on all plans and delineate these areas on the site with silt, construction, or other appropriate fencing to protect soils and vegetation from construction damage.
- Meet and walk property with equipment operators to clarify construction boundaries and limits of disturbance.
- Protect drainage areas during construction. If an area has any type of channel or drainage swale that provides a hydrologic connection to vegetation protection area(s), the channel must also be protected throughout the construction phase by fencing and erosion control measures to prevent untreated runoff from the construction site to flow into the channel.
- Install signs and fences to identify and protect natural resource protection areas.
- Protect trees and tree root systems using the following methods:
  - Reduce soil compaction during the construction phase by protecting critical tree root zones that extend beyond the trees canopy or drip line. Determine the critical tree root zone using the tree's diameter breast height (6-inch diameter breast height = 8-foot radius; 10-inch diameter breast height = 10-foot radius, 30-inch diameter breast height = 45-foot radius) (see Figure 3.1).
  - Prohibit excavation within the critical tree root zone.
  - Prohibit stockpiling or disposal of excavated or construction materials in vegetation retention areas to prevent contaminants from damaging vegetation and soils.
  - Avoid excavation or grade changes near trees designated for protection. If raising the grade level around a tree, a dry rock wall or rock well shall be constructed around the tree. The diameter of this wall or well shall be at least equal to the diameter of the tree canopy plus 5 feet.
  - Restrict trenching in critical tree root zone areas.
  - Prevent wounds to tree trunks and limbs during the construction phase.
  - Prohibit installation of impervious surfaces in critical root zone areas. Where road or sidewalk surfaces are needed under a tree canopy, use unmortared porous pavers or flagstone (rather than concrete or asphalt) or bridging techniques (see Figure 3.1).

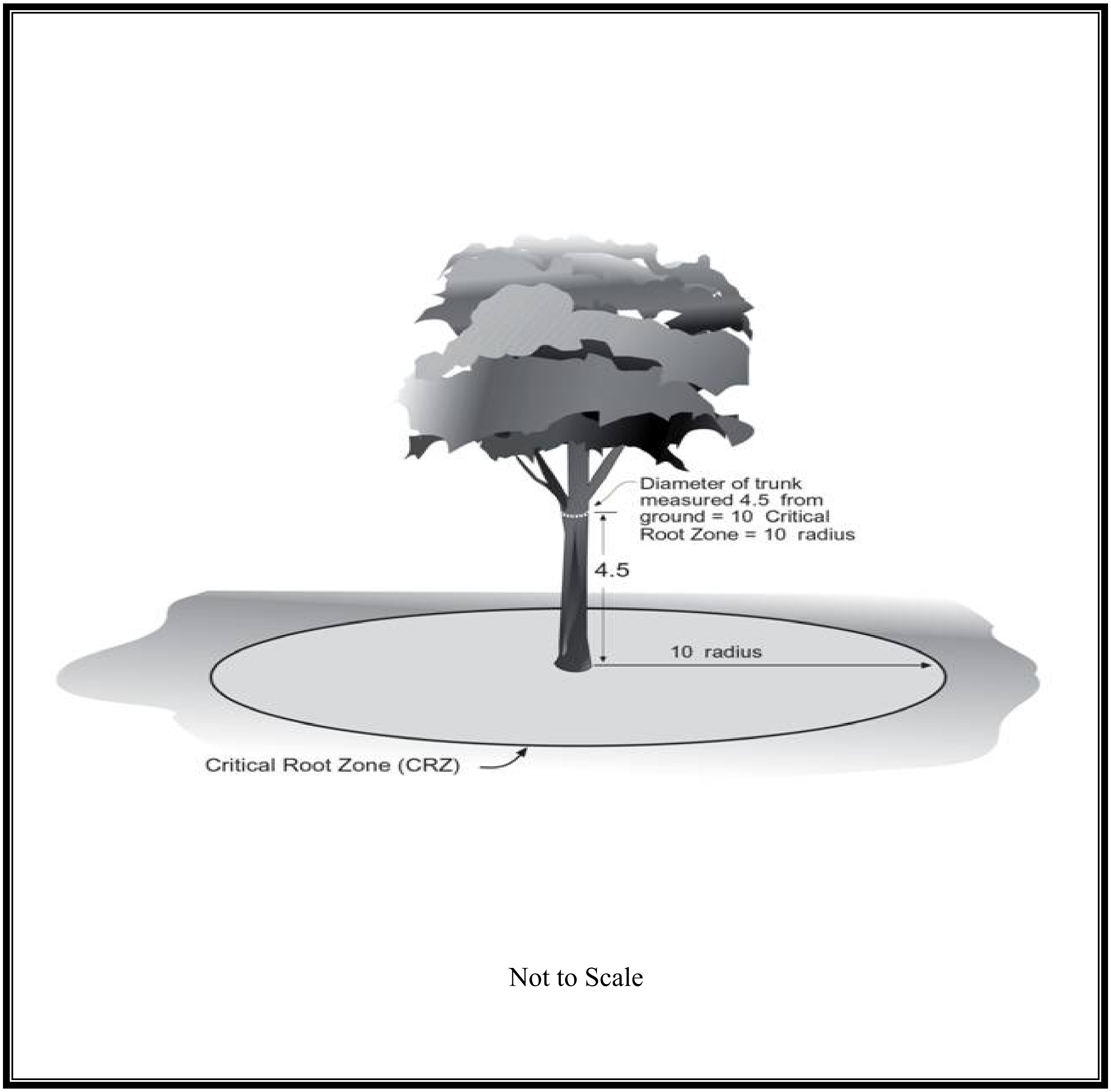


Figure 3.1. Critical Root Zone (CRZ), in feet.

  - Prepare tree conservation areas to better withstand the stresses of the construction phase by fertilizing, pruning, and mulching around them well in advance of construction activities.

Problems that can be encountered with a few specific trees include:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment, so take special care to protect these trees.

- The windthrow hazard of Pacific Silver Fir and Madrona is high, while that of Western hemlock is moderate. The danger of windthrow increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils less than 20 inches deep) have a low windthrow hazard.

- Cottonwoods, maples, and willows have water-seeking roots that can infiltrate and block sewer lines and drain fields. However, these trees thrive in high moisture conditions that other trees would not.

- Thinning operations in pure or mixed stands of Grand Fir, Pacific Silver Fir, Noble Fir, Sitka Spruce, Western Red Cedar, Western Hemlock, Pacific Dogwood, and Red Alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots, and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

Maintenance Standards

- Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

- If tree roots have been exposed or injured, “prune” cleanly with an appropriate pruning saw or lopers directly above the damaged roots and recover with native soils. Treatment of sap flowing trees (fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

3.1.2 BMP C252: Preservation of Upper Soil Structure (Native Topsoil)

Purpose

Preservation of the existing upper soil horizon is critical to the success of LID developments that maintain natural stormwater processes on the site.

Conditions of Use

- Native topsoil protection is critical in areas where infiltration or dispersion facilities are proposed.
- On sites underlain by cemented till layers, which are nearly impermeable, the upper soil horizon (native topsoil) processes the majority of stormwater on the site. Therefore, it is necessary to ensure that the existing depth of the upper soil horizon is either left in place or removed and replaced during the grading process. For soils removed and replaced on site, the soil amendment requirements outlined in Section 3.1.8 must also be met.
- On sites underlain by outwash soils, the existing topsoil is not usually as deep but is still necessary for preservation to provide water quality treatment of runoff before infiltration into the outwash soils.
- As required by the County.

Design and Installation Specifications

- Fence or clearly mark areas around soil areas that are to be protected.
- In buildable areas where minimal excavation foundation systems can be applied, existing top soils shall be left in place to the greatest extent possible and shaped or feathered only with tracked grading equipment not exceeding 650 pounds per square foot machine loads. Where some re-grading is required, re-compaction of placed materials, which may include topsoils free of vegetated matter, shall be limited to the minimum densities required by the foundation system engineering.
- In buildable areas of the site where conventional grading is required, the areas requiring cuts shall have the upper native topsoil removed and stockpiled for replacement to areas of the development utilized for LID stormwater management (yards, bioretention areas, interflow pathways, vegetated channels, or degraded natural resource protection areas).

- The depth of upper native topsoil required to be stockpiled and replaced shall be the entire depth of the native topsoil horizon up to a required maximum 3 feet.

- Over-excavation of cut sections are required if the cut is in a location that will be utilized for LID stormwater management. Cut to a depth that will allow replacement of stockpiled native topsoil to the entire depth that was on the site post development, up to a required maximum of 3 feet.

- Cut sections where native topsoil replacement is required shall require ripping of any cemented till layers to a depth of 6 inches. Subsequently, the replacement of stockpiled topsoil shall be thoroughly mixed into the ripped till to provide a gradual transition between the cemented till layer and the topsoil.

- Stockpiled topsoil shall be replaced in lifts no greater than 1 foot deep and compacted by rolling to a density that matches existing conditions.

- For any soils removed and replaced on site as described above, the soil amendment requirements outlined in Section 3.1.8 must also be met.

Maintenance Standards

- Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing has been damaged or visibly reduced, it shall be repaired or replaced immediately and visibly restored.

3.1.3 BMP C102: Buffer Zones

Purpose

To provide a living filter to reduce soil erosion and runoff velocities.

Conditions of Use

Natural buffer zones are used along streams, wetlands, and other bodies of water that need protection from erosion and sedimentation. Vegetative buffer zones can protect natural swales and can be incorporated into natural landscaping.

Do not use buffer zones as sediment treatment areas. These areas shall remain completely undisturbed. The County may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.

Design and Installation Specifications

- Preserving natural vegetation or plantings in clumps, blocks, or strips is the easiest and most successful method.
- Leave all unstable steep slopes in natural vegetation.
- Mark clearing limits and keep all equipment and construction debris out of the natural areas. High visibility plastic fencing is the most effective method in protecting sensitive areas and buffers. Wire-backed silt fence on steel posts is marginally effective. Flagging alone is typically not effective.
- Keep all excavations outside the dripline of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage from burying and smothering.
- Vegetative buffer zones for streams, lakes or other waterways shall be established by the County or other state or federal permits or approvals.

Maintenance Standards

- Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed.

3.1.4 BMP C103: High Visibility Plastic Fence

Purpose

To: restrict clearing to approved limits, prevent disturbance of sensitive areas and their buffers limit construction traffic to designated construction entrances or roads, and protect areas where survey tape markers may not provide adequate protection.

Conditions of Use

To establish clearing limits plastic fence may be used:

- At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared.
- As necessary to control vehicle access to and on the site.

Design and Installation Specifications

- High visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least 4 feet in height. Posts for the fencing shall be steel or wood and placed every 6 feet on center (maximum) or as needed to ensure rigidity. The fencing shall be fastened to the post every 6 inches with a polyethylene tie. On long continuous lengths of fencing, a tension wire or rope shall be used as a top stringer to prevent sagging between posts. The fence color shall be high visibility orange. The fence tensile strength shall be 360 lbs./ft. using the ASTM D4595 testing method.
- Fences shall not be wired or stapled to trees.

Maintenance Standards

- If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

3.1.5 BMP C105: Stabilized Construction Entrance

Purpose

To reduce the amount of sediment transported onto paved roads by vehicles or equipment by constructing a stabilized pad of quarry spalls at entrances to construction sites.

Conditions of Use

Construction entrances shall be stabilized wherever traffic will leave a construction site and travel on paved roads or other paved areas within 1,000 feet of the site.

On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized entrances not shown in the initial Construction SWPPP. It is difficult to determine exactly where access to these projects will take place; additional materials will enable the contractor to install them where needed.

Design and Installation Specifications

- See Figure 3.2 for details. Note: the 100 foot minimum length of the entrance shall be reduced to the maximum practicable size when the size or configuration of the site does not allow the full length (100 feet).

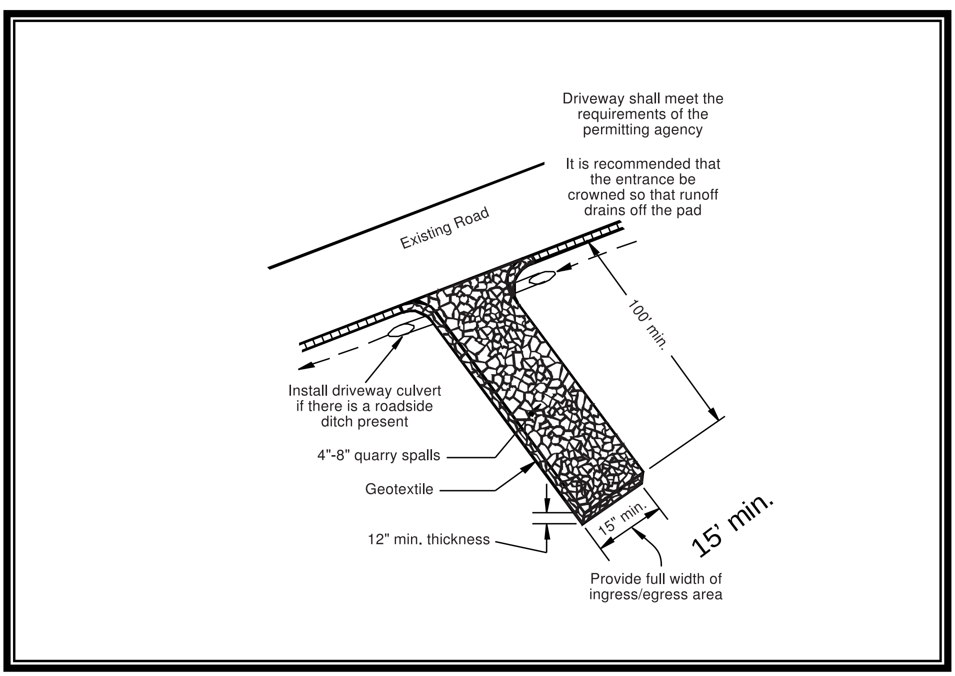


Figure 3.2. Stabilized Construction Entrance.

- A separation geotextile shall be placed under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet the following standards:
  - Grab Tensile Strength (ASTM D4751): 200 psi min.
  - Grab Tensile Elongation (ASTM D4632): 30% max.
  - Mullen Burst Strength (ASTM D3786-80a): 400 psi min.
  - AOS (ASTM D4751): 20-45 (U.S. standard sieve size).
- Hog fuel (wood-based mulch) may be substituted for (or combined with) quarry spalls in areas that will not be used for permanent roads. Hog fuel is generally less effective at stabilizing construction entrances and should be used only at sites where the traffic is very limited. Hog fuel is not recommended for entrance stabilization in urban areas. The effectiveness of hog fuel is highly variable and usually requires more maintenance than quarry spalls. The inspector may require the use of quarry spalls at any time if the hog fuel is not preventing sediment from being tracked onto pavement, or if hog fuel is being carried onto pavement. Hog fuel is prohibited in permanent roadbeds because organics in the subgrade soils cause degradation of the subgrade support over time.
- Fencing (see BMPs C103) shall be installed as necessary to restrict traffic to the construction entrance.
- Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.

Maintenance Standards

- Quarry spalls (or hog fuel) shall be added if the pad is no longer in accordance with the specifications.
- If the entrance is not preventing sediment from being tracked onto pavement, then alternative measures to keep the streets free of sediment shall be used. This may include an increase in the dimensions of the entrance or the installation of a wheel wash.
- Any sediment that is tracked onto pavement shall be removed by shoveling or street sweeping. The sediment collected by sweeping shall be removed or stabilized on site. The pavement shall not be cleaned by washing down the street, except when sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, the construction of a small sump shall be considered. The sediment would then be washed into the sump where it can be controlled.

- Any quarry spalls loosened from the pad that end up on the roadway shall be removed immediately.

- If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (see BMP C103) shall be installed to control traffic.

- Upon project completion and site stabilization, all construction accesses intended as permanent access for maintenance shall be permanently stabilized.

3.1.6 BMP C106: Wheel Wash

Purpose

To reduce the amount of sediment transported onto paved roads by motor vehicles.

Conditions of Use

When a stabilized construction entrance (see BMP C105) is not preventing sediment from being tracked onto pavement.

- Wheel washing is an effective BMP when installed with careful attention to topography. However, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where water from the dripping truck can run unimpeded into the street, for example.
- Pressure washing combined with an adequately sized and surfaced pad with direct drainage to a large 10-foot x 10-foot sump can be very effective.

Design and Installation Specifications

Suggested details are shown in Figure 3.3. A minimum of 6 inches of asphalt treated base (ATB) over crushed base material or 8 inches over a good subgrade is recommended to pave the wheel wash.

Use a low clearance truck to test wheel wash clearance before paving. Either a belly dump or lowboy will work well.

Keep the water level from 12 to 14 inches deep to avoid damage to truck hubs and filling the truck tongues with water.

Midpoint spray nozzles are only needed in extremely muddy conditions.

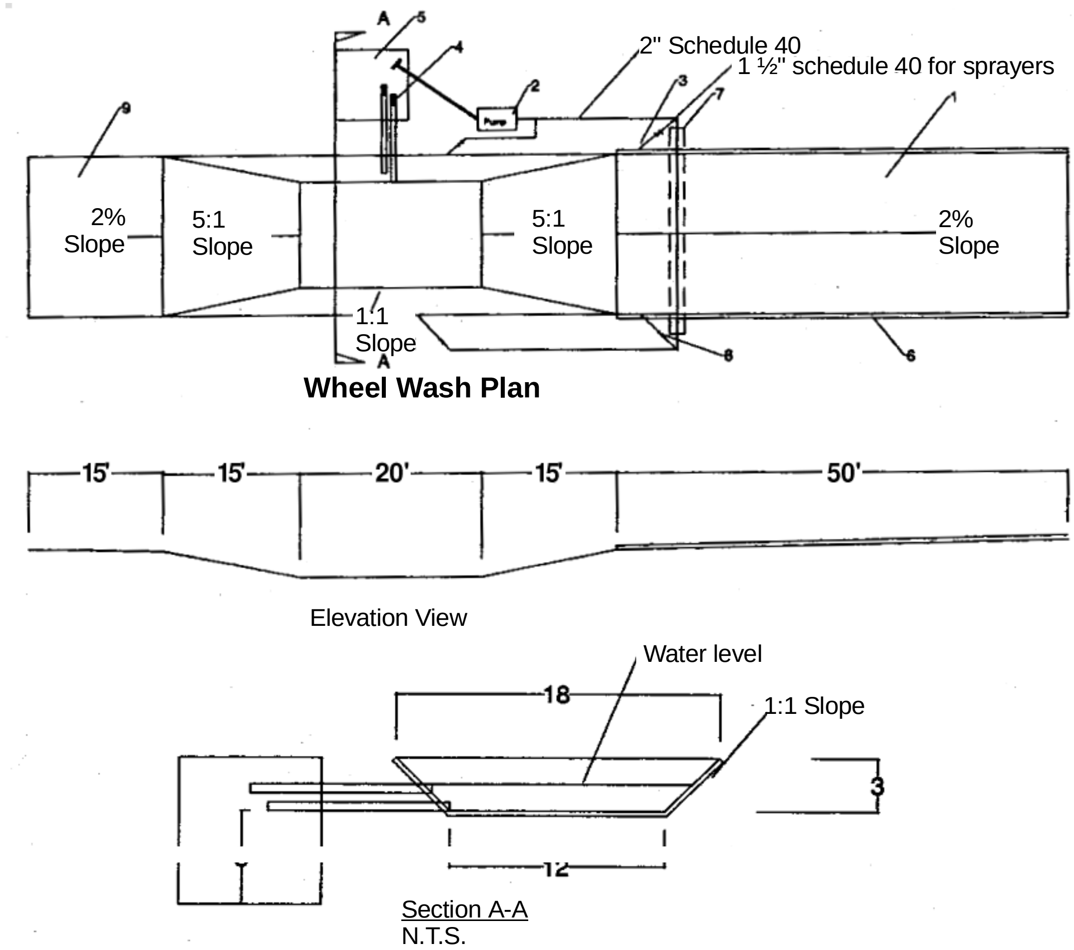
Design wheel wash systems with a small grade change (6 to 12 inches for a 10-foot-wide pond) to allow sediment to flow to the low side of pond to help prevent re-suspension of sediment. Install a drainpipe with a 2- to 3-foot riser on the low side of the pond to allow for easy cleaning and refilling. Polymers may be used to promote coagulation and flocculation in a closed-loop system.

Maintenance Standards

The wheel wash should start each day with fresh water.

Change the wash water a minimum of once per day. On large earthwork jobs where more than 10 to 20 trucks per hour are expected, the wash water will need to be changed more often.

Wheel wash or tire bath wastewater shall be controlled by pumping back on site to an approved infiltration facility, or otherwise must be prevented from discharging into systems tributary to state surface waters. Options include discharge to the sanitary sewer, or discharge to an approved offsite treatment system. For discharges to the sanitary sewer, permits must be obtained from LOTT or local sewer service provider.



Notes:
1. Asphalt construction entrance 6 in. asphalt treated base (ATB).
2. 3-inch trash pump with floats on the suction hose.
3. Midpoint spray nozzles, if needed.
4. 6-inch sewer pipe with butterfly valves. Bottom one is a drain. Locate top pipe's invert 1 foot above bottom of wheel wash.
5. 8 foot x 8 foot sump with 5 feet of catch. Build so can be cleaned with trackhoe.
6. Asphalt curb on the low road side to direct water back to pond.
7. 6-inch sleeve under road.
8. Ball valves.
9. 15 foot. ATB apron to protect ground from splashing water.

Figure 3.3. Wheel Wash.

3.1.7 BMP C107: Construction Road/Parking Area Stabilization

Purpose

To reduce erosion caused by construction traffic or runoff.

Conditions of Use

- Roads or parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.
- Fencing (see BMP C103) shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

- On areas that will receive asphalt, install the first lift as soon as possible.
- A 6-inch depth of 2- to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or utility installation. A 4-inch course of asphalt treated base (ATB) may also be used, or the road/parking area may be paved. It may also be possible to use cement or calcium chloride for soil stabilization. If cement or cement kiln dust is used for roadbase stabilization, pH monitoring and BMPs are necessary to evaluate and minimize the effects on stormwater. If the area will not be used for permanent roads, parking areas, or structures, a 6-inch depth of hog fuel may also be used, but this is likely to require more maintenance. Whenever possible, construction roads and parking areas shall be placed on a firm, compacted subgrade.
- Temporary road gradients shall not exceed 15 percent. Roadways shall be carefully graded to drain. Drainage ditches shall be provided on each side of the roadway in the case of a crowned section, or on one side in the case of a super-elevated section. Drainage ditches shall be directed to a sediment control BMP.
- Rather than relying on ditches, it may also be possible to grade the road so that runoff sheet-flows into a heavily vegetated area with a well-developed topsoil. Landscaped areas are not adequate. If this area has at least 50 feet of vegetation, then it is preferable to use the vegetation to treat runoff, rather than a sediment pond or trap. The 50 feet shall not include wetlands. If runoff is allowed to sheetflow through adjacent vegetated areas, it is vital to design the

roadways and parking areas so that no concentrated runoff is created.

- Storm drain inlets shall be protected to prevent sediment-laden water entering the storm drain system (see BMP C220).

Maintenance Standards

- Inspect stabilized areas regularly, especially after large storm events.
- Crushed rock, gravel base, hog fuel, etc. shall be added as required to maintain a stable driving surface and to stabilize any areas that have eroded.
- Following construction, these areas shall be restored to pre-construction condition or better to prevent future erosion.

3.1.8 BMP C120: Temporary and Permanent Seeding

Purpose

To reduce erosion by stabilizing exposed soils. A well-established vegetative cover is one of the most effective methods of reducing erosion.

Conditions of Use

- Seeding shall be used throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.

- Install channels that will be vegetated before major earthwork and hydroseed them with a bonded fiber matrix. The vegetation should be well established before water is allowed to flow in the ditch. With channels that will have high flows, install erosion control blankets over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod shall be installed in the bottom of the ditch over hydromulch and blankets.

- Retention/detention ponds shall be seeded as required.

- Mulch is required at all times because it protects seeds from heat, moisture loss, and transport due to runoff.

- All disturbed areas shall be reviewed in late August to early September and all seeding should be completed by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.

- At final site stabilization, all disturbed areas not otherwise vegetated or stabilized shall be seeded and mulched. Final stabilization means the completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as pavement, riprap, gabions or geotextiles) which will prevent erosion.

Design and Installation Specifications

- Seeding should be done during those seasons most conducive to growth and will vary with the climate conditions of the region. Local experience should be used to determine the appropriate seeding periods.

- The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1.

Seeding that occurs between July 1 and August 30 requires irrigation until 75 percent grass cover is established. Seeding that occurs between October 1 and March 30 will require a mulch or plastic cover until 75 percent grass cover is established.

- To prevent seed from being washed away, confirm that all required surface water control measures have been installed.

- The seedbed should be firm and rough. All soil shall be roughened regardless of slope. If compaction is required for engineering purposes, slopes must be track walked before seeding. Backblading or smoothing of slopes greater than 4:1 is not allowed if they are to be seeded.

- New and more effective restoration-based landscape practices rely on deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical, initially rip the subgrade to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches, perform the rototilling process in multiple lifts, or the prepared soil system shall be prepared properly and then placed to achieve the specified depth.

- Organic matter is the most appropriate form of “fertilizer” because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form. A natural system typically releases 2 to 10 percent of its nutrients annually. Chemical fertilizers have since been formulated to simulate what organic matter does naturally.

- In general, 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer can be used at a rate of 90 pounds per acre. Slow-release fertilizers should always be used because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil tests to determine the exact type and quantity of fertilizer needed. This will prevent the over-application of fertilizer. Fertilizer should not be added to the hydromulch machine and agitated more than 20 minutes before it is to be used. If agitated too much, the slow-release coating is destroyed.

- There are numerous products available on the market that take the place of chemical fertilizers. These include several with seaweed extracts that are beneficial to soil microbes and organisms. If 100 percent cottonseed meal is used as the mulch in hydroseed, chemical fertilizer may not be necessary. Cottonseed meal is a good source of long-term, slow-release, available nitrogen.

- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier, along with the seed and fertilizer. Mulch can be 100 percent cottonseed meal, wood fibers, recycled cellulose, hemp, kenaf, compost, or blends of these. Tackifier shall be plant-based (such as guar or alpha plantago) or chemical-based (such as polyacrylamide or polymers). Any mulch or tackifier product used shall be installed per manufacturer's instructions.

- Mulch is always required for seeding. Mulch can be applied on top of the seed or simultaneously by hydroseeding.

- On steep slopes, use bonded fiber matrix (BFM) or mechanically bonded fiber matrix (MBFM) products. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer's instructions. Most products require 24 to 36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40 to 50 pound bags and include all necessary ingredients except for seed and fertilizer.

  BFMs and MBFMs have some advantages over blankets, including:

  - No surface preparation required
  - Can be installed via helicopter in remote areas
  - On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety
  - BFMs and MBFMs are at least $1,000 per acre cheaper to install.

  In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.

  - When installing seed via hydroseeding operations, only about 1/3 of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. One way to overcome this is to increase seed quantities by up to 50 percent.

- Vegetation establishment can also be enhanced by dividing the hydromulch operation into two phases:

  - Phase 1 – Install all seed and fertilizer with 25 to 30 percent mulch and tackifier onto soil in the first lift;

  - Phase 2 – Install the rest of the mulch and tackifier over the first lift.

An alternative is to install the mulch, seed, fertilizer, and tackifier in one lift. Then, spread or blow straw over the top of the hydromulch at a rate of about 800 to 1,000 pounds per acre. Hold straw in place with a standard tackifier. Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:

- Irrigation
- Reapplication of mulch
- Repair of failed slope surfaces.

This technique works with standard hydromulch (1,500 pounds per acre minimum) and BFM/MBFMs (3,000 pounds per acre minimum).

- Areas to be permanently landscaped shall provide a healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetal health and vitality, improves hydrologic characteristics, and reduces the need for irrigation. This can be accomplished in a number of ways:

  - Recent research has shown that the best method to improve till soils is to amend these soils with compost. The optimum mixture is approximately two parts soil to one part compost. This equates to 4 inches of compost mixed to a depth of 12 inches in till soils. Increasing the concentration of compost beyond this level can have negative effects on vegetal health, while decreasing the concentrations can reduce the benefits of amended soils. Please note: The compost shall meet specifications for Grade A quality compost in Ecology Publication 94-038.

  - Other soils, such as gravel or cobble outwash soils, may require different approaches. Organics and fines easily migrate through the loose structure of these soils. Therefore, the importation of at least 6 inches of quality topsoil, underlain by some type of filter fabric to prevent the migration of fines, may be more appropriate for these soils.

- Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.

- Areas that will be seeded only and not landscaped may need compost or meal-based mulch included in the hydroseed in order to establish vegetation. Replace native topsoil on the disturbed soil surface before application.

- Seed installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed installed as a permanent measure may be installed by hand on small areas (usually less than 1 acre) that will be covered with mulch, topsoil, or erosion blankets. The seed mixes listed below include recommended mixes for both temporary and permanent seeding. These mixes, with the exception of the wetland mix, shall be applied at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Consult local suppliers or the Thurston County Conservation District for recommendations because the appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the County may be used.

  Table 3.1 represents the standard mix for those areas where just a temporary vegetative cover is required.

Table 3.1. Temporary Erosion Control Seed Mix.

	% Weight	% Purity	% Germination
Chewings or annual blue grass *Festuca rubra var. commutata* or *Poa anna*	40	98	90
Perennial rye *Lolium perenne*	50	98	90
Redtop or colonial bentgrass *Agrostis alba* or *Agrostis tenuis*	5	92	85
White dutch clover *Trifolium repens*	5	98	90

Table 3.2 provides just one recommended possibility for landscaping seed.

Table 3.2. Landscaping Seed Mix.

	% Weight	% Purity	% Germination
Perennial rye blend *Lolium perenne*	70	98	90
Chewings and red fescue blend *Festuca rubra var. commutata* or Festuca *rubra*	30	98	90

This turf seed mix in Table 3.3 is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.

Table 3.3. Low-Growing Turf Seed Mix.

	% Weight	% Purity	% Germination
Dwarf tall fescue (several varieties) *Festuca arundinacea var.*	45	98	90
Dwarf perennial rye (Barclay) *Lolium perenne var. barclay*	30	98	90
Red fescue *Festuca rubra*	20	98	90
Colonial bentgrass *Agrostis tenuis*	5	98	90

Table 3.4 presents a mix recommended for bioswales and other intermittently wet areas.

Table 3.4. Bioswale Seed Mix.

	% Weight	% Purity	% Germination
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	75-80	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10-15	92	85
Redtop bentgrass *Agrostis alba* or *Agrostis gigantea*	5-10	90	80

[a] Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

The seed mix shown in Table 3.5 is a recommended low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Other mixes may be appropriate, depending on the soil type and hydrology of the area. Recent research suggests that bentgrass (*agrostis* sp.) should be emphasized in wet-area seed mixes. Apply this mixture at a rate of 60 pounds per acre.

Table 3.5. Wet Area Seed Mix.

	% Weight	% Purity	% Germination
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	60-70	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10-15	98	85
Meadow foxtail *Alepocurus pratensis*	10-15	90	80
Alsike clover *Trifolium hybridum*	1-6	98	90
Redtop bentgrass *Agrostis alba*	1-6	92	85

[a] Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

The meadow seed mix in Table 3.6 is recommended for areas that will be maintained infrequently or not at all and where native plant colonization is desired. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. The appropriateness of clover in the mix may need to be considered, as this can be a fairly invasive species. If the soil is amended, the addition of clover may not be necessary.

Table 3.6. Meadow Seed Mix.

	% Weight	% Purity	% Germination
Redtop or Oregon bentgrass *Agrostis alba* or *Agrostis oregonensis*	20	92	85
Red fescue *Festuca rubra*	70	98	90
White dutch clover *Trifolium repens*	10	98	90

Maintenance Standards

- Any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows) shall be reseeded. If reseeding is ineffective, an alternate method, such as sodding, mulching, or nets/blankets shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the County when sensitive areas would otherwise be protected.

- After adequate cover is achieved, any areas that experience erosion shall be reseeded and protected by mulch. If the erosion problem is drainage related, the problem shall be fixed and the eroded area reseeded and protected by mulch.
- Seeded areas shall be supplied with adequate moisture, but not to the extent that it causes runoff.

3.1.9 BMP C121: Mulching

Purpose

To provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture and holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches, but only the most common types are discussed in this section.

Conditions of Use

As a temporary cover measure, use mulch:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed during the wet season and hot summer months.
- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.

Mulch may be applied at any time of the year and must be refreshed periodically.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table 3.7. Note: Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

Mulch used within the ordinary high-water mark of surface waters should be selected to minimize potential flotation of organic matter. Composted organic materials have higher specific gravities (densities) than straw, wood, or chipped material.

Maintenance Standards

- The thickness of the cover must be maintained.
- Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

Table 3.7. Mulch Standards and Guidelines.

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2 to 3 inches thick; 5 bales per 1,000 sf or 2 to 3 tons per acre	Cost-effective when applied with adequate thickness. Hand-application requires greater thickness than blown straw. Straw thickness may be reduced by half when used in conjunction with seeding. In windy areas, straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier since light winds will blow it away. Straw, however, has several deficiencies to consider when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and has no significant long-term benefits. Use straw only if mulches with long-term benefits are unavailable. It also shall not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	No growth inhibiting factors.	Approximately 25 to 30 lbs per 1,000 sf or 1,500 to 2,000 lbs per acre	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Fibers longer than about 3/4 to 1 inch clog hydromulch equipment. Keep fibers to less than 3/4 inch.
Composted Mulch and Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit (unless exempt).	2-inch thick minimum; approximately 100 tons per acre (approximately 800 lbs per yard)	Increase thickness to 3 inches to improve effectiveness. Excellent mulch for protecting final grades until landscaping, because it can be directly seeded or tilled into soil as an amendment. Composted mulch has a coarser size gradation than compost. It is more stable and practical to use in wet areas and during rainy weather conditions.
Chipped Site Vegetation	Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.	2-inch minimum thickness	A cost-effective way to dispose of debris from clearing and grubbing, and eliminates problems associated with burning. Should not be used on slopes above about 10 percent because of its tendency to be transported by runoff. Not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.
Wood-based Mulch	No visible water or dust during handling. Must be purchased from a supplier with a Solid Waste Handling Permit or one exempt from solid waste regulations.	2 inches thick; approximately 100 tons per acre (approximately 800 lbs. per cubic yard)	Often called “hog or hogged fuel.” It is usable as a material for Stabilized Construction Entrances (BMP C105) and as a mulch. The use of mulch ultimately improves the organic matter in the soil. Special caution is advised regarding the source and composition of wood-based mulches. Its preparation typically does not provide any weed seed control, so evidence of residual vegetation in its composition or known inclusion of weed plants or seeds should be monitored and prevented (or minimized).

3.1.10 BMP C122: Nets and Blankets

Purpose

To prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. Some nets and blankets can permanently reinforce turf to protect drainage ways during high flows. Nets (commonly called *matting*) are strands of material woven into an open but high-tensile strength net (for example, coconut fiber matting). Blankets are strands of material that are not tightly woven but form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). Blankets generally have lower tensile strength than nets, but cover the ground more completely. Coir (coconut fiber) fabric comes as both nets and blankets.

Conditions of Use

Use erosion control nets and blankets:

- To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.

- For drainage ditches and swales. Using netting or blankets in drainage ditches and swales can protect bare soil from channelized runoff until vegetation is established. Nets and blankets can also capture a large amount of sediment due to their open, porous structure. Synthetic nets and blankets can permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches can be easily reused as temporary ditch liners.

Disadvantages of blankets include:

- Surface preparation required

- On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety

- They cost at least $4,000 to 6,000 per acre installed.

Advantages of blankets include:

- Can be installed without mobilizing special equipment

- Can be installed by anyone with minimal training

- Can be installed in stages or phases as the project progresses
- Seed and fertilizer can be hand-placed by the installers as they progress down the slope
- Can be installed in any weather
- There are numerous types of blankets that can be designed with various parameters in mind. Those parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.

Design and Installation Specifications

- See Figures 3.4 and 3.5 for typical orientation and installation of blankets used in channels and as slope protection. All blankets must be installed using manufacturer's installation instructions.
- Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.
- Installing Blankets on Slopes:
    - Complete final grade and track walk up and down the slope.
    - Install hydromulch with seed and fertilizer.
    - Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.
    - Install the leading edge of the blanket into the small trench and staple approximately every 18 inches. Staples are metal, "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are available.
    - Roll the blanket slowly down the slope as installer walks backwards. The blanket rests against the installer's legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern is used for the blanket being installed. Do not allow the blanket to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, do not walk on the blanket after it is in place.

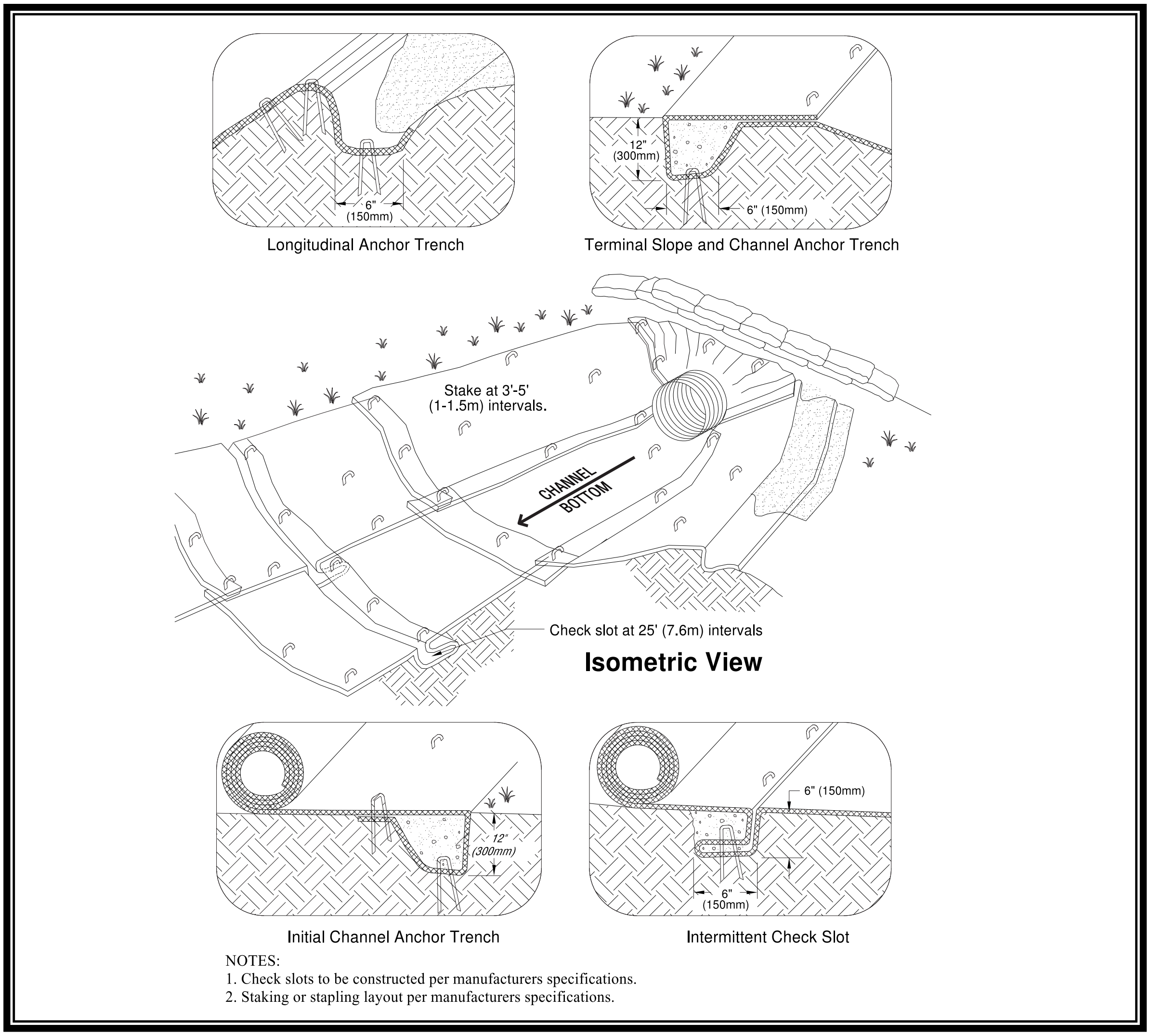


Figure 3.4. Channel Installation.

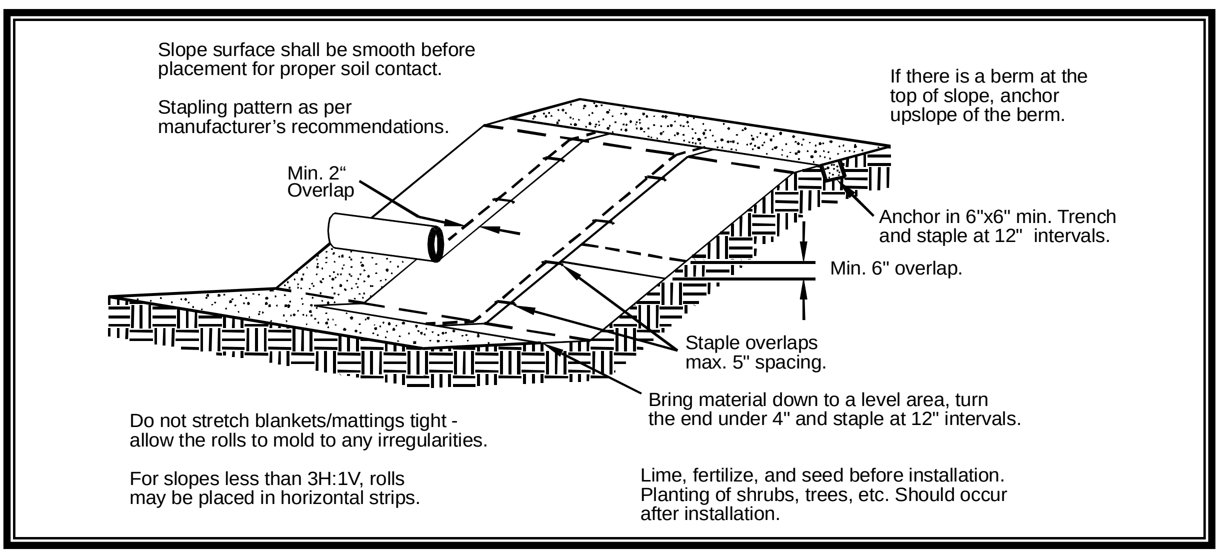


Figure 3.5. Slope Installation.

- If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket shall overlap the leading edge of the lower blanket and be stapled. On steeper slopes, install this overlap in a small trench, staple it, and cover it with soil.

- A wide variety of products is available. Therefore, it is critical that the design engineer consults the manufacturer's information and that a site visit takes place in order to ensure that the product specified is appropriate. Information is also available at the following web sites:

  - WSDOT: http://www.wsdot.wa.gov/eesc/environmental/

  - Texas Transportation Institute: http://www.dot.state.tx.us/insdtdot/orgchart/cmd/erosion/contents.htm

- Jute matting must be used in conjunction with mulch (BMP C121). Excelsior, woven straw blankets and coir (coconut fiber) blankets may be installed without mulch. There are many other types of erosion control nets and blankets on the market that may be appropriate in certain circumstances.

- In general, most nets require mulch in order to prevent erosion because of their open structure. Blankets typically do not require mulch because they normally provide complete protection of the surface.

- Extremely steep, unstable, wet, or rocky slopes are often appropriate locations for use of synthetic blankets, as are riverbanks, beaches and other high-energy environments. If synthetic blankets are used, hydromulch the soil first.

- 100 percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which can last up to a year.

- Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

Maintenance Standards

- Good contact with the ground must be maintained, and erosion must not occur beneath the net or blanket.
- Any areas of the net or blanket that are damaged or not in close contact with the ground shall be repaired and stapled.
- If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area protected.

3.1.11 BMP C123: Plastic Covering

Purpose

To provide immediate, short-term erosion protection of slopes and disturbed areas.

Conditions of Use

- Plastic covering may be used on disturbed areas that require cover measures for less than 30 days, except as stated below.
- Plastic is particularly useful for protecting cut and fill slopes and stockpiles, but the rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than 6 months) applications.
- Clear plastic sheeting can be used over newly-seeded areas to create a greenhouse effect and encourage grass growth if the hydroseed was installed too late in the season to establish 75 percent grass cover, or if the wet season started earlier than normal. Clear plastic should not be used for this purpose during the summer months because the resulting high temperatures can kill the grass.
- Due to rapid runoff caused by plastic sheeting, this method shall not be used upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.
- Plastic sheeting requires close monitoring and frequent maintenance to ensure proper performance. Water quality standards must be met at all times.
- While plastic is inexpensive to purchase, the added cost of installation, maintenance, removal, and disposal make this an expensive material, up to $1.50-2.00 per square yard.
- Whenever plastic is used to protect slopes, water collection measures must be installed at the base of the slope. These measures include plastic-covered berms, channels, and pipes used to covey clean rainwater away from bare soil and disturbed areas. At no time is clean runoff from a plastic covered slope to be mixed with dirty runoff from a project.
- Other uses for plastic include:
    - Temporary ditch liner
    - Pond liner in temporary sediment pond

  - Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored
  - Emergency slope protection during heavy rains
  - Temporary drainpipe ("elephant trunk") used to direct water.

Design and Installation Specifications

- Plastic slope cover must be installed as follows:
  - Run plastic up and down slope, not across slope
  - Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet
  - Minimum of 8-inch overlap at seams
  - Tape all seams on long or wide slopes, or slopes subject to wind
  - Place plastic into a small (12-inch wide by 6-inch deep) slot trench at the top of the slope and backfill with soil to keep water from flowing underneath
  - Place sand filled burlap or geotextile bags every 3 to 6 feet along seams and pound a wooden stake through each to hold them in place
  - Inspect plastic for rips, tears, and open seams regularly and repair immediately. This prevents high velocity runoff from contacting bare soil which causes extreme erosion.
  - Sandbags may be lowered into place tied to ropes. However, all sandbags must be staked in place.
- Plastic sheeting shall have a minimum thickness of 0.06 millimeters.
- If erosion at the toe of a slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe of the slope in order to reduce the velocity of runoff.

Maintenance Standards

- Torn sheets must be replaced and open seams repaired.
- If the plastic begins to deteriorate due to ultraviolet radiation, it must be completely removed and replaced.
- When the plastic is no longer needed, it shall be completely removed.

3.1.12 BMP C124: Sodding

Purpose

To establish permanent turf for immediate erosion protection and stabilize drainage ways where concentrated overland flow will occur.

Conditions of Use

Sodding may be used in the following areas:

- Disturbed areas that require short-term or long-term cover.
- Disturbed areas that require immediate vegetative cover.
- All waterways that require vegetative lining. Waterways may also be seeded rather than sodded, and protected with a net or blanket.

Design and Installation Specifications

Sod shall be free of weeds, of uniform thickness (approximately 1 inch thick), and shall have a dense root mat for mechanical strength.

The following steps are recommended for sod installation:

- Shape and smooth the surface to final grade in accordance with the approved grading plan. The swale needs to be overexcavated 4 to 6 inches below design elevation to allow room for placing soil amendment and sod.
- Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than ten percent or the permeability is less than 0.6 inches per hour. Compost used shall meet Ecology publication 94-038 specifications for Grade A quality compost.
- Fertilize according to the supplier's recommendations.
- Work lime and fertilizer 1 to 2 inches into the soil, and smooth the surface.
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.
- Roll the sodded area and irrigate.

- When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

Maintenance Standards

If the grass is unhealthy, the cause shall be determined and appropriate action taken to reestablish a healthy groundcover. If it is impossible to establish a healthy groundcover due to frequent saturation, instability, or some other cause, the sod shall be removed, the area seeded with an appropriate mix, and protected with a net or blanket.

3.1.13 BMP C125: Topsoiling

Purpose

To provide a suitable growth medium for final site stabilization with vegetation.

While not a permanent cover practice, topsoiling is an integral component of providing permanent cover in areas with an unsuitable soil surface for plant growth. Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the water, fertilizer and pesticides needed to support installed landscapes. Topsoil does not include any subsoils but only the material from the top several inches including organic debris.

Conditions of Use

- Leave native soils undisturbed as much as possible. Restore native soils disturbed during clearing and grading as much as possible, to a condition where moisture-holding capacity is equal to or better than the original site conditions. This criterion can be met by using onsite native topsoil, incorporating amendments into onsite soil, or importing blended topsoil.
- Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.
- Stripping of existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. If an existing soil system is functioning properly it shall be preserved in its undisturbed and uncompacted condition.
- Depending on where the topsoil comes from, or what vegetation was on site before disturbance, invasive plant seeds may be included and could cause problems for establishing native plants, landscaped areas, or grasses.
- Topsoil from the site will contain mycorrhizal bacteria that are necessary for healthy root growth and nutrient transfer. These native mycorrhiza are acclimated to the site and will provide optimum conditions for establishing grasses. Use commercially available mycorrhiza products when topsoil is brought in from offsite.

Design and Installation Specifications

If topsoiling is to be done, consider the following:

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium. Topsoil depth shall be at least 8 inches with a minimum organic content of 10 percent dry weight and pH between 6.0 and 8.0 or matching the pH of the undisturbed soil. This can be accomplished either by returning native topsoil to the site and/or incorporating organic amendments. Incorporate organic amendments to a minimum 8-inch depth except where tree roots or other natural features limit the depth of incorporation. Subsoils below the 12-inch depth shall be scarified at least 2 inches to avoid stratified layers, where feasible. The decision to either layer topsoil over a subgrade or incorporate topsoil into the underlying layer may vary depending on the planting specified.

- If blended topsoil is imported, then limit fines to 25 percent passing through a 200 sieve.

- The final composition and construction of the soil system will result in a natural selection or favoring of certain plant species over time. For example, recent practices have shown that incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.

- Locate the topsoil stockpile so that it meets specifications and does not interfere with work on the site. It may be possible to locate more than one pile in proximity to areas where topsoil will be used.

- Allow sufficient time in scheduling for topsoil to be spread prior to seeding, sodding, or planting.

- Care must be taken not to apply to subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.

- If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to prevent a lack of bonding is to actually work the topsoil into the layer below for a depth of at least 6 inches.

- Ripping or re-structuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.

- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Avoid areas of natural ground water recharge.

- Stripping shall be confined to the immediate construction area. A 4- to 6-inch stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.

Stockpiling of topsoil shall occur in the following manner:

- Side slopes of the stockpile shall not exceed 2:1.
- An interceptor dike with gravel outlet and silt fence shall surround all topsoil stockpiles between October 1 and April 30. Between May 1 and September 30, an interceptor dike with gravel outlet and silt fence shall be installed if the stockpile will remain in place for a longer period of time than active construction grading.
- Erosion control seeding or covering with clear plastic or other mulching materials of stockpiles shall be completed within 2 days (October 1 through April 30) or 7 days (May 1 through September 30) of the formation of the stockpile. Native topsoil stockpiles shall not be covered with plastic.
- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.
- When native topsoil is to be stockpiled and reused the following should apply to ensure that the mycorrhizal bacterial, earthworms, and other beneficial organisms will not be destroyed:
    - Topsoil is to be re-installed within 4 to 6 weeks
    - Topsoil is not to become saturated with water
    - Plastic cover is not allowed.

Maintenance Standards

Inspect stockpiles regularly, especially after large storm events. Stabilize any areas that have eroded.

3.1.14 BMP C126: Polyacrylamide for Soil Erosion Protection

Purpose

A soil binding agent to prevent soil erosion.

Applying Polyacrylamide (PAM) to bare soil in advance of rain significantly reduces erosion and controls sediment in two ways. First, PAM increases the soil's available pore volume, thus increasing infiltration through flocculation and reducing the quantity of stormwater runoff. Second, it increases flocculation of suspended particles and aids in their deposition, thus reducing stormwater runoff turbidity and improving water quality.

Conditions of Use

PAM shall only be applied with prior acceptance by the County by means of a variance, and PAM shall not be directly applied to water or allowed to enter a water body. Some PAMs are more toxic and carcinogenic than others. Only the most environmentally safe PAM products should be used, as noted in the following paragraph.

The specific PAM copolymer formulation must be anionic. Cationic PAM shall not be used in any application because of known aquatic toxicity problems. Only the highest drinking water grade PAM, certified for compliance with ANSI/NSF Standard 60 for drinking water treatment, will be used for soil applications. Recent media attention and high interest in PAM has resulted in some entrepreneurial exploitation of the term "polymer." All PAM are polymers, but not all polymers are PAM, and not all PAM products comply with ANSI/NSF Standard 60. PAM use shall be reviewed and approved by the County. The Washington State Department of Transportation (WSDOT) has listed approved PAM products on their web page.

In areas that drain to a sediment pond, PAM can be applied to bare soil under the following conditions:

- During rough grading operations
- Staging areas
- Balanced cut and fill earthwork
- Haul roads prior to placement of crushed rock surfacing
- Compacted soil roadbase

- Stockpiles
- After final grade and before paving or final seeding and planting
- Pit sites
- Sites having a winter shut down. In the case of winter shut down, or where soil will remain unworked for several months, use PAM together with mulch.

Design and Installation Specifications

PAM may be applied in dissolved form with water, or it may be applied in dry, granular or powdered form. The preferred application method is the dissolved form.

PAM is to be applied at a maximum rate of 2/3 pound PAM per 1,000 gallons water (80 mg/L) per 1 acre of bare soil. Table 3.8 can be used to determine the PAM and water application rate for a disturbed soil area. Higher concentrations of PAM **do not** provide any additional effectiveness.

Table 3.8. PAM and Water Application Rates.

Disturbed Area (ac)	PAM (lbs)	Water (gal)
0.50	0.33	500
1.00	0.66	1,000
1.50	1.00	1,500
2.00	1.32	2,000
2.50	1.65	2,500
3.00	2.00	3,000
3.50	2.33	3,500
4.00	2.65	4,000
4.50	3.00	4,500
5.00	3.33	5,000

The Preferred Method:

- Pre-measure the area where PAM is to be applied and calculate the amount of product and water necessary to provide coverage at the specified application rate (2/3 pound PAM/1,000 gallons/acre).
- PAM has high solubility in water, but dissolves very slowly. Dissolve pre-measured dry granular PAM with a known quantity of clean water in a bucket several hours or overnight. Mechanical

mixing will help dissolve the PAM. Always add PAM to water - not water to PAM.

- Pre-fill the water truck about 1/8 full with water. The water does not have to be potable, but it must have relatively low turbidity – in the range of 20 NTU or less.
- Add PAM /Water mixture to the truck
- Completely fill the water truck to specified volume.
- Spray PAM/Water mixture onto dry soil until the soil surface is uniformly and completely wetted.

An Alternate Method:

PAM may also be applied as a powder at the rate of 5 lbs. per acre. This must be applied on a day that is dry. For areas less than 5 to 10 acres, a hand-held "organ grinder" fertilizer spreader set to the smallest setting will work. Tractor-mounted spreaders will work for larger areas.

The following shall be used for application of PAM:

- PAM shall be used in conjunction with other BMPs and not in place of other BMPs.
- Do not use PAM on a slope that flows directly into a stream or wetland. The stormwater runoff shall pass through a sediment control BMP prior to discharging to surface waters.
- Do not add PAM to water discharging from site.
- When the total drainage area is greater than or equal to 5 acres, PAM treated areas shall drain to a sediment pond.
- Areas less than 5 acres shall drain to sediment control BMPs, such as a minimum of three check dams per acre. The total number of check dams used shall be maximized to achieve the greatest amount of settlement of sediment prior to discharging from the site. Each check dam shall be spaced evenly in the drainage channel through which stormwater flows are discharged offsite.
- On all sites, the use of silt fence shall be maximized to limit the discharges of sediment from the site.
- All areas not being actively worked shall be covered and protected from rainfall. PAM shall not be the only cover BMP used.

- PAM can be applied to wet soil, but dry soil is preferred due to less sediment loss.

- PAM will work when applied to saturated soil but is not as effective as applications to dry or damp soil.

- Keep the granular PAM supply out of the sun. Granular PAM loses its effectiveness in three months after exposure to sunlight and air.

- Proper application and re-application plans are necessary to ensure total effectiveness of PAM usage.

- PAM, combined with water, is very slippery and can be a safety hazard. Care must be taken to prevent spills of PAM powder onto paved surfaces. During an application of PAM, prevent over-spray from reaching pavement as pavement will become slippery. If PAM powder gets on skin or clothing, wipe it off with a rough towel rather than washing with water-this only makes cleanup messier and take longer.

- PAM designated for these uses should be "water soluble" or "linear" or "non-crosslinked". Cross-linked or water absorbent PAM, polymerized in highly acidic (pH<2) conditions, are used to maintain soil moisture content.

- The PAM anionic charge density may vary from 2 to 30 percent; a value of 18 percent is typical. Studies conducted by the United States Department of Agriculture (USDA)/ARS demonstrated that soil stabilization was optimized by using very high molecular weight (12 to 15 mg/mole), highly anionic (>20 percent hydrolysis) PAM.

- PAM tackifiers are available and being used in place of guar and alpha plantago. Typically, PAM tackifiers should be used at a rate of no more than 0.5 to 1 lb. per 1,000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at a rate of 3 to 5 lbs. per acre, which can be too much. In addition, pump problems can occur at higher rates due to increased viscosity.

Maintenance Standards

- PAM may be reapplied on actively worked areas after a 48-hour period.

- Reapplication is not required unless PAM treated soil is disturbed or unless turbidity levels show the need for an additional application. If PAM treated soil is left undisturbed a reapplication may be necessary after 2 months. More PAM applications may be required for steep slopes, silty and clayey soils (USDA Classification Type "C" and "D" soils), long grades, and high precipitation areas. When PAM is applied first to bare soil and then covered with straw, a reapplication may not be necessary for several months.

- Loss of sediment and PAM may be a basis for penalties per RCW 90.48.080.

3.1.15 BMP C130: Surface Roughening

Purpose

To aid in the establishment of vegetative cover, reduce runoff velocity, increase infiltration, and provide for sediment trapping through the provision of a rough soil surface. Horizontal depressions are created by operating a tiller or other suitable equipment on the contour, or by leaving slopes in a roughened condition by not fine grading them.

Conditions for Use

- All slopes steeper than 3:1 and greater than 5 vertical feet require surface roughening.
- Areas with grades steeper than 3:1 shall be roughened to a depth of 2 to 4 inches prior to seeding.
- Areas that will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.
- Slopes with a stable rock face do not require roughening.
- Slopes where mowing is planned should not be excessively roughened.

Design and Installation Specifications

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, contour furrows, and tracking. See Figure 3.6 for tracking and contour furrows. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material that sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment. Stair steps must be on contour or gullies will form on the slope.

- Areas that will be mowed (these areas should have slopes less steep than 3:1) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.

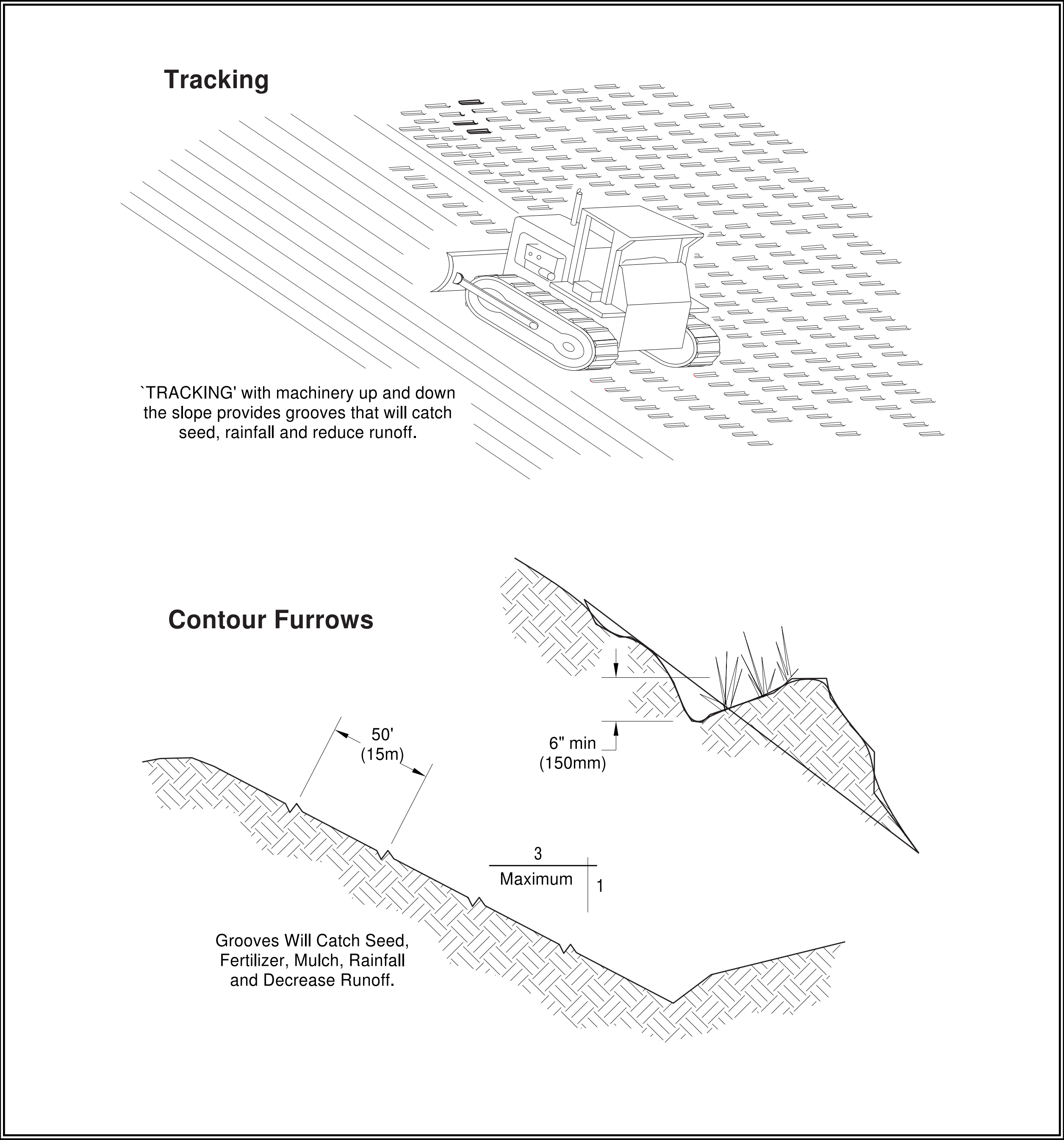


Figure 3.6. Surface Roughening by Tracking and Contour Furrows.

- Graded areas with slopes greater than 3:1 but less than 2:1 shall be roughened before seeding. This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.

- Tracking is done by operating equipment up and down the slope to leave horizontal depressions in the soil.

Maintenance Standards

- Seed areas graded in this manner as quickly as possible.
- Regular inspections should be made of the area. If rills appear, re-grade and re-seed immediately.

3.1.16 BMP C131: Gradient Terraces

Purpose

To reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity.

Conditions of Use

- Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may be used only where suitable outlets are or will be made available. See Figure 3.7 for gradient terraces.

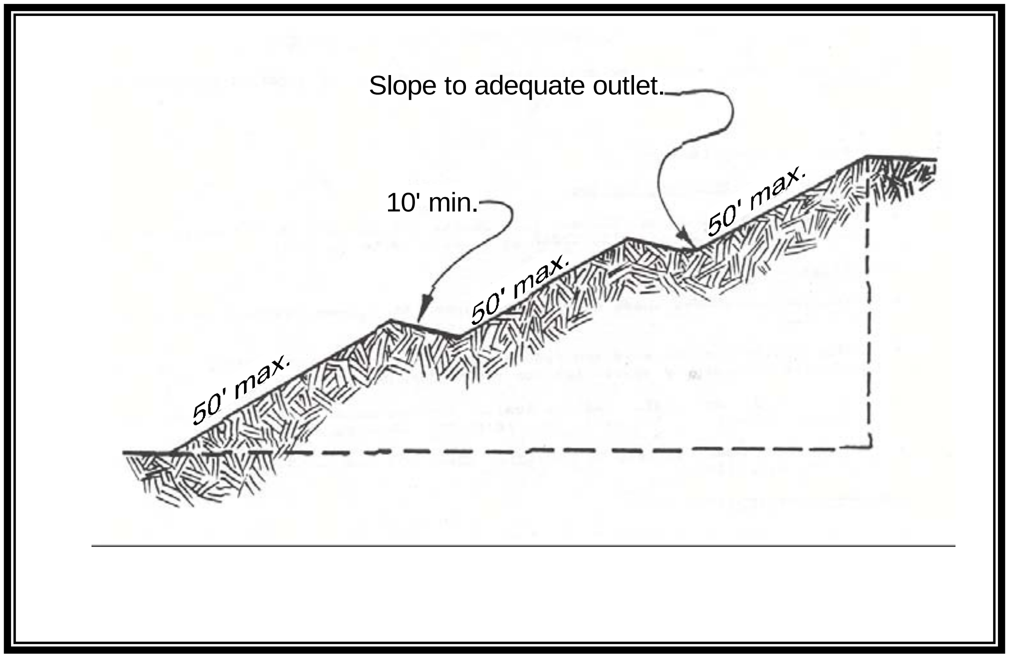


Figure 3.7. Gradient Terraces.

Design and Installation Specifications

- Determine the maximum spacing of gradient terraces using the following formula:

$$VI = (0.8)s + y$$

Where: VI = vertical interval in feet
s = land rise per 100 feet, expressed in feet
y = a soil and cover variable with values from 1.0 to 4.0

Values of "y" are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The higher value is applicable only to erosion-resistant soils where a large amount of residue (1-1/2 tons of straw/acre equivalent) is on the surface.

- The minimum constructed cross-section shall meet the design dimensions.
- The top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace shall have a cross-section equal to that specified for the terrace channel.
- Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length. For short distances, terrace grades may be increased to improve alignment. The channel velocity shall not exceed that which is nonerosive for the soil type with the planned treatment.
- All gradient terraces shall have adequate outlets. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Use vegetative cover in the outlet channel.
- The design elevation of the water surface of the terrace shall not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.
- Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet.
- The drainage area above the top shall not exceed the area that would be drained by a terrace with normal spacing.
- The terrace shall have enough capacity to handle the peak runoff expected from a 2-year, 24-hour design storm without overtopping.
- The terrace cross-section should be proportioned to fit the land slope. The ridge height should include a reasonable settlement factor. The ridge shall have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel shall be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for

slopes steeper than 8 percent. The terrace can be constructed wide enough to be maintained using a small cat.

Maintenance Standards

- Performance maintenance as needed. Terraces should be inspected regularly; at least once a year, and after large storm events.

3.1.17 BMP C140: Dust Control

Purpose

To prevent wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.

Conditions of Use

Dust control must be used in areas (including roadways) subject to surface and air movement of dust, where impacts to drainage ways or surface waters are likely.

Design and Installation Specifications

- Vegetate or mulch areas that will not receive vehicle traffic. In areas where planting, mulching, or paving is impractical, apply gravel or landscaping rock.
- Limit dust generation by clearing only those areas where immediate activity will take place, leaving the remaining area(s) in the original condition, if stable. Maintain the original ground cover as long as practical.
- Construct natural or artificial windbreaks or windscreens. These may be designed as enclosures for small dust sources.
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto streets, see Stabilized Construction Entrance (BMP C105).
- Irrigation water can be used for dust control. Install irrigation systems as a first step on sites where dust control is a concern.
- Spray exposed soil areas with a dust palliative, following the manufacturer's instructions and cautions regarding handling and application. Oil based products are prohibited from use as a dust suppressant. The County may approve other dust palliatives such as calcium chloride or PAM.
- PAM (BMP C126) added to water at a rate of 0.5 lbs. per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to the increased infiltration of water into the soil and reduced evaporation. In addition, small soil particles are bonded together and are not as easily transported by wind. Adding PAM may actually reduce the quantity of water needed for dust control. PAM has also shown to

be relatively affordable and thus an extremely cost-effective dust control method.

Techniques that can be used for unpaved roads and lots include:

- Lower speed limits. High vehicle speed increases the amount of dust stirred up from unpaved roads and lots.
- Upgrade the road surface strength by improving particle size, shape, and mineral types that make up the surface and base materials.
- Add surface gravel to reduce the source of dust emission. Limit the amount of fine particles (those smaller than .075 mm) to 10 to 20 percent.
- Use geotextile fabrics to increase the strength of new roads or roads undergoing reconstruction.
- Encourage the use of alternate, paved routes, if available.
- Restrict use by tracked vehicles and heavy trucks to prevent damage to road surface and base.
- Apply chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments.
- Pave unpaved permanent roads and other trafficked areas.
- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- Limit dust-causing work on windy days.
- Contact the Olympic Region Clean Air Agency (ORCAA) for guidance and training on other dust control measures. Compliance with the ORCAA constitutes compliance with this BMP.

Maintenance Standards

Respray area as necessary to keep dust to a minimum.

3.1.18 BMP C150: Materials on Hand

Purpose

Quantities of erosion prevention and sediment control materials can be kept on the project site at all times for emergency situations such as unexpected heavy summer rains. Having these materials onsite reduces the time needed to implement BMPs when inspections indicate that existing BMPs are not meeting the Construction SWPPP requirements.

Conditions of Use

- Construction projects of any size or type can benefit from having materials on hand. A small commercial development project could have a roll of plastic and some gravel available for immediate protection of bare soil and temporary berm construction. A large earthwork project, such as highway construction, might have several tons of straw, several rolls of plastic, flexible pipe, sandbags, geotextile fabric, and steel “T” posts.

- Materials are stockpiled and readily available before any site clearing, grubbing, or earthwork begins. A large contractor or developer could keep a stockpile of materials that are available to be used on several projects.

- If storage space at the project site is at a premium, the contractor could maintain the materials at their office or yard. The office or yard must be less than an hour from the project site.

Design and Installation Specifications

Depending on project type, size, complexity, and length, materials and quantities will vary. A good minimum that will cover numerous situations includes:

Material	Measure	Quantity
Clear Plastic, 6 mil	100 foot roll	1-2
Drainpipe, 6- or 8-inch diameter	25 foot section	4-6
Sandbags, filled	each	25-50
Straw Bales for mulching,	approx. 50# each	10-20
Quarry Spalls	ton	2-4
Washed Gravel	cubic yard	2-4
Geotextile Fabric	100 foot roll	1-2
Catch Basin Inserts	each	2-4
Steel “T” Posts	each	12-24

Maintenance Standards

- All materials with the exception of the quarry spalls, steel "T" posts, and gravel should be kept covered and out of both sun and rain.
- Re-stock materials used as needed.

3.1.19 BMP C151: Concrete Handling

Purpose

To minimize and eliminate concrete process water and slurry from entering waters of the state.

Conditions of Use

Any time concrete is used, these management practices shall be utilized, since concrete work can generate process water and slurry that contain fine particles and high pH, both of which can violate water quality standards in the receiving water. Concrete construction projects include, but are not limited to, the following:

- Curbs
- Sidewalks
- Roads
- Bridges
- Foundations
- Floors
- Runways.

Design and Installation Specifications

- Concrete truck chutes, pumps, and internals shall be washed out only into formed areas awaiting installation of concrete or asphalt.

- Unused concrete remaining in the truck and pump shall be returned to the originating batch plant for recycling, as feasible.

- Hand tools including, but not limited to, screeds, shovels, rakes, floats, and trowels shall be washed off only into formed areas awaiting installation of concrete or asphalt.

- Equipment that cannot be easily moved, such as concrete pavers, shall only be washed in areas that do not directly drain to natural or constructed stormwater conveyances.

- Washdown from areas such as concrete aggregate driveways shall not drain directly to natural or constructed stormwater conveyances.

- When no formed areas are available, washwater and leftover product shall be contained in a lined container or a lined hole dug on site. Lining shall be a minimum of 10-mil polyethylene sheeting and shall be free of holes, tears, or other defects that compromise the impermeability of the material. The soil base shall be prepared free of rocks or other debris that may cause tears or holes in the plastic lining material. Contained concrete shall be disposed of in a manner that does not violate groundwater or surface water quality standards.

Maintenance Standards

Containers shall be checked for holes in the liner daily during concrete pours and repaired the same day.

3.1.20 BMP C152: Sawcutting and Surfacing Pollution Prevention

Purpose

To minimize and eliminate process water and slurry from entering waters of the State.

Conditions of Use

Anytime sawcutting or surfacing operations take place, these management practices shall be utilized, since sawcutting and surfacing operations generate slurry and process water that contains fine particles and high pH (concrete cutting), both of which can violate the water quality standards in the receiving water. Sawcutting and surfacing operations include, but are not limited to, the following:

- Sawing
- Coring
- Grinding
- Roughening
- Hydro-demolition
- Bridge and road surfacing.

Design and Installation Specifications

- Slurry and cuttings shall be vacuumed during cutting and surfacing operations.
- Slurry and cuttings shall not remain on permanent concrete or asphalt pavement overnight.
- Slurry and cuttings shall not drain to any natural or constructed drainage conveyance.
- Collected slurry and cuttings shall be disposed of in a manner that does not violate groundwater or surface water quality standards.
- Process water that is generated during hydro-demolition, surface roughening or similar operations shall not drain to any natural or constructed drainage conveyance and shall be disposed of in a manner that does not violate groundwater or surface water quality standards.
- Cleaning waste material and demolition debris shall be handled and disposed of in a manner that does not cause contamination of

water. If the area is swept with a pick-up sweeper, the material must be hauled out of the area to an appropriate disposal site.

Maintenance Standards

Continually monitor operations to determine whether slurry, cuttings, or process water could enter waters of the state. If inspections show that a violation of water quality standards could occur, stop operations and immediately implement preventive measures such as berms, barriers, secondary containment, and vacuum trucks.

3.1.21 BMP C153: Material Delivery, Storage and Containment

Purpose

To prevent, reduce, or eliminate pollutant discharge from material delivery and storage to the stormwater system or watercourses by minimizing onsite hazardous materials storage, storing materials in a designated area, and installing secondary containment.

Conditions of Use

These procedures are suitable for use at all construction sites with delivery and storage of the following materials:

- Petroleum products such as fuel, oil and grease
- Soil stabilizers and binders (e.g., Polyacrylamide)
- Fertilizers, pesticides and herbicides
- Detergents
- Asphalt and concrete compounds
- Hazardous chemicals such as acids, lime, adhesives, paints, solvents and curing compounds
- Any other material that may be detrimental if released to the environment.

Design and Installation Specifications

To minimize risk, do the following:

- Locate temporary storage area away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Supply Material Safety Data Sheets (MSDS) for all stored materials. Chemicals should be kept in their original labeled containers.
- Minimize onsite hazardous material storage.
- Handle hazardous materials as infrequently as possible.

- During the wet weather season (October 1 – April 30), consider storing materials in a covered area.
- Store materials in secondary containments such as earthen dike, a horse trough, or even a children's wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in "bus boy" trays or concrete mixing trays.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, in secondary containment.
- If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids to reduce corrosion. Domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.

Material Storage Areas and Secondary Containment Practices:

- Liquids, petroleum products, and substances listed in 40 CFR Parts 110, 117, or 302 shall be stored in approved containers and drums and shall not be overfilled. Containers and drums shall be stored in temporary secondary containment facilities.
- Temporary secondary containment facilities shall provide for a spill containment volume able to contain precipitation from a 25-year, 24-hour storm event, plus 10 percent of the total enclosed container volume of all containers, or 110 percent of the capacity of the largest container within its boundary, whichever is greater.
- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, accumulated rainwater and spills shall be collected and placed into drums. These liquids shall be handled as hazardous waste unless testing determines them to be non-hazardous.
- Provide sufficient separation between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (October 1 – April 30), each secondary containment facility shall be covered during non-working days, prior to and during rain events.

- Keep material storage areas clean, organized and equipped with an ample supply of appropriate spill clean-up material (spill kit).

- The spill kit should include, at a minimum:

  - 1-Water Resistant Nylon Bag
  - 3-Oil Absorbent Socks 3” x 4’
  - 2-Oil Absorbent Socks 3” x 10’
  - 12-Oil Absorbent Pads 17” x 19”
  - 1-Pair Splash Resistant Goggles
  - 3-Pair Nitrile Gloves
  - 10-Disposable Bags with Ties
  - Instructions.

3.1.22 BMP C160: Certified Erosion and Sediment Control Lead

Purpose

To ensure compliance with all local, state, and federal erosion and sediment control and water quality requirements by designating a Certified Erosion and Sediment Control Lead (CESCL).

Conditions of Use

A CESCL shall be made available on projects disturbing ground 1 acre or larger and that discharge stormwater to surface waters of the state

- The CESCL shall:
  - Have a current certificate proving attendance in an erosion and sediment control training course that meets the minimum ESC training and certification requirements established by Ecology (see details below).

    Ecology will maintain a list of ESC training and certification providers at: www.ecy.wa.gov/programs/wq/stormwater.

    OR
  - Be a Certified Professional in Erosion and Sediment Control (CPESC); for additional information go to: www.cpesc.net.

Specifications

Certification shall remain valid for 3 years.

- The CESCL shall have authority to act on behalf of the contractor or developer and shall be available, on call, 24 hours per day throughout the period of construction.
- The Construction SWPPP shall include the name, telephone number, fax number, and address of the designated CESCL.
- A CESCL may provide inspection and compliance services for multiple construction projects in the same geographic region.

Duties and responsibilities of the CESCL shall include, but are not limited to the following:

- Maintaining permit file on site at all times which includes the SWPPP and any associated permits and plans.

- Directing BMP installation, inspection, maintenance, modification, and removal.
- Updating all project drawings and the Construction SWPPP with changes made.
- Keeping daily logs, and inspection reports. Inspection reports shall include:
    - Inspection date/time.
    - Weather information; general conditions during inspection and approximate amount of precipitation since the last inspection.
    - A summary or list of all BMPs implemented, including observations of all erosion/sediment control structures or practices. The following shall be noted:
        - Locations of BMPs inspected
        - Locations of BMPs that need maintenance
        - Locations of BMPs that failed to operate as designed or intended
        - Locations of where additional or different BMPs are required.
    - Visual monitoring results, including a description of discharged stormwater. The presence of suspended sediment, turbid water, discoloration, and oil sheen shall be noted, as applicable.
    - Any water quality monitoring performed during inspection.
    - General comments and notes, including a brief description of any BMP repairs, maintenance or installations made as a result of the inspection.
- Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.

Minimum Requirements for ESC Training and Certification Courses

General Requirements

1. The course shall teach the construction stormwater pollution prevention guidance provided in the most recent version of:

    a. The Washington State Dept. of Ecology Stormwater Management Manual for Western Washington,

    b. Other equivalent stormwater management manuals approved by Ecology.

2. Upon completion of course, each attendee shall receive documentation of certification, including, at a minimum, a wallet-sized card that certifies completion of the course. Certification shall remain valid for 3 years. Recertification may be obtained by completing the 8-hour refresher course or by taking the initial 16-hour training course again.

3. The initial certification course shall be a minimum of 16 hours (with a reasonable time allowance for lunch, breaks, and travel to and from field) and include a field element and test.

    a. The field element must familiarize students with the proper installation, maintenance and inspection of common erosion and sediment control BMPs including, but not limited to, blankets, check dams, silt fence, straw mulch, plastic, and seeding.

    b. The test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.

4. The refresher course shall be a minimum of 8 hours and include a test.

    a. The refresher course shall include:

        i. Applicable updates to the Stormwater Management Manual that is used to teach the course, including new or updated BMPs; and

        ii. Applicable changes to the NPDES General Permit for Construction Activities.

    b. The refresher course test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.

    c. The refresher course may be taught using an alternative format (e.g., internet, CD ROM, etc.) if the module is approved by Ecology.

Required Course Elements

1. Erosion and Sedimentation Impacts

    a. Examples/Case studies

2. Erosion and Sedimentation Processes
    a. Definitions
    b. Types of erosion
    c. Sedimentation
        i. Basic settling concepts
        ii. Problems with clays/turbidity
3. Factors Influencing Erosion Potential
    a. Soil
    b. Vegetation
    c. Topography
    d. Climate
4. Regulatory Requirements
    a. NPDES – Construction Stormwater General Permit
    b. Local requirements and permits
    c. Other regulatory requirements
5. Stormwater Pollution Prevention Plan (SWPPP)
    a. A SWPPP is a living document – revise it as necessary
    b. 12 Elements of a SWPPP; discuss suggested BMPs (with examples)
        1. Mark Clearing Limits
        2. Establish Construction Access
        3. Control Flow Rates
        4. Install Sediment Controls
        5. Stabilize Soils
        6. Protect Slopes
        7. Protect Drain Inlets
        8. Stabilize Channels and Outlets
        9. Control Pollutants
        10. Control De-watering
        11. Maintain BMPs
        12. Manage the Project

6. Monitoring/Reporting/Recordkeeping
    a. Site inspections/visual monitoring
        i. Disturbed areas
        ii. BMPs
        iii. Stormwater discharge points
    b. Water quality sampling/analysis
        i. Turbidity
        ii. pH
    c. Monitoring frequency
        i. Set by NPDES permit
        ii. Inactive sites – reduced frequency
    d. Adaptive Management
        i. When monitoring indicates problem, take appropriate action (e.g., install/maintain BMPs)
        ii. Document the corrective action(s) in SWPPP
    e. Reporting
        i. Inspection reports/checklists
        ii. Discharge Monitoring Reports (DMR)
        iii. Non-compliance notification

Instructor Qualifications

1. Instructors must be qualified to effectively teach the required course elements.
2. At a minimum, instructors must have:
    a. Current certification as a Certified Professional in Erosion and Sediment Control (CPESC), or
    b. Completed a training program for teaching the required course elements, or
    c. The academic credentials and instructional experience necessary for teaching the required course elements.
3. Instructors must demonstrate competent instructional skills and knowledge of the applicable subject matter.

3.1.23 BMP C161: Payment of Erosion Control Work

Purpose

As with any construction operation, pay the contractor for erosion control work. Payment for erosion control must be addressed during project development and design. Method of payment should be identified in the SWPPP.

Conditions of Use

Erosion control work should never be "incidental" to the contract as it is extremely difficult for the contractor to bid the work. Work that is incidental to the contract is work where no separate measurement or payment is made. The cost for incidental work is included in payments made for applicable bid items in the Schedule of Unit Prices. For example, any erosion control work associated with an item called "Clearing and Grubbing" is bid and paid for as part of that item, not separately.

Several effective means for payment of erosion control work are described below. These include:

- Temporary Erosion and Sediment Control (TESC) Lump Sum
- TESC-Force Account
- Unit Prices
- Lump Sum.

TESC Lump Sum

One good method for achieving effective erosion and sediment control is to set up a Progress Payment system whereby the contract spells out exactly what is expected and allows for monthly payments over the life of the contract.

For example, an Item called "TESC Lump Sum" is listed in the Bid Schedule of Unit Prices. An amount, such as $10,000, is written in both the Unit Price and Amount columns. This requires all bidders to bid $10,000 for the item. If $10,000 is not shown in the Amount column, each contractor bids the amount. Often this is under-bid, which can cause compliance difficulties later. In this example, the contractor is required to revise the project Construction SWPPP by developing a Contractor's Construction SWPPP (CSWPPP) that is specific to their operations.

Next, the following language is included in the TESC specification Payment section:

Based upon lump sum Bid Item “TESC Lump Sum”, payments will be made as follows:

A. Upon receipt of the Contractor’s CSWPPP, 25 percent.

B. After Notice To Proceed and before Substantial Completion, 50 percent will be prorated and paid monthly for compliance with the CSWPPP. Non-compliance will result in withholding of payment for the month of non-compliance.

C. At Final Payment, 25 percent for a clean site.

Payment for “TESC Lump Sum” will be full compensation for furnishing all labor, equipment, materials and tools to implement the CSWPPP, install, inspect, maintain, and remove temporary erosion and sediment controls as detailed in the drawings and specified herein, with the exception of those items measured and paid for separately.

TESC Force Account

One good method for ensuring that contingency money is available to address unforeseen erosion and sediment control problems is to set up an item called “TESC-Force Account”. For example, an amount such as $15,000 is written in both the Unit Price and Amount columns for the item. This requires all bidders to bid $15,000 for the item.

The Force Account is used only at the discretion of the contracting agency or developer. If there are no unforeseen erosion problems, the money is not used. If there are unforeseen erosion problems, the contracting agency would direct the work to be done and pay an agreed upon amount for the work (such as predetermined rates under a Time and Materials setting).

Contract language for this item could look like this:

Measurement and Payment for “TESC-Force Account” will be on a Force Account basis in accordance with _________ (include appropriate section of the Contract Specifications). The amount entered in the Schedule of Unit Prices is an estimate.

Unit Prices – When the material or work can be quantified, it can be paid by Unit Prices. For example, the project designer knows that 2 acres will need to be hydroseeded and sets up an Item of Work for Hydroseed, with a Bid Quantity of 2, and a Unit for Acre. The bidder writes in the unit Prices and Amount.

Unit Price items can be used in conjunction with TESC-Force Account and TESC-Lump Sum.

Lump Sum – In contracts where all the work in a project is paid as a Lump Sum, erosion control is usually not paid as a separate item. In order to ensure that appropriate amounts are bid into the contract, the contracting agency can request a Schedule of Values and require that all erosion control costs be identified.

3.1.24 BMP C162: Scheduling

Purpose

To reduce the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.

Conditions of Use

The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sedimentation control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so that serious erosion and sedimentation problems can be avoided.

Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The removal of surface ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide timely installation of erosion and sedimentation controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

Design Considerations

- Avoid rainy periods.
- Schedule projects to disturb only small portions of the site at any one time. Complete grading as soon as possible. Immediately stabilize the disturbed portion before grading the next portion. Practice staged seeding in order to revegetate cut and fill slopes as the work progresses.

3.1.25 BMP C180: Small Project Construction Stormwater Pollution Prevention

Purpose

To minimize or eliminate the discharge of sediment and other pollutants from small construction projects.

Conditions of Use

On small construction projects, those adding or replacing less than 2,000 square feet of impervious surface or clearing less than 7,000 square feet.

Design and Installation Specifications

- Plan and implement proper clearing and grading of the site. It is most important only to clear the areas needed, thus keeping exposed areas to a minimum. Phase clearing so that only those areas that are actively being worked are uncovered.

  Note: Flag clearing limits in the lot or area prior to initiating clearing.

- Soil shall be managed in a manner that does not permanently compact or deteriorate the final soil and landscape system. If disturbance and/or compaction occur the impact must be corrected at the end of the construction activity. This shall include restoration of soil depth, soil quality, permeability, and percent organic matter. Construction practices must not cause damage to or compromise the design of permanent landscape or infiltration areas.

- Locate excavated basement soil a reasonable distance behind the curb, such as in the backyard or side yard area. This will increase the distance eroded soil must travel to reach the storm sewer system. Cover soil piles until the soil is either used or removed. Locate piles so that sediment does not run into the street or adjoining yards.

- Backfill basement walls as soon as possible and rough grade the lot. This will eliminate large soil mounds, which are highly erodible, and prepares the lot for temporary cover, which will further reduce erosion potential.

- Remove excess soil from the site as soon as possible after backfilling. This will eliminate any sediment loss from surplus fill.

- If a lot has a soil bank higher than the curb, install a trench or berm, moving the bank several feet behind the curb. This will reduce the occurrence of gully and rill erosion while providing a storage and settling area for stormwater.

- Stabilize the construction entrance where traffic will leave the construction site and travel on paved roads or other paved areas within 1,000 feet of the site.

- Provide for periodic street cleaning to remove any sediment that may have been tracked out. Remove sediment by shoveling or sweeping and carefully removed to a suitable disposal area where it will not be re-eroded.

- Utility trenches that run up and down slopes must be backfilled within 7 days. Cross-slope trenches may remain open throughout construction to provide runoff interception and sediment trapping, provided that they do not convey turbid runoff off site.

3.2 Runoff Conveyance and Treatment BMPs

3.2.1 BMP C200: Interceptor Dike and Swale

Purpose

Convey stormwater by creating a ridge of compacted soil, or a ridge with an upslope swale, at the top or base of a disturbed slope or along the perimeter of a disturbed construction area.

Conditions of Use

Use the dike or swale to intercept runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent storm runoff from entering the work area and sediment-laden runoff from leaving the construction site.

Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility which can safely contain the stormwater:

- Locate upslope of a construction site to prevent runoff from entering disturbed area.

- When placed horizontally across a disturbed slope, it reduces the amount and velocity of runoff flowing down the slope.

- Locate downslope to collect runoff from a disturbed area and direct it to a sediment basin.

Design and Installation Specifications

- Dike and/or swale and channel must be stabilized with temporary or permanent vegetation or other channel protection during construction.

- Channel requires a positive grade for drainage; steeper grades require channel protection and check dams.

- Review construction for areas where overtopping may occur.

- Can be used at top of new fill before vegetation is established.

- May be used as a permanent diversion channel to carry the runoff.

- Sub-basin tributary area shall be 1 acre or less.

- Design capacity for the peak flow from a 10-year, 24-hour storm, assuming a Type 1A rainfall distribution, for temporary facilities. Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model. If a 15-minute (or less) time step is used, no correction factor is required. For conveyance systems that will also serve on a permanent basis, see design standards in Volume III, Chapter 3.

- **Interceptor dikes** shall meet the following criteria:

    - Top Width: 2 feet minimum
    - Height: 1.5 feet minimum on berm
    - Side Slope: 2:1 or flatter
    - Grade: Depends on topography, however, dike system minimum is 0.5 percent, maximum is 1 percent
    - Compaction Minimum of 90 percent ASTM D698 standard proctor.
    - Horizontal Spacing of Interceptor Dikes:

Average Slope	Slope Percent	Flowpath Length
20H:1V or less	3-5%	300 feet
(10 to 20)H:1V	5-10%	200 feet
(4 to 10)H:1V	10-25%	100 feet
(2 to 4)H:1V	25-50%	50 feet

Stabilization depends on velocity and reach:
Slopes <5 percent: Seed and mulch applied within 5 days of dike construction (see *BMP C121, Mulching*).
Slopes 5 to 40 percent: Dependent on runoff velocities and dike materials. Stabilization shall be done immediately using either sod or riprap or other measures to avoid erosion.

- The upslope side of the dike shall provide positive drainage to the dike outlet. No erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.

- Minimize construction traffic over temporary dikes. Use temporary cross culverts for channel crossing.

- **Interceptor swales** shall meet the following criteria:

  - Bottom Width: 2 feet minimum; the bottom shall be level
  - Depth: 1-foot minimum
  - Side Slope: 2:1 or flatter
  - Grade: Maximum 5 percent, with positive drainage to a suitable outlet (such as a sediment pond)
  - Stabilization: Seed as per *BMP C120*, *Temporary and Permanent Seeding*, or *BMP C202*, *Channel Lining*, 12 inches thick of riprap pressed into the bank and extending at least 8 inches vertical from the bottom.

- Inspect diversion dikes and interceptor swales once a week and after every rainfall. Immediately remove sediment from the flow area.

- Damage caused by construction traffic or other activity must be repaired before the end of each working day.

- Check outlets and make timely repairs as needed to avoid gully formation. When the area below the temporary diversion dike is permanently stabilized, remove the dike and fill and stabilize the channel to blend with the natural surface.

3.2.2 BMP C201: Grass-Lined Channels

Purpose

To provide a channel with a vegetative lining for conveyance of runoff. See Figure 3.8 for typical grass-lined channels.

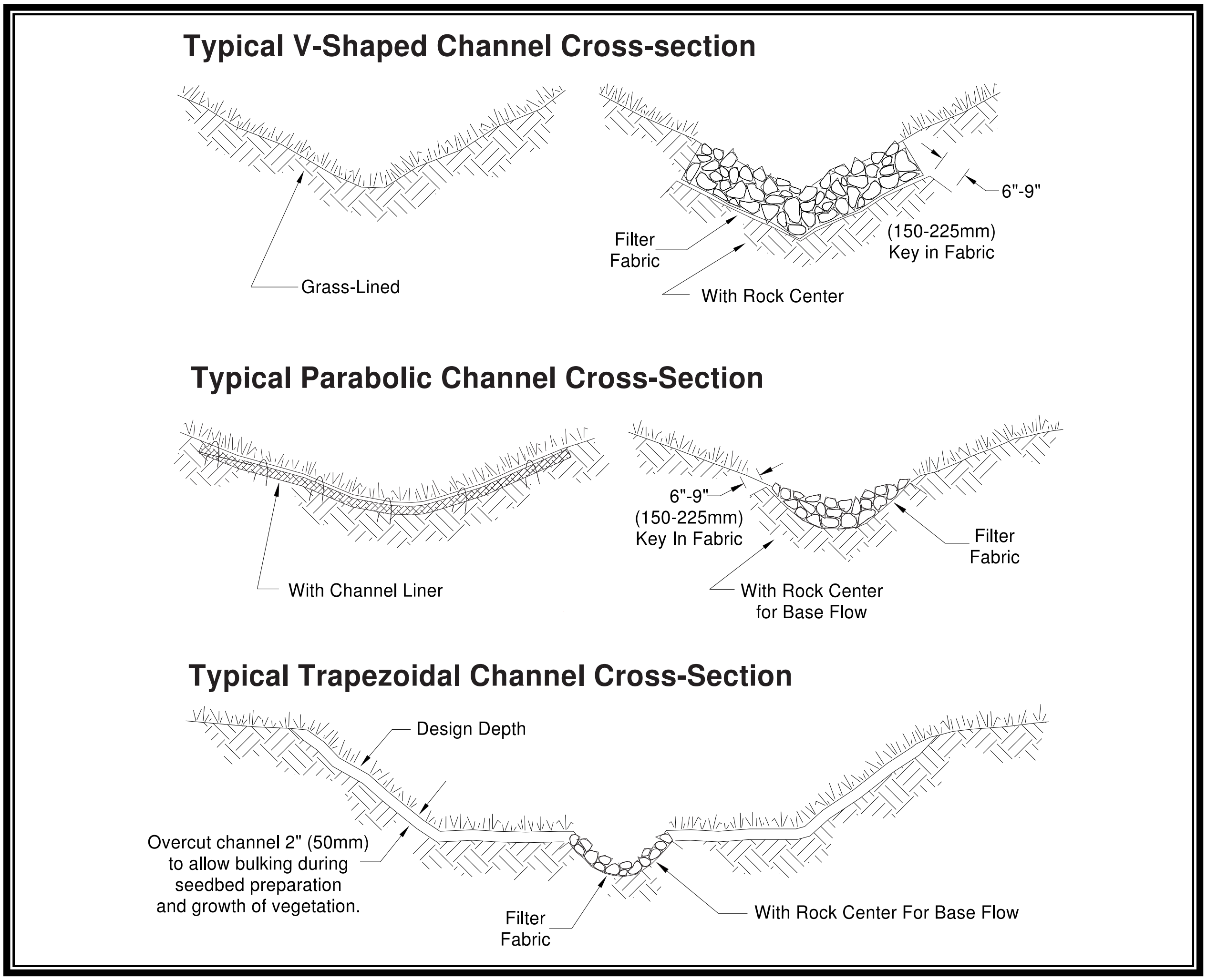


Figure 3.8. Typical Grass-Lined Channels.

Conditions of Use

This practice applies to construction sites where concentrated runoff needs to be contained to prevent erosion or flooding.

- When a vegetative lining can provide sufficient stability for the channel cross-section and at lower velocities of water (normally dependent on grade). This means that the channel slopes are generally less than 5 percent and space is available for a relatively large cross-section.

- Typical uses include roadside ditches, channels at property boundaries, outlets for diversions, and other channels and drainage ditches in low areas.

- Install channels to be vegetated before major earthwork and hydroseeded with a bonded fiber matrix (BFM). The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, install erosion control blankets over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, install in the bottom of the ditch in lieu of hydromulch and blankets.

Design and Installation Specifications

- Locate the channel where it can conform to the topography and other features such as roads.

- Locate them to use natural drainage systems to the greatest extent possible.

- Avoid sharp changes in alignment or bends and changes in grade.

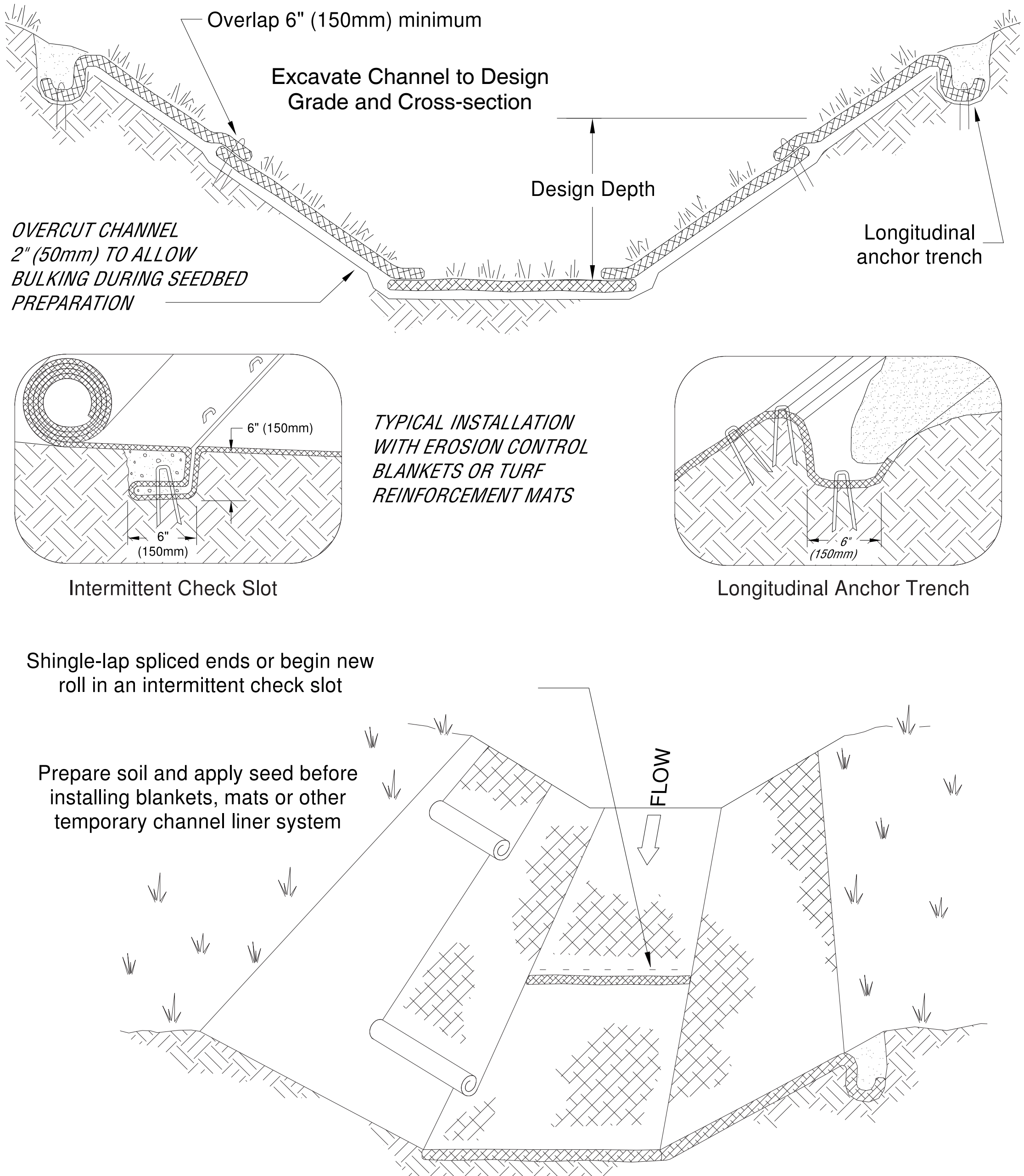
- Do not reshape the landscape to fit the drainage channel.

- The maximum design velocity shall be based on soil conditions, type of vegetation, and method of revegetation, but at no times shall velocity exceed 5 feet/second. The channel shall not be overtopped by the peak runoff from a 10-year, 24-hour storm, assuming a Type 1A rainfall distribution." Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model to determine a flow rate which the channel must contain.

- Where the grass-lined channel will also function as a permanent stormwater conveyance facility the channel must meet the conveyance requirements defined in Volume III, Chapter 3.

- An **established** grass or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or blankets.

- If design velocity of a channel to be vegetated by seeding exceeds 2 ft/sec, a temporary channel liner is required. Geotextile or mulch protection such as straw or netting should be used to provide stability until the vegetation is fully established. See Figure 3.9.



NOTES:

1. Design velocities exceeding 2 ft/sec (0.5m/sec) require temporary blankets, mats or similar liners to protect seed and soil until vegetation becomes established.
2. Grass-lined channels with design velocities exceeding 6 ft/sec (2m/sec) should include turf reinforcement mats.

Figure 3.9. Temporary Channel Liners.

- Temporary check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

- If vegetation is established by sodding, the permissible velocity for established vegetation may be used and no temporary liner is needed.

- Do not subject grass-lined channel to sedimentation from disturbed areas. Use sediment-trapping BMPs upstream of the channel.

- **V-shaped grass channels** generally apply where the quantity of water is small, such as in short reaches along roadsides. The V-shaped cross-section is least desirable because it is difficult to stabilize the bottom where velocities may be high.

- **Trapezoidal grass channels** are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings. (Note: it is difficult to construct small parabolic shaped channels.)

- Subsurface drainage, or riprap channel bottoms, may be necessary on sites that are subject to prolonged wet conditions due to long duration flows or a high water table.

- Provide outlet protection at culvert ends and at channel intersections.

- Grass channels, at a minimum, shall carry peak runoff for temporary construction drainage facilities from the 10-year, 24-hour storm without eroding. Where flood hazard exists, increase the capacity according to the potential damage.

- Grassed channel side slopes generally are constructed 3:1 or flatter to aid in the establishment of vegetation and for maintenance.

- Construct channels a minimum of 0.2 foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

Maintenance Standards

- During the establishment period, check grass-lined channels after every rainfall.

- After grass is established, periodically check the channel; check it after every heavy rainfall event. Immediately make repairs.

- It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes.

- Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.

3.2.3 BMP C202: Channel Lining

Purpose

To protect erodable channels by providing a channel liner using blankets or riprap.

Conditions of Use

Channel lining must be used when natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion.

- When a permanent ditch or pipe system is to be installed and a temporary measure is needed.

- In almost all cases, synthetic and organic coconut blankets are more effective than riprap for protecting channels from erosion. Blankets can be used with and without vegetation. Blanketed channels can be designed to handle any expected flow and longevity requirement. Some synthetic blankets have a predicted life span of 50 years or more, even in sunlight.

- Other reasons why blankets are better than rock include the availability of blankets over rock. In many areas of the state, rock is not easily obtainable or is very expensive to haul to a site. Blankets can be delivered anywhere. Rock requires the use of dump trucks to haul and heavy equipment to place. Blankets usually only require laborers with hand tools, and sometimes a backhoe.

- The Federal Highway Administration recommends not using flexible liners whenever the slope exceeds 10 percent or the shear stress exceeds 8 lbs/ft^2.

Design and Installation Specifications

See BMP C122 for information on blankets.

Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay.

- Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.

- The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size. The possibility of drainage structure damage by children shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.

- Stone for riprap shall consist of field stone or quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended.

- Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirement of this standard and specification.

- A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. The geotextile shall be keyed in at the top of the bank.

- Filter fabric shall not be used on slopes greater than 1-1/2:1 as slippage may occur. Use it in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.

3.2.4 BMP C203: Water Bars

Purpose

To divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch by constructing a small ditch or ridge of material diagonally across a road or right-of-way.

Conditions of Use

Clearing right-of-way and construction of access for power lines, pipelines, and other similar installations often require long narrow right-of-ways over sloping terrain. Disturbance and compaction promotes gully formation in these cleared strips by increasing the volume and velocity of runoff. Gully formation may be especially severe in tire tracks and ruts. To prevent gullying, runoff can often be diverted across the width of the right-of-way to undisturbed areas by using small predesigned diversions.

- Give special consideration to each individual outlet area, as well as to the cumulative effect of added diversions. Use gravel to stabilize the diversion where significant vehicular traffic is anticipated.

Design and Installation Specifications

- Height: 8-inch minimum measured from the channel bottom to the ridge top.
- Side slope of channel: 2:1 maximum; 3:1 or flatter when vehicles will cross.
- Base width of ridge: 6-inch minimum.
- Locate them to use natural drainage systems and to discharge into well vegetated stable areas.
- Guideline for Spacing:

Slope %	Spacing (ft)
< 5	125
5 - 10	100
10 - 20	75
20 - 35	50
> 35	Use rock lined ditch

- Grade of water bar and angle: Select angle that results in ditch slope less than 2 percent.
- Install as soon as the clearing and grading is complete. Reconstruct when construction is complete on a section when utilities are being installed.
- Compact the ridge when installed.
- Stabilize, seed and mulch the portions that are not subject to traffic. Gravel the areas crossed by vehicles.

Maintenance Standards

- Periodically inspect right-of-way diversions for wear and after every heavy rainfall for erosion damage.
- Immediately remove sediment from the flow area and repair the dike.
- Check outlet areas and make timely repairs as needed.
- When permanent road drainage is established and the area above the temporary right-of-way diversion is permanently stabilized, remove the dike and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

3.2.5 BMP C204: Pipe Slope Drains

Purpose

To convey stormwater when diverting water away from (or over) bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

Conditions of Use

Use pipe slope drains when a temporary or permanent stormwater conveyance is needed to move the water down a steep slope to avoid erosion (Figure 3.10).

On highway projects, use pipe slope drains at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches. These can be designed into a project and included as bid items. Another use on road projects is to collect runoff from pavement and pipe it away from side slopes. These are useful because there is generally a time lag between having the first lift of asphalt installed and the curbs, gutters, and permanent drainage installed. Used in conjunction with sand bags, or other temporary diversion devices, these will prevent massive amounts of sediment from leaving a project.

Water can be collected, channeled with sand bags, Triangular Silt Dikes, berms, or other material, and piped to temporary sediment ponds.

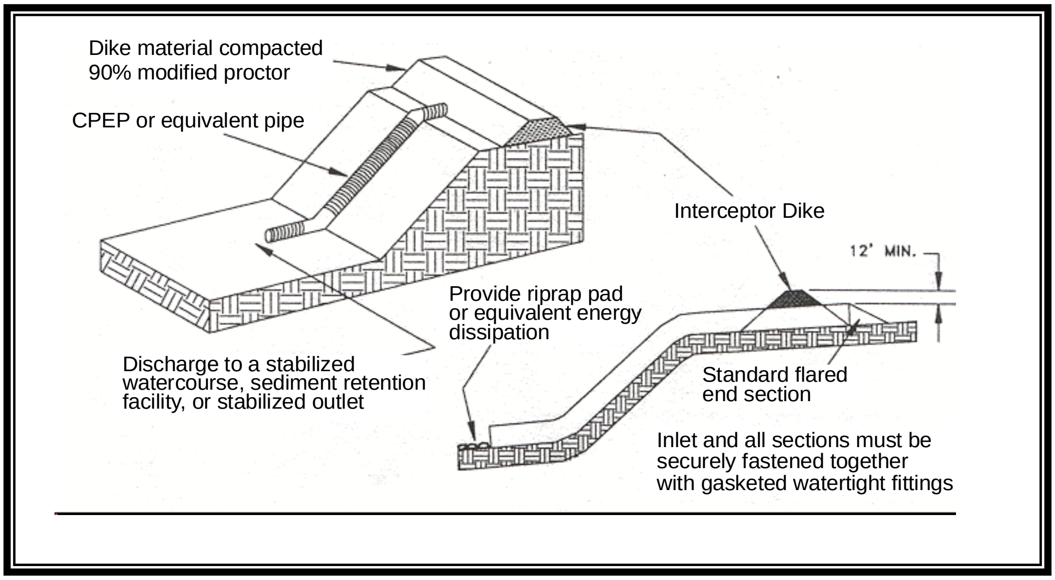


Figure 3.10. Pipe Slope Drain.

Pipe slope drains can be:

- Connected to new catch basins and used temporarily until all permanent piping is installed
- Used to drain water collected from aquifers exposed on cut slopes and take it to the base of the slope
- Used to collect clean runoff from plastic sheeting and direct it away from exposed soil
- Installed in conjunction with silt fence to drain collected water to a controlled area
- Used to divert small seasonal streams away from construction. They have been used successfully on culvert replacement and extension jobs. Large flex pipe can be used on larger streams during culvert removal, repair, or replacement.
- Connected to existing down spouts and roof drains and used to divert water away from work areas during building renovation, demolition, and construction projects.

There are now several commercially available collectors that are attached to the pipe inlet and help prevent erosion at the inlet.

Design and Installation Specifications

Size the pipe to convey the flow. The capacity for temporary drains shall be sufficient to handle the peak flow from a 10-year, 24-hour storm event, assuming a Type 1A rainfall distribution. Alternatively, use 1.6 times the 10-year, 1-hour time-step flow indicated by an approved continuous runoff model. If a 15-minute (or less) time step is used, no correction factor is required.

- Use care in clearing vegetated slopes for installation.
- Re-establish cover immediately on areas disturbed by installation.
- Use temporary drains on new cut or fill slopes.
- Use diversion dikes or swales to collect water at the top of the slope.
- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- Dike material shall be compacted to 90 percent modified proctor to prevent piping of water through the berm. The entrance area is a common failure location.
- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent. Sand bags may also be used at pipe entrances as a temporary measure.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together, fused or have gasketed watertight fittings, and shall be securely anchored into the soil.
- Install thrust blocks anytime 90 degree bends are used. Depending on size of pipe and flow, these can be constructed with sand bags, straw bales staked in place, “t” posts and wire, or ecology blocks.
- Pipe needs to be secured along its full length to prevent movement. This can be done with steel “t” posts and wire. A post is installed on each side of the pipe and the pipe is wired to them. Do this

approximately every 10 to 20 feet of pipe length, depending on the size of the pipe and quantity of water to be diverted.

- Interceptor dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe.
- The area below the outlet must be stabilized with a riprap apron (see BMP C209 Outlet Protection, for the appropriate outlet material).
- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.
- Materials specifications for any permanent piped system are listed in Volume III, Section 3.7.3 and shall be acceptable to the County.

Maintenance Standards

- Check inlet and outlet points regularly, especially after storms.
- The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, reinforce the headwall with compacted earth or sand bags.
- The outlet point should be free of erosion and installed with appropriate outlet protection.
- For permanent installations, inspect pipe periodically for vandalism and physical distress such as slides and wind-throw.
- Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe, however, debris may become lodged in the pipe.

3.2.6 BMP C205: Subsurface Drains

Purpose

To intercept, collect, and convey ground water to a satisfactory outlet, using a perforated pipe or conduit below the ground surface. Subsurface drains are also known as “french drains”. The perforated pipe provides a dewatering mechanism to drain excessively wet soils, provide a stable base for construction, improve stability of structures with shallow foundations, and to reduce hydrostatic pressure to improve slope stability.

Conditions of Use

Use when you must remove excessive water from the soil. The soil permeability, depth to water table and impervious layers are all factors which may govern the use of subsurface drains.

Design and Installation Specifications

Relief drains are used either to lower the water table in large, relatively flat areas, improve the growth of vegetation, or to remove surface water.

They are installed along a slope and drain in the direction of the slope.

They can be installed in a grid pattern, a herringbone pattern, or a random pattern.

Interceptor drains are used to remove excess ground water from a slope, stabilize steep slopes, and lower the water table immediately below a slope to prevent the soil from becoming saturated.

They are installed perpendicular to a slope and drain to the side of the slope.

They usually consist of a single pipe or series of single pipes instead of a patterned layout.

- **Depth and spacing of interceptor drains** – The depth of an interceptor drain is determined primarily by the depth to which the water table is to be lowered or the depth to a confining layer. For practical reasons, the maximum depth is usually limited to 6 feet, with a minimum cover of 2 feet to protect the conduit.
- The soil should have depth and sufficient permeability to permit installation of an effective drainage system at a depth of 2 to 6 feet.
- An adequate outlet for the drainage system must be available either by gravity or by pumping.
- The quantity and quality of discharge needs to be accounted for in the receiving stream (additional detention may be required).
- This standard does not apply to subsurface drains for building foundations or deep excavations.
- The capacity of an interceptor drain is determined by calculating the maximum rate of ground water flow to be intercepted. Therefore, it is good practice to make complete subsurface

investigations, including hydraulic conductivity of the soil, before designing a subsurface drainage system.

- **Size of drain** – Size subsurface drains to carry the required capacity without pressure flow. Minimum diameter for a subsurface drain is 4 inches.

- The minimum velocity required to prevent silting is 1.4 ft./sec. The line shall be graded to achieve this velocity at a minimum. The maximum allowable velocity using a sand-gravel filter or envelope is 9 ft/sec.

- Filter material and fabric shall be used around all drains for proper bedding and filtration of fine materials. Envelopes and filters shall surround the drain to a minimum of 3-inch thickness.

- The outlet of the subsurface drain shall empty into a sediment pond through a catch basin. If free of sediment, it can then empty into a receiving channel, swale, or stable vegetated area adequately protected from erosion and undermining.

- The trench shall be constructed on a continuous grade with no reverse grades or low spots.

- Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.

- Backfilling shall be done immediately after placement of the pipe. No sections of pipe shall remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drain pipe is not displaced or damaged.

- Do not install permanent drains near trees to avoid the tree roots that tend to clog the line. Use solid pipe with watertight connections where it is necessary to pass a subsurface drainage system through a stand of trees.

- **Outlet –** Ensure that the outlet of a drain empties into a channel or other watercourse above the normal water level.

- Secure an animal guard to the outlet end of the pipe to keep out rodents.

- Use outlet pipe of corrugated metal, cast iron, or heavy-duty plastic without perforations and at least 10 feet long. Do not use an envelope or filter material around the outlet pipe, and bury at least two-thirds of the pipe length.

- When outlet velocities exceed those allowable for the receiving stream, outlet protection must be provided.

Maintenance Standards

- Subsurface drains shall be checked periodically to ensure that they are free-flowing and not clogged with sediment or roots.
- The outlet shall be kept clean and free of debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees as a last resort. Plan drain placement to minimize this problem.
- Where drains are crossed by heavy vehicles use steel plate or boards to prevent the lines from being crushed. After work is complete the line shall be checked to ensure that it was not crushed.

3.2.7 BMP C206: Level Spreader

Purpose

To provide a temporary outlet for dikes and diversions, and to convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

Conditions of Use

A level spreader consists of an excavated depression constructed at zero grade across a slope. It is used when a concentrated flow of water needs to be dispersed over a large area with existing stable vegetation.

Items to consider are:

- What is the risk of erosion or damage if the flow may become concentrated?
- Is an easement required if discharged to adjoining property?
- Most of the flow should be as ground water and not as surface flow.
- Is there an unstable area downstream that cannot accept additional ground water?

Use only where the slopes are gentle, the water volume is relatively low, and the soil will adsorb most of the low flow events.

Design and Installation Specifications

- Use above undisturbed areas that are stabilized by existing vegetation.
- If the level spreader has any low points, flow will concentrate, create channels and may cause erosion.
- Discharge area below the outlet must be uniform with a slope of less than 5H:1V.
- Outlet to be constructed level in a stable, undisturbed soil profile (not on fill).
- The runoff shall not reconcentrate after release unless intercepted by another downstream measure.
- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- A 6-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2- to 4-inch or 3/4-inch to 1½-inch size.
- The spreader length shall be determined by estimating the peak flow expected from the 10-year, 24-hour design storm. The length of the spreader shall be a minimum of 15 feet for 0.1 cfs and shall be 10 feet for each 0.1 cfs thereafter to a maximum of 0.5 cfs per spreader. Use multiple spreaders for higher flows.
- The width of the spreader shall be at least 6 feet.
- The depth of the spreader as measured from the lip shall be at least 6 inches and it should be uniform across the entire length.
- Level spreaders shall be setback 100 feet minimum from the property line unless there is an easement for flow or the flow is directed to a natural drainage course.
- Level spreaders, when installed every so often in grassy swales, keep the flows from concentrating. Materials that can be used include sand bags, lumber, logs, concrete, and pipe. To function properly, the material needs to be installed level and on contour. Figures 3.11 and 3.12 provide a cross-section and a detail of a level spreader.

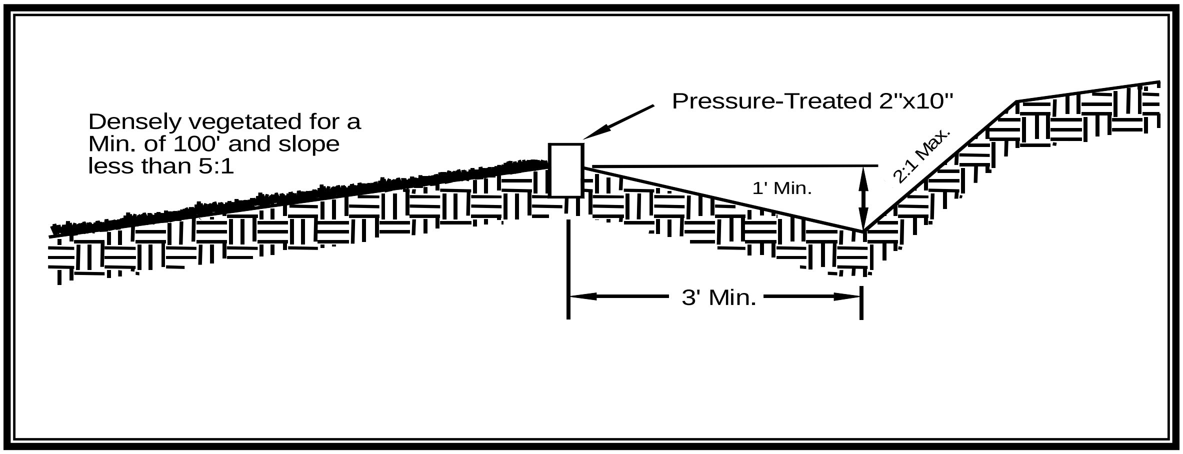


Figure 3.11. Cross-Section of Level Spreader.

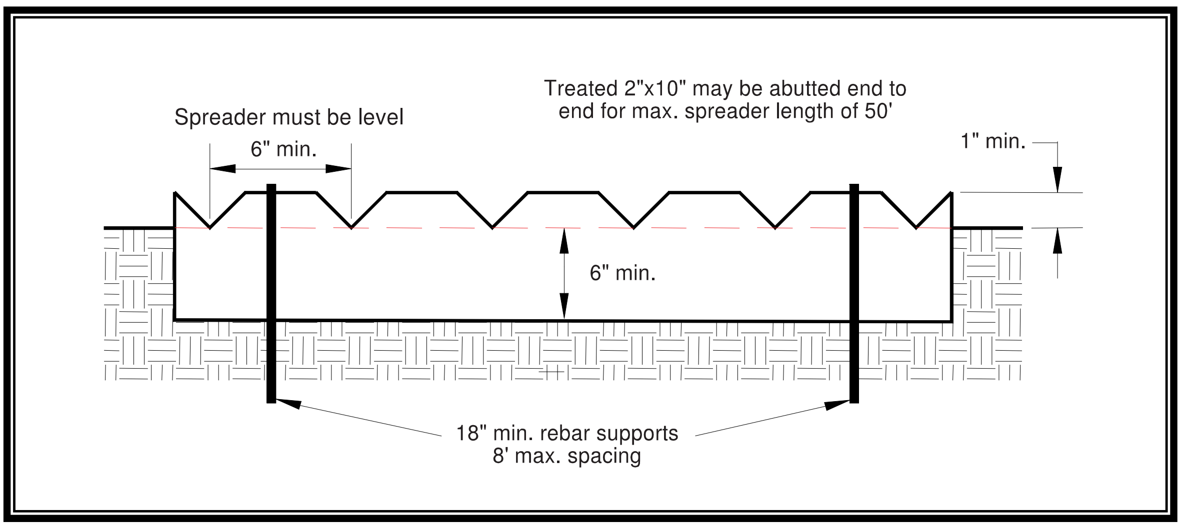


Figure 3.12. Detail of Level Spreader.

Maintenance Standards

- Inspect the spreader after every runoff event to ensure that it is functioning correctly.
- The contractor should avoid the placement of any material on the structure and should prevent construction traffic from crossing over the structure.
- If the spreader is damaged by construction traffic, it shall be immediately repaired.

3.2.8 BMP C207: Check Dams

Purpose

Check dams are used to reduce the velocity of concentrated flow and dissipate energy.

Conditions of Use

- Where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible, and velocity checks are required.
- Check dams may not be placed in streams unless approved by the State Department of Fish and Wildlife. Check dams may not be placed in wetlands without approval from Thurston County or another applicable permitting agency.
- Check dams shall not be placed below the expected backwater from any salmonid bearing water between October 1 and May 31 to ensure that there is no loss of high flow refuge habitat for overwintering juvenile salmonids and emergent salmonid fry.

Design and Installation Specifications

Whatever material is used, the dam should form a triangle when viewed from the side. This prevents undercutting as water flows over the face of the dam rather than falling directly onto the ditch bottom.

Check dams in association with sumps work more effectively at slowing flow and retaining sediment than just a check dam alone. Provide a deep sump immediately upstream of the check dam.

- In some cases, if carefully located and designed, check dams can remain as permanent installations with very minor regrading. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to prevent further sediment from leaving the site.
- Check dams can be constructed of either rock or pea-gravel filled bags. Straw bales are not an allowed construction material. Numerous new products are also available for this purpose. They tend to be re-usable, quick and easy to install, effective, and cost efficient.
- Place check dams perpendicular to the flow of water.
- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
- Keep the maximum height at 2 feet at the center of the dam.
- Keep the center of the check dam at least 12 inches lower than the outer edges at natural ground elevation.
- Keep the side slopes of the check dam at 2:1 or flatter.
- Key the stone into the ditch banks and extend it beyond the abutments a minimum of 18 inches to avoid washouts from overflow around the dam.
- Use filter fabric foundation under a rock or sand bag check dam. If a blanket ditch liner is used, this is not necessary. A piece of organic or synthetic blanket cut to fit will also work for this purpose.
- Rock check dams shall be constructed of appropriately sized rock. The rock must be placed by hand or by mechanical means (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.
- In the case of grass-lined ditches and swales, all check dams and accumulated sediment shall be removed when the grass has

matured sufficiently to protect the ditch or swale – unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

- Ensure that channel appurtenances, such as culvert entrances below check dams, are not subject to damage or blockage from displaced stones. Figure 3.13 depicts a typical rock check dam.

Maintenance Standards

- Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one half the sump depth.
- Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam.
- If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel.

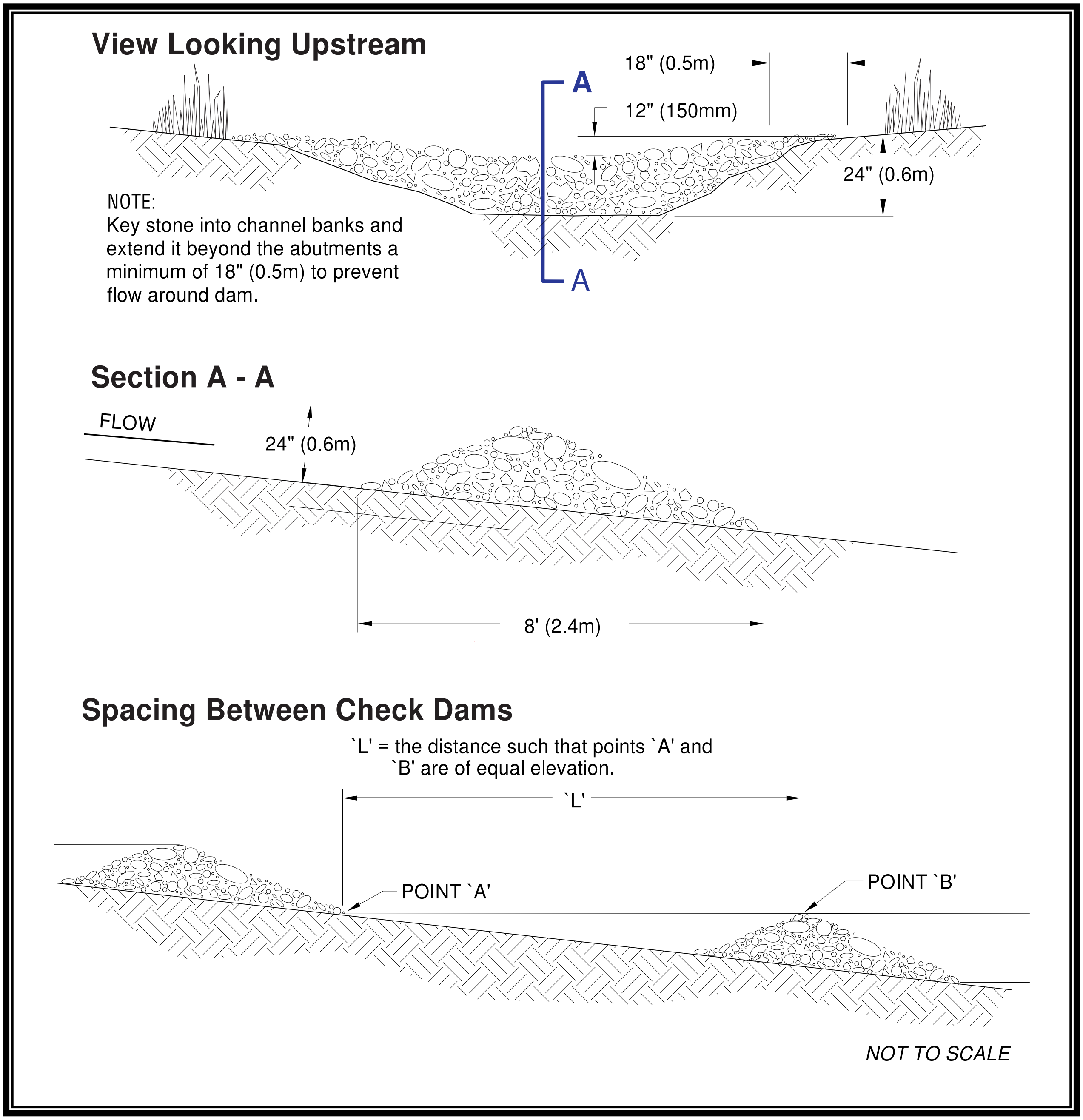


Figure 3.13. Check Dams.

3.2.9 BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)

Purpose

Triangular silt dikes may be used as check dams for perimeter protection, temporary soil stockpile protection, drop inlet protection, or as a temporary interceptor dike.

Conditions of Use

- May be used for temporary check dams in ditches of any dimension.
- May be used on soil or pavement with adhesive or staples.
- TSDs have been used to build temporary:
    - Sediment ponds
    - Diversion ditches
    - Concrete wash out facilities
    - Curbing
    - Water bars
    - Level spreaders
    - Berms.

Design and Installation Specifications

Silt dikes are typically made of urethane foam sewn into a woven geosynthetic fabric.

It is triangular, 10 inches to 14 inches high in the center, with a 20-inch to 28-inch base. A 2–foot apron extends beyond both sides of the triangle along its standard section of 7 feet. A sleeve at one end allows attachment of additional sections as needed.

- Install with ends curved up to prevent water from flowing around the ends.
- The fabric flaps and check dam units are attached to the ground with wire staples. Wire staples shall be No. 11 gauge wire and shall be 200 mm to 300 mm in length.
- When multiple units are installed, the sleeve of fabric at the end of the unit shall overlap the abutting unit and be stapled.
- Locate and install check dams as soon as construction will allow.
- Place check dams perpendicular to the flow of water.
- When used as check dams, the leading edge must be secured with rocks, sandbags, or a small key slot and staples.
- In the case of grass-lined ditches and swales, check dams and accumulated sediment shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.

Maintenance Standards

- Triangular silt dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one half the height of the dam.
- Anticipate submergence and deposition above the triangular silt dam and erosion from high flows around the edges of the dam. Immediately repair any damage or any undercutting of the dam.

3.2.10 BMP C209: Outlet Protection

Purpose

To prevent scour at conveyance outlets and minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions of Use

Outlet protection is required at the outlets of all ponds, pipes, ditches, or other conveyances, and where runoff is conveyed to a natural or manmade drainage feature such as a stream, wetland, lake, or ditch.

Design and Installation Specifications

The receiving channel at the outlet of a culvert shall be protected from erosion by rock lining a minimum of 6 feet downstream and extending up the channel sides a minimum of 1 foot above the maximum tailwater elevation or 1 foot above the crown, whichever is higher. For large pipes (more than 18 inches in diameter), the outlet protection lining of the channel is lengthened to four times the diameter of the culvert.

- Standard wingwalls, and tapered outlets and paved channels should also be considered when appropriate for permanent culvert outlet protection. (See WSDOT Hydraulic Manual, available through WSDOT Engineering Publications.)

- Organic or synthetic erosion blankets, with or without vegetation, are usually more effective than rock, cheaper, and easier to install. Materials can be chosen using manufacturer product specifications. ASTM test results are available for most products and the designer can choose the correct material for the expected flow.

- With low flows, vegetation (including sod) can be effective.

- The following guidelines shall be used for riprap outlet protection:

    - If the discharge velocity at the outlet is less than 5 fps (pipe slope less than 1 percent), use 2-inch to 8-inch riprap. Minimum thickness is 1 foot.

    - For 5 to 10 fps discharge velocity at the outlet (pipe slope less than 3 percent), use 24-inch to 4-foot riprap. Minimum thickness is 2 feet.

    - For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), an engineered energy dissipater shall be used.

- Filter fabric or erosion control blankets shall always be used under riprap to prevent scour and channel erosion.

- New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. See Volume III for more information on outfall system design.

Maintenance Standards

- Inspect and repair as needed.

- Add rock as needed to maintain the intended function.

- Clean energy dissipater if sediment builds up.

3.2.11 BMP C220: Storm Drain Inlet Protection

Purpose

Inlet protection prevents coarse sediment from entering drainage systems prior to permanent stabilization of a disturbed area.

Conditions of Use

Use this BMP where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Provide protection for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap. Inlet protection may be used anywhere to protect the drainage system. It is likely that the drainage system will still require cleaning.

Table 3.9 lists several options for inlet protection. All of the methods for storm drain inlet protection are prone to plugging and require a high frequency of maintenance. Limit drainage areas to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe treatment may be required.

Table 3.9. Storm Drain Inlet Protection.

Type of Inlet Protection	Emergency Overflow	Applicable for Paved/Earthen Surfaces	Conditions of Use
Drop Inlet Protection			
Excavated drop inlet protection	Yes, temporary flooding will occur	Earthen	Applicable for heavy flows. Easy to maintain. Large Area Requirement: 30' X 30'/acre.
Rock socks and gravel	Yes	Paved or Earthen	Applicable for heavy concentrated flows.
Gravel and wire drop inlet protection	No		Applicable for heavy concentrated flows. Will pond. Can withstand traffic.
Catch basin filters	Yes	Paved or Earthen	Frequent maintenance required.
Curb Inlet Protection			
Curb inlet protection with a wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Rock socks and gravel	Yes	Paved	Sturdy, but limited filtration.
Culvert Inlet Protection			
Culvert inlet sediment trap			18 month expected life.

Design and Installation Specifications

Excavated Drop Inlet Protection – An excavated impoundment around the storm drain. Sediment settles out of the stormwater prior to entering the storm drain.

- Depth 1 to 2 feet as measured from the crest of the inlet structure.
- Side Slopes of excavation no steeper than 2:1.
- Minimum volume of excavation 35 cubic yards.
- Shape basin to fit site with longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water problems.
- Clear the area of all debris.
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.
- It may be necessary to build a temporary dike to the down slope side of the structure to prevent bypass flow.

Rock Sock Drop Inlet Protection – A barrier formed around the storm drain inlet with overlapping rock socks. See Figure 3.14.

- Rock socks are bags made out of burlap or geotextile fabric approximately 40 inches long and 6 inches in diameter. They are filled with 1/2 inch round rock to 24 inch length and a weight of 16 to 20 pounds.
- Use loosely woven material, such as burlap for filtration and a tight weave geotextile for diversion.
- Completely circle inlet with rock socks.
- Overlap ends to prevent gaps.
- Rock socks may be stacked if required, but should be replaced with gravel filled sandbags for large flows.

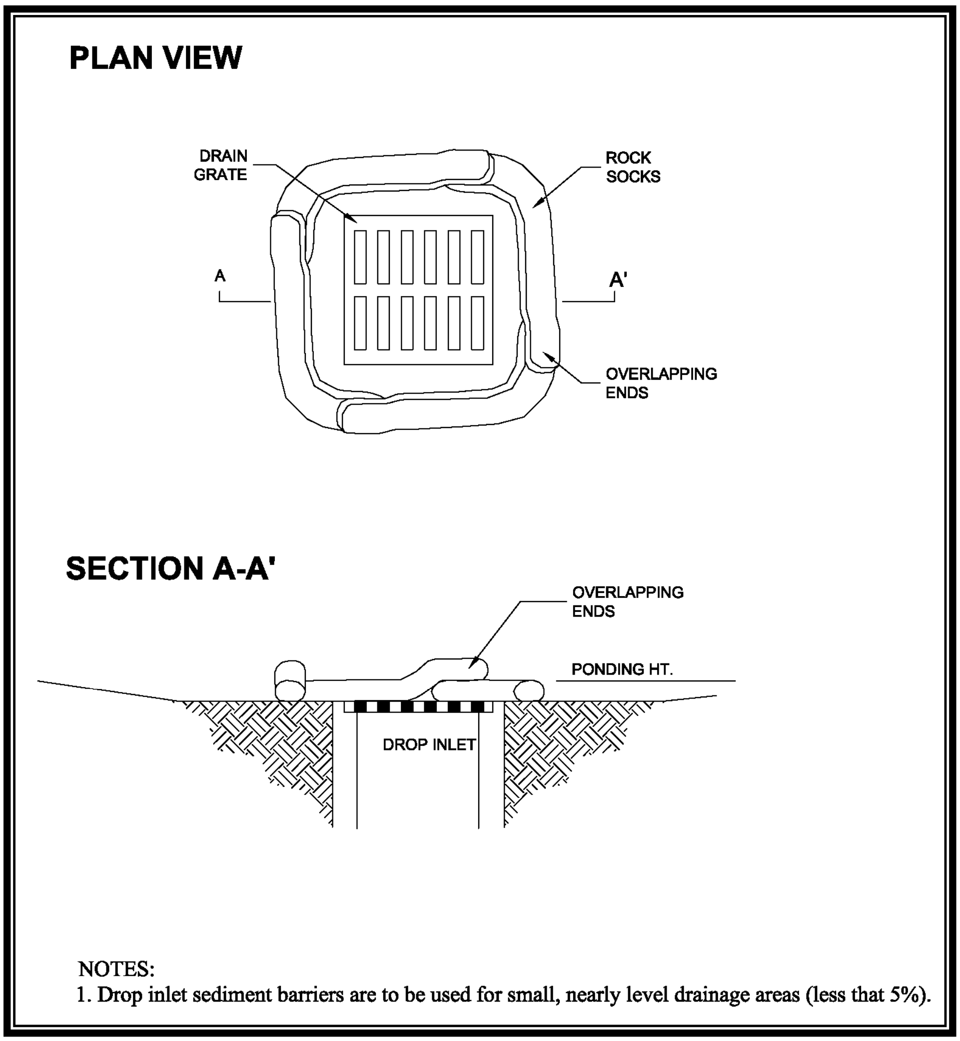


Figure 3.14. Rock Sock Drop Inlet Protection.

Curb Inlet Protection with Wooden Weir – Barrier formed around a curb inlet with a wooden frame and gravel.

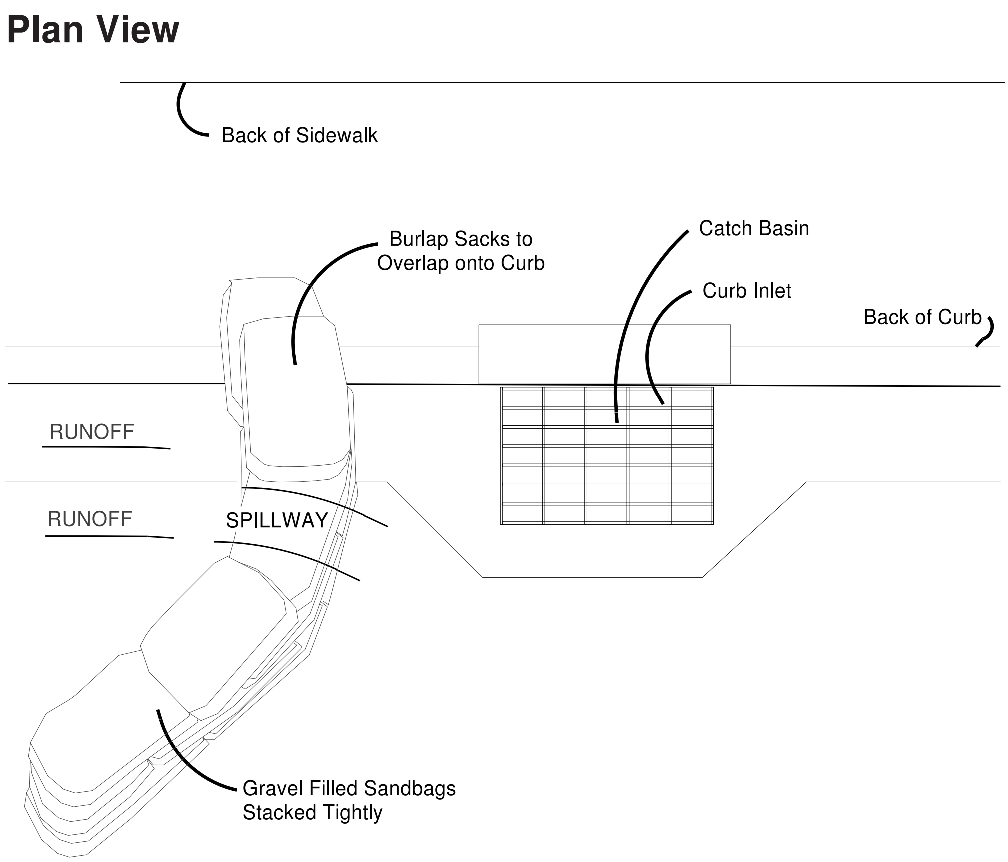
- Wire mesh with 1/2-inch openings.
- Extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against wire/fabric.
- Place weight on frame anchors.

Curb and Gutter Sediment Barrier – Sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See Figure 3.15.

- Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.
- Construct a horseshoe shaped sedimentation trap on the outside of the berm sized to sediment trap standards for protecting a culvert inlet.

Maintenance Standards

- Inspect catch basin filters frequently, especially after storm events. If the insert becomes clogged, it should be cleaned or replaced.
- For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.



NOTES:
1. Place curb type sediment barriers on gently sloping street segments, where water can pond and allow sediment to separate from runoff.
2. Sandbags of either burlap or woven `geotextile' fabric, are filled with gravel, layered and packed tightly.
3. Leave a one sandbag gap in the top row to provide a spillway for overflow.
4. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Figure 3.15. Curb and Gutter Barrier.

3.2.12 BMP C233: Silt Fence

Purpose

To reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow. See Figure 3.16 for details on silt fence construction.

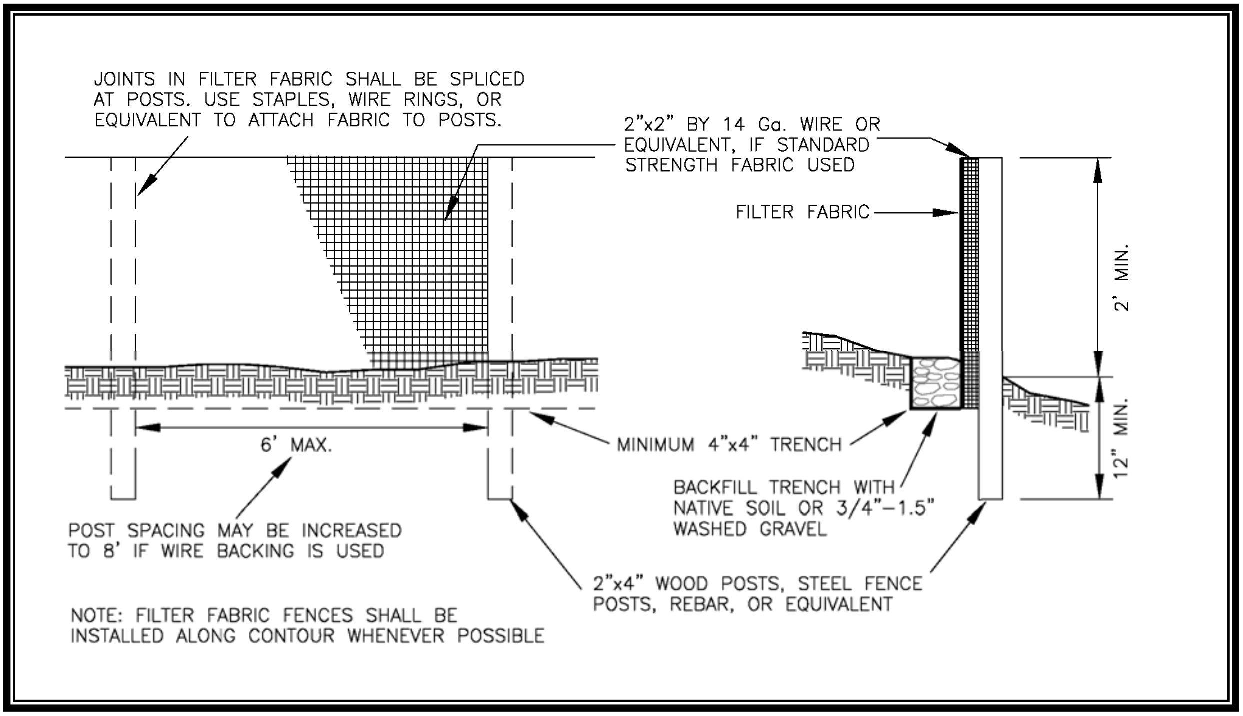


Figure 3.16. Silt Fence.

Conditions of Use

- Silt fence may be used downslope of all disturbed areas.
- Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment pond. The only circumstance in which overland flow can be treated solely by a silt fence, rather than by a sediment pond, is when the area draining to the fence is one acre or less and flow rates are less than 0.5 cfs.
- Silt fences should not be constructed in streams or used in V-shaped ditches. They are not an adequate method of silt control for anything deeper than sheet or overland flow.

Design and Installation Specifications

- Drainage area of 1 acre or less or in combination with sediment basin in a larger site.
- Maximum slope steepness (normal (perpendicular) to fence line) 1:1.
- Maximum sheet or overland flow path length to the fence of 100 feet.
- No flows greater than 0.5 cfs.
- The geotextile used shall meet the following standards. All geotextile properties listed below are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in Table 3.10):

Table 3.10. Geotextile Standards.

Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for film wovens (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#100 sieve).
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. Minimum for extra strength fabric. 100 lbs minimum for standard strength fabric.
Grab Tensile Strength (ASTM D4632)	30% maximum
Ultraviolet Resistance (ASTM D4355)	70% minimum

- Standard strength fabrics shall be supported with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to increase the strength of the fabric. Silt fence materials are available that have synthetic mesh backing attached.
- Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F. to 120°F.
- 100 percent biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed. It may be used subject to Administrator acceptance.
- Standard Notes for construction plans and specifications follow. Refer to Figure 3.16 for standard silt fence details.
- The contractor shall install and maintain temporary silt fences at the locations shown in the Plans. The silt fences shall be

constructed in the areas of clearing, grading, or drainage prior to starting those activities. A silt fence shall not be considered temporary if the silt fence must function beyond the life of the contract. The silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.

- The minimum height of the top of silt fence shall be 2 feet and the maximum height shall be 2-1/2 feet above the original ground surface.

- The geotextile shall be sewn together at the point of manufacture, or at an approved location as determined by the Engineer, to form geotextile lengths as required. All sewn seams shall be located at a support post. Alternatively, two sections of silt fence can be overlapped, provided the Contractor can demonstrate, to the satisfaction of the Engineer, that the overlap is long enough and that the adjacent fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.

- The geotextile shall be attached on the up-slope side of the posts and support system with staples, wire, or in accordance with the manufacturer's recommendations. The geotextile shall be attached to the posts in a manner that reduces the potential for geotextile tearing at the staples, wire, or other connection device. Silt fence back-up support for the geotextile in the form of a wire or plastic mesh is dependent on the properties of the geotextile selected for use. If wire or plastic back-up mesh is used, the mesh shall be fastened securely to the up-slope of the posts with the geotextile being up-slope of the mesh back-up support.

- The geotextile at the bottom of the fence shall be buried in a trench to a minimum depth of 4 inches below the ground surface. The trench shall be backfilled and the soil tamped in place over the buried portion of the geotextile, such that no flow can pass beneath the fence and scouring cannot occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the trench a minimum of 3 inches.

- The fence posts shall be placed or driven a minimum of 18 inches. A minimum depth of 12 inches is allowed if topsoil or other soft subgrade soil is not present and a minimum depth of 18 inches cannot be reached. Fence post depths shall be increased by 6 inches if the fence is located on slopes of 3:1 or steeper and the slope is perpendicular to the fence. If required post depths cannot be obtained, the posts shall be adequately secured by bracing or guying to prevent overturning of the fence due to sediment loading.

- Silt fences shall be located on contour as much as possible, except at the ends of the fence, where the fence shall be turned uphill such that the silt fence captures the runoff water and prevents water from flowing around the end of the fence.

- If the fence must cross contours, with the exception of the ends of the fence, gravel check dams placed perpendicular to the back of the fence shall be used to minimize concentrated flow and erosion along the back of the fence. The gravel check dams shall be approximately 1 foot deep at the back of the fence. It shall be continued perpendicular to the fence at the same elevation until the top of the check dam intercepts the ground surface behind the fence. The gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. The gravel check dams shall be located every 10 feet along the fence where the fence must cross contours. The slope of the fence line where contours must be crossed shall not be steeper than 3:1.

- Wood, steel or equivalent posts shall be used. Wood posts shall have minimum dimensions of 2 inches by 2 inches by 3 feet minimum length, and shall be free of defects such as knots, splits, or gouges. Steel posts shall consist of either size No. 6 rebar or larger, ASTM A 120 steel pipe with a minimum diameter of 1 inch, U, T, L, or C shape steel posts with a minimum weight of 1.35 lbs./ft. or other steel posts having equivalent strength and bending resistance to the post sizes listed. The spacing of the support posts shall be a maximum of 6 feet.

- Fence back-up support, if used, shall consist of steel wire with a maximum mesh spacing of 2 inches, or a prefabricated polymeric mesh. The strength of the wire or polymeric mesh shall be equivalent to or greater than 180 lbs. grab tensile strength. The polymeric mesh must be as resistant to ultraviolet radiation as the geotextile it supports.

- Silt fence installation using the slicing method specification details follow. Refer to Figure 3.17 for slicing method details.

- The base of both end posts must be at least 2 to 4 inches above the top of the silt fence fabric on the middle posts for ditch checks to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.

- Install posts 3 to 4 feet apart in critical retention areas and 6 feet apart in standard applications.
- Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the fabric, enabling posts to support the fabric from upstream water pressure.
- Install posts with the nipples facing away from the silt fence fabric.

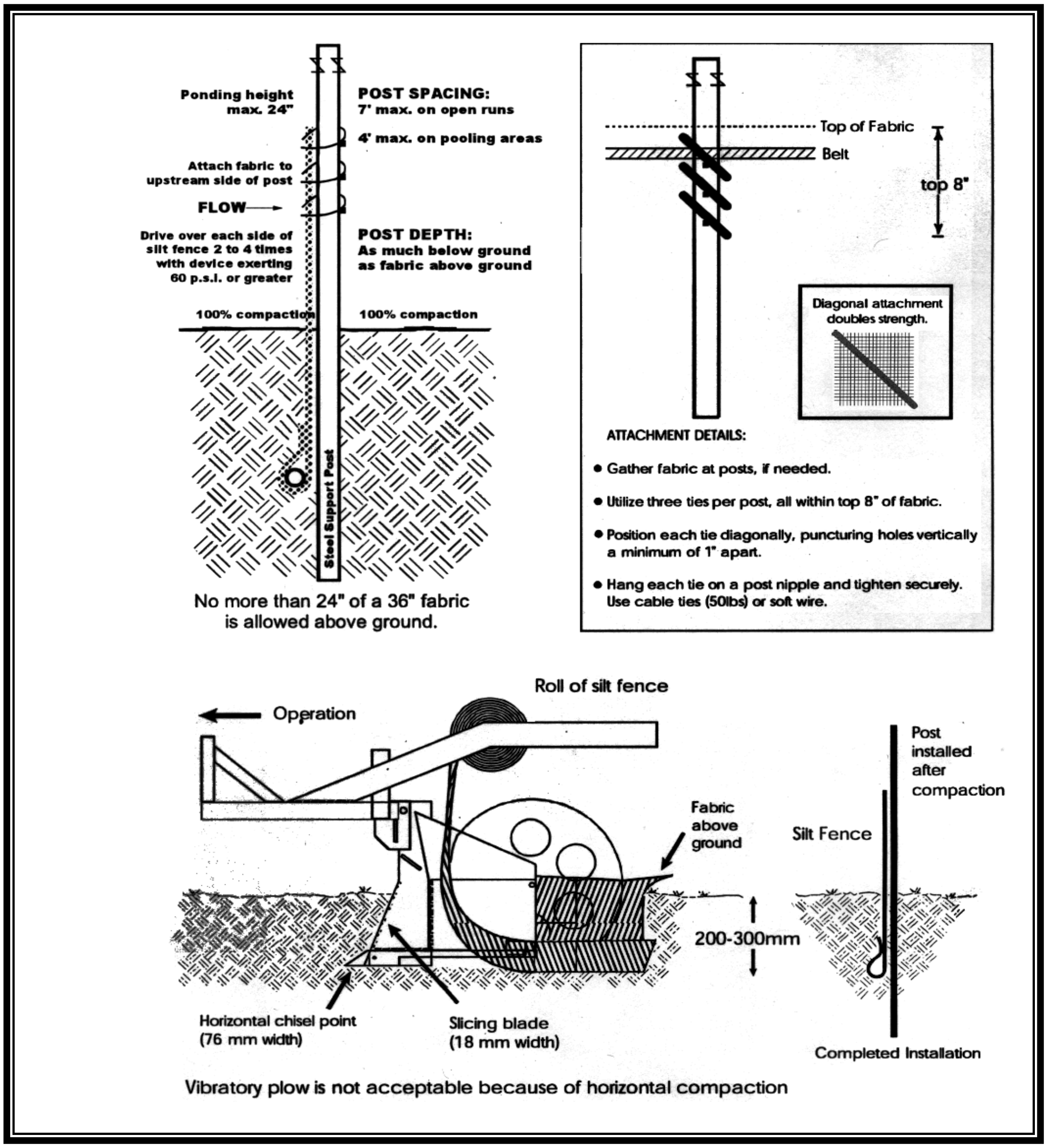


Figure 3.17. Silt Fence Installation by Slicing Method.

- Attach the fabric to each post with three ties, all spaced within the top 8 inches of the fabric. Attach each tie diagonally 45 degrees through the fabric, with each puncture at least 1 inch vertically apart. In addition, position each tie to hang on a post nipple when tightening to prevent sagging.

- Wrap approximately 6 inches of fabric around the end posts and secure with three ties.
- No more than 24 inches of a 36-inch fabric is allowed above ground level.
- The rope lock system must be used in all ditch check applications.
- The installation should be checked and corrected for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground if necessary.
- Compaction is vitally important for effective results. Compact the soil immediately next to the silt fence fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of four trips.

Maintenance Standards

- Any damage shall be repaired immediately.
- If concentrated flows are evident uphill of the fence, they must be intercepted and conveyed to a sediment pond.
- It is important to check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence or remove the trapped sediment.
- Sediment deposits shall either be removed when the deposit reaches approximately one-third the height of the silt fence, or a second silt fence shall be installed.
- If the filter fabric (geotextile) has deteriorated due to ultraviolet breakdown, it shall be replaced.

3.2.13 BMP C234: Vegetated Strip

Purpose

To reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

- Vegetated strips may be used downslope of all disturbed areas.
- Vegetated strips are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment pond. The only circumstance in which overland flow can be treated solely by a strip, rather than by a sediment pond, is when the following criteria are met (see Table 3.11):

Table 3.11. Vegetated Strips.

Average Slope	Slope Percent	Contributing Flowpath Length
1.5H:1V or less	67% or less	100 feet
2H:1V or less	50% or less	115 feet
4H:1V or less	25% or less	150 feet
6H:1V or less	16.7% or less	200 feet
10H:1V or less	10% or less	250 feet

Design and Installation Specifications

- The vegetated strip shall consist of a continuous strip of dense vegetation with a permeable topsoil and have a minimum 25-foot long flowpath. Grass-covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips shall consist of undisturbed native growth with a well-developed soil that allows for infiltration of runoff.
- The slope within the strip shall not exceed 4H:1V.
- The uphill boundary of the vegetated strip shall be delineated with clearing limits.

Maintenance Standards

- Any areas damaged by erosion or construction activity shall be seeded immediately and protected by mulch.

- If more than 5 feet of the original vegetated strip width has had vegetation removed or is being eroded, sod must be installed.
- If there are indications that concentrated flows are traveling across the buffer, surface water controls must be installed to reduce the flows entering the buffer, or additional perimeter protection must be installed.

3.2.14 BMP C235: Straw Wattles

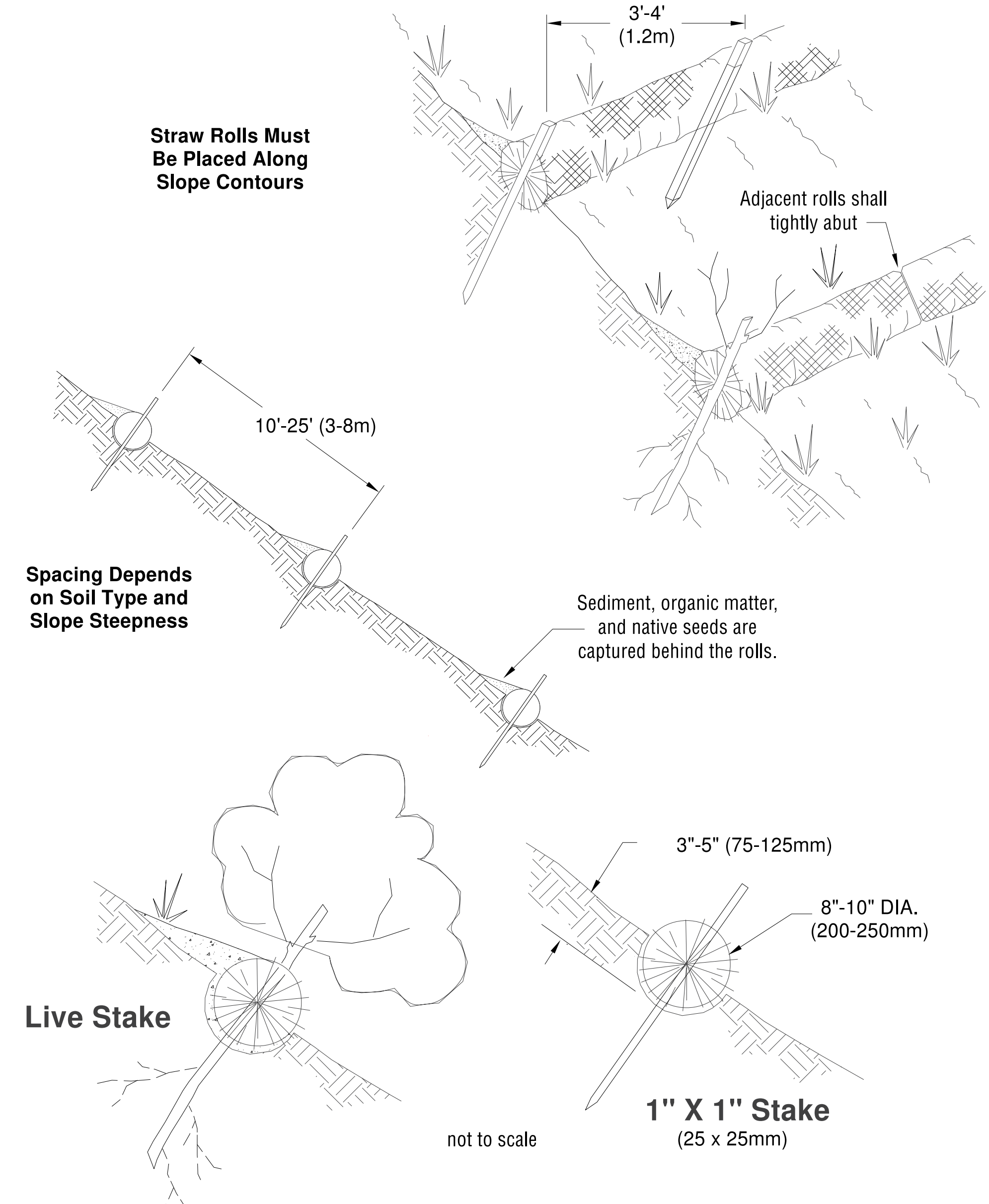
Purpose

To reduce the velocity and spread the flow of rill and sheet runoff, and to capture and retain sediment.

Straw wattles are temporary erosion and sediment control barriers consisting of straw wrapped in biodegradable tubular plastic or similar material. They are typically 8 to 10 inches in diameter and 25 to 30 feet in length. The wattles are placed in shallow trenches and staked along the contour of disturbed or newly constructed slopes. See Figure 3.18 for typical construction details.

Conditions of Use

- Disturbed areas that require immediate erosion protection.
- Exposed soils during the period of short construction delays, or over winter months.
- On slopes requiring stabilization until permanent vegetation can be established.
- Straw wattles are effective for one to two wet seasons.
- If conditions are appropriate, wattles can be staked to the ground using willow cuttings for added revegetation.
- Rilling can occur beneath wattles if not properly entrenched and water can pass between wattles if not tightly abutted together.



NOTE:
1. Straw roll installation requires the placement and secure staking of the roll in a trench, 3"-5" (75-125mm) deep, dug on contour. runoff must not be allowed to run under or around roll.

Figure 3.18. Straw Wattles.

Design Criteria

- It is critical that wattles are installed perpendicular to the flow direction and parallel to the slope contour.
- Narrow trenches should be dug across the slope on contour to a depth of 3 to 5 inches on clay soils and soils with gradual slopes. On loose soils, steep slopes, and areas with high rainfall, dig

trenches to a depth of 5 to 7 inches, or 1/2 to 2/3 of the thickness of the wattle.

- Start building trenches and installing wattles from the base of the slope and work up. Spread excavated material evenly along the uphill slope and compacted using hand tamping or other methods.
- Construct trenches on contours at intervals of 10 to 25 feet apart depending on the steepness of the slope, soil type, and rainfall. The steeper the slope the closer together the trenches.
- Install the wattles snugly into the trenches and abut tightly end to end. Do not overlap the ends.
- Install stakes at each end of the wattle, and at 4-foot centers along entire length of wattle.
- If required, install pilot holes for the stakes using a straight bar to drive holes through the wattle and into the soil.
- At a minimum, wooden stakes shall be approximately 3/4 x 3/4 x 24 inches. Willow cuttings or 3/8-inch rebar can also be used for stakes.

Maintenance Standards

- Drive stakes through the middle of the wattle, leaving 2 to 3 inches of the stake protruding above the wattle.
- Wattles may require maintenance to ensure they are in contact with soil and thoroughly entrenched, especially after significant rainfall on steep sandy soils.
- Inspect the slope after significant storms and repair any areas where wattles are not tightly abutted or water has scoured beneath the wattles.

3.2.15 BMP C240: Sediment Trap

Purpose

To collect and store sediment from sites cleared and/or graded during construction.

A sediment trap is a small temporary ponding area using a gravel outlet. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Conditions of Use

Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or trap or other appropriate sediment removal best management practice. Non-engineered sediment traps may be used onsite prior to an engineered sediment trap or sediment pond to provide additional sediment removal capacity.

It is intended for use on sites where the tributary drainage area is less than 3 acres, with no unusual drainage features, and a projected build-out time of 6 months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Sediment traps are only effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

Whenever possible, sediment-laden water shall be discharged into onsite, relatively level, vegetated areas (see BMP C234 – Vegetated Strip). This is the only way to effectively remove fine particles from runoff unless chemical treatment or filtration is used. This can be particularly useful after initial treatment in a sediment trap. The areas of release must be evaluated on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Vegetated wetlands shall not be used for this purpose. Frequently, it may be possible to pump water from the collection point at the downhill end of the site to an upslope vegetated area. Pumping shall only augment the treatment system, not replace it, because of the possibility of pump failure or runoff volume in excess of pump capacity.

All projects that are constructing permanent facilities for runoff quantity control should use the rough-graded or final-graded permanent facilities for traps. This includes combined facilities and infiltration facilities. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of 2 feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized. When permanent facilities are used as temporary sedimentation facilities, the surface area requirement of a sediment trap or pond must be met. If the surface area requirements are larger than the surface area of the permanent facility, then the trap or pond shall be enlarged to comply with the surface area requirement. The permanent pond shall also be divided into two cells as required for sediment ponds.

Either a permanent control structure or the temporary control structure (described in BMP C241, Temporary Sediment Pond) can be used. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond. A shut-off valve may be added to the control structure to allow complete retention of stormwater in emergency situations. In this case, an emergency overflow weir must be added.

A skimmer may be used for the sediment trap outlet if approved by the County.

Design and Installation Specifications

- See Figures 3.19 and 3.20 for details.
- If permanent runoff control facilities are part of the project, use them for sediment retention.

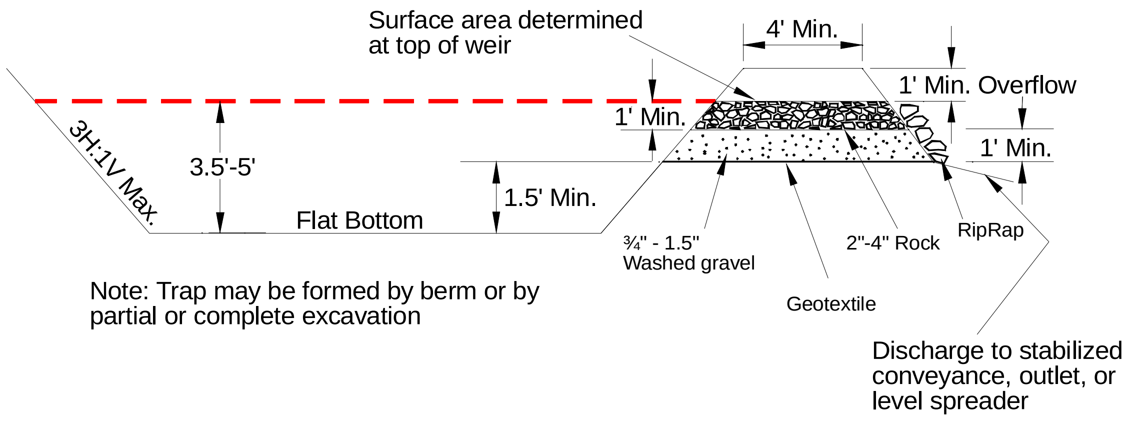


Figure 3.19. Cross-Section of Sediment Trap.

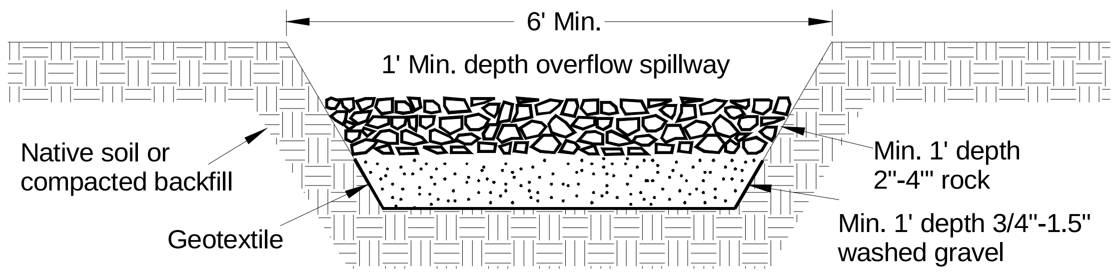


Figure 3.20. Sediment Trap Outlet.

- To determine the sediment trap geometry, first calculate the design surface area (*SA*) of the trap, measured at the invert of the weir. Use the following equation:

$$SA = FS(Q_2/V_S)$$

Where: Q_2 = Design inflow (cfs) based on the 2-year recurrence interval flow rate. Use a 15-minute time step using an approved continuous runoff model for the developed (unmitigated) site. If the time of concentration is less than 30-minutes, a 5-minute time step may be required. The 10-year recurrence interval peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the rational method may be used.

V_S = The settling velocity of the soil particle of interest. The 0.02 mm (medium silt) particle with an assumed density of 2.65 g/cm^3 has been selected as the particle of interest and has a settling velocity (V_s) of 0.00096 ft/sec.

FS = A safety factor of 2 to account for non-ideal settling.

Therefore, the equation for computing surface area becomes:

$$SA = 2 \text{ x } Q_2/0.00096$$

OR

2,080 square feet per cfs of inflow

Note: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent labeled mark for each 1-foot interval above the bottom of the trap.
- Sediment traps may not be feasible on utility projects due to the limited work space or the short-term nature of the work. Portable tanks may be used in place of sediment traps for utility projects.

Maintenance Standards

- Sediment shall be removed from the trap when it reaches 1 foot in depth.
- Any damage to the pond embankments or slopes shall be repaired.

3.2.16 BMP C241: Temporary Sediment Pond

Purpose

To remove sediment from runoff originating from disturbed areas of the site.

NOTE: Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they may reduce turbidity only slightly.

Conditions of Use

Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or other appropriate sediment removal best management practice.

A sediment pond shall be used where the contributing drainage area is 3 acres or more. Ponds must be used in conjunction with erosion control practices to reduce the amount of sediment flowing into the basin.

Design and Installation Specifications

- Sediment ponds must be installed only on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment traps and ponds are attractive to children and can be very dangerous. If fencing of the pond is planned, the type of fence and its location shall be shown on the ESC plan.

- Structures having a maximum storage capacity at the top of the dam of 10 acre-ft (435,600 ft^3) or more are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).
- See Figures 3.21, 3.22, and 3.23 for details.
- If permanent runoff control facilities are part of the project, use them for sediment retention. The surface area requirements of the sediment pond must be met. This may require enlarging the permanent pond to comply with the surface area requirements. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond.
- Use of infiltration facilities for sedimentation ponds during construction tends to clog the soils and reduce their capacity to infiltrate. If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of 2 feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized. The infiltration pretreatment facility should be fully constructed and used with the sedimentation pond to help prevent clogging.

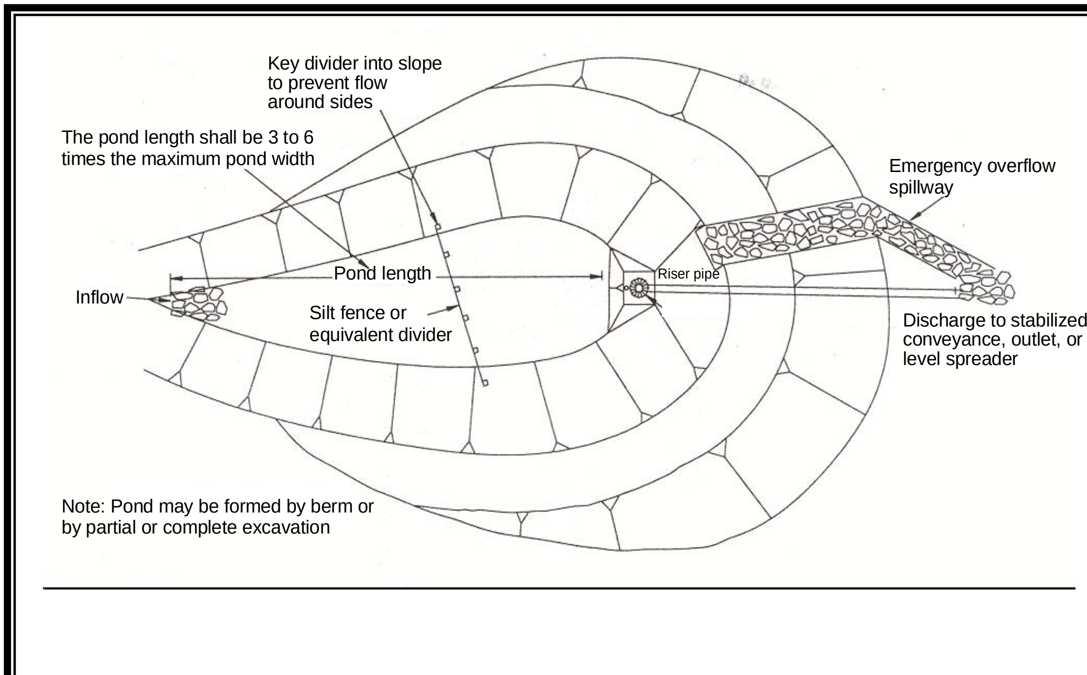


Figure 3.21. Sediment Pond Plan View.

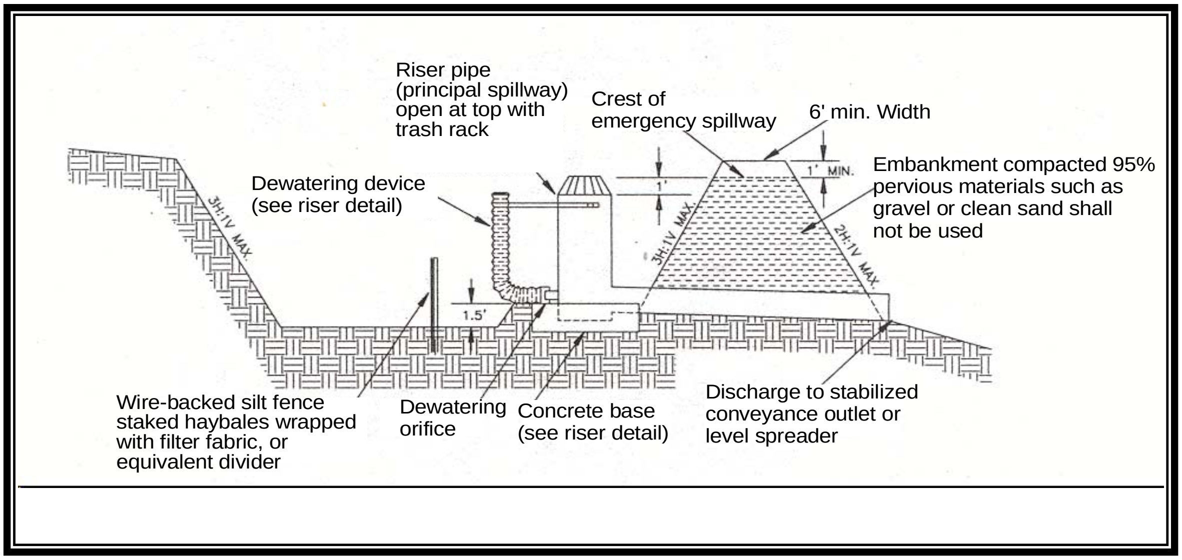


Figure 3.22. Sediment Pond Cross-Section.

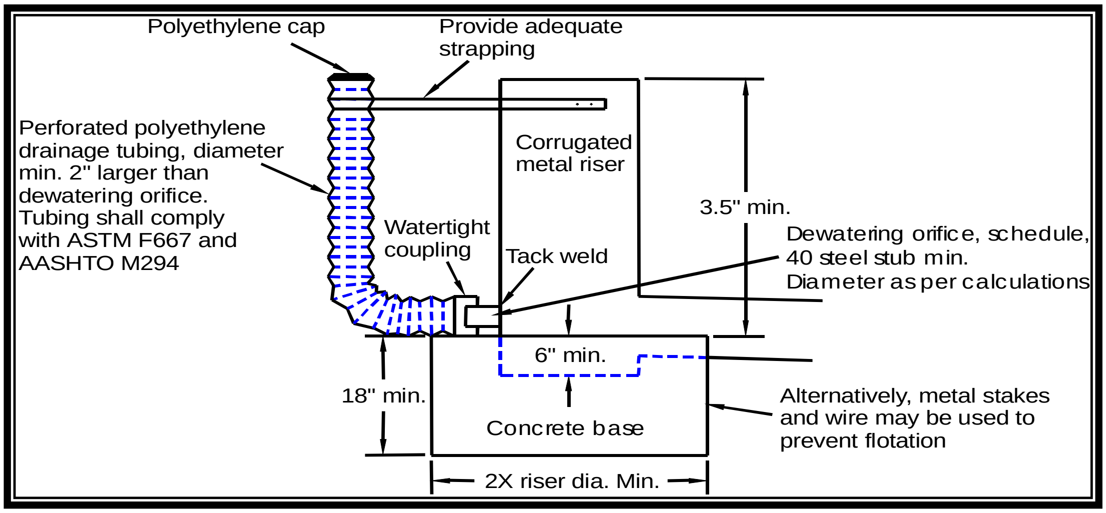


Figure 3.23. Sediment Pond Riser Detail.

Determining Pond Geometry:

- Obtain the discharge from the hydrologic calculations of the peak flow for the 2-year recurrence interval runoff event (Q_2). Use a 15-minute time step and an approved continuous runoff model for the developed (unmitigated) site. If the time of concentration is less than 30 minutes, a 5-minute time step may be required. The 10-year recurrence interval peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used.

- Determine the required surface area at the top of the riser pipe with the equation:

$$SA = 2 \times Q_2/0.00096$$

OR

2,080 square feet per cfs of inflow

- See BMP C240 for more information on the derivation of the surface area calculation.
- The basic geometry of the pond can now be determined using the following design criteria:
    - Required surface area SA (from Step 2 above) at top of riser.
    - Minimum 3.5-foot depth from top of riser to bottom of pond.
    - Maximum 3:1 interior side slopes and maximum 2:1 exterior slopes. The interior slopes can be increased to a maximum of 2:1 if fencing is provided at or above the maximum water surface.
    - One foot of freeboard between the top of the riser and the crest of the emergency spillway.
    - Flat bottom.
    - Minimum 1-foot deep spillway.
    - Length-to-width ratio between 3:1 and 6:1.

Sizing of Discharge Mechanisms:

- The outlet for the pond consists of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 100-year recurrence interval storm. If, due to site conditions and pond geometry, a separate emergency spill-way is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year recurrence interval storm. However, an attempt to provide a separate emergency spillway shall always be made. The runoff calculations shall be based on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the 100-year recurrence interval storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.

- The principal spillway designed by the procedures contained in this standard will result in some reduction in the peak rate of runoff. However, the riser outlet design will not adequately control the pond discharge to the predevelopment discharge limitations as stated in Minimum Requirement #7: Flow Control. However, if the basin for a permanent stormwater detention pond is used for a temporary sedimentation pond, the control structure for the permanent pond can be used to maintain predevelopment discharge limitations. The size of the pond, the expected life of the construction project, the anticipated downstream effects and the anticipated weather conditions during construction, should be considered to determine the need of additional discharge control. See Figure 3.24 for riser inflow curves.

    - **Principal Spillway:** Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the pre-developed 10-year peak flow (Q_{10}) determined using a 15-minute time step in an approved continuous runoff model for the developed. Use Figure 3.24 to determine this diameter (h = 1-foot). *Note: A permanent control structure may be used instead of a temporary riser.*

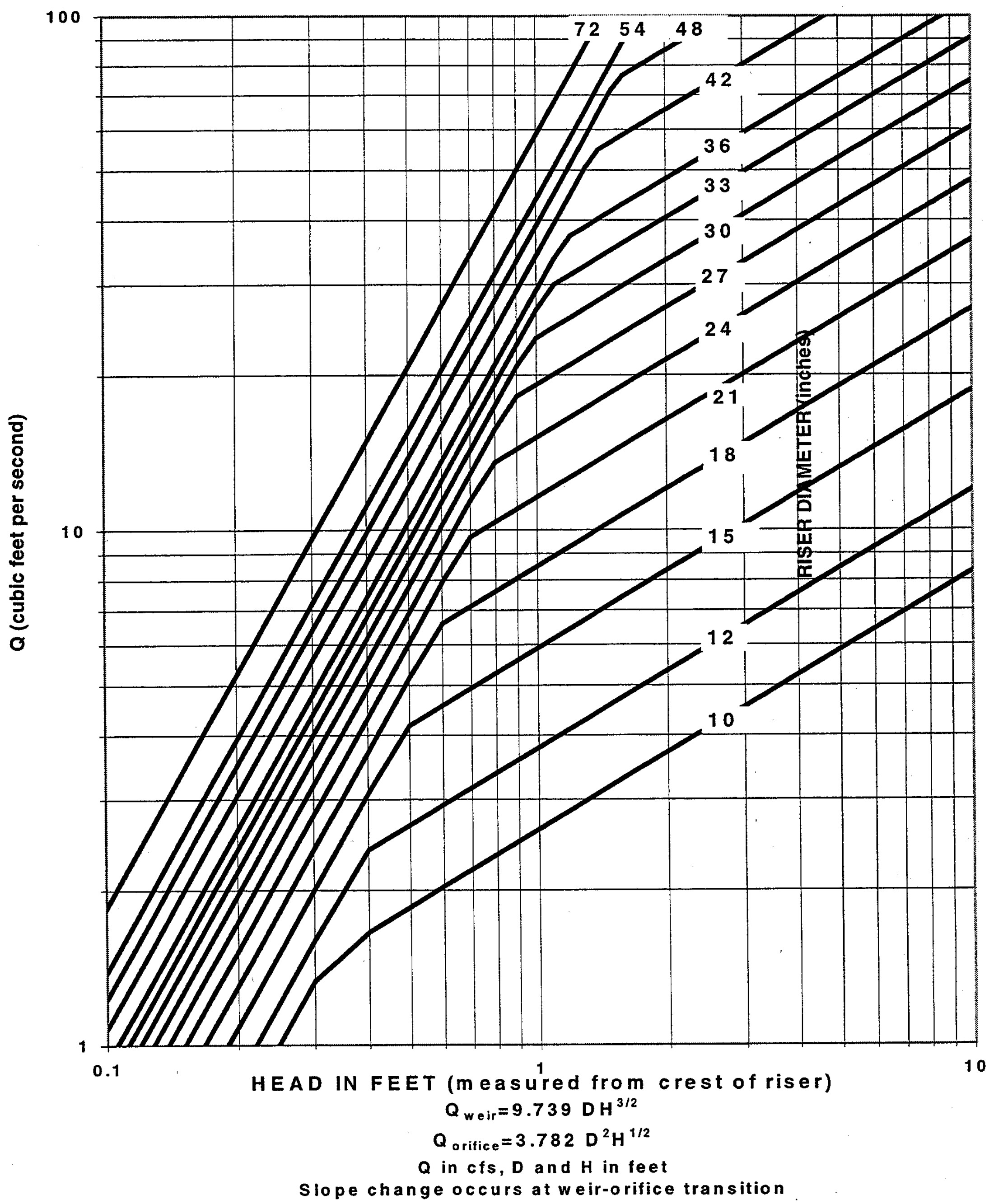


Figure 3.24. Riser Inflow Curves.

- **Emergency Overflow Spillway:** Determine the required size and design of the emergency overflow spillway for the developed 100-year peak flow indicated by an approved continuous runoff model using a 15-minute time step

- **Dewatering Orifice:** Determine the size of the dewatering orifice(s) (minimum 1-inch diameter) using a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice. Determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s (2h)^{0.5}}{0.6\text{x}3600Tg^{0.5}}$$

where: A_O = orifice area (square feet)

A_S = pond surface area (square feet)

h = head of water above orifice (height of riser in feet)

T = dewatering time (24 hours)

g = acceleration of gravity (32.2 feet/second^2)

Convert the required surface area to the required diameter D of the orifice:

$$D = 24\text{x}\sqrt{\frac{A_o}{\pi}} = 13.54\text{x}\sqrt{A_o}$$

The vertical, perforated tubing connected to the dewatering orifice must be at least 2 inches larger in diameter than the orifice to improve flow characteristics. Make the size and number of perforations in the tubing so that the tubing does not restrict flow. The orifice should control the flow rate.

Additional Design Specifications:

The **pond shall be divided** into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells. The divider shall be at least one-half the height of the riser and a minimum of 1 foot below the top of the riser. Wire-backed, 2- to 3-foot high, extra strength filter fabric supported by treated 4"x4"s can be used as a divider. Alternatively, staked straw bales wrapped with filter fabric (geotextile) may be used. If the pond is more than 6 feet deep, a different mechanism must be proposed. A riprap embankment is one acceptable method of separation for deeper ponds. Other designs that satisfy the intent of this provision are allowed as long as the divider is permeable, structurally sound, and designed to prevent erosion under or around the barrier.

To aid in determining sediment depth, **1-foot intervals** above the pond bottom shall be prominently marked on the riser or a staff gauge.

If an **embankment** of more than 6 feet is proposed, the pond must comply with the criteria contained in Volume V regarding dam safety for detention BMPs.

- The most common structural failure of sedimentation ponds is caused by piping. Piping refers to two phenomena: (1) water seeping through fine-grained soil, eroding the soil grain by grain and forming pipes or tunnels; and (2) water under pressure flowing upward through a granular soil with a head of sufficient magnitude to cause soil grains to lose contact and capability for support.

  The most critical construction sequences to prevent piping will be:

  - Tight connections between riser and barrel and other pipe connections.
  - Adequate anchoring of riser.
  - Proper soil compaction of the embankment and riser footing.
  - Proper construction of anti-seep devices.

Maintenance Standards

- Sediment shall be removed from the pond when it reaches 1 foot in depth.
- Any damage to the pond embankments or slopes shall be repaired.

3.2.17 BMP C250: Construction Stormwater Chemical Treatment

Purpose

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. Sedimentation ponds are effective at removing larger particulate matter by gravity settling, but are ineffective at removing smaller particulates such as clay and fine silt. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Chemical treatment may be used to reduce the turbidity of stormwater runoff.

Conditions of Use

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Very high turbidities can be reduced to levels comparable to what is found in streams during dry weather. Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Chemical treatment may be required to protect streams from the impact of turbid stormwater discharges, especially when construction is to proceed through the wet season.

Formal written approval from Ecology and acceptance by the County is required for the use of chemical treatment regardless of site size. The intention to use Chemical Treatment shall be indicated on the Notice of Intent for coverage under the General Construction Permit. Chemical treatment systems should be designed as part of the Construction SWPPP, not after the fact. Chemical treatment may be used to correct problem sites in limited circumstances with formal written approval from Ecology and acceptance by the County.

The intention to use chemical treatment should be included in the SEPA documentation for the project. The SEPA review authority (typically Thurston County) must be notified at the application phase of the project review (or the time that the SEPA determination on the project is performed) that chemical treatment is proposed. If it is added after this stage, an addendum may be necessary and may result in project approval delay.

Design and Installation Specifications

See Appendix II-B for background information on chemical treatment.

Criteria for Chemical Treatment Product Use: Chemically treated stormwater discharged from construction sites must be nontoxic to aquatic organisms. The Chemical Technology Assessment Protocol (CTAPE) must be used to evaluate chemicals proposed for stormwater treatment. Only chemicals approved by Ecology under the CTAPE may be used for stormwater treatment. The approved chemicals, their allowable application techniques (batch treatment or flow-through treatment), allowable application rates, and conditions of use can be found at the Department of Ecology Emerging Technologies website: <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html>.

Treatment System Design Considerations: The design and operation of a chemical treatment system should take into consideration the factors that determine optimum, cost-effective performance. It is important to recognize the following:

- Only Ecology approved chemicals may be used and must follow approved dose rates.

- The pH of the stormwater must be in the proper range for the polymers to be effective, which is typically 6.5 to 8.5.
- The coagulant must be mixed rapidly into the water to ensure proper dispersion.
- A flocculation step is important to increase the rate of settling, to produce the lowest turbidity, and to keep the dosage rate as low as possible.
- Too little energy input into the water during the flocculation phase results in flocs that are too small and/or insufficiently dense. Too much energy can rapidly destroy floc as it is formed.
- Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. Discharge from a batch treatment system shall be directed through a physical filter such as a vegetated swale that would catch any unintended floc discharge. Currently, flow-through systems always discharge through the chemically enhanced sand filtration system.
- System discharge rates must take into account downstream conveyance integrity.

Polymer Batch Treatment Process Description:

A batch chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

The batch treatment system shall use a minimum of two lined treatment cells in addition to the untreated stormwater storage pond. Multiple treatment cells allow for clarification of treated water while other cells are being filled or emptied. Treatment cells may be ponds or tanks. Ponds with constructed earthen embankments greater than 6 feet high require special engineering analyses.

Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

The first step in the treatment sequence is to check the pH of the stormwater in the untreated stormwater storage pond. The pH is adjusted by the application of carbon dioxide or a base until the stormwater in the storage pond is within the desired pH range, 6.5 to 8.5. When used, carbon dioxide is added immediately downstream of the transfer pump. Typically sodium bicarbonate (baking soda) is used as a base, although other bases may be used. When needed, base is added directly to the untreated stormwater storage pond. The stormwater is recirculated with the treatment pump to provide mixing in the storage pond. Initial pH adjustments should be based on daily bench tests. Further pH adjustments can be made at any point in the process.

Once the stormwater is within the desired pH range (dependant on polymer being used), the stormwater is pumped from the untreated stormwater storage pond to a treatment cell as polymer is added. The polymer is added upstream of the pump to facilitate rapid mixing.

After polymer addition, the water is kept in a lined treatment cell for clarification of the sediment-floc. In a batch mode process, clarification typically takes from 30 minutes to several hours. Prior to discharge samples are withdrawn for analysis of pH and turbidity. If both are acceptable, the treated water is discharged.

Several configurations have been developed to withdraw treated water from the treatment cell. The original configuration is a device that withdraws the treated water from just beneath the water surface using a float with adjustable struts that prevent the float from settling on the cell bottom. This reduces the possibility of picking up sediment-floc from the bottom of the pond. The struts are usually set at a minimum clearance of about 12 inches; that is, the float will come within 12 inches of the bottom of the cell. Other systems have used vertical guides or cables which constrain the float, allowing it to drift up and down with the water level. More recent designs have an H-shaped array of pipes, set on the horizontal.

This scheme provides for withdrawal from four points rather than one. This configuration reduces the likelihood of sucking settled solids from the bottom. It also reduces the tendency for a vortex to form. Inlet diffusers, a long floating or fixed pipe with many small holes in it, are also an option.

Safety is a primary concern. Design should consider the hazards associated with operations, such as sampling. Facilities should be designed to reduce slip hazards and drowning. Tanks and ponds should have life rings, ladders, or steps extending from the bottom to the top.

Polymer Flow-Through Treatment Process Description:

At a minimum, a flow-through chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, and the chemically enhanced sand filtration system.

Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

Stormwater is then pumped from the untreated stormwater storage pond to the chemically enhanced sand filtration system where polymer is added. Adjustments to pH may be necessary before chemical addition. The sand filtration system continually monitors the stormwater for turbidity and pH. If the discharge water is ever out of an acceptable range for turbidity or pH, the water is recycled to the untreated stormwater pond where it can be retreated.

For batch treatment and flow-through treatment, the following equipment should be located in a lockable shed:

- The chemical injector
- Secondary non-corrosive containment for acid, caustic, buffering compound, and treatment chemical
- Emergency shower and eyewash
- Monitoring equipment.

System Sizing

Certain sites are required to implement flow control for the developed sites. These sites must also control stormwater release rates during construction. Generally, these are sites that discharge stormwater directly, or indirectly, through a conveyance system, into a fresh water. System sizing is dependent on flow control requirements.

Sizing Criteria for Batch Treatment Systems for Flow Control Exempt Water Bodies

The total volume of the untreated stormwater storage pond and treatment ponds or tanks must be large enough to treat the volume of stormwater that is produced during multiple day storm events. It is recommended that at a minimum the untreated stormwater storage pond be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event. Bypass shall be provided around the chemical treatment system to accommodate extreme storm events.

Primary settling should be encouraged in the untreated stormwater storage pond. A forebay with access for maintenance may be beneficial.

There are two opposing considerations in sizing the treatment cells. A larger cell is able to treat a larger volume of water each time a batch is processed. However, the larger the cell the longer the time required to empty the cell. A larger cell may also be less effective at flocculation and therefore require a longer settling time. The simplest approach to sizing the treatment cell is to multiply the allowable discharge flow rate times the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour of flocculation followed by 2 hours of settling.

If the discharge is directly to a lake, flow control exempt receiving water listed in Volume I, or to an infiltration system, there is no discharge flow limit.

Ponds sized for flow control water bodies must at a minimum meet the sizing criteria for flow control exempt waters.

Sizing Criteria for Flow-Through Treatment Systems for Flow Control Exempt Water Bodies:

When sizing storage ponds or tanks for flow-through systems for flow control exempt water bodies, the treatment system capacity should be a factor. The untreated stormwater storage pond or tank shall be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event minus the treatment system flowrate for an 8-hour period. For a chitosan-enhanced sand filtration system, the treatment system flowrate shall be sized using a hydraulic loading rate between 6 to 8 gpm/ft^2. Other hydraulic loading rates may be more appropriate for other systems. Bypass shall be provided around the chemical treatment system to accommodate extreme storms.

Sizing Criteria for Flow Control Water Bodies

Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from 50 percent of the 2-year recurrence interval flow through the 10-year flow as predicted by an approved continuous runoff model. The pre-developed condition to be matched shall be the land cover condition immediately prior to the development project. This restriction on release rates can affect the size of the storage pond and treatment cells.

The following is how WWHM can be used to determine the release rates from the chemical treatment systems:

- Determine the pre-developed flow durations to be matched by entering the land use area under the "Pre-developed" scenario in WWHM. The default flow range is from 50 percent of the 2-year recurrence interval flow through the 10-year flow.
- Enter the post developed land use area in the "Developed Unmitigated" scenario in WWHM.
- Copy the land use information from the "Developed Unmitigated" to "Developed Mitigated" scenario.
- While in the "Developed Mitigated" scenario, add a pond element under the basin element containing the post-developed land use areas. This pond element represents information on the available untreated stormwater storage and discharge from the chemical treatment system. In cases where the discharge from the chemical treatment system is controlled by a pump, a stage/storage/ discharge (SSD) table representing the pond must be generated outside WWHM and imported into WWHM. WWHM can route the runoff from the post-developed condition through this SSD table (the pond) and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial SSD table proved to be inadequate, the designer would have to modify the SSD table outside WWHM and re-import in WWHM and route the runoff through it again. The iteration will continue until a pond that complies with the flow duration standard is correctly sized.

Notes on SSD table characteristics:

- The pump discharge rate would likely be initially set at just below 50 percent of the 2-year recurrence interval flow from the pre-developed condition. As runoff coming into the untreated stormwater storage pond increases and the available untreated stormwater storage volume gets used up, it would be necessary to increase the pump discharge rate above 50 percent of the 2-year recurrence interval flow. The increase(s) above 50 percent of the 2-year recurrence interval flow must be such that they provide some relief to the untreated stormwater storage needs but at the same time will not cause violations of the flow duration standard at the higher flows. The final design SSD table will identify the appropriate pumping rates and the corresponding stage and storages.
- When building such a flow control system, the design must ensure that any automatic adjustments to the pumping rates will be as a

result of changes to the available storage in accordance with the final design SSD table.

It should be noted that the above procedures would be used to meet the flow control requirements. The chemical treatment system must be able to meet the runoff treatment requirements. It is likely that the discharge flow rate of 50 percent of the 2-year recurrence interval or more may exceed the treatment capacity of the system. If that is the case, the untreated stormwater discharge rate(s) (i.e., influent to the treatment system) must be reduced to allow proper treatment. Any reduction in the flows would likely result in the need for a larger untreated stormwater storage volume.

- If the discharge is to a municipal storm drainage system, the allowable discharge rate may be limited by the capacity of the public system. It may be necessary to clean the municipal storm drainage system prior to the start of the discharge to prevent scouring solids from the drainage system. If the municipal storm drainage system discharges to a water body not on the flow control exempt list, the project site is subject to flow control requirements.

- If system design does not allow you to discharge at the slower rates as described above and if the site has a retention or detention pond that will serve the planned development, the discharge from the treatment system may be directed to the permanent retention/detention pond to comply with the flow control requirement. In this case, the untreated stormwater storage pond and treatment system will be sized according to the sizing criteria for flow-through treatment systems for flow control exempt water bodies described earlier except all discharge (water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent retention/detention pond. If site constraints make locating the untreated stormwater storage pond difficult, the permanent retention/detention pond may be divided to serve as the untreated stormwater storage pond and the post-treatment flow control pond. A berm or barrier must be used in this case so the untreated water does not mix with the treated water. Both untreated stormwater storage requirements, and adequate post-treatment flow control must be achieved. The post-treatment flow control pond's revised dimensions must be entered into the WWHM and the WWHM must be run to confirm compliance with the flow control requirement.

Maintenance Standards

Monitoring: At a minimum, the following monitoring shall be conducted. Test results shall be recorded on a daily log kept on site.

Additional testing may be required by the NPDES Permit based on site conditions:

Operational Monitoring

- Total volume treated and discharged
- Flow must be continuously monitored and recorded at not greater than 15-minute intervals
- Type and amount of chemical used for pH adjustment, if any
- Quantity of chemical used for treatment
- Settling time.

Compliance Monitoring

- Influent and effluent pH and turbidity must be continuously monitored and recorded at not greater than 15-minute intervals.
- pH and turbidity of the receiving water.

Biomonitoring

- Treated stormwater must be non-toxic to aquatic organisms. Treated stormwater must be tested for aquatic toxicity or residual chemical content. Frequency of biomonitoring will be determined by Ecology.
- Residual chemical tests must be approved by Ecology prior to their use.
- If testing treated stormwater for aquatic toxicity, you must test for acute (lethal) toxicity. Bioassays shall be conducted by a laboratory accredited by Ecology, unless otherwise approved by Ecology. Acute toxicity tests shall be conducted per the CTAPE protocol.
- Discharge Compliance: Prior to discharge, treated stormwater must be sampled and tested for compliance with pH and turbidity limits. These limits may be established by the Construction Stormwater General Permit or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. The pH must be within the range of 6.5 to 8.5 standard units and not cause a change in the pH of the receiving water of more than 0.2 standard units.

- Treated stormwater samples and measurements shall be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge. Samples used for determining compliance with the water quality standards in the receiving water shall not be taken from the treatment pond prior to decanting. Compliance with the water quality standards is determined in the receiving water.

- Operator Training: Each contractor who intends to use chemical treatment shall be trained by an experienced contractor on an active site.

Standard BMPs:

- Surface stabilization BMPs should be implemented on site to prevent significant erosion. All sites shall use a truck wheel wash to prevent tracking of sediment off site.

Sediment Removal and Disposal:

- Sediment shall be removed from the storage or treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the cells. Sediment remaining in the cells between batches may enhance the settling process and reduce the required chemical dosage.

- Sediment that is known to be non-toxic may be incorporated into the site away from drainages.

3.2.18 BMP C251: Construction Stormwater Filtration

Purpose

To remove sediment from runoff originating from disturbed areas of the site.

Conditions of Use

Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Filtration may be used in conjunction with gravity settling to remove sediment as small as fine silt (0.5 µm). The reduction in turbidity will be dependent on the particle size distribution of the sediment in the stormwater. In some circumstances, sedimentation and filtration may achieve compliance with the water quality standard for turbidity.

The use of construction stormwater filtration does not require prior approval from Ecology or Thurston County as long as treatment chemicals are not used. Filtration in conjunction with polymer treatment requires testing under the Chemical Technology Assessment Protocol – Ecology (CTAPE) before it can be initiated. Approval from the appropriate regional Ecology office and acceptance by Thurston County must be obtained at each site where polymers use is proposed prior to use. For more guidance on stormwater chemical treatment see BMP C250.

Design and Installation Specifications

Background Information

Filtration with sand media has been used for over a century to treat water and wastewater. The use of sand filtration for treatment of stormwater has developed recently, generally to treat runoff from streets, parking lots, and residential areas. The application of filtration to construction stormwater treatment is currently under development.

Two types of filtration systems may be applied to construction stormwater treatment: rapid and slow. Rapid sand filters are the typical system used for water and wastewater treatment. They can achieve relatively high hydraulic flow rates, on the order of 2 to 20 gpm/sf, because they have automatic backwash systems to remove accumulated solids. In contrast, slow sand filters have very low hydraulic rates, on the order of 0.02 gpm/sf, because they do not have backwash systems. To date, slow sand filtration has generally been used to treat stormwater. Slow sand filtration is mechanically simple in comparison to rapid sand filtration but requires a much larger filter area.

Filtration Equipment. Sand media filters are available with automatic backwashing features that can filter to 50 µm particle size. Screen or bag filters can filter down to 5 µm. Fiber wound filters can remove particles down to 0.5 µm. Sequence filters from the largest to the smallest pore opening. Sediment removal efficiency will be related to particle size distribution in the stormwater.

Treatment Process Description. Stormwater is collected at interception point(s) on the site and is diverted to a sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. The stormwater is pumped from the trap, pond, or tank through the filtration system in a rapid sand filtration system. Slow sand filtration systems are designed as flow through systems using gravity.

If large volumes of concrete are being poured, pH adjustment may be necessary.

Sizing Criteria for Flow-Through Treatment Systems for Flow Control

Exempt Water Bodies:

When sizing storage ponds or tanks for flow-through systems for flow control exempt water bodies the treatment system capacity should be a factor. The untreated stormwater storage pond or tank shall be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event minus the treatment system flowrate for an 8-hour period. For a chitosan-enhanced sand filtration system, the treatment system flowrate shall be sized using a hydraulic loading rate between 6 to 8 gpm/ft^2. Other hydraulic loading rates may be more appropriate for other systems. Bypass shall be provided around the chemical treatment system to accommodate extreme storms.

Sizing Criteria for Flow Control Water Bodies:

Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from 50 percent of the 2-year recurrence interval flow through the 10-year flow as predicted by an approved continuous runoff model. The pre-developed condition to be matched shall be the land cover condition immediately prior to the development project. This restriction on release rates can affect the size of the storage pond, the filtration system, and the flow rate through the filter system.

The following is how WWHM can be used to determine the release rates from the filtration systems:

- Determine the pre-developed flow durations to be matched by entering the land use area under the “Pre-developed” scenario in WWHM. The default flow range is from 50 percent of the 2-year recurrence interval flow through the 10-year flow.
- Enter the post developed land use area in the “Developed Unmitigated” scenario in WWHM.
- Copy the land use information from the “Developed Unmitigated” to “Developed Mitigated” scenario.
- There are two possible ways to model stormwater filtration systems:
    - o The stormwater filtration system uses an untreated stormwater storage pond/tank and the discharge from this pond/tank is

pumped to one or more filters. In-line filtration chemicals would be added to the flow right after the pond/tank and before the filter(s). Because the discharge is pumped, WWHM cannot generate a stage/storage/discharge (SSD) table for this system. This system is modeled the same way as described in BMP C250 and is as follows:

– While in the "Developed Mitigated" scenario, add a pond element under the basin element containing the post-developed land use areas. This pond element represents information on the available untreated stormwater storage and discharge from the filtration system. In cases where the discharge from the filtration system is controlled by a pump, a stage/storage/ discharge (SSD) table representing the pond must be generated outside WWHM and imported into WWHM. WWHM can route the runoff from the post-developed condition through this SSD table (the pond) and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial SSD table proved to be out of compliance, the designer would have to modify the SSD table outside WWHM and re-import in WWHM and route the runoff through it again. The iteration will continue until a pond that enables compliance with the flow duration standard is designed.

o Notes on SSD table characteristics:

– The pump discharge rate would likely be initially set at just below one-half if the 2-year recurrence interval flow from the pre-developed condition. As runoff coming into the untreated stormwater storage pond increases and the available untreated stormwater storage volume gets used up, it would be necessary to increase the pump discharge rate above 50 percent of the 2-year recurrence interval flow. The increase(s) above 50 percent of the 2-year must be such that they provide some relief to the untreated stormwater storage needs but at the same time they will not cause violations of the flow duration standard at the higher flows. The final design SSD table will identify the appropriate pumping rates and the corresponding stage and storages.

- When building such a flow control system, the design must ensure that any automatic adjustments to the pumping rates will be as a result of changes to the available storage in accordance with the final design SSD table.

- The stormwater filtration system uses a storage pond/tank and the discharge from this pond/tank gravity flows to the filter. This is usually a slow sand filter system and it is possible to model it in WWHM as a Filter element or as a combination of Pond and Filter element placed in series. The stage/storage/discharge table(s) may then be generated within WWHM as follows:

  - While in the "Developed Mitigated" scenario, add a Filter element under the basin element containing the post-developed land use areas. The length and width of this filter element would have to be the same as the bottom length and width of the upstream untreated stormwater storage pond/tank.

  - In cases where the length and width of the filter is not the same as those for the bottom of the upstream untreated stormwater storage tank/pond, the treatment system may be modeled as a Pond element followed by a Filter element. By having these two elements, WWHM would then generate a SSD table for the storage pond which then gravity flows to the Filter element. The Filter element downstream of the untreated stormwater storage pond would have a storage component through the media, and an overflow component for when the filtration capacity is exceeded.

- WWHM can route the runoff from the post-developed condition through the treatment systems in 4b and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial sizing estimates for the treatment system proved to be inadequate, the designer would have to modify the system and route the runoff through it again. The iteration would continue until compliance with the flow duration standard is achieved.

- It should be noted that the above procedures would be used to meet the flow control requirements. The filtration system must be able to meet the runoff treatment requirements. It is likely that the discharge flow rate of 50 percent of the 2-year recurrence interval flow or more may exceed the treatment capacity of the system. If that is the case, the untreated stormwater discharge rate(s) (i.e., influent to the treatment system) must be reduced to allow proper treatment. Any reduction in the flows would likely result in the need for a larger untreated stormwater storage volume.

- If system design does not allow you to discharge at the slower rates as described above and if the site has a retention or detention pond that will serve the planned development, the discharge from the treatment system may be directed to the permanent retention/detention pond to comply with the flow control requirements. In this case, the untreated stormwater storage pond and treatment system will be sized according to the sizing criteria for flow-through treatment systems for flow control exempt waterbodies described earlier except all discharges (water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent retention/detention pond. If site constraints make locating the untreated stormwater storage pond difficult, the permanent retention/detention pond may be divided to serve as the untreated stormwater discharge pond and the post-treatment flow control pond. A berm or barrier must be used in this case so the untreated water does not mix with the treated water. Both untreated stormwater storage requirements, and adequate post-treatment flow control must be achieved. The post-treatment flow control pond's revised dimensions must be entered into the WWHM and the WWHM must be run to confirm compliance with the flow control requirement.

Maintenance Standards

Rapid sand filters typically have automatic backwash systems that are triggered by a pre-set pressure drop across the filter. If the backwash water volume is not large or substantially more turbid than the stormwater stored in the holding pond or tank, backwash return to the pond or tank may be appropriate. However, land application or another means of treatment and disposal may be necessary.

- Screen, bag, and fiber filters must be cleaned and/or replaced when they become clogged.

- Sediment shall be removed from the storage and/or treatment ponds as necessary. Typically, sediment removal is required once or twice during a wet season and at the decommissioning of the ponds.

3.2.19 BMP C252: High pH Neutralization Using CO_2

Description

When pH levels in stormwater rise above 8.5, it is necessary to lower the pH levels to the acceptable range of 6.5 to 8.5, this process is called pH neutralization. The pH neutralization involves the use of solid or compressed carbon dioxide gas in water requiring neutralization. Neutralized stormwater may be discharged to surface waters under the General Construction NPDES Permit but neutralized process water must be managed to prevent discharge to surface waters. Process wastewater includes wastewaters such as concrete truck wash-out, hydro-demolition, or saw-cutting slurry.

Reason for pH Neutralization

- A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this neutral pH is required for the survival of aquatic organisms. Should the pH rise or drop out of this range, fish and other aquatic organisms may become stressed and may die.
- Calcium hardness can contribute to high pH values and cause toxicity that is associated with high pH conditions. A high level of calcium hardness in waters of the state is not allowed.
- The water quality standard for pH in Washington State is in the range of 6.5 to 8.5. Groundwater standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

Causes of High pH

High pH at construction sites is most commonly caused by the contact of stormwater with poured or recycled concrete, cement, mortars, and other Portland cement or lime-containing construction materials. (See BMP C151: Concrete Handling for more information on concrete handling procedures.) The principal caustic agent in cement is calcium hydroxide (free lime).

Advantages of CO_2 Sparging

- Rapidly neutralizes high pH water
- Cost effective and safer to handle than acid compounds
- CO_2 is self-buffering. It is difficult to overdose and create harmfully low pH levels.
- Material is readily available.

The Chemical Process

- When carbon dioxide (CO_2) is added to water (H_2O), carbonic acid (H_2CO_3) is formed which can further dissociate into a proton (H^+) and a bicarbonate anion (HCO_3^-) as shown below:

$$CO_2 + H_2O \longleftrightarrow H_2C0_3 \longleftrightarrow H^+ + HCO_3^-$$

- The free proton is a weak acid that can lower the pH. Water temperature has an effect on the reaction as well. The colder the water temperature is the slower the reaction occurs and the warmer the water temperature is the quicker the reaction occurs. Most construction applications in Washington State have water temperatures in the 50°F or higher range so the reaction is almost simultaneous.

Treatment Procedures

- High pH water may be treated using continuous treatment, continuous discharge systems. These manufactured systems continuously monitor influent and effluent pH to ensure that pH values are within an acceptable range before being discharged. All systems must have fail safe automatic shut off switches in the event that pH is not within the acceptable discharge range. Only trained operators may operate manufactured systems. System manufacturers often provide trained operators or training on their devices.

- The following procedure may be used when not using a continuous discharge system:

    - Prior to treatment, Thurston County must be notified.

    - Every effort should be made to isolate the potential high pH water in order to treat it separately from other stormwater onsite.

    - Water should be stored in an acceptable storage facility, detention pond, or containment cell prior to treatment.

    - Transfer water to be treated to the treatment structure. Ensure that treatment structure size is sufficient to hold the amount of water that is to be treated. Do not fill tank completely, allow at least 2 feet of freeboard.

    - The operator samples the water for pH and notes the clarity of the water. As a rule of thumb, less CO_2 is necessary for clearer water. This information shall be recorded.

  - In the pH adjustment structure, add CO_2 until the pH falls in the range of 6.9 to 7.1. Remember that pH water quality standards apply so adjusting pH to within 0.2 pH units of receiving water (background pH) is recommended. It is unlikely that pH can be adjusted to within 0.2 pH units using dry ice. Compressed carbon dioxide gas should be introduced to the water using a carbon dioxide diffuser located near the bottom of the tank; this will allow carbon dioxide to bubble up through the water and diffuse more evenly.

  - Slowly release the water to discharge making sure water does not get stirred up in the process. Release about 80 percent of the water from the structure leaving any sludge behind.

  - Discharge treated water through a pond or drainage system.

  - Excess sludge needs to be disposed of properly as concrete waste. If several batches of water are undergoing pH treatment, sludge can be left in treatment structure for the next batch treatment. Dispose of sludge when it fills 50 percent of tank volume.

- Sites that must implement flow control for the developed site must also control stormwater release rates during construction. All treated stormwater must go through a flow control facility before being released to surface waters which require flow control.

Safety and Materials Handling

- All equipment should be handled in accordance with OSHA rules and regulations

- Follow manufacturer guidelines for materials handling.

Operator Records

- Each operator should provide:

  - A diagram of the monitoring and treatment equipment

  - A description of the pumping rates and capacity the treatment equipment is capable of treating.

- Each operator shall keep a written record of the following:

  - Client name and phone number

  - Date of treatment

- Weather conditions
- Project name and location
- Volume of water treated
- pH of untreated water
- Amount of CO_2 needed to adjust water to a pH range of 6.9 to 7.1
- pH of treated water
- Discharge point location and description.

A copy of this record shall be given to the client/contractor who shall retain the record for 3 years.

3.2.20 BMP C253: pH Control for High pH Water

Description

When pH levels in stormwater rise above 8.5, it is necessary to lower the pH levels to the acceptable range of 6.5 to 8.5; this process is called pH neutralization. Stormwater with pH levels exceeding water quality standards may be treated by infiltration, dispersion in vegetation or compost, pumping to a sanitary sewer, disposal at a permitted concrete batch plant with pH neutralization capabilities, or carbon dioxide sparging. BMP C252 gives guidelines for carbon dioxide sparging, the other methods are presented below.

Reason for pH Neutralization

A pH level between 6.5 and 8.5 is typical for most natural watercourses, and this pH range is required for the survival of aquatic organisms. Should the pH rise or drop out of this range, fish and other aquatic organisms may become stressed and may die.

Causes of High pH

High pH levels at construction sites are most commonly caused by the contact of stormwater with poured or recycled concrete, cement, mortars, and other Portland cement or lime-containing construction materials. (See BMP C151: Concrete Handling for more information on concrete handling procedures.) The principal caustic agent in cement is calcium hydroxide (free lime).

Disposal Methods

Infiltration

- Infiltration is only allowed if soil type allows all water to infiltrate (no surface runoff) without causing or contributing to a violation of surface or groundwater quality standards.
- Infiltration techniques should be consistent with Volume V, Chapter 3.

Dispersion

- Use Volume V, Chapter 2, sheet flow or concentrated flow dispersion BMPs.

Sanitary Sewer Disposal

- Thurston County approval is required prior to disposal via the sanitary sewer.

Concrete Batch Plant Disposal

- Only permitted facilities may accept high pH water
- Facility should be contacted before treatment to ensure they can accept the high pH water.

Stormwater Discharge

- Any pH treatment options that generate treated water that must be discharged off site are subject to flow control requirements. Sites that must implement flow control for the developed site must also control stormwater release rates during construction. All treated stormwater must go through a flow control facility before being released to surface waters which require flow control.

Resource Materials

Association of General Contractors of Washington, Water Quality Manual.

Clark County Conservation District, Erosion and Runoff Control, January 1981.

King County Conservation District, Construction and Erosion Control, December 1981.

King County Department of Transportation Road Maintenance BMP Manual (Final Draft), May 1998.

King County Surface Water Design Manual, September 1998.

Maryland Erosion and Sedimentation Control Manual, 1983.

Michigan State Guidebook for Erosion and Sediment Control, 1975.

Snohomish County Addendum to the 1992 Ecology Stormwater Management Manual for the Puget Sound Basin, September 1998.

University of Washington, by Loren Reinelt, Construction Site Erosion and Sediment Control Inspector Training Manual, Center for Urban Water Resources Management, October 1991.

University of Washington, by Loren Reinelt, Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity, Center for Urban Water Resources Management, October 1991.

Virginia Erosion and Sediment Control Handbook, 2nd Edition, 1980.

Appendix II-A
Recommended Standard Notes for Construction Stormwater Pollution Prevention Plans

The following standard notes are suggested for use in construction stormwater pollution prevention plans (SWPPP). The County has other mandatory notes for construction plans that may be applicable, see Volume I Appendix I-G. Plans should also identify with phone numbers the person or firm responsible for the preparation of and maintenance of the erosion and sediment control (ESC) facilities.

Standard Notes

Acceptance of this SWPPP by Thurston County does not constitute an acceptance of permanent road or drainage design (e.g., size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.).

The implementation of this SWPPP and the construction, maintenance, replacement, and upgrading of ESC facilities is the responsibility of the owner and contractor until all construction is completed and approved and vegetation/landscaping is established.

The boundaries of the clearing limits shown on this plan shall be clearly flagged in the field prior to construction. During the construction period, no disturbance beyond the flagged clearing limits shall be permitted. The flagging shall be maintained by the applicant/contractor for the duration of construction.

The ESC facilities shown on this plan must be constructed in conjunction with all clearing and grading activities, and in such a manner as to insure that sediment and sediment laden water do not enter the drainage system, roadways, or violate applicable water standards.

The ESC facilities shown on this plan are the minimum requirements for anticipated site conditions. During the construction period, these ESC facilities shall be upgraded as needed for unexpected storm events and to ensure that sediment and sediment-laden water do not leave the site.

The ESC facilities shall be inspected daily by the applicant/contractor and maintained as necessary to ensure their continued functioning.

The ESC facilities on inactive sites shall be inspected and maintained a minimum of once a month or within the 48 hours following a major storm event (>1” in 24 hours).

At no time shall more than 1 foot or 1/3 of the sump volume, whichever is less, of sediment be allowed to accumulate within a trapped catch basin. All catch basins shall have silt socks installed. All catch basins and conveyance lines shall be cleaned prior to paving. The cleaning operation shall not flush sediment laden water into the downstream system.

Stabilized construction entrances shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures may be required to insure that all paved areas are kept clean for the duration of the project.

Appendix II-B
Background Information on Chemical Treatment

Coagulation and *flocculation* have been used for over a century to treat water. Both are used less frequently for the treatment of wastewater, and their use for treating stormwater is a very recent application. Experience with water and wastewater treatment has resulted in a basic understanding of the process, especially factors that affect performance. This experience can provide insights on how to most effectively design and operate similar systems in the treatment of stormwater.

Fine particles suspended in water give it a milky appearance, measured as *turbidity*. Their small size, often much less than 1 µm in diameter, give them a very large surface area relative to their volume. These fine particles typically carry a negative surface charge. Because of these two factors, fine particles tend to stay in suspension for extended periods of time, making removal by gravity settling impractical. These are called stable suspensions. Polymers and inorganic chemicals such as alum speed the process of clarification by destabilizing the suspension and causing the smaller particles to agglomerate. This process consists of three steps: coagulation, flocculation, and clarification, or settling. Each step is explained below.

1. **Coagulation**: Coagulation is the process of disrupting negative charges on the fine particles that prevent their agglomeration. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals used for this purpose are called coagulants. Coagulation is complete when the suspension is destabilized by the neutralization of the negative charges. Coagulants perform best when they are thoroughly and evenly dispersed under relatively intense mixing. This rapid mixing involves adding the coagulant in a manner that promotes rapid dispersion, followed by a short time period for destabilization of the particle suspension. The particles are still very small and not readily separated by clarification until flocculation occurs.

2. **Flocculation**: Flocculation occurs when fine particles that have been destabilized bind together to form larger, rapidly settling particles. Flocculation begins naturally following coagulation but is enhanced by gentle mixing of the destabilized suspension. Mixing helps to bring particles in contact with one another so that they bind and continually grow to form "flocs." As the size of the

flocs increases, they become heavier and tend to settle more rapidly.

3. **Clarification**: The final step is the settling of the particles. Particle density, size and shape are important during settling. Dense, compact flocs settle more readily than less dense, fluffy flocs. Because of this, flocculation to form dense, compact flocs is particularly important during water treatment. Both the density and viscosity of water are affected by temperature; these in turn affect settling. Cold temperatures increase viscosity and density, thus slowing down the rate at which the particles settle.

Currents can affect settling. Currents can be produced by wind, by differences between the temperature of the incoming water and the water in the clarifier, and by flow conditions near the inlets and outlets. Quiescent water such as that which occurs during batch clarification provides a good environment for effective performance as many of these factors become less important in comparison to typical sedimentation basins. One source of currents that is likely important in batch systems is movement of the water leaving the clarifier unit. Since flocs are small and light, the exit velocity of the water must be as low as possible. Sediment on the bottom of the basin can be resuspended and removed by moderate velocities.

Coagulants: Polymers are large organic molecules made up of subunits linked together in a chain-like structure. Attached to these chain-like structures are other groups that carry positive or negative charges, or have no charge. Polymers that carry groups with positive charges are called cationic, those with negative charges are called anionic, and those with no charge (neutral) are called nonionic.

Cationic polymers can be used as coagulants to destabilize negatively charged turbidity particles present in natural waters, wastewater and stormwater. Aluminum sulfate (alum) can also be used as this chemical becomes positively charged when dispersed in water. In practice, the only way to determine whether a polymer is effective for a specific application is to perform preliminary or onsite testing.

Polymers are available as powders, concentrated liquids, and emulsions (which appear as milky liquids). The latter are petroleum based, which are not allowed for construction stormwater treatment. Polymer effectiveness can degrade with time and also from other influences. Thus, manufacturers' recommendations for storage should be followed. Manufacturer’s recommendations usually do not provide assurance of water quality protection or safety to aquatic organisms. Consideration of water quality protection is necessary in the selection and use of all polymers.

Application Considerations: Application of coagulants at the appropriate concentration or dosage rate for optimum turbidity removal is important for management of chemical cost, for effective performance, and to avoid aquatic toxicity. The optimum dose in a given application depends on several site-specific features. Turbidity of untreated water can be important with turbidities greater than 5,000 NTU. The surface charge of particles to be removed is also important. Environmental factors that can influence dosage rate are water temperature, pH, and the presence of constituents that consume or otherwise affect polymer effectiveness. Laboratory experiments indicate that mixing previously settled sediment (floc sludge) with the untreated stormwater significantly improves clarification, therefore reducing the effective dosage rate. Preparation of working solutions and thorough dispersal of polymers in water to be treated is also important to establish the appropriate dosage rate.

For a given water sample, there is generally an optimum dosage rate that yields the lowest residual turbidity after settling. When dosage rates below this optimum value (underdosing) are applied, there is an insufficient quantity of coagulant to react with, and therefore destabilize, all of the turbidity present. The result is residual turbidity (after flocculation and settling) that is higher than with the optimum dose. Overdosing, application of dosage rates greater than the optimum value, can also negatively impact performance. Again, the result is higher residual turbidity than that with the optimum dose.

Mixing in Coagulation/Flocculation: The G-value, or just "G", is often used as a measure of the mixing intensity applied during coagulation and flocculation. The symbol G stands for “velocity gradient”, which is related in part to the degree of turbulence generated during mixing. High G-values mean high turbulence, and vice versa. High G-values provide the best conditions for coagulant addition. With high G's, turbulence is high and coagulants are rapidly dispersed to their appropriate concentrations for effective destabilization of particle suspensions.

Low G-values provide the best conditions for flocculation. Here, the goal is to promote formation of dense, compact flocs that will settle readily. Low G's provide low turbulence to promote particle collisions so that flocs can form. Low G's generate sufficient turbulence such that collisions are effective in floc formation, but do not break up flocs that have already formed.

Design engineers wishing to review more detailed presentations on this subject are referred to the following textbooks.

- Fair, G., J. Geyer and D. Okun, Water and Wastewater Engineering, Wiley and Sons, NY, 1968.
- American Water Works Association, Water Quality and Treatment, McGraw-Hill, NY, 1990.
- Weber, W.J., Physiochemical Processes for Water Quality Control, Wiley and Sons, NY, 1972.

Polymer Batch Treatment Process Description: Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to a storage pond or other holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

The first step in the treatment sequence is to check the pH of the stormwater in the storage pond. The pH is adjusted by the application of acid or base until the stormwater in the storage pond is within the desired pH range. When used, acid is added immediately downstream of the transfer pump. Typically sodium bicarbonate (baking soda) is used as a base, although other bases may be used. When needed, base is added directly to the storage pond. The stormwater is recirculated with the treatment pump to provide mixing in the storage pond. Base initial pH adjustments on daily bench tests. Further pH adjustments can be made at any point in the process.

Once the stormwater is within the desired pH range, the stormwater is pumped from the storage pond to a treatment cell as polymer is added. The polymer is added upstream of the pump to facilitate rapid mixing.

After polymer addition, the water is kept in a lined treatment cell for clarification of the sediment-floc. In a batch mode process, clarification typically takes from 30 minutes to several hours. Prior to discharge samples are withdrawn for analysis of pH and turbidity. If both are acceptable, the treated water is discharged.

Several configurations have been developed to withdraw treated water from the treatment cell. The original configuration is a device that withdraws the treated water from just beneath the water surface using a float with adjustable struts that prevent the float from settling on the cell bottom. This reduces the possibility of picking up sediment-floc from the bottom of the pond. The struts are usually set at a minimum clearance of about 12 inches; that is, the float will come within 12 inches of the bottom of the cell. Other systems have used vertical guides or cables which constrain the float, allowing it to drift up and down with the water level. More recent designs have an H-shaped array of pipes, set on the horizontal.

This scheme provides for withdrawal from four points rather than one. This configuration reduces the likelihood of sucking settled solids from the bottom. It also reduces the tendency for a vortex to form. Inlet diffusers, a long floating or fixed pipe with many small holes in it, are also an option.

Safety is a primary concern. Design should consider the hazards associated with operations, such as sampling. Design facilities to reduce slip hazards and drowning. Tanks and ponds should have life rings, ladders, or steps extending from the bottom to the top.

Adjustment of the pH and Alkalinity: The pH must be in the proper range for the polymers to be effective, which is 6.5 to 8.5 for Calgon CatFloc 2953, the most commonly used polymer. As polymers tend to lower the pH, it is important that the stormwater have sufficient buffering capacity. Buffering capacity is a function of alkalinity. Without sufficient alkalinity, the application of the polymer may lower the pH to below 6.5. A pH below 6.5 not only reduces the effectiveness of the polymer, it may create a toxic condition for aquatic organisms. Stormwater may not be discharged without readjustment of the pH to above 6.5. The target pH should be within 0.2 standard units of the receiving water pH.

Experience gained at several projects in the City of Redmond has shown that the alkalinity needs to be at least 50 mg/L to prevent a drop in pH to below 6.5 when the polymer is added. Baking soda has been used to raise both the alkalinity and the pH. Although lime is less expensive than baking soda, if overdosed lime can raise the pH above 8.5 requiring downward adjustment for the polymer to be effective. Baking soda has the advantage of not raising the pH above 8.3 regardless of the amount that is added. Experience indicates that the amount of baking soda sufficient to raise the alkalinity to above 50 mg/L produces a pH near neutral or 7.

Alkalinity cannot be easily measured in the field. Therefore, conductivity, which can be measured directly with a hand-held probe, has been used to ascertain the buffering condition. It has been found through local experience that when the conductivity is above about 100 µS/cm, the alkalinity is above 50 mg/L. This relationship may not be constant and therefore care must be taken to define the relationship for each site.

Experience has shown that the placement of concrete has a significant effect on the pH of construction stormwater. If the area of fresh exposed concrete surface is significant, the pH of the untreated stormwater may be considerably above 8.5. Concrete equipment washwater shall be controlled to prevent contact with stormwater. Acid may be added to lower the pH to the background level pH of the receiving water. The amount of acid needed to adjust the pH to the desired level is not constant but depends upon the polymer dosage, and the pH, turbidity, and alkalinity of the untreated stormwater. The acid commonly used is sulfuric although muriatic and ascorbic acids have been used. Pelletized dry ice has also been used and reduces the safety concerns associated with handling acid.

Appendix II-C
Short Form Construction Stormwater Pollution Prevention Plan (SWPPP) Template

Short Form Construction Stormwater Pollution Prevention Plan (SWPPP) Template

This Short Form Construction Stormwater Pollution Prevention Plan (SWPPP) may be used for projects less than 1-acre that require submittal of only an Abbreviated or Engineered Abbreviated Drainage Plan.

Section 1 –Project and Contact Information

Project Name/Description ____
Contact/Owner ______________________ Phone number ____________
Erosion Control Supervisor ________________ Phone number ____________
Emergency (after hour) contact ________________ Phone number ____________

Section 2 –Site Information

Site address ____
Parcel # ____
Soil type ____
(Soil type A, B, C, or D & Soil series per SCS Soil survey)

To find parcel number: *http://www.geodata.org/parcelsrch.asp*

For soil information, see *http://websoilsurvey.nrcs.usda.gov/app/*

For County Use Only:

County Permit No. ____________________________ Review Date ___________________
Reviewer _____________ ________________________

Section 3 – Eligibility for Abbreviated Drainage Plan/ Short Form SWPPP

Have you reviewed Volume I, Chapter 3 to confirm that your project is eligible to use the Abbreviated Drainage Plan? **YES** **NO**

Section 4 - Project Narrative

This narrative must be completed as part of the Construction SWPPP. Any information described as part of the narrative shall be shown on the site plan.

Note: From October 1 thru April 30, clearing, grading, and other soil disturbing activities are not permitted unless it can be demonstrated that no silt laden water will discharge from the site and except with authorization from Thurston County Development Services.

Project Description (check all that apply)

Project Type

Subdivision, Type ____________________	
Single Family Residential Project (building permit)	
Large Lot (>2.5 acres)	
Grading Permit	
Commercial Development	
Land Clearing	
Conversion of native vegetation to landscaping or pasture	
Other ____	

Project Areas

Total site area		SF
What is the area of land disturbance?		SF
Area of existing impervious surfaces		SF
Area of new impervious surfaces		SF
Total area of new, replaced, and existing impervious surface after project improvements		SF
Area of existing native vegetation to be converted to landscaping or pasture		SF
Will there be stormwater runoff or sediment discharges to adjoining properties or waters of the U.S. from the site?	YES	NO
If a grading permit is required, what is the total volume of grading?		CY

Additional Project Information (attach additional sheets if necessary)

____

____

____

____

____ _

Existing Site Conditions

1. What existing vegetation is present on the site? (check all that apply)

Description	EXIST? (Y/N)	% of Total Area
Forest		
Pasture/prairie grass		
Pavement		
Lawn/landscaping		
Brush		
Deciduous Trees		
Other		

2. How does surface water drainage flows across/from the site? (check all that apply)

Sheet flow/dispersion (with runoff from site)	
Sheet flow/dispersion (no runoff from site)	
Infiltration – no surface drainage leaving site	
Ditch/swale	
Stream	
Storm Sewer/catch basin or inlet	
Other	

3. Which of the following site condition(s) or other features of note are present on the site (indicate their location on site map)?

Steep slopes (>20%)	
Large depression	
Underground tanks	
Springs/Seeps	
Easements	
Existing structures	
Existing utilities	
Existing roadways	
Waters of the State (pond, stream, creek, river, etc.)	
Other	

Adjacent Areas

1. Which of the following adjacent areas could be impacted by site disturbance?

Streams*	
Lakes*	
Wetlands*	
Steep slopes*	
Residential Areas	
Roads	
Ditches, pipes, culverts	
Marine Bluff*	
Other	

*Note: If site is on or adjacent to a critical area, Thurston County may require additional information, engineering, and other permits to be submitted with this short-form.

2. Describe the downstream drainage path leading from the site to the receiving body of water. (Minimum distance of ¼-mile (1,320 feet)) {e.g., water flows from site, into curb-line to catch basin at intersection of X and Y streets. A 10-inch pipe system conveys water another 1,000 feet to a ravine/wetland.} (attach additional sheets if necessary)

____

____

____

____

____

____

Section 5 – Abbreviated Erosion Control Plan

Enter estimated start/end dates for the following construction activities/milestones.

Construction Schedule	Estimated Start/End Date
1. Permit obtained (start date)	____________________
2. Mark clearing limits	____________________
3. Establish construction access	____________________
4. Install sediment controls	____________________
5. Demolition	____________________
6. Grading	____________________
7. Utility construction	____________________
8. Building or structure construction	____________________
9. Landscaping/final site stabilization	____________________

Complete Checklist for all Projects

Element/ Description	Requirement	Applicable BMP(s)[1]	Confirmation
Mark Clearing Limits	Prior to beginning land-disturbing activities, mark clearing limits and delineate sensitive areas and their buffers with high visibility fence	BMP C101: Preserving Natural Vegetation BMP C102: Buffer Zones BMP C103: High Visibility Plastic Fence	Will comply ☐ N/A (explain):
Establish Construction Access	Provide stabilized construction entrance (e.g., quarry spalls or crushed rock); clean public roads if any sediment is transported off site. If an existing driveway will be used for construction access, describe condition and show on Site Plan.	BMP C105: Stabilized Construction Entrance	Will comply ☐ N/A (explain):
Install Sediment Controls	Provide suitable sediment control BMP to prevent sediment from leaving site.	BMP C233: Silt Fence BMP C234: Vegetated Strip BMP C235: Straw Wattles	Will comply ☐ N/A (explain):
Stabilize Soils	All unworked and exposed soils shall be stabilized to prevent erosion. From October 1 through April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days.	BMP C120: Temporary and Permanent Seeding BMP C121: Mulching BMP C122: Nets and Blankets BMP C123: Plastic Covering	Will comply ☐ N/A (explain):
Protect Slopes	Design and construct cut and fill slopes to minimize erosion.	BMP C120: Temporary and Permanent Seeding BMP C130: Surface Roughening	Will comply ☐ N/A (explain):
Protect Drain Inlets	Protect conveyance system from sediment by providing filtration of stormwater prior to entering inlets.	BMP C220: Storm Drain Inlet Protection	Will comply ☐ N/A (explain):
Control Pollutants	Handle and dispose of construction debris in dumpster or by hauling to waste transfer station so that it does not contaminate stormwater.		Will comply ☐ N/A (explain):
Control Dewatering	Manage dewatering water from construction activities to prevent sediment discharge from site. Manage highly turbid dewatering water separate from stormwater.		Will comply ☐ N/A (explain):
Maintain BMPs	Maintain BMPs to insure continued function.		Will comply ☐ N/A (explain):
Manage the Project	Phase the project to avoid soil disturbance from Oct. 1 through April 30 if possible. Modify BMPs if not effective or to meet changed conditions.		Will comply ☐ N/A (explain):

[1] Descriptions of BMPs designated can be found in Volume II of this manual.

Section 6 – Site Plan (see attached example)

A site plan, to scale, shall be included with this checklist that shows the following items:

Item	Complete
Address, Parcel Number, and Street names*	
North Arrow	
Indicate boundaries of existing vegetation (e.g., tree lines, grassy areas, pasture areas, fields, etc.)*	
Identify any onsite or adjacent critical areas and associated buffers (e.g., wetlands, steep slopes, streams, etc.).	
Identify any FEMA base flood boundaries and Shoreline Management boundaries. *	
Show existing and proposed contours. *	
Delineate areas that are to be cleared and graded.	
Show all cut and fill slopes, indicating top and bottom of slope catch lines	
Indicate existing surface water flow direction(s).	
Label final grade contours and indicate proposed surface water flow direction and surface water conveyance systems (e.g., pipes, catch basins, ditches, etc.).	
Show grades, dimensions, and direction of flow in all (existing and proposed) ditches, swales, culverts, and pipes.	
Indicate locations and outlets of any dewatering systems (usually to sediment trap).	
Identify and locate all erosion control techniques to be used during and after construction.	

* For GIS information on these items, see Thurston County Geodata at www.geodata.org

Thurston County
Drainage Design and Erosion Control Manual

Volume III
Hydrologic Analysis and Stormwater Conveyance

Prepared by:
Thurston County Department of Resource Stewardship
Water Resources Unit

July 2009

Table of Contents

Tables

Figures

Chapter 1 - Introduction to Volume III

1.1 What is the Purpose of this Volume?

This volume of the *Drainage Design and Erosion Control Manual* describes hydrologic analysis techniques and general design criteria for flow control and water quality Best Management Practices (BMPs). Design details and requirements for specific flow control and water quality BMPs are provided in Volume V. This volume also includes hydrologic analysis techniques, design criteria and specifications for stormwater conveyance systems including pipes, open channels, outfalls and other stormwater conveyance structures.

This volume is intended to prescribe approved methods and requirements for calculating infiltration rates, runoff flow volumes and rates to be used in sizing water quality treatment and flow control BMPs to minimize or eliminate impacts on downstream properties and natural resources. The County recognizes that it is not always possible to fully prevent any downstream impacts; in these cases, the County may require the project to provide offsite mitigation.

These regulations and criteria are based on fundamental principles of drainage, hydraulics, and hydrology, environmental considerations, and publications, manuals, and texts accepted by the professional engineering community. The project design engineer is responsible for being knowledgeable of and proficient with necessary design methodologies identified in this manual. The following is a partial list of publications which may be used as reference documents:

- The Washington State Department of Ecology *Stormwater Management Manual For Western Washington*
- Any Washington State Department of Ecology Approved Stormwater Management Manual, such as one produced by an NPDES Phase I community
- Washington State Department of Transportation *Highway Runoff Manual*.
- *Applied Handbook of Hydrology*, by V.T. Chow
- *Handbook of Hydraulics*, by E.G. Brater and H.W. King
- "Hydraulics Manual", published by the Washington State Department of Transportation – WSDOT
- *Soil Survey of Thurston County, Washington*, published by the Natural Resource Conservation Service, U.S. Department of Agriculture

- *Standard Plans for Road, Bridge and Municipal Construction*, published by WSDOT
- *Thurston County Road Standards*, or the latest amendment

The most current edition of all publications shall be used.

1.2 How This Volume is Organized

Volume III is organized into three chapters and three appendices:

- **Chapter 1**: Introduction
- **Chapter 2**: Hydrologic design standards and acceptable analysis methods, including the use of hydrograph methods for BMP design, an overview of computerized modeling methods, analysis of closed depressions, and evaluation of the feasibility and sizing of infiltration facilities.
- **Chapter 3**: Natural and constructed conveyance systems and acceptable analysis methods. This chapter also discusses hydraulic structures linking conveyance systems to runoff treatment and flow control facilities.
- **Appendix A**: Infiltration testing procedures. This appendix also includes the USDA soil textural triangle, used for alternative methods of determining infiltration rates.
- **Appendix B**: SBUH/SCS computer models and charts and tables useful in designing conveyance systems with event-based hydrologic models. This includes: design storm rainfall totals, isopluvial maps for western Washington, common Thurston County Soil types, and hydrologic groupings, SCS curve numbers, and hydraulic roughness coefficients.
- **Appendix C**: Nomographs useful for culvert sizing.

1.3 How Do I Get Started?

First, consult Chapter 2 of Volume I to determine which minimum requirements apply to your project and to select BMPs. After determining the minimum requirements for your project and selecting BMPs, use Volume III (this volume) to determine the methods of estimating design volume or flow rates for those BMPs. Design guidelines for stormwater BMPs are included in Volume V. These facilities can then be included in any required stormwater submittals (see Volume I, Chapter 3). Chapter 3 of this volume also includes information on the design of stormwater conveyance systems.

Chapter 2 - Hydrologic Analysis and Design Standards

Hydrology is the study of the source, properties, distribution, and laws of water as it moves through its closed cycle (the hydrologic cycle). In this manual, however, the term "hydrologic analysis" addresses and quantifies only a small portion of this cycle, the relatively short-term movement of water over land resulting from precipitation, called surface water or stormwater runoff. Localized and long-term ground water movement is also a concern for successful stormwater management, but only as this relates to the movement of water on or near the surface, such as stream base flow or shallow groundwater effects on stormwater infiltration systems.

This chapter defines the minimum computational standards for conducting hydrologic analysis and how to apply these standards. It also explains the hydrologic design process, including flow routing through onsite stormwater management facilities.

Due to the relationship between stormwater runoff quantity (both flow and volume) and quality, it is critical to consider runoff treatment when designing for flow control and vice versa. Runoff treatment and flow control goals can often be accomplished in one facility. For example, wet ponds can be designed to provide both runoff treatment and flow control by providing for live storage volume above the permanent pool.

Site planning and layout play an important role in the amount of stormwater runoff generated by a project site. Reductions in impervious areas result in smaller runoff treatment and flow control facilities, thereby reducing stormwater management costs. Low Impact Development (LID) directly addresses this idea by limiting runoff and creating more aesthetically appealing sites. LID is discussed in Chapter 2 of Volume V.

2.1 Minimum Computational Standards

Minimum computational standards depend on the type of information required and the size of the drainage area to be analyzed, as follows:

When designing runoff treatment and flow control BMPs, use a continuous simulation hydrologic model based on the EPA's Hydrologic Simulation Program-Fortran (HSPF) program (i.e., Ecology's Western Washington Hydrology Model (WWHM) or WSDOT's MGS Flood model) to calculate runoff and determine flow rates and volumes. Continuous models simulate rainfall and runoff over a long period of time, usually years, encompassing many storm events. Additional design standards applicable for selection and sizing of specific runoff treatment and flow control BMPs are found in Volume V.

For conveyance system design, the designer may use a single event hydrologic model, or the Rational Method to determine peak flow rate. For conveyance facilities that are also designed as water quality or flow control BMPs a continuous simulation runoff model shall be used to design the facility to meet the water quality or flow control requirements and the methodologies of this chapter shall be used to design the same facility for conveyance of stormwater.

Conveyance design is discussed in detail in Chapter 3 of this Volume.

Circumstances where different methodologies apply are summarized in Table 2.1 below.

Table 2.1. Summary of Applicable Hydrologic Design Methodologies for Design of Stormwater Best Management Practices in Thurston County

Method	Runoff Treatment	Flow Control	Conveyance
Continuous Runoff Models: (WWHM or MGS Flood)	Method applies to all BMPs	Method applies to all BMPs	Not Allowed
SCSUH/SBUH (Soil Conservation Service Unit Hydrograph/Santa Barbara Urban Hydrograph)	Not Applicable[a]	Not Applicable	Method applies
Rational Method	Not Applicable	Not Applicable	Method applies for some conveyance design

[a] can be used for biofiltration BMPs (BF.01 – BF.05)

By default, the Department of Ecology's WWHM uses rainfall/runoff relationships originally developed for specific basins in the Puget Sound region for all parts of western Washington. These default parameters may be replaced with basin-specific rainfall/runoff data established by extensive field monitoring approved by the County where such data will improve the model's accuracy.

Thurston County has incorporated additional field monitoring stations into the WWHM and where applicable the Thurston County specific rainfall/runoff data shall be used for design. Thurston County has also developed a modification to the WWHM that provides site infiltration data for use in meeting the minimum infiltration requirement for projects in Thurston County (see Volume 1). These Thurston County modifications will be incorporated into the versions WWHM available for download at Ecology's web-site.

Free WWHM software and documentation can be found at the Department of Ecology website:

http://www.ecy.wa.gov/programs/wq/stormwater/wwhmtraining/wwhm/wwhm_v3/index.html.

A professional version of WWHM with expanded capabilities can be purchased from Clear Creek Solutions, Inc. at http://www.clearcreeksolutions.com/.

Use of continuous simulation runoff models other than WWHM or MGS Flood must be approved by the County before being used as a computational standard.

If a basin plan is being prepared, then a hydrologic analysis shall be performed using a continuous simulation runoff model such as the EPA's HSPF model, Stormwater Management Model (SWMM), or a model approved by the County and the Department of Ecology. WWHM and MGS Flood do not have the capability to model and route flows in conveyance systems.

For large, master-planned developments, the County may require a basin-specific calibration of HSPF rather than default parameters. Basin-specific calibrations may be required for projects that encompass more than 320 acres.

2.1.1 Hydrologic Analysis of LID BMPs

The implementation of Low Impact Development (LID) BMPs may affect flow control and runoff treatment analysis for a project by reducing "Effective Impervious Area" which affects the thresholds associated with Minimum Requirements #6 (Runoff Treatment) and #7 (Flow Control). LID BMPs may also have associated flow credits for use in the WWHM that allow modification of how the impervious area is modeled – effectively reducing the size of downstream flow control and runoff treatment facilities. Newer versions of WWHM allow directly modeling LID BMPs and eliminate the need for the use of flow credits.

Hydrologic modeling for LID BMPs must conform to all applicable minimum requirements outlined in Volume I, specifically:

- Minimum Requirement #4 – Preservation of Natural Drainage System and Outfalls
- Minimum Requirement #5 – Onsite Stormwater Management
- Minimum Requirement #6 – Runoff Treatment
- Minimum Requirement #7 – Flow Control

- Minimum Requirement #8 – Wetland Protection (including applicable predeveloped land-cover assumptions used in hydrologic modeling).

Modeling requirements and applicable flow credits for use in modeling individual LID BMPs are described in Volume V. Simplified sizing methods can be applied for some LID BMPs, as described in Volume V.

2.1.2 Hydrologic Analysis of Flow Control BMPs

The flow control standard (Minimum Requirement #7) must be met using an approved continuous runoff model. The standard flow control requirement is summarized below:

- Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. The pre-developed condition to be matched shall be a forested land cover unless:
  - Reasonable, historic information is available that indicates the site was prairie prior to settlement (modeled as “pasture” in the Western Washington Hydrology Model); or
  - The drainage area of the immediate stream and all subsequent downstream basins have had at least 40 percent total impervious area since 1985. In this case, the predeveloped condition to be matched shall be the existing land cover condition. Where basin-specific studies determine a stream channel to be unstable, even though the above criterion is met, the pre-developed condition assumption shall be the “historic” land cover condition, or a land cover condition commensurate with achieving a target flow regime identified by an approved basin study.

See the documentation for WWHM (or alternate model) for instructions on how to use the model to meet this standard.

If off-site drainage combines with site runoff, these off-site flows must be included in the flow control BMP sizing analysis. See Chapter 3 for conveyance requirements for off-site drainage.

2.1.3 Hydrologic Analysis of Runoff Treatment BMPs

Water Quality Design Storm Volume

The 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model shall be used as the water quality design storm volume.

Water Quality Design Flow Rate

Downstream of detention facilities: The full 2-year recurrence interval release rate from a detention facility (using an approved continuous runoff model) designed to meet the flow duration standard shall be used as the design flow rate.

Preceding detention facilities or when detention facilities are not required: The flow rate at or below which 91 percent of the runoff volume, as estimated by an approved continuous runoff model, is routed through the treatment facility shall be used as the design flow rate. The 91 percent volume for treatment facilities is designed to achieve the applicable performance goal at the water quality design flow rate (e.g., 80 percent total suspended solids removal).

- *Offline facilities*: When runoff flow rates exceed the water quality design flow rate and treatment facilities are not preceded by an equalization or storage basin, the treatment facility should continue to receive and treat the water quality design flow rate to the applicable treatment performance goal. Only the portion of flow rates that exceed the water quality design flow may be bypassed around a treatment facility.

  Treatment facilities preceded by an equalization or storage basin may identify a lower water quality design flow rate provided that at least 91 percent of the estimated runoff volume in the time series of an approved continuous runoff model is treated to the applicable performance goals (e.g., 80 percent total suspended solids removal at the water quality design flow rate and 80 percent total suspended solids removal on an annual average basis).

- *Online facilities*: Runoff flow rates in excess of the water quality design flow rate can be routed through the facility provided a net pollutant reduction is maintained, and the applicable annual average performance goal is likely to be met. When on-line runoff treatment facilities experience flows greater than the water quality design flow rate, it is assumed that no pollutant removal is occurring. For this reason, water quality design flow rates for on-line facilities are higher than design flow rates for off-line facilities with the same drainage characteristics.

Treatment facilities that are located downstream of detention facilities shall only be designed as on-line facilities.

2.1.4 Hydrologic Analysis of Conveyance Systems

For design of storm drainage conveyance systems, several design storms may have to be used to adequately assess the project and any downstream impact. The design of conveyance systems can be performed using one of two methods, either the single event hydrograph method (SCS, SBUH) or the Rational Method (for small projects).

Single Event Storms – Hydrograph

Hydrograph analysis uses a plot of runoff flow versus time for a given single design storm event, allowing the key runoff characteristics like peak discharge, volume, and timing to be considered in drainage facility design. All storm event hydrograph methods require parameters that describe physical drainage basin characteristics. These parameters provide the basis of development of the runoff hydrograph. Because single event methods are only used in this manual to size conveyance systems and flow-through treatment facilities (biofiltration swales), discussion of design storms, curve numbers and peak runoff calculation is limited (see Appendix III-B).

For conveyance design, the preferred single event method is the Santa Barbara Urban Hydrograph Method or, if unavailable, the SCS Unit Hydrograph Method.

Rational Method

The rational method is a simple method used to estimate peak flows, and may be used for conveyance sizing on sites 25 acres or less in size, and having a time of concentration of less than 100 minutes. See Appendix III-B for details on the method.

2.2 Closed Depression Analysis

Closed depressions (potholes, kettles) represent a “dead end” for surface water flows and generally facilitate infiltration of runoff. If a closed depression is classified as a wetland or the discharge path flows through a wetland, then Minimum Requirement #8 for wetlands applies. If there is an outflow from this depression to a surface water (such as a creek), then the flow must also meet Minimum Requirement #7 for flow control.

A calibrated continuous simulation runoff model must be used for closed depression analysis and design of mitigation facilities. If a closed depression is not classified as a wetland, model the ponding area at the bottom of the closed depression as an infiltration pond using WWHM or an approved continuous runoff model.

2.2.1 Analysis and Design Criteria

The infiltration rates used in the analysis of closed depressions must be determined according to the procedures of Section 2.3. For closed depressions containing standing water, soil texture tests must be performed on dry land adjacent to, and on opposite sides of the standing water (as practicable). The elevation of the testing surface at the bottom of the test pit must be one foot above the standing water elevation. A minimum of four tests must be performed to estimate an average surface infiltration rate.

The criteria which must be met for discharge to a closed depression depend upon the location, whether the proponent has control of, or a right to discharge to the closed depression and the results of a hydrologic analysis of the closed depression.

2.2.2 Closed Depression Located On-Site or with a Legal Right to Discharge to Closed Depression

For a closed depression entirely on the subject property, or a closed depression to which the Proponent has acquired a legal right to discharge, analyze the closed depression using hydrologic methods described in Section 2.1. Infiltration must be addressed where appropriate. In assessing the impacts of the proposed project on the performance of the closed depression, there are three cases that dictate different approaches to meeting Minimum Requirement #7 – *Flow Control.*

Case 1

The 100-year recurrence interval storm runoff from an approved continuous simulation program, flowing from the TDA to the closed depression, is routed into the closed depression using only infiltration as outflow. If predevelopment runoff does not overflow the closed depression, then no runoff may leave the closed depression at the 100-year recurrence interval storm runoff following development of the proposed project. This may be accomplished by excavating additional storage volume in the closed depression, subject to all applicable requirements (for example, providing a defined overflow system).

Case 2

The 100-year recurrence interval storm runoff from an approved continuous simulation program, from the TDA to the closed depression, is routed into the closed depression using only infiltration as outflow, and overflow occurs in both the existing and the proposed conditions. The closed depression must then be analyzed as a detention/infiltration pond. The required performance, therefore, is to meet the runoff duration standard specified in Minimum Requirement 7 – *Flow Control*, using an adequately calibrated continuous simulation model. This will require a control structure, emergency overflow spillway, access road, and other design criteria and may require excavating additional storage volume in the closed depression. Also depending on who will maintain the system, it will require placing the closed depression in a tract dedicated to the responsible party.

2.2.3 Closed Depression Located Off-Site

For a closed depression shared with, or entirely on other properties, absent a legal agreement to the contrary, the peak water elevation for the 100-year recurrence interval storm runoff from an approved continuous simulation program, from the Threshold Discharge Area to the closed depression shall not cause an increase in water levels exceeding:

- 0.1 feet above the base, if available information indicates that the base is to be dry at all times, or
- 0.1 feet above the current peak water elevation, if this elevation can be clearly demonstrated.

In all cases, discharge to a closed depression shall be allowed only if the Project Engineer can satisfactorily demonstrate that no significant public health, safety, welfare, or property damage issues are present.

2.3 Site Suitability and Hydrologic Analysis of Infiltration Facilities

Infiltration is the percolation of surface water into the ground, and is an effective way to meet the flow control requirements of Minimum Requirement #7. While other flow control facilities, such as detention ponds, just reduce peak flow rates associated with developed areas, infiltration facilities reduce the total volume of surface runoff as well as peak flow rates. When properly sited and designed, infiltration facilities can help recharge groundwater and protect downstream receiving waters. In some cases, infiltration facilities can be used to meet the runoff treatment requirements of Minimum Requirement #6 also (see Section 2.3.1 below).

2.3.1 Infiltration Facilities for Runoff Treatment

Infiltration facilities can be designed for runoff treatment within Thurston County. The soil texture and design infiltration rates should be considered along with the physical and chemical characteristics specified below to determine if the soil is adequate for removing the target pollutants.

- Short-term soil infiltration rate should be 2.4 inches per hour, or less, to a depth of 2.5 times the maximum design pond water depth, or a minimum of 6 feet below the base of the infiltration facility. This infiltration rate is also typical for soil textures that possess sufficient physical and chemical properties for adequate treatment, particularly for soluble pollutant removal. It is comparable to the textures represented by Hydrologic Group B and C. Long-term infiltration rates up to 2.0 inches per hour can also be considered, if the infiltration receptor is not a sole-source aquifer, and in the judgment of the site professional, the treatment soil has characteristics comparable to those considered suitable for treatment (see description later in this section) to control target pollutants.

- Cation exchange capacity (CEC) of the treatment soil must be ≥5 milliequivalents CEC/100 g dry soil (USEPA Method 9081). Consider empirical testing of soil sorption capacity, if practicable. Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. CEC values of >5 meq/100g are expected in loamy sands, according to Rawls et al. Lower CEC content may be considered if it is based on a soil loading capacity determination for the target pollutants that is accepted by Thurston County.

- Depth of suitable treatment soil used for infiltration treatment must be a minimum of 18 inches. If native soils cannot meet the treatment criteria of this section, soils may be amended or an engineered soil (minimum depth of 18 inches) may be used. See BMP LID.08 Bioretention in Volume V for an acceptable engineered soil for runoff treatment.

- Organic content of the treatment soil (ASTM D 2974): Organic matter can increase the sorptive capacity of the soil for many pollutants. The site professional shall evaluate whether the organic matter content is sufficient for control of the target pollutant(s). Generally, a minimum organic content of 10% by weight is required to meet treatment requirements.

- Waste fill materials shall not be used as infiltration soil media nor should such media be placed over uncontrolled or non-engineered fill soils.

- Engineered soils may be used to meet infiltration BMP design criteria in Volume V and the performance goals in Minimum Requirement 6 (Runoff Treatment; Volume I). BMP LID.08 Bioretention provides an acceptable engineered soil specification for runoff treatment. Use of alternate engineered soils must be accepted by the County, and requires field performance evaluation(s), using acceptable protocols, to determine effectiveness, feasibility, and acceptability.

Also note that although infiltration is one of the preferred methods for disposing of excess stormwater, and may be required to meet Minimum Requirement #7 – *Flow Control*, infiltration may be regulated by the Department of Ecology and the Underground Injection Control (UIC) Program (WAC 173-218) if an injection device, such as a dry well or trench with distribution pipe is used. Additional information and requirements on UIC and how it applies to infiltration and stormwater management is included in Volume V, Section 3.1.3.

2.3.2 Site Suitability and Analysis Procedures

The following procedures must be followed when considering and designing an infiltration facility. Each step is outlined in more detail in the subsequent sections. Figure 2.1 illustrates the process of analyzing and sizing infiltration facilities.

Step 1 – Conduct general site reconnaissance, and review survey and other information to identify existing drinking water wells or aquifers, designated well head protection areas for public water systems, existing and proposed buildings, steep slopes, and septic systems in the vicinity of the proposed facility.

Step 2 – Evaluate minimum requirements for infiltration facilities to determine whether infiltration is feasible for the site.

Step 3 – Infiltration Receptor Characterization. Estimate depth to groundwater from the bottom of proposed infiltration facility. If estimated depth to groundwater is less than 50 feet, installation of groundwater monitoring wells and characterization of the infiltration receptor will be required. If less than 15 feet to groundwater, then a mounding analysis will be required.

Step 4 – Determine whether the simple or detailed method of analysis will be used to establish a design infiltration rate. Consultation with Thurston County is required at this stage to obtain acceptance of the proposed method of analysis (simple or detailed).

Step 5 – Complete simple analysis or detailed analysis, as determined in Step 4 and described in Sections 2.3.3 and 2.3.5.

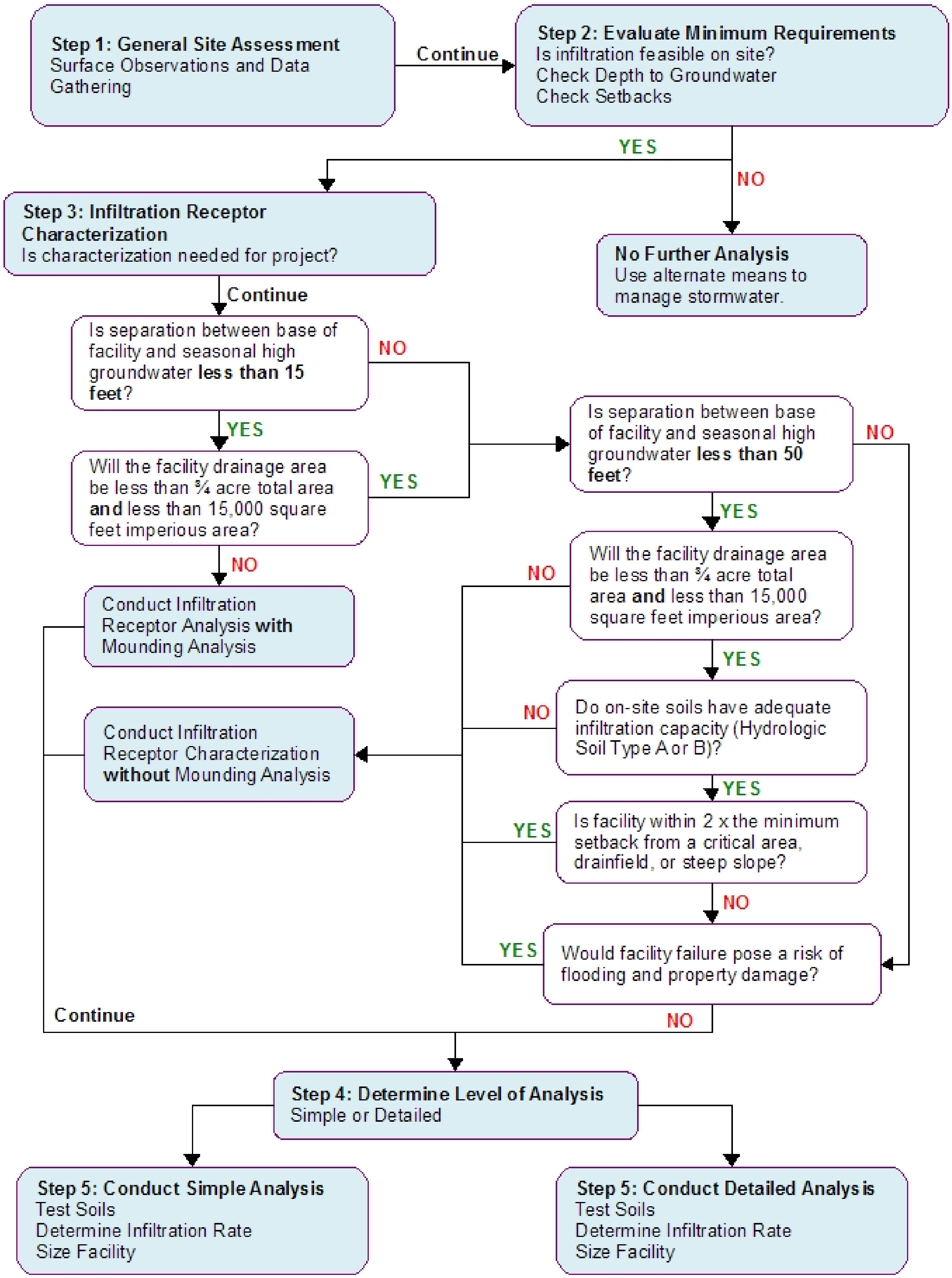


Figure 2.1. Infiltration Analysis and Sizing Flow Chart.

Details of these five steps are provided in the sections below.

Step 1: General Surface Characterization

The first step in designing an infiltration facility is to select a location and assess the site's suitability. The information to be reviewed as part of this initial site characterization varies by site, but may include:

- Topography within 500 feet of the proposed facility
- Anticipated site use (street/highway, residential, commercial, high-use site)
- Location of water supply wells within 500 feet of proposed facility
- Location of project relative to any designated well head protection areas for public water systems. (enhanced treatment required prior to infiltration if located within a designated WHPA).
- Location of steep slopes (>15%) or landslide hazard areas
- Location of septic systems in the vicinity of the proposed facility
- A description of local site geology, including soil or rock units likely to be encountered, the groundwater regime, and geologic history of the site.
- Analysis of site borings and soil testing and review of any available existing soils information for the site or adjacent sites.
- Analyze any existing runoff flowing into and out of the site. Speculate on possible flows generated by greater than the 100-year event. Check the proximity of other stormwater facilities on adjacent properties.
- Location of any high groundwater hazard areas or wetlands per the Thurston County Critical Areas Ordinance, TCC Title 17.

This information, along with additional geotechnical information necessary to design the facility, shall be summarized in the geotechnical report prepared in Step 5.

Step 2: Evaluate Minimum Requirements for Infiltration Facilities

Infiltration is not permitted unless all of the Depth to Seasonal High Groundwater and Setbacks criteria below are met. Note: not all sites that meet the following criteria will be suitable for infiltration – these are **minimum** requirements only.

Depth to Seasonal High Groundwater

The base of all infiltration basins or trench systems shall be a minimum of 3 feet above seasonal high groundwater levels, bedrock (or hardpan), or any other low permeability layer. Small bioretention (BMP LID.08) facilities with less than 10,000 square feet of impervious area contributing to the facility may be designed with a reduced vertical separation of 1 foot minimum.

Seasonal high groundwater level is the upper level at which the groundwater table normally is located during the season of the year when such levels are at their highest (typically December 1 through April 30). This level is determined using a test pit (reviewed by a soil analyst for soil color patterns in the soil profile) or using groundwater monitoring data gathered through a minimum of one wet period (December through April). See Step 3 for additional criteria related to groundwater depth.

Setbacks

Infiltration basins may not be constructed within a floodplain area or high groundwater flood hazard area as defined in Thurston County Code, Title 17. Additional setbacks are summarized in Appendix V-E.

Step 3: Infiltration Receptor Characterization

An Infiltration receptor characterization consists of monitoring and analysis of groundwater, and (in some cases) mounding analysis. This characterization must be conducted if any of the following conditions are present:

- Proposed facility would pose a risk of flooding or property damage if failure were to occur.
- Separation between base of facility and seasonal high groundwater is less than 50 feet AND tributary drainage area contains more than 15,000 square feet impervious surface or ¾ acre total area.
- Separation between base of facility and seasonal high groundwater is less than 50 feet AND on-site soils may not have adequate infiltration capacity (Hydrologic Soil Group C or D [till soils]).
- Separation between base of facility and seasonal high groundwater is less than 50 feet AND there is less than 2 times the minimum setback to a critical area, drainfield, or steep slope (>15%).

In addition, mounding analysis must be conducted if BOTH of the following condition are present:

- Separation between base of facility and seasonal high groundwater is less than 15 feet, AND
- Tributary drainage area is greater than 3/4 acre or there is greater than 15,000 square feet of impervious surface contributing to the facility.

A mounding analysis may also be required by the Administrator for conditions other than those listed above if any of the following conditions are present:

- Hydrologic Soil Group C or D soils with an estimated infiltration rate of less than 0.5 inches/hour.
- The potential impact to downstream properties and/or critical areas is high as a result of a facility failure.
- Urban environment (> 4 units per acre).
- Facility is within 100-feet of a steep slope (>15%) with soils less than a 1 inch/hour infiltration rate.
- When soils work indicates there may be a perched low permeability layer above the water table.

An exemption from the mounding analysis may be granted if the geotechnical professional can demonstrate to the satisfaction of Administrator that it is not necessary. This demonstration shall be based on site specific information that in the judgment of the geotechnical professional mitigates against the requirement to conduct a mounding analysis. Examples of circumstances that the Administrator will consider in granting an exemption include:

- Soils are classified as outwash with an estimated design infiltration rate of greater than 5 in/hr.
- Soils are uniform and easily characterized as outwash. Risk of low permeability lenses is low.
- Site topography, etc. indicates no substantial risk to slopes, wetlands, structures etc. in the event groundwater breaches the surface.
- Other studies of groundwater mounding for the same or adjacent sites indicate that mounding would not be a concern.

If it is determined that an Infiltration Receptor Characterization is not required for a project, continue to Step 4.

Monitor Groundwater Levels

A minimum of three groundwater monitoring wells shall be installed per infiltration facility that will establish a three-dimensional relationship for the groundwater table. Seasonal groundwater levels must be monitored at the site through at least one wet season (December 1 through April 30).

Monitoring wells shall be installed and monitored in accordance with the following requirements:

- Well shall be screened across the water table.
- Maximum screen and sand pack length of 15 feet.
- Weekly water level monitoring resulting in at least 16 measurements over 4 months.

Document Characterization

A geotechnical report will be developed in Step 5. This report shall include the following information to characterize the infiltration receptor (unsaturated and saturated soil receiving the stormwater):

- Depth to groundwater and to bedrock/impermeable layers.
- Seasonal variation of groundwater table based on well water levels and observed mottling of soils. Provide an estimated seasonal high groundwater level and an estimated maximum high groundwater level taking into account historical and seasonal groundwater table fluctuations.
- Existing groundwater flow direction and gradient
- Volumetric water holding capacity of the infiltration receptor soils. The volumetric water holding capacity is the storage volume in the soil layer directly below the infiltration facility and above the seasonal high groundwater mark, bedrock, hardpan, or other low permeability layer.
- Consider the potential for both unconfined and confined aquifers, or confining units, at the site that may influence the proposed infiltration facility as well as the groundwater gradient.
- Determine ambient ground water quality, if that is a concern.

- Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water
- Approximation of the lateral extent of infiltration receptor
- Impact of the infiltration rate and proposed added volume from the project site on local groundwater mounding, flow direction, and water table; and the discharge point or area of the infiltrating water.
- Location of the project within the Salmon Creek Basin requires specific groundwater characterization elements be met and reference to the Salmon Creek Basin Plan and Interim Site Development Standards for New Development in Salmon Creek Basin should be referred to for specific requirements.
- State whether location is suitable for infiltration and recommend a method for estimating the design infiltration rate (simple or detailed, in-situ or gradation based).

Mounding Analysis

If a mounding analysis is required, the geotechnical professional shall develop an approach and obtain its acceptance from Thurston County prior to initiating the study. Simple, conservative methods of estimating groundwater mounding are available and may be acceptable with the use of conservative parameters to demonstrate that risks from groundwater mounding are acceptable. The methodology, approach, software program, input data, calibration requirements and output format for the mounding analysis shall be proposed by the geotechnical professional in the geotechnical report for acceptance by Thurston County.

The purpose the mounding analysis is to identify the impact of groundwater mounding on the estimated design infiltration rate, the seasonal high groundwater elevation at the property boundary and at any on-site or off-site structures, critical areas, or other site features that might be impacted by groundwater mounding.

The results of the mounding analysis will be reported by the geotechnical professional as part of the Infiltration Receptor Characterization and shall include the following determinations:

- A minimum separation of at least 3-feet to seasonal high groundwater will be maintained from the bottom of the facility with mounding.

- There will be no breakout of groundwater to the surface in the vicinity of the project as a result of mounding.
- That a minimum separation to groundwater from the estimated lowest elevation of any basement, building foundation, road, or other structure will be at least 3-feet.
- That there will be no intrusion of the groundwater mound into any existing or proposed drainfield or reserve area and that there will be no greater than a 6-inch increase in groundwater elevation beneath any septic drainfield or reserve area as a result of groundwater mounding.
- That the increase in groundwater elevation at the property boundaries of the project will not result in impacts to adjacent property owners. Generally demonstrating that the increase in groundwater level at the property boundary is less than 1-foot due to mounding would meet this criterion unless there are special circumstances.

Step 4: Determine Method of Analysis

Thurston County requires consideration of infiltration facilities for sites where conditions are appropriate. Some sites may not be appropriate for infiltration due to soil characteristics, groundwater levels, steep slopes, or other constraints.

The design infiltration rate for a proposed infiltration facility shall be calculated based on either the Simple Method or Detailed Method as described in this section.

Simple Method

The Simple Method of calculating a design infiltration rates includes several alternative methods as follows:

- Field Testing by In-Situ Methods (must incorporate safety factors) including:
  - Split Double Ring Infiltrometer
  - Ecology Pilot Infiltration Test (PIT)
  - Single Ring Falling Head Infiltration Method (US EPA 1980) as Modified by Thurston County.
- USDA Soil Textural Classification
- ASTM Gradation Testing

The Simple Method was derived from high ground water and shallow pond sites in western Washington, and in general will produce conservative designs. The Simple Method (Section 2.3.3) should be considered a suitable method of calculating design infiltration rates in the following circumstances:

- When determining the trial geometry of the infiltration facility,
- For small or low impact facilities
- For facilities where a more conservative design is acceptable.
- For Type A/B soils

Where the combination of depth to ground water/low permeability layer and soil type results in the possibility of groundwater mounding effects the Simple Method should not be applied. The suitability of the Simple Method should be discussed in the geotechnical report.

Detailed Method

The detailed method of analysis is more suitable when it is unclear if a site is well-suited to infiltration and in cases where failure of an infiltration facility would create a high risk of flooding and/or property damage. The detailed method of analysis, described in Section 2.3.4, includes more intensive field testing and soils investigation and analyses than the Simple Method and takes into account the depth to groundwater. Sites that have **ANY** of the following conditions should be considered for use of the detailed method:

- Low infiltration capacity soils (NRCS [SCS] soil types C or D)
- History of unsuccessful infiltration facility performance
- A large contributing drainage area (greater than 1-acre).
- Shallow groundwater levels (Less than 50 feet to seasonal high groundwater).
- High risk of flooding and property damage in the event of clogging or other failure.

The County may allow the Simple Method in circumstances that might warrant the detailed method if it is demonstrated that the infiltration facility could be converted to a detention facility of adequate size if the infiltration facility were to fail.

Step 5: Conduct Simple or Detailed Analysis

Based on the results of Step 3, conduct a simple analysis (Section 2.3.3), or a detailed analysis (Section 2.3.4).

2.3.3 Simple Analysis Procedures

All proposed infiltration projects must evaluate soils, determine the design infiltration rate, prepare a geotechnical report, and estimate the volume of stormwater to be infiltrated.

Soil Testing

Test holes or test pits must be dug according to the following guidelines (see Table 2.3):

- Test hole or test pit explorations shall be conducted during mid to late in the wet season (with the wet season defined as December 1 through April 30).
- Collect representative samples from each soil type and/or unit to a depth of 6 feet below the proposed base of the infiltration facility or 2.5 times the estimated depth of the infiltration pond, whichever is greater. For infiltration ponds, there shall be one test pit or test hole per 5,000 square feet of pond infiltrating surface with a minimum of two per pond, regardless of pond size. For infiltration trenches, there shall be one test pit or test hole per 100 feet of trench length with a minimum of two required per trench, regardless of length.
- Soil characterization for each soil unit (soils of the same texture, color, density, compaction, consolidation and permeability) encountered should include:
    - Grain size distribution (ASTM D422 or equivalent AASHTO specification).
    - Textural class (USDA).
    - Percent clay content (include type of clay, if known).
    - Color/mottling.
    - Variations and nature of stratification.
    - Cation exchange capacity (CEC) and organic matter content (if facility may be considered to provide treatment as well as flow control).

- For small-scale infiltration facilities (contributing drainage area is less than 7,500 square feet), only one testing location is required.
- The required number of test pits/test holes may be modified by the Administrator or designee if provided adequate evidence of consistent subsurface conditions.
- Prepare detailed logs for each test pit or test hole and a map showing the location of the test pits or test holes. Logs must include the depth, soil descriptions, depth to water, evidence of seasonal high groundwater elevation, existing ground surface elevation, proposed pond bottom elevation, and presence of stratification that may impact the infiltration design. Elevations shall be referenced to a vertical datum such as NGVD 29. Use the soil evaluation report forms in Appendix I-F.

Table 2.3. Required Number of Test Pits, Test Holes, and In-Situ Testing Locations for infiltration Facilities.

Contributing Drainage Area	BMP Type	Number of Test Pits/Test Holes per BMP	Number of In-Situ Infiltration Testing Locations per BMP (If Using In-Situ Testing Method of Simple Method)[a]
SFR or Commercial, less than 7,500 square feet	All Infiltration BMPs	1	1
Greater than 7,500 square feet or other land use type	Infiltration trench (BMP IN.02) or linear configuration of other Infiltration BMP	1 per 100 linear feet (2 minimum)	1 per 500 linear feet (2 minimum) [a,b]
Greater than 7,500 square feet or other land use type	Bioretention Area (BMP LID.08) or Infiltration Pond (BMP IN.01)	1 per 5,000 square feet (2 minimum)	1 per 10,000 square feet (2 minimum) [a,c]

BMP: best management practice
SFR: single family residential
[a] In-Situ testing only required if applicant intends to use In-Situ Method for Estimating Design Infiltration Rate. Test pits are still required to characterize subsurface. For small scale in-situ methods, a minimum of three tests are required at each location. Small scale in-situ testing includes ASTM D3385 Method (DRI) and Single-Ring Falling Head Infiltration method.
[b] Tests must be conducted at the test pits with the least permeable soils, as determined by observation of grain size gradation.
[c] Tests must be conducted at the test pits with the least permeable soils, as determined by observation of grain size gradation
Note: The required number of test pits/test holes may be modified by the Administrator or designee if provided adequate evidence of consistent subsurface conditions

2.3.4 Determine Design Infiltration Rate

There are two ways of estimating design infiltration rates: in-situ testing or using relationships between soil properties and infiltration rates.

Note: It should be recognized that there is a distinction between infiltration rate and hydraulic conductivity. These two parameters are related by Darcy's equation where:

f = Ki where f = infiltration rate, i = hydraulic gradient (head in ft/ft) and K = hydraulic conductivity.

In cases where water percolates under free draining conditions the hydraulic gradient is 1.0 and the infiltration rate equals the hydraulic conductivity. However, in circumstances where groundwater mounding or pond depth creates a hydraulic gradient, the infiltration rate and hydraulic conductivity would not be equal. In the simple methods, it is likely that the hydraulic gradient is close to 1.0 and therefore the infiltration rate and hydraulic conductivity are close to equal. The design professionals should keep these distinctions in mind and account for the differences as appropriate to the circumstances.

Prescriptive BMP sizing methods can be used in lieu of estimating an infiltration rate for downspout infiltration (BMP LID.04) when the following conditions apply:

- Contributing drainage area is less than 7,500 square feet.
- Property is a single family residential lot or commercial development.
- Soils are characterized as outwash by a soils professional (including a septic system designer).

These prescriptive methods are included in the BMP descriptions in Volume V.

The two following general methods of estimating the design infiltration rate can be used:

Method 1 – In-Situ Testing Methods

- Ecology Pilot Infiltration Test (PIT) is a large-scale test of infiltration. The PIT (described in Appendix III-A) is the preferred method of determining infiltration rate in Thurston County, and can be used for any infiltration BMP. The PIT method requires a substantial amount of water, which may not be available at some sites. If the test is not feasible for this reason, the two alternative methods described below can be used.
- Single-Ring Falling-Head Infiltration method (US EPA 1980), as modified in Appendix III-A or as modified by Clark County (2008)

is an acceptable in-situ method when the PIT method cannot be conducted due to site constraints, or the availability of sufficient water.

- Double-Ring Infiltrometer method (ASTM D3385) is an acceptable in-situ method when the PIT method cannot be conducted due to site constraints, or the availability of sufficient water.

Method 2 – Soil Property Relationships

- USDA Soil Textural Classification method (USDA 1993). This method is applicable to sites with soils classified as loam, sandy loam, loamy sand, sand, sandy gravel or gravelly sand, and is described in Appendix III-A.

- ASTM Gradation Testing method (ASTM D422). This method is applicable to sites with soils classified as sand or sandy gravel, and is described in Appendix III-A.

If conducting in-situ testing of infiltration rates, see Table 2.3 for guidelines on the frequency of in-situ infiltration tests.

Determine Infiltration Rate of Engineered Treatment Soils

If engineered soils are used for the treatment soils the following procedure will be used to determine the design infiltration rate for the facility and inputs for hydrologic modeling (WWHM).

1. The infiltration rate used for hydrologic modeling and facility sizing shall be the lower of the long-term infiltration rate of the engineered soils and the short term infiltration rate of the underlying soils.

2. The long term rate of the engineered soils will be based on ASTM 2434 Standard Test Method for Permeability of Granular Soils (Constant Head) with a compaction rate of 85 percent of maximum density using ASTM 1557 Test Method (Modified Proctor) with an infiltration reduction factor of 4 (multiply calculated infiltration rate by 0.25 to get long term infiltration rate).

3. The short term rate for the underlying soils will be based on the calculated rate as determined by the methods described above without application of the adjustment factor for clogging of the soils. This is based on the assumption that the treatment soil layer removes the silt and sediment that would have resulted in clogging of the underlying soils.

4. Use the lower infiltration rate of the two determined above in the hydrologic model and use an infiltration reduction factor of 1.

Prepare Geotechnical Report

A geotechnical report shall be prepared by or under the direct supervision of, and stamped by either a professional engineer with geotechnical expertise, or a licensed geologist, engineering geologist, or hydrogeologist. The report must summarize site characteristics and demonstrates that sufficient permeable soil for infiltration exists. In addition to the information required by Step 3 – *Infiltration Receptor Characterization* (as applicable), at a minimum, the report must contain the following:

- Figure showing the following:
  - Topography within 500 feet of the proposed facility
  - Locations of any water supply wells within 500 feet of the proposed facility
  - Location of groundwater protection areas, aquifer recharge areas, or 1-, 5-, and 10-year times of travel zones for designated wellhead protection areas.
  - Location of high groundwater hazard or flood plain areas in the project vicinity.
  - Locations of test pits or test holes.
- Results of soils tests, including detailed soil logs
- Description of local site geology, including soil or rock units likely to be encountered at soil sampling depths and the seasonal high groundwater elevation
- Detailed documentation of the design infiltration rate determination, as specified above
- State whether location is suitable for infiltration and recommend a design infiltration rate.

Estimate Volume of Stormwater

Use the Western Washington Hydrologic Model (WWHM), MGSFlood, or other approved continuous simulation runoff model to generate a runoff inflow file that will be used to size the infiltration facility. The facility must either:

- Infiltrate all of the flow volume as specified by the inflow file without any overflow, or
- Infiltrate a sufficient amount of the flow volume such that any overflow/bypass meets the flow duration standard in Minimum Requirement #7 – Flow Control, or
- Be designed as a combined infiltration/detention facility such that the minimum infiltration standard is met and any discharge to surface water from the facility meets the flow duration standards in Minimum Requirement #7 – Flow Control.

If the facility is designed to meet runoff treatment requirements of Minimum Requirement #6, it must infiltrate the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.

For downspout infiltration (BMP LID.04) a simplified sizing table can be used if the facility meets soils requirements and contributing drainage area thresholds. Simplified sizing methods are presented in the corresponding BMP description in Volume V.

2.3.5 Detailed Analysis Procedure

This detailed approach was obtained from Massmann (2003). Procedures for the detailed approach are as follows (see Figure 2.2):

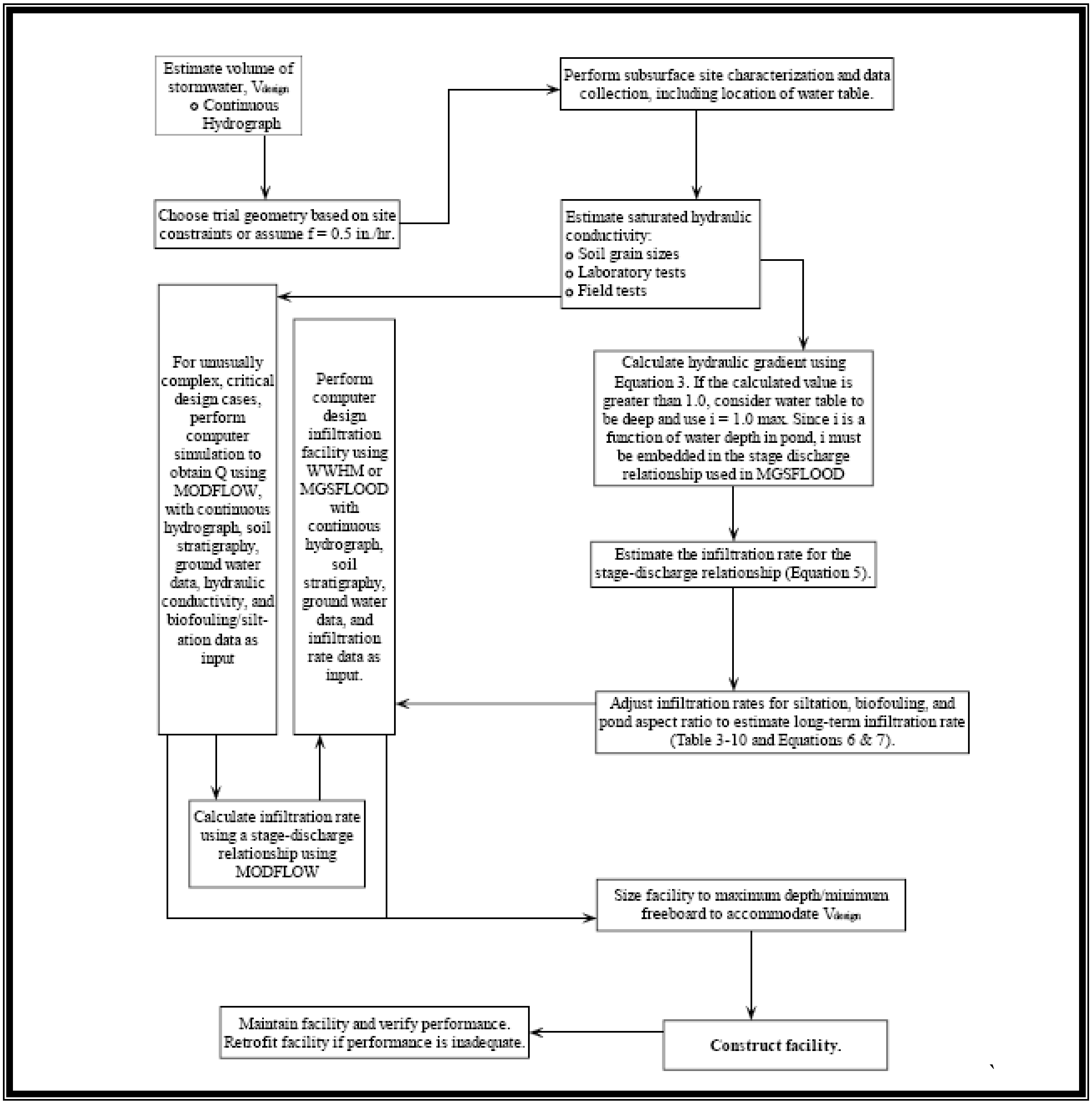


Figure 2.2. Engineering Design Steps for Final Design of Infiltration Facilities Using the Continuous Hydrograph Method (from Ecology [2005]).

Develop a Trial Infiltration Facility Geometry Based on Length, Width, and Depth

To accomplish this, either assume an infiltration rate based on previously available data, or use a default infiltration rate of 0.5 inches/hour. This trial geometry should be used to help locate the facility, and for planning purposes in developing the geotechnical subsurface investigation plan.

Conduct a Geotechnical Investigation

A geotechnical investigation must be conducted to evaluate the site's suitability for infiltration, to establish the infiltration rate for design, and to evaluate slope stability, foundation capacity, and other geotechnical design information needed to design and assess constructability of the facility. Geotechnical investigation requirements are provided below.

The depth, number of test holes or test pits, and sampling described below should be increased if a licensed engineer with geotechnical expertise (P.E.), or a licensed geologist or hydrogeologist judges that conditions are highly variable and make it necessary to increase the depth or the number of explorations to accurately estimate the infiltration system's performance. The exploration program described below may be decreased if the licensed professional judges that conditions are relatively uniform, or design parameters are known to be conservative based on site specific data or experience, and the borings/test pits omitted will not influence the design or successful operation of the facility.

- For infiltration basins (ponds), at least one test pit or test hole per 5,000 ft^2 of basin infiltrating surface (two minimum).

- For infiltration trenches, at least one test pit or test hole per 100 feet of trench length (two minimum).

- Subsurface explorations (test holes or test pits) to a depth below the base of the infiltration facility of at least 5 times the maximum design depth of water proposed for the infiltration facility, or at least 2 feet into the saturated zone (whichever is less).

- Continuous sampling to a depth below the base of the infiltration facility of 2.5 times the maximum design depth of water proposed for the infiltration facility, or at least 2 feet into the saturated zone, but not less than 6 feet. Samples obtained must be adequate for the purpose of soil gradation/classification testing.

- Conduct Infiltration Receptor Characterization as described in Step 3 if required.

- Laboratory testing as necessary to establish the soil gradation characteristics and other properties as necessary, to complete the infiltration facility design. At a minimum, one-grain size analysis per soil stratum in each test hole must be conducted within 2.5 times the maximum design water depth, but not less than 6 feet. When assessing the hydraulic conductivity characteristics of the site, soil layers at greater depths must be considered if the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, requiring soil gradation/classification testing for layers deeper than indicated above.

Prepare Geotechnical Report

A report must be prepared by or under the direction supervision of and stamped by either a professional engineer with geotechnical expertise, or a licensed geologist, engineering geologist, or hydrogeologist The report must summarize site characteristics and demonstrates that sufficient permeable soil for infiltration exists. In addition to information required in Step 3 – *Infiltration Receptor Characterization* (as applicable), at a minimum, the report must contain the following:

- Figure showing the following:
  - Topography within 500 feet of the proposed facility
  - Locations of any water supply wells within 500 feet of the proposed facility
  - Location of groundwater protection areas, aquifer recharge areas, or 1-, 5-, and 10-year times of travel zones for designated wellhead protection areas
  - Location of high groundwater hazard areas and flood plains in the vicinity of the project.
  - Locations of test pits or test holes.
- Results of soils tests, including detailed soil logs
- Description of local site geology, including soil or rock units likely to be encountered at soil sampling depths and the seasonal high groundwater elevation
- Detailed documentation of the design infiltration rate determination, as specified above
- State whether location is suitable for infiltration and recommend a design infiltration rate
- The stratification of the soil/rock below the infiltration facility, including the soil gradation (and plasticity, if any) characteristics of each stratum
- The depth to the ground water table and to any bedrock/ impermeable layers

- Seasonal variation of the ground water table
- The existing ground water flow direction and gradient
- The hydraulic conductivity or the infiltration rate for the soil/rock at the infiltration facility
- The porosity of the soil below the infiltration facility but above the water table
- The lateral extent of the infiltration receptor
- Impact of the infiltration rate and volume on flow direction and water table at the project site, and the potential discharge point or area of the infiltrating water.

Determine Design Infiltration Rate

Procedures for determining the design infiltration rate of the site soils are included in Appendix III-A.

As with the simple analysis described above, if engineered soils are used for the treatment soils, the lower of the long-term infiltration rate of the engineered soils and the short term infiltration rate of the underlying soils shall be used for facility sizing.

2.3.6 Sizing of Infiltration Facilities

Design Criteria – Sizing Facilities

- The size of the infiltration facility can be determined using a continuous runoff model by routing the inflow runoff file through the proposed infiltration facility. In general, an infiltration facility would have two discharge modes. The primary mode of discharge from an infiltration facility is infiltration into the ground. However, when the infiltration capacity of the facility is reached, additional runoff to the facility will cause the facility to overflow. If a project is subject to Minimum Requirement #7 (Flow Control), overflows from an infiltration facility must comply with the flow control standard. Infiltration facilities designed to meet Minimum Requirement #6 (Runoff Treatment) must not overflow more than 9 percent of the total volume of runoff in the inflow runoff file. However, if the facility is an infiltration basin (BMP IN.01) configured as an off-line facility, it must be sized as follows: ***Off-line, upstream of detention facility (or without detention facility):*** A flow splitter shall be designed to send all flows at or below the 15-minute water quality flow rate, as predicted by an approved continuous runoff model to the treatment facility. Within the

WWHM, the flow splitter icon is placed ahead of the pond icon which represents the infiltration basin. The treatment facility must be sized to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

- ***Off-line, downstream of detention facility:*** A flow splitter shall be designed to send all flows at or below the 2-year flow frequency from the detention pond, as predicted by an approved continuous runoff model, to the infiltration basin. Within the WWHM, the flow splitter icon is placed ahead of the pond icon which represents the infiltration basin. The treatment facility must be sized to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

For infiltration facilities designed for runoff treatment, document that the 91st percentile, 24-hour runoff volume (indicated by WWHM or MGS Flood) can infiltrate through the infiltration basin surface within 48 hours (using the long-term infiltration rate). This can be calculated using a horizontal projection of the infiltration basin mid-depth dimensions and the estimated long-term infiltration rate. This drawdown restriction is intended to meet the following objectives:

- aerate vegetation and soil to keep the vegetation healthy
- enhance the biodegradation of pollutants and organics in the soil.

In order to determine compliance with the flow control requirements, the Western Washington Hydrology Model (WWHM), or an appropriately calibrated continuous simulation runoff model based on HSPF, must be used. When using WWHM for simulating flow through an infiltrating facility, the facility is represented by using the Pond Icon and entering the pre-determined infiltration rates. Below are the procedures for sizing a pond to completely infiltrate 100 percent of runoff.

For 100 Percent Infiltration

- Input dimensions of your infiltration pond.

- Input infiltration rate and safety (rate reduction) factor. In general, the rate reduction factor is 1 if the design infiltration rate is used with the applicable adjustment factors described in Appendix III-A. If amended soils or engineered soils are used for treatment in the bottom of the facility, an adjustment factor would be applied to the infiltration rate as described in Volume V.

- Input a riser height and diameter (any flow through the riser indicates that you have less than 100 percent infiltration and must increase your infiltration pond dimensions).

- Run only HSPF for Developed Mitigated Scenario (if that is where you put the infiltration pond). It is not necessary to run duration.
- Go back to your infiltration pond and look at the Percentage Infiltrated at the bottom right. If less than 100 percent infiltrated, increase pond dimension until you get 100 percent.

Chapter 3 - Conveyance Systems and Hydraulic Structures

3.1 Overview

This chapter presents acceptable methods for analysis and design of conveyance systems. It also discusses hydraulic structures linking the conveyance system to runoff treatment and flow control facilities. The chapter is organized as follows:

- Design and analysis methods (Sections 3.2 through 3.6)
- Pipe systems (Section 3.7)
- Outfalls (Section 3.8)
- Culverts (Section 3.9)
- Open conveyances (Section 3.10)
- Private Drainage Systems (Section 3.11)
- Floodplains/floodways (covered in TCC 17.15).

Where space and topography permit, open conveyances are the preferred means of collecting and conveying stormwater.

3.2 Design Event Storm Frequency

Ideally, every conveyance system and hydraulic structure would be designed for the largest possible amount of flow. Since this would require unusually large structures and be too costly, hydraulic structure designs are analyzed using a specific storm frequency. When selecting a storm frequency, consideration is given to potential adjacent property damage, potential hazard and inconvenience to the public, the number of users, and initial construction cost of the conveyance system or hydraulic structure.

The design event recurrence interval is related to the probability that such an event will occur in any one-year period. For example, a peak flow having a 25-year recurrence interval has a 4 percent probability of being equaled or exceeded in any future year (100/25 = 4). A peak flow having a 2-year recurrence interval has a 50 percent probability of being equaled or exceeded in any future year (100/2 = 50). The greater the recurrence interval, the lower the probability that the event will occur in any given year.

Conveyance systems shall be designed to convey the peak flows from the following storm events:

- The project's internal piped conveyance system shall be designed for a 25-year, 24-hour storm event. In areas where the County determines there is a high risk of damage or vital service interruption, a backwater analysis of the peak flows from the 100-year, 24-hour storm events shall be conducted.

- All open channel conveyance systems shall be designed for the 100-year, 24-hour storm event.
- Piped conveyance under public roads and arterials shall convey a 25-year, 24-hour storm event under fully developed basin conditions. Additional criteria:
    - In the urban area inside of the long-term urban growth management boundary (boundary is depicted on current zoning maps available at the County) the outside driving lane of public roads and streets must not have water over more than 50 percent of the lane for a design event of a 25-year, 24-hour storm.
    - In the area outside of the long-term urban growth management boundary, the design event shall be the 100-year, 24-hour storm.
    - In areas where the County determines there is a high risk of damage or vital service interruption (e.g., more than 6 inches of standing water in the streets), the Administrator or designee may specify up to the 100-year, 24-hour event as the design event.
- Natural channel bridges and culverts shall be designed to convey at least the 100-year, 24-hour storm event under fully developed drainage basin conditions based on the tributary area zoning and maximum allowable impervious surface area. Culvert and bridge designs must also meet applicable fish passage and scour criteria.

3.3 Determination of Design Flows

All existing and proposed conveyance systems shall be analyzed and designed using peak flows from hydrographs developed through single event storm hydrologic analyses described in Section 2.1.4. See Chapter 2 and Appendix III-B for more information.

EXCEPTION: For drainage subbasins 25 acres or less, and having a time of concentration of less than 100 minutes, peak flows for analyzing the capacity of conveyance elements may be determined using the Rational Method (see Chapter 2 and Appendix III-B).

3.4 Open Channel Flow – Hydraulic Analysis

Two hydraulic analysis methods are used to analyze and design conveyance systems:

- The Uniform Flow Analysis Method (Section 3.4.1 below), commonly referred to as the Manning's equation, is used for the design of open conveyances (Section 3.10) and new pipe systems (Section 3.7), as well as for analysis of existing pipe systems. Manning's equation is only valid for pipe flow when the pipe is flowing less than full. If the pipe is surcharged, the backwater method must be used.
- The Backwater Analysis Method (Section 3.4.2 below), is used to analyze the capacity of both proposed and existing pipe systems when a pipe is surcharged. If the County determines that, as a result of the project, runoff for any event up to and including the 100-year, 24-hour event would exceed the pipes' unsurcharged capacity, a backwater (pressure sewer) analysis shall be required. Results shall be submitted in tabular and graphic format showing hydraulic and energy gradient.

3.4.1 Uniform Flow Analysis - Manning's Equation

Manning's equation can be used for open channel flow or for a pipe that is flowing less than full. Manning's equation is expressed as:

$$V = \frac{1.486}{n} \times R^{0.67} \times S^{0.5}$$

Where:

V = velocity (feet per second),

n = Manning's roughness factor (-)

R = hydraulic radius (area/wetted perimeter; feet), and

S = Channel slope (feet/foot)

Manning's equation can also be expressed in terms of discharge (Q):

$$Q = \frac{1.486}{n} \times A \times R^{0.67} \times S^{0.5}$$

Where A = cross-sectional area of flow (square feet).

Manning's roughness factors (n) for open channels are shown in Table 3.1, and for piped conveyances in Table 3.2. A more extensive table of Manning's roughness factors can be found in Table B-3 in Appendix III-B.

Table 3.1. Manning's Roughness Factors for Open Channel Conveyances

Channel Lining	Manning's Roughness Factor (n)
Concrete	0.012
Short grass	0.030
Stony bottom and weedy grass	0.035
Cobble bottom and grass banks	0.040
Dense weeds as high as flow	0.080
Dense woody brush as high as flow	0.120
Biofiltration swale	see Volume V

Table 3.2. Manning's Roughness Factors for Pipe Conveyances

	Analysis Method	
Type of Pipe Material	**Backwater Flow**	**Manning's Equation Flow [a]**
A. Concrete pipe	0.013	0.015
B. Annular Corrugated Metal Pipe or Pipe Arch:		
1. 2-2/3" x 1/2" corrugation (riveted)	0.024	0.028
2. 3" x 1" corrugation	0.027	0.031
3. 6" x 2" corrugation (field bolted)	0.030	0.035
C. Helical 2-2/3" x 1/2" corrugation	0.024	0.028
D. Spiral rib metal pipe	0.016	0.018
E. Ductile iron pipe cement lined	0.013	0.015
F. Plastic	0.010	0.012

[a] The roughness values for this method are 15 percent higher in order to account for entrance, exit, junction, and bend head losses

3.4.2 Backwater Analysis

When a backwater calculation is required for a pipe conveyance, the design engineer shall analyze for the 100-year, 24-hour design storm event against the following criteria:

- For the 100-year event, overtopping of the pipe conveyance system may occur; however, the additional flow shall not extend beyond half the lane width of the outside lane of the traveled way and shall not exceed 4 inches in depth at its deepest point.

- Off-channel storage on private property is allowed with recording of the proper easements (see Section 3.6). The additional flow shall be analyzed by open channel flow methods.

A backwater profile analysis computer program such as the King County Backwater (KCBW) computer program prepared by the King County Department of Natural Resources and Parks, Water and Land Resources Division is recommended over manual calculations. The BPIPE subroutine of KCBW may be used for quick computation of backwater profiles, given a range of flows through the existing or proposed pipe system. This program is available free of charge from King County.

3.5 Conveyance System Route Design and Off-Site Drainage

All pipe shall be located under the pavement flow line or lie outside of the pavement. Perpendicular crossings and cul-de-sacs are exempted from this requirement. New conveyance system alignments that are not in dedicated tracts or right-of-way shall be located in drainage easements that are adjacent and parallel to property lines. The width of the permanent easement will be completely within a single parcel or tract. Topography and existing conditions are the only conditions under which a drainage easement that is not adjacent and parallel to a property line may be placed. Requirements for conveyance system tracts and easements are discussed in Section 3.6 below.

EXCEPTION: Streams and natural drainage channels can not be relocated to meet this routing requirement.

Development projects are required to handle offsite drainage in the same manner as exists in the predeveloped condition. In other words, after development of the subject site, offsite flows shall be infiltrated within or passed through the project site in the same proportion as occurred prior to development. The area and existing use of the off-site land area should be included in any modeling performed to design new facilities. If the adjacent site is undeveloped, the potential for increased future flow volumes should be factored in to the design of facilities. This may require modeling the off-site land area as if it were developed with a detention facility discharging per the minimum requirements of this manual. To avoid this analysis, it would be preferable to collect and bypass off-site drainage around the site or infiltrate it prior to the flow being combined with on-site drainage. If the offsite drainage is to be infiltrated on site, the infiltration facilities shall be sized to accommodate the correct proportion of offsite flows.

Offsite pass-through flows shall be routed separately across the development site. They shall not be routed through the project's conveyance, runoff treatment, or flow control systems. Storage and treatment of off-site pass-through flows is not required.

However, if the Project Engineer and the Administrator or designee agree that separate handling of offsite flows is impracticable, then offsite flows may be routed through the project's stormwater management systems. Those systems affected by the offsite flows shall be sized as if the offsite flows were generated within the development project's boundaries.

3.6 Easements, Access, and Dedicated Tracts

All man-made drainage facilities and conveyances, and all natural channels (on the project site) used for conveyance of altered flows due to development shall be located within easements or dedicated tracts as required by the County. Easements shall contain the natural features and facilities and shall allow County access for purposes of inspection, maintenance, repair or replacement, flood control, water quality monitoring, and other activities permitted by law.

The easement shall include easement boundary markers which shall be fiberglass utility markers with a reflective easement tag, located at each corner of the easement, at angle points and at least every 100-ft along the length of the easement. Contact Thurston County Water Resources Unit for additional information on easement marker requirements.

3.6.1 .Maintenance Access to Stormwater Facilities

All drainage facilities such as detention or wet ponds or infiltration systems whether privately maintained or maintained by the County shall be located in separate tracts. Conveyance systems and dedicated stormwater dispersion areas can be in easements. Drainage facilities shall not be located in dedicated public road right-of-way areas, with the exception of County and highway facilities.

The dedicated tract for a stormwater facility shall include a minimum 15-foot wide access from a public street or right-of-way. If the development is served by private roads or is gated then the Proponent shall provide for County access through the gate or private roads to access stormwater facilities. This may include providing a pass code to the Administrator or other means acceptable to the County.

An easement shall be granted through the tract for access to the stormwater facility and shall not be included as part of any individual lots within a subdivision. Access easements across individual lots for access to a stormwater facility are discouraged and shall only be allowed with specific acceptance of Thurston County (including the Administrator or designee) and only upon demonstration that measures are in place to ensure that the easement will not be encroached upon by the lot owner.

The access shall be surfaced with a minimum 12-foot width of crushed rock or other approved surface to allow year-round equipment access to the facility and delineated by a gate, fencing or some other measure to indicate to adjacent property owners that an easement exists. See individual BMP descriptions in Volume V for additional stormwater facility access requirements.

Drainage facilities that are designed to function as multi-use recreational facilities shall be located in separate tracts or in designated open space and shall be privately maintained and owned, unless accepted by and dedicated to the County.

Maintenance access must be provided for all manholes, catch basins, vaults, or other underground drainage facilities. Maintenance shall be through an access easement (see requirements above) or dedicated tract. Drainage structures for conveyance without vehicular access must be channeled.

3.6.2 Access to Conveyance Systems

All publicly and privately maintained conveyance systems shall be located in dedicated tracts, drainage easements, or public rights-of-way in accordance with this manual. Exception: Roof downspout, minor yard, and footing drains unless they serve other adjacent properties.

Conveyance systems to be maintained and operated by Thurston County must be located in a dedicated tract or drainage easement granted to the County. Any new conveyance system on private property conveying drainage from other private properties must be located in a dedicated tract or private drainage easement granted to the stormwater contributors.

Any easement for access to a conveyance system shall include measures to ensure that the easement will not be encroached upon by adjacent lot owners such as delineation by a gate, fencing, signage or some other measure to indicate to adjacent property owners that an easement exists.

All drainage tracts and easements must have a minimum width of 15 feet. All pipes and channels must be located within the easement in accordance with Table 3.3. If circumstances require the location of the pipe or channel within the easement to differ from the requirements of Table 3.3, then, at a minimum each pipe face or top channel edge shall be no closer than 5 feet from its adjacent easement boundary. Easements or Tract widths shown in Table 3.3 are minimums for drainage facilities and may be increased depending on pipe/channel size, depth or other factors.

Table 3.3. Minimum Easement Widths for Conveyance Systems for Access, Inspection and Maintenance

Conveyance Width	Easement/Tract Width
Channels ≤ 30 feet wide	Channel Width + 15 feet from top, one side
Channels > 30 feet wide	Channel Width + 15 feet from top, both sides
Pipes/Outfalls ≤ 36 inches	15 feet centered on pipe
Pipes/Outfalls ≤ 60 inches	20 feet centered on pipe*
Pipes/Outfalls > 60 inches	30 feet centered on pipe*

* May be greater, depending on depth and number of pipes in easement.

3.6.3 Discharge to Private Property

When the proposed project site discharges to an adjacent property where no public drainage facility or no defined drainage course exists (e.g., a natural channel with a measurable annual discharge such as a Department of Natural Resources (DNR) Type 5 rated stream), the Proponent shall obtain an easement from the adjacent property owner(s) to establish a drainage way to connect to a defined drainage system. In the absence of such an easement, the discharge from stormwater management facilities shall be distributed along the property line in approximately the same flow pattern as before development. A quantitative downstream analysis shall be conducted to determine any potential impacts of the distributed flow to downstream property.

The Administrator or designee may, under highly unusual circumstances, excuse the Proponent from requirements of this section (e.g., adjacent property is a wetland and is not a closed basin, and discharge to the wetland would not significantly alter the hydrology, degrade wetland functions and values, or reduce the value of the property).

3.7 Pipe System Design Criteria

Pipe systems are networks of storm drain pipes, catch basins, manholes, and inlets designed and constructed to convey storm and surface water. The hydraulic design of new storm drain pipes is limited to gravity flow; however, in analyzing existing systems, it may be necessary to address pressurized conditions.

3.7.1 Analysis Methods

Two methods of hydraulic analysis (using Manning's Equation) are used for pipe system analysis (see Section 3.4):

- Uniform Flow Analysis Method (Section 3.4.1), commonly referred to as the Manning's Equation.
- Backwater Analysis Method (Section 3.4.2).

When using the Manning's Equation for design, each pipe within the system shall be sized and sloped so that its barrel capacity at normal full flow is equal or greater than the required conveyance capacity as identified in Section 3.2. Pipes should not be designed to surcharge.

Nomographs may also be used for sizing the pipes. For pipes flowing partially full, the actual velocity may be estimated from engineering nomographs by calculating Q_{full} and V_{full} and using the ratio of Q_{design}/Q_{full} to find V and d (depth of flow). Appendix III-C includes several nomographs that may be useful for culvert sizing.

3.7.2 Acceptable Pipe Sizes

Storm drainage pipe are subject to the following minimum diameters:

- Private drainage system = 4 inches
- Public right-of-way = 12 inches (exception: laterals connecting catch basins to main lines may be 8 inches)

The Administrator or designee may waive these minimums in cases where topography and existing drainage systems make it impractical to meet the standard. For culverts, see Section 3.9.

3.7.3 Pipe Materials

All storm drainage pipe, except as otherwise indicated, shall be a rubber-gasketed concrete pipe, or double-walled, corrugated, polyethylene pipe, with a smooth internal diameter (AASHTO M-294 Type-S) ADS N-12 plastic pipe (up to twenty-four (24) inch diameter only) or approved equal, coupled with a company produced PVC coupling or approved equal, except for perforated pipe and major underground detention facilities. ADS N-12 pipe shall have a minimum cover of two (2) feet measured from the top of pipe to the top of paved surface. The rubber-gasket requirement may be waived if it can be shown that joint leakage will not be detrimental to the road prism.

When extreme slope conditions or other unusual topographic conditions exist, other pipe materials and methods such as (but not limited to) PVC, HDPE, or ductile iron pipe may be used with prior County approval.

If other pipe materials are used, they shall meet the following minimum requirements and shall have prior County approval:

- Ductile Iron, Class 50 or 52
- Reinforced concrete pipe
- Galvanized corrugated iron or steel pipe (with Treatment 1 through 6)
- Galvanized steel spiral rib pipe (with Treatment 1 through 6)
- Corrugated aluminum pipe
- Aluminum spiral rib pipe
- Aluminized Type 2 corrugated steel (meeting AASHTO treatment M274 and M56)
- Corrugated high density polyethylene pipe (CPEP) - smooth interior (maximum 24 inch diameter) meeting AASHTO standard M-294
- Corrugated high density polyethylene pipe (CPEP) - single wall, fully corrugated meeting AASHTO standard M-252 (permitted only outside public right-of-way and for use in temporary storm sewer systems and as downspout/footing/yard drain collectors on private property)
- Polyvinyl chloride (PVC) sewer pipe (SDR 35, meeting requirements of ASTM D3034)
- High density polyethylene (HDPE) pipe. Pipe must comply with requirement of Type III C5P34 per ASTM D1248 and have the PPI recommended designation of PE3408 and have an ASTM D3350 cell classification of 345434C or 345534C. Pipe shall have a manufacturer's recommended hydrostatic design stress rating of 800 psi based on a material with a 1600 psi design basis determined in accordance with ASTM D2837-69. Pipe shall have a suggested design working pressure of 50 psi at 73.4 degrees F and SDR of 32.5. Designs utilizing HDPE pipe shall include consideration of the material's thermal expansion/contraction properties for anchoring.

Pipe material, joints, and protective treatment shall meet WSDOT Standard Specifications, Sections 7-04 and 9-05 and AASHTO and ASTM treatment standards as amended by the County. The Applicant is responsible for contacting the County to determine the allowable pipe materials which can be used.

3.7.4 Pipe Slope and Velocity

Minimum velocity is 2 feet per second at design flow. The County may waive these minimums when topography and existing drainage systems make it impractical.

Maximum slopes, velocities, and anchor spacings are shown in Table 3.4. If velocities exceed 15 feet per second for the conveyance system design event, provide anchors at bends and junctions.

Table 3.4. Maximum Pipe Slopes and Velocities

Pipe Material	Pipe Slope Above Which Pipe Anchors Required	Max. Slope Allowed	Max. Velocity @ Full Flow
PVC(1), CPEP-singlewall(1) Corrugated Metal Pipe(1)	20% (1 anchor per 100 LF of pipe)	30% (3)	30 fps
Concrete(1) or CPEP-smooth interior(1)	10% (1 anchor per 50 LF of pipe)	20% (3)	30 fps
Ductile Iron (4)	40% (1 anchor per pipe section)	None	None
HDPE (2)	50% (1 anchor per 100 LF of pipe – cross slope installations may be allowed with additional anchoring and analysis)	None	None

NOTES:

(1) Not allowed in landslide hazard areas.

(2) Butt-fused pipe joints required. Above ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.

(3) Maximum slope of 200% allowed for these pipe materials with no joints (one section) if structures are provided at each end and the pipes are properly grouted or otherwise restrained to the structures.

(4) Restrainted joints required on slopes greater than 25%. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes:

KEY:

PVC = Polyvinyl chloride pipe
HDPE = High density polyethylene
fps = Feet per second

Downsizing of pipes is only allowed under special conditions (i.e. no hydraulic jump can occur; downstream pipe slope is significantly greater than the upstream slope; velocities remain in the 3 to 8 feet per second range, etc.).

Downsizing of downstream culverts within a closed system with culverts 18 inches in diameter or smaller will not be permitted.

3.7.5 Pipes on Steep Slopes

Steep slopes (greater than 30 percent) shall require all drainage to be piped from the top to the bottom in HDPE pipe (butt fused) or ductile iron pipe welded or mechanically restrained. If slopes exceed 40 percent, then pipe shall be installed above ground and anchored (see Table 3.4). Additional anchoring design may be required for these pipes.

3.7.6 Pipe System Layout Criteria

Pipes must be laid true to line and grade with no curves, bends, or deflections in any direction (except for HDPE and ductile iron with flanged restrained mechanical joint bends, not greater than 30°, on steep slopes).

A break in grade or alignment or changes in pipe material shall occur only at catch basins or manholes.

Connections to a pipe system shall be made only at catch basins or manholes. No wyes or tees are allowed except on private roof/footing/yard drain systems on pipes 8 inches in diameter, or less, with clean-outs upstream of each wye or tee.

Provide 6 inches minimum vertical and 3 feet minimum horizontal clearance (outside surfaces) between storm drain pipes and other utility pipes and conduits. Development Standards for Water and Sewer Systems, Thurston County will apply for crossings of or parallel runs with Thurston County sewer lines and for crossings of water lines. Additional requirements for crossings of septic transport lines or water supply lines may apply. Contact the Thurston County Environmental Health Division or the local water purveyor for these requirements. Contact the Environmental Health Division of the Thurston County Department of Public Health and Social Services at (360) 754-3355 (x6518) for more information.

Suitable pipe cover over storm pipes in road rights-of-way shall be calculated for HS-20 loading by the Project Engineer. Pipe cover is measured from the finished grade elevation to the top of the outside surface of the pipe. Pipe manufacturer recommendations are acceptable, if verified by the Project Engineer.

PVC SDR 35 minimum cover shall be 3 feet in areas subject to vehicular traffic; maximum cover shall be 30 feet or per the manufacturer's recommendations and as verified with calculations from the Project Engineer.

Pipe cover in areas not subject to vehicular loads, such as landscape planters and yards, may be reduced to a 1 foot minimum.

Access barriers are required on all pipes 18 inches and larger exiting a closed pipe system. Debris barriers (trash racks) are required on all pipes entering a pipe system.

Where a minimal fall is necessary between inlet and outlet pipes in a structure, pipes must be aligned vertically by one of the following in order of preference:

- Match pipe crowns
- Match 80 percent diameters of pipes
- Match pipe inverts

Where inlet pipes are higher than outlet pipes, drop manhole connections may be required or increased durability in the structure floor may be required.

High Density Polyethylene (HDPE) pipe systems longer than 100 feet must be anchored at the upstream end if the slope exceeds 25 percent and the downstream end placed in a minimum 4 foot long section of the next larger pipe size. This sliding sleeve connection allows for the high thermal expansion/contraction coefficient of the pipe material.

3.7.7 Pipe Structure Criteria

Catch Basins and Manholes

All catch basins and manholes shall meet WSDOT standards such as Type 1L, Type 1, and Type 2. The following criteria shall be used when designing a conveyance system which uses catch basins or manholes.

Unless otherwise required by the County, Type 1 catch basins shall be used at the following locations or for the following situations:

- When overall structure height does not exceed 8 feet, or when invert does not exceed 5 feet.

- When pipe sizes do not exceed 18 inches and connect at right angles to the long side of the structure; or 12 inches connecting to the short side.

- When all pipes tying into the structure connect at or very near to right angles.

Unless otherwise required by the County, Type 1L catch basins must be used at the following locations or for the following situations:

- When overall structure height does not exceed 8 feet or when invert does not exceed 5 feet.
- When any pipes tying into the structure exceed 18 inches connecting to the long side, or 15 inches connecting to the short side at or very near to right angles.

Unless otherwise required by the County, Type 2 (48-inch minimum diameter) catch basins shall be used at the following locations or for the following situations:

- When overall structure height does not exceed 15 feet.
- When all pipes tying into the structure do not exceed the limits set forth by the manufacturers. Type 2 catch basins over 4 feet in height shall have standard ladders.

Where an approved connection of a private storm drainage system into a County system occurs, a minimum of a Type 1 catch basin shall be used in Thurston County.

Maximum spacing on main storm sewers between access structures, whether catch basins or manholes, shall be 300 feet (Table 3.5).

Table 3.5. Maximum Surface Runs Between Inlet Structures on the Paved Roadway Surface in Thurston County

Roadway Slope (%)	Thurston County Max. Spacing (ft)
0.5 to 1.0	150
1.0 to 3.0	200
>3.0	300

Catch basin (or manhole) diameter shall be determined by pipe diameter and orientation at the junction structure. A plan view of the junction structure, drawn to scale, is required when more than four pipes enter the structure on the same plane, or if angles of approach and clearance between pipes is of concern. The plan view (and sections if necessary) must insure a minimum distance (of solid concrete wall) between pipe openings of 8 inches for 48-inch and 54-inch diameter catch basins and 12 inches for 72-inch and 96-inch diameter catch basins.

Catch basin evaluation of structural integrity for H-20 loading will be required for multiple junction catch basins and other structures which exceed the recommendations of the manufacturers.

The WSDOT Hydraulics Manual can be used to determine inlet grate capacity when capacity is of concern. When verifying capacity, assume grate areas on slopes are 80 percent free of debris, and "vaned" grates are 95 percent free. In sags or low spots, assume grates are 50 percent free of debris, and "vaned" grates are 75 percent free.

The maximum slope of the ground surface shall be 3:1 for a radius of 5 feet around a catch basin grate.

Catch basins shall be provided within 50 feet of the entrance to a pipe system to provide for silt and debris removal.

Maximum spacing of structures for storm drainage conveyance lines running within an easement area shall be 350 feet for pipe grades greater than 0.3 percent and 200 feet for grades less than 0.3 percent. Structures not acting as points of entry for stormwater shall have locking lids and have solid covers.

Locking lids will be installed on all structures containing restrictor or flow devices. The locking lids shall be of a quality and design acceptable to the County.

A metal frame and grate for catch basin and inlet, WSDOT Standard Plan B-2a or B-2b or pre-approved county standard grate that is deemed bicycle safe, shall be used for all structures collecting drainage from the paved roadway surface.

When the road profile equals or exceeds 6 percent between structures, an asphalt berm shall be installed around the inlet of the structure or the catch basin may be recessed into the curb per this detail.

Table 3.6 presents the allowable structures and pipe sizes allowed by size of structure. All catch basins, inlets, etc., shall be marked as shown in Volume IV, Figure 4.24.

Table 3.6. Allowable Structure and Pipe Sizes

	Maximum Pipe Diameter	
Catch Basin Type (1)	Spiral Rib CPEP, HDPE, PVC (2) (Inches)	Concrete and Ductile Iron (Inches)
Inlet (4)	12	12
Type 1 (3)	15	15
Type IL (3)	18	18
Type 2-48-inch dia.	30	24
Type 2-54-inch dia.	36	30
Type 2-72-inch dia.	54	48
Type 2-96-inch dia.	72	72

(1) Catch basins, including manhole steps, ladder, and handholds shall conform to the WSDOT Standard Plans or an approved equal based upon submittal for approval.

(2) Maintain the minimum side wall thickness per WSDOT standards.

(3) Maximum 5 vertical feet allowed between grate and invert elevation.

(4) Normally allowed only for use in privately maintained drainage systems and must discharge to a catch basin immediately downstream.

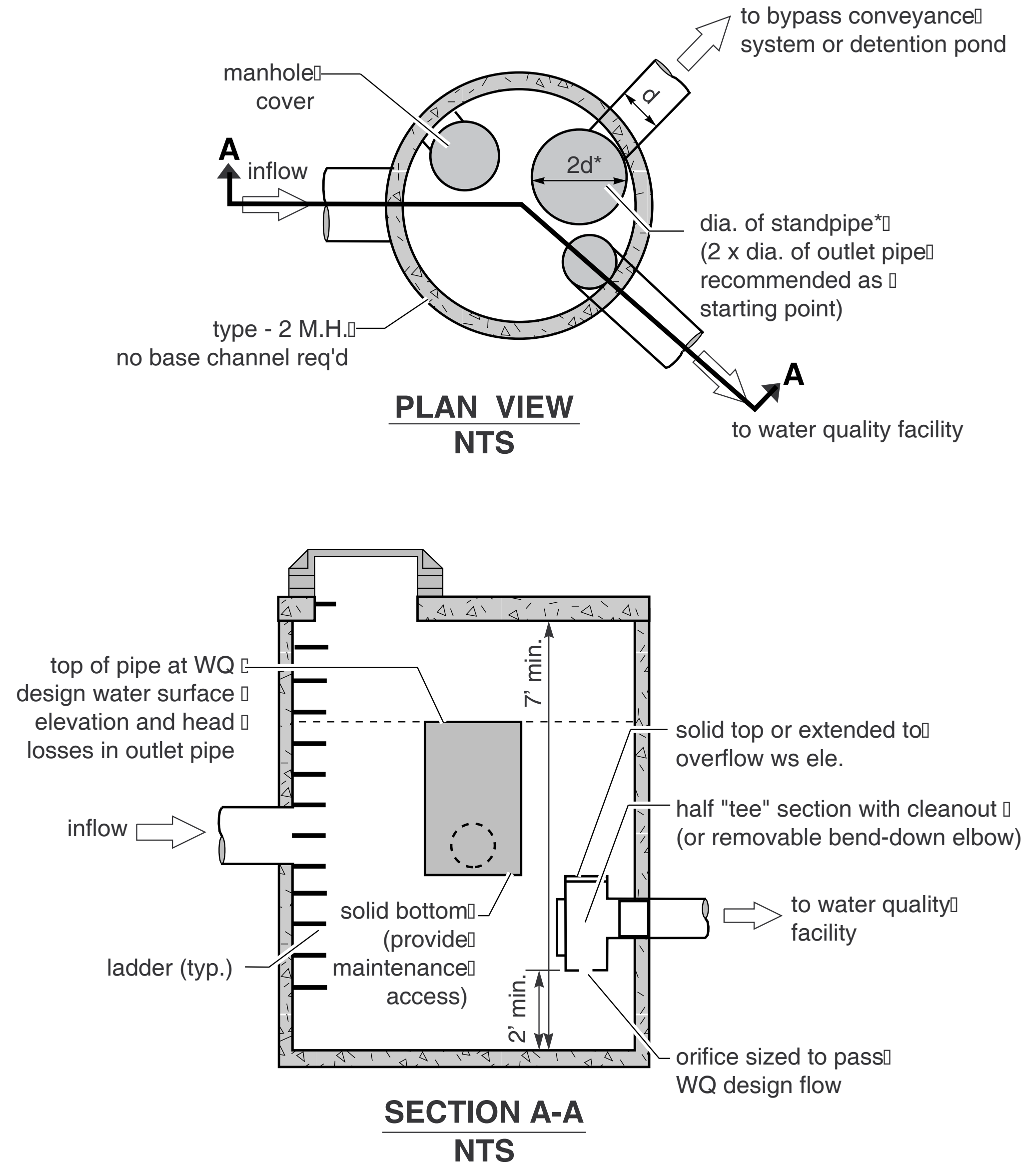
NOTE: The applicant shall check with the County to determine the allowable pipe materials.

Flow Splitter Designs

Many runoff treatment 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 at a lower pollutant removal efficiency. However, it is sometimes desirable to restrict flows to runoff treatment facilities and bypass the remaining higher flows around them through 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. In most cases, it is a designer's choice whether runoff treatment facilities are designed as on-line or off-line; an exception is oil/water separators, which must be designed off-line.

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 runoff treatment facility under high flow conditions. Flow splitters may be used for purposes other than diverting flows to runoff treatment facilities. However, the following discussion is generally focused on using flow splitters in association with runoff treatment facilities.

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 tee section. A full tee option may also be used as described below in the "General Design Criteria." Two possible design options for flow splitters are shown in Figure 3.1 and Figure 3.2. Other equivalent designs that achieve the result of splitting low flows and diverting higher flows around the facility are also acceptable.



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

Figure 3.1. Flow Splitter, Option A.

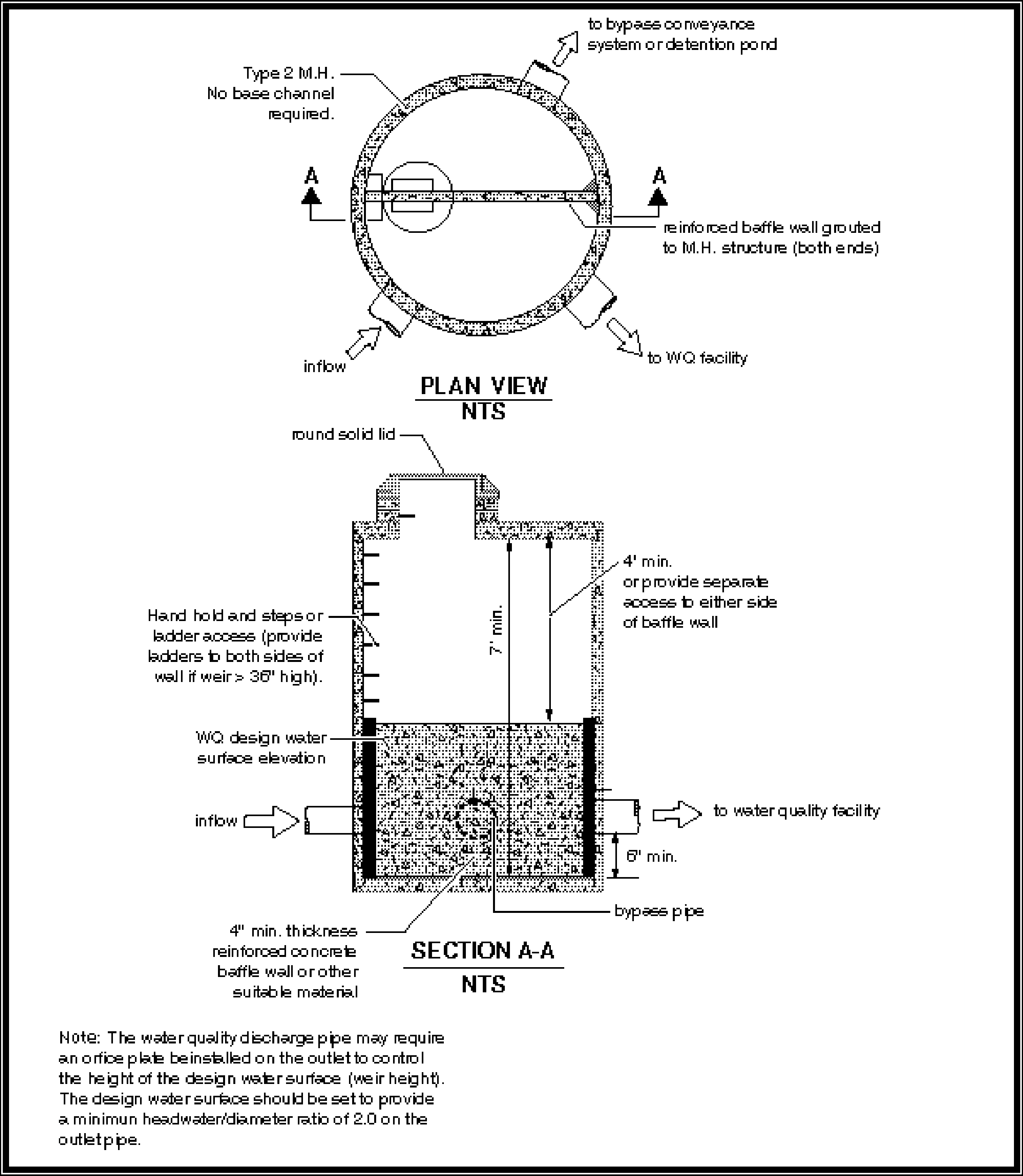


Figure 3.2. Flow Splitter, Option B.

General Design Recommendations

- Unless otherwise specified, a flow splitter should be designed to deliver the water quality design flow rate specified to the runoff treatment facility (see also Volume V). Flows modeled using a continuous simulation runoff model should use 15-minute time steps.

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

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

- Either design shown in Figure 3.1 or Figure 3.2 or an equivalent design may be used.

- As an alternative to using a solid top plate in Figure 3.2, a full tee section may be used with the top of the tee at the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the runoff treatment facility rather than back up from the manhole.

- Special applications, such as roads, may require the use 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.

- For ponding facilities, back water effects must be included in designing the height of the standpipe in the manhole.

- Ladder or step and handhold access must be provided. If the weir wall is higher than 36 inches, two ladders, one to either side of the wall, should be used.

Materials

- The splitter baffle may be installed in a Type 2 manhole or vault.

- The baffle wall should 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 manhole cover should be 4 feet; otherwise, dual access points shall be provided.

- All metal parts must be corrosion resistant. Examples of preferred materials include aluminum, stainless steel, and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painted metal parts should not be used because of poor longevity.

3.8 Outfalls

All piped discharges to streams, rivers, ponds, lakes, or other open bodies of water are designated outfalls and shall provide for energy dissipation to prevent erosion at or near the point of discharge. Properly designed outfalls are critical to reducing the risk of adverse impacts of concentrated discharges from onsite and downstream pipe systems and culverts. Outfall systems include rock splash pads, flow dispersal trenches, gabion or other energy dissipaters, and tightline systems. A tightline system is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

Outfalls to streams, wetlands, or other waters of the State may be subject to review through the SEPA process, Shorelines Management Act, Thurston County Marine Bluff requirements and other applicable regulations, as well as subject to state or federal requirements including hydraulic and permitting requirements of the Washington State Department of Fish and Wildlife, Army Corps of Engineers or Washington State Department of Natural Resources. The requirements of these other reviews and permitting processes shall take precedence where more restrictive than those stated herein.

3.8.1 General Design Criteria for Outfall Features

Outfalls shall be designed to pass the peak flow from the design event for conveyances (Section 3.2) and to suffer no structural damage or undercutting during the 100-year, 24-hour storm event. The Project Engineer shall present calculations showing the velocity, discharge, and flow path of the 100-year, 24-hour event.

The standard for outfall design is as shown in Figure 3.3. This design is limited to slopes of 2:1 or flatter where native vegetation is well established or where slope armoring is engineered to the Administrator or designee's satisfaction. For sites where the Project Engineer determines and the Administrator or designee agrees that the standard is impractical because of lack of space, danger of erosion, etc., see alternate outfall designs shown in Figures 3.6 and 3.7. Other outfall designs will be allowed upon acceptance of the Administrator or designee.

See Table 3.7 for a summary of the rock protection requirements at outfalls.

Table 3.7. Rock Protection at Outfalls

Discharge Velocity at Design Flow in feet per second (fps)	Required Protection				
	Minimum Dimensions				
	Type	Thickness	Width	Length	Height
0 – 5	Rock lining[(1)]	1 foot	Diameter + 6 feet	8 feet *or* 4 x diameter, whichever is greater	Crown + 1 foot
5^+ - 12	Riprap[(2)]	2 feet	Diameter + 6 feet *or* 3 x diameter, whichever is greater	12 feet *or* 4 x diameter, whichever is greater	Crown + 1 foot
12^+	Engineered Design	As required	As required	As required	Crown + 1 foot

Footnotes:

(1) **Rock lining** shall be quarry spalls with gradation as follows:

Passing 8-inch square sieve:	100%
Passing 3-inch square sieve:	40 to 60% maximum
Passing ¾-inch square sieve:	0 to 10% maximum

(2) **Riprap** shall be reasonably well graded with gradation as follows:

Maximum stone size:	24 inches (nominal diameter)
Median stone size:	16 inches
Minimum stone size:	4 inches

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3:1.

Outfalls with flow velocity under 12 feet per second and discharge under 2 cfs for the conveyance system design event (Section 3.2) are to be provided (at minimum) with a splash pad (e.g., rock, gabions, concrete).

Outfalls where flow is 2 cfs or greater or velocity is 12 feet per second or greater for the conveyance system design event (Section 3.2), an engineered energy dissipater is required. Examples are gabion splash blocks, stilling basins, drop pools, hydraulic jump pools, baffled aprons, bubble up structures, etc.

Outfalls must be protected against undercutting. Also consider scour, sedimentation, anchor damage, etc. Pipe and fittings materials shall be corrosion resistant such as aluminum, plastic, fiberglass, high density polyethylene, etc. Galvanized or coated steel will not be acceptable.

Outfalls on Steep Slopes

Outfall pipes on steep slopes (refer to Table 3.4) must be anchored and must be fused or butt-welded or mechanically restrained. They may not be gasketed, slip fit, or banded.

On steep slopes, High Density Polyethylene (HDP) pipe may be laid on the surface or in a shallow trench, anchored, protected against sluicing, and hand compacted.

HDP outfall systems must be designed to address the material limitations as specified by the manufacturer, in particular thermal expansion and contraction. The coefficient of thermal expansion and contraction for HDP is on the order of 0.001-inch per foot per Fahrenheit degree. Sliding connections to address this thermal expansion and contraction must be located as close to the discharge end of the outfall system as is practical.

HDP systems longer than 100 feet must be secured at the upstream end and the downstream end placed in a four-foot section of the next larger pipe size. This sliding sleeve connection allows for high thermal expansion/contraction.

HDP shall comply with the requirements of Type III C5P34 as tabulated in ASTM D1248 and have the PPI recommended designation of PE3408 and have an ASTM D3350 cell classification of 345434C or 345534C. The pipe shall have a manufacturer's recommended hydrostatic design stress rating of 800 psi based on a material with a 1,600 psi design basis determined in accordance with ASTM D2837-69. The pipe shall have a suggested design working pressure of 50 psi at 73.4 degrees F and SDR of 32.5.

Outfall Pipe Energy Dissipation

Outfall pipes that discharge directly into a channel or water body shall be provided at a minimum with a rock splash pad (Figure 3.3). See Table 3.7 for minimum rock protection at outfalls.

Due to HDP pipe's ability to transmit flows of very high energy, special consideration for energy dissipation must be made. A sample gabion mattress energy dissipater for this purpose has been provided as Figure 3.6. This mechanism may not be adequate to address flows of very high energy: therefore, a more engineered energy dissipater structure as described above, may be warranted.

Mechanisms which reduce velocity prior to discharge from an outfall are encouraged. Examples are drop manholes and rapid expansion into pipes of much larger diameter.

The following sections provide general design criteria for various types of Outfall Features.

General Design Criteria to Protect Aquatic Species and Habitat

Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitats. However, new pipe outfalls are also opportunities for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and energy dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall to the stream (as shown in Figure 3.8). Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Potential habitat improvements should be discussed with the Washington Department of Fish and Wildlife area habitat biologist prior to inclusion in design.

Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. Outfalls that discharge to the Puget Sound or a major waterbody may require tide gates. Contact the County for specific requirements.

Flow Dispersal Trench

The flow dispersal trenches shown in Figures 3.4 and 3.5 should only be used when an outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists, the natural (existing) discharge is unconcentrated, and the 100-year peak discharge rate is less than or equal to 0.5 cfs. Other flow dispersal BMPs are described in Volume V.

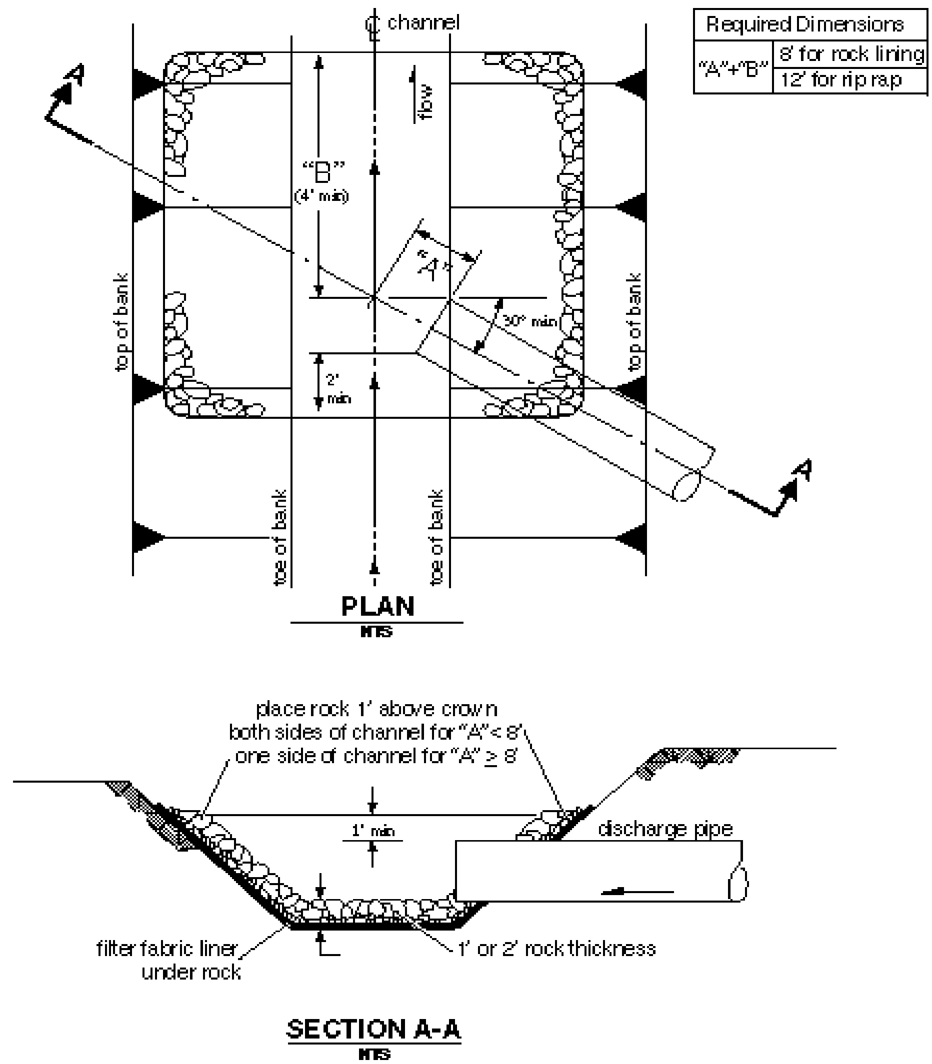


Figure 3.3. Pipe/Culvert Outfall Discharge Protection.

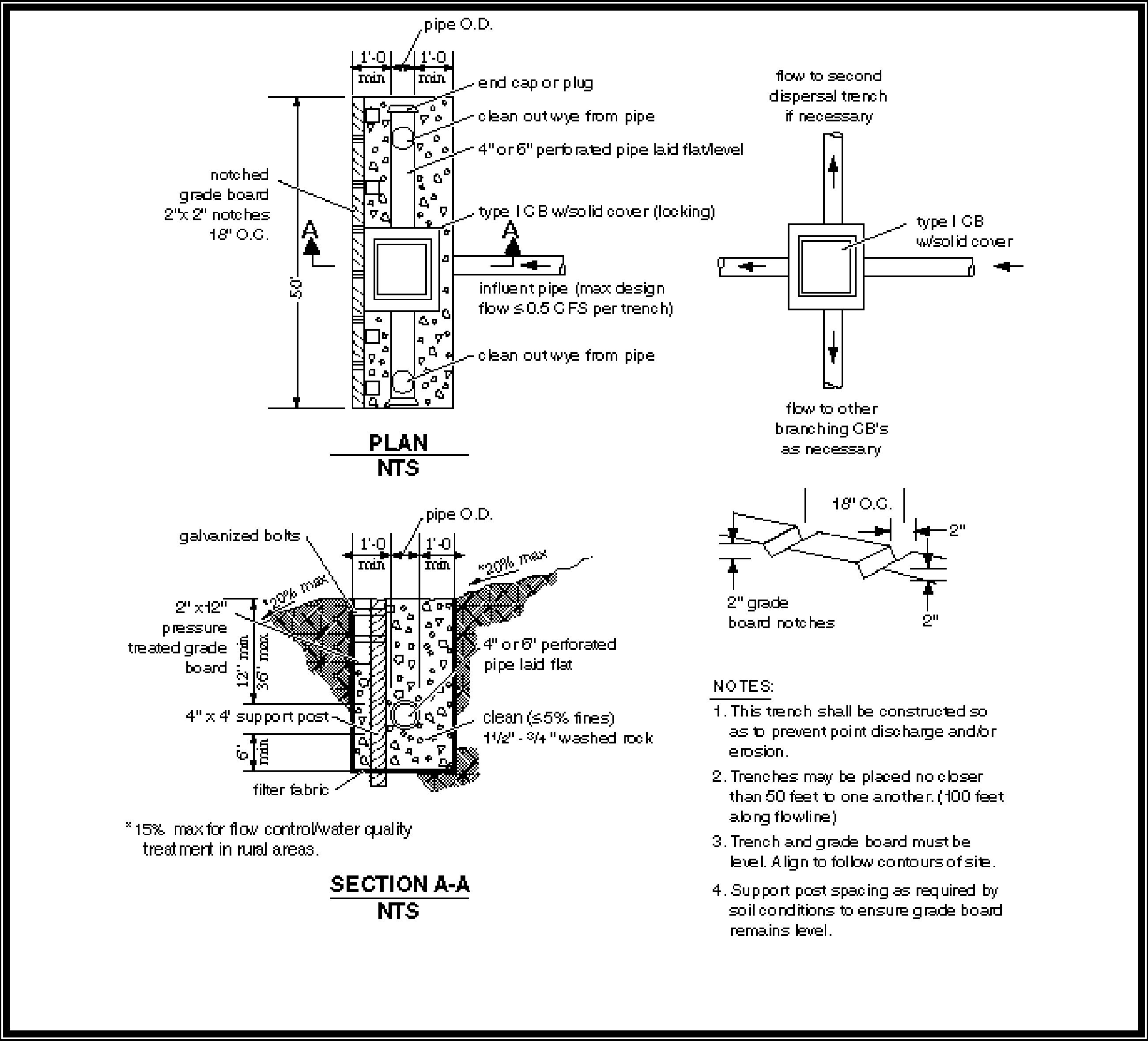


Figure 3.4. Flow Dispersal Trench.

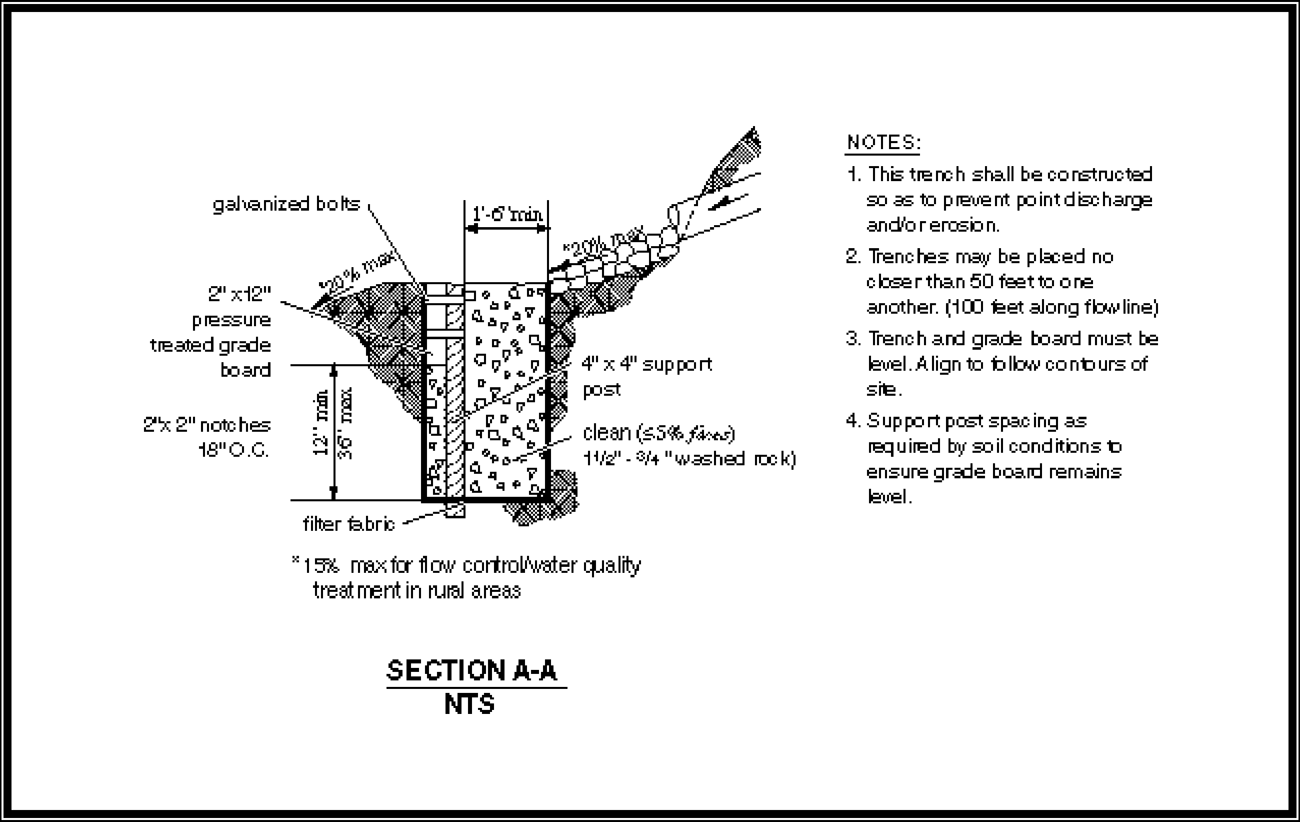


Figure 3.5. Alternative Flow Dispersal Trench.

3.8.2 Tightline Systems

Tightline systems may be needed to prevent aggravation or creation of a downstream erosion problem. The following design criteria apply to tightline systems:

- Outfall tightlines may be installed in trenches with standard bedding on slopes up to 20 percent. In order to minimize disturbance to slopes greater than 20 percent, it is recommended that tightlines be placed at grade with proper pipe anchorage and support.

- Except as indicated above, tightlines or conveyances that traverse the marine intertidal zone and connect to outfalls should be buried at a depth sufficient to avoid exposure of the line during storm events or future changes in beach elevation. If non-native material is used to bed the tightline, such material should be covered with at least 3 feet of native bed material or equivalent.

- High density polyethylene pipe (HDPP) tightlines must be designed to address the material limitations, particularly thermal expansion and contraction and pressure design, as specified by the manufacturer. The coefficient of thermal expansion and contraction for solid wall polyethylene pipe (SWPE) is on the order of 0.001 inch per foot per Fahrenheit degree. Sliding sleeve connections should be used to address this thermal expansion and contraction. These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections should be located as close to the discharge end of the outfall system as is practical.

- Due to the ability of HDPP tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. Details of a sample gabion mattress energy dissipater have been provided as Figure 3.6. Flows of very high energy will require a specifically engineered energy dissipater structure.

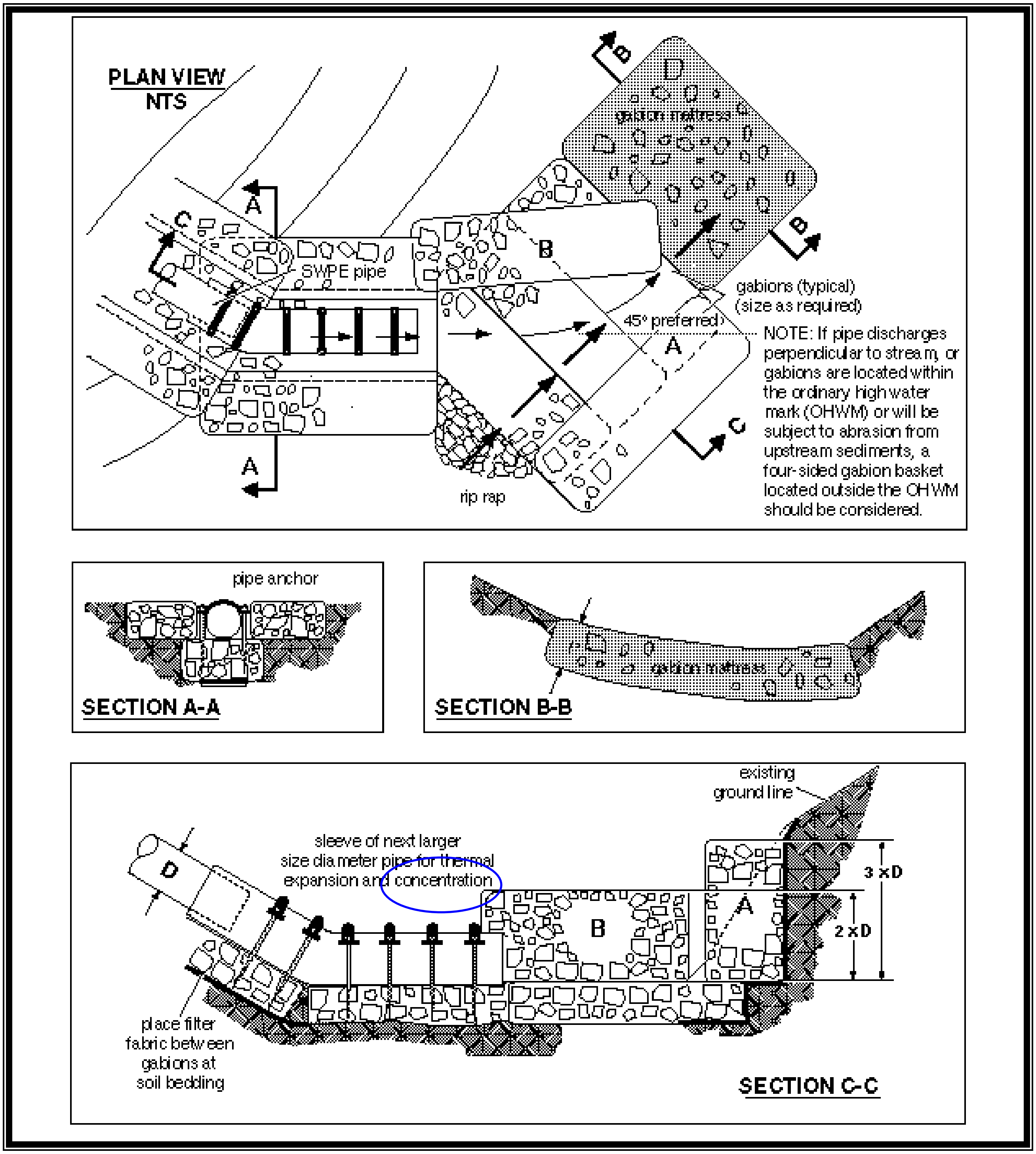


Figure 3.6. Gabion Outfall Detail.

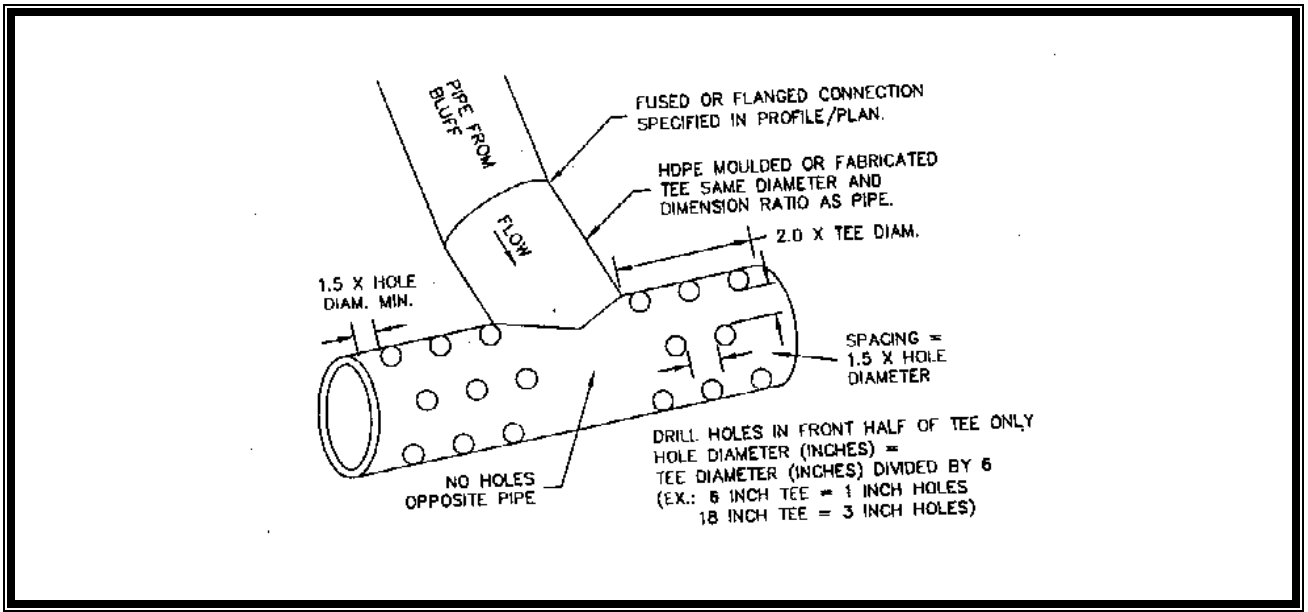


Figure 3.7. Diffuser TEE (an example of energy dissipating end feature).

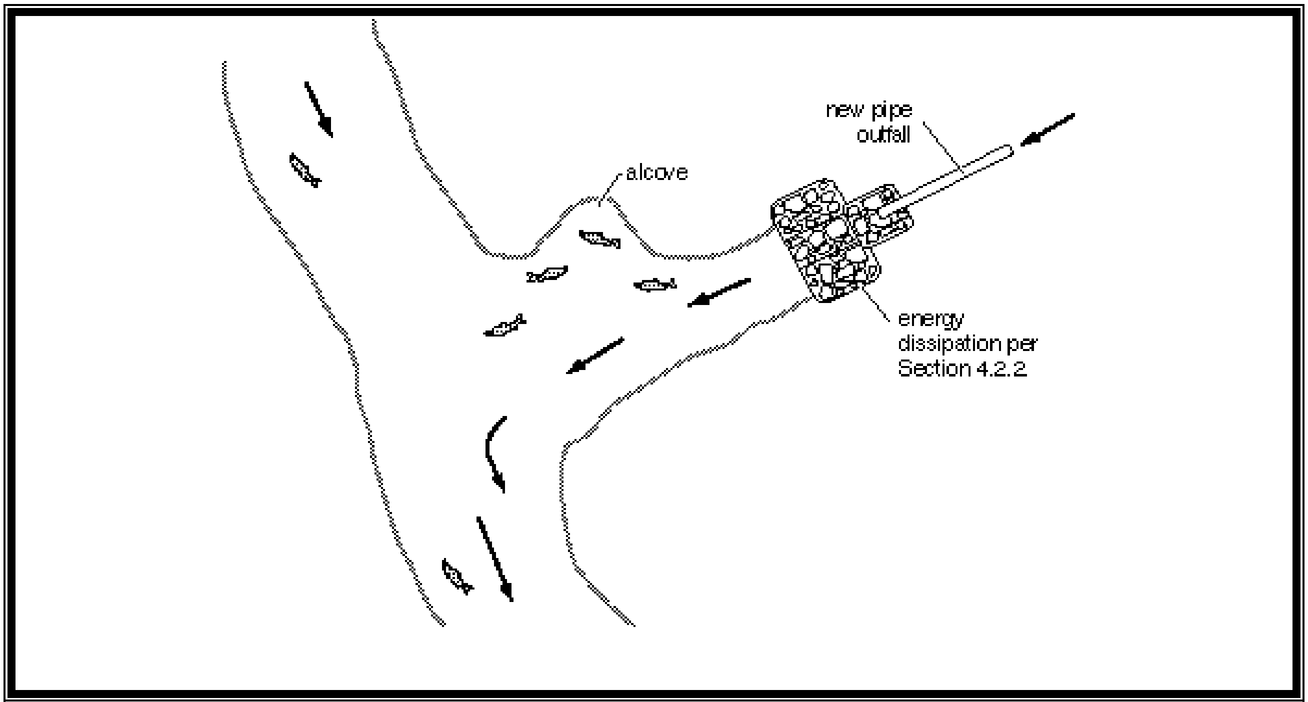


Figure 3.8. Fish Habitat Improvement at New Outfalls.

3.9 Culvert Criteria

Culverts are single runs of pipe that are open at both ends and have no structures, such as manholes or catch basins.

Approved pipe materials are detailed in Section 3.7.3. Galvanized or aluminized pipe is not permitted in marine environments or where contact with salt water may occur, even infrequently through backwater events.

3.9.1 Culvert Design Criteria

Flow capacity shall be determined by analyzing inlet and outlet control for headwater depth. Nomographs used for culvert design shall be included in the submitted Drainage Report. Appendix III-C also includes several nomographs useful for culvert sizing.

All culverts shall be designed to convey the flows per Section 3.2. The maximum design headwater depth shall be 1.5 times the diameter of the culvert, with no saturation of roadbeds. Minimum culvert diameters are as follows:

- For cross culverts under public roadways – minimum 18 inches, 12 inches if grade and cover do not allow for 18 inches, with County acceptance.
- For roadside culverts, including driveway culverts – minimum 12 inches.
- For culverts on private property – minimum 8 inches.

Inlets and outlets shall be protected from erosion by rock lining, riprap, or bio-stabilization as detailed in Table 3.8, Channel Protection.

Debris and access barriers are required on inlet and outlet ends of all culverts equal to or greater than 18 inches in diameter. Culverts equal to or greater than 36 inches in diameter within stream corridors are exempt.

Minimum culvert velocity shall be 2 feet per second and maximum culvert velocity shall be 15 feet per second. Thirty (30) feet per second may be used with an engineered outlet protection design. There is no maximum velocity for ductile iron or HDPE pipe, but outlet protection shall be provided.

All CPEP and PVC culverts and pipe systems shall have concrete or rock headwalls at exposed pipe ends.

Bends are not permitted in culvert pipes.

The following minimum cover shall be provided over culverts:

- 2 feet under roads.
- 1 foot under roadside applications and on private property, exclusive of roads.

If the minimum cover cannot be provided on a flat site, use ductile iron pipe and analyze for loadings.

- Maximum culvert length: 250 feet
- Minimum separation from other pipes:
  - 6 inches vertical (with bedding) (and in accord with the sewer or water purveyor design criteria).
  - 3 feet horizontal.

Culvert trench bedding, backfill and compaction shall be in accordance with the WSDOT standard specifications for the type of culvert pipe used in the application.

All driveway culverts shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled end sectioned to match the side slope.

3.9.2 Fish Passage Criteria

Culverts in stream corridors must meet applicable fish passage requirements of the Washington Department of Fish and Wildlife.

3.10 Open Conveyances

Open conveyances can be roadside ditches, grass lined swales, or a combination thereof. Where space and topography permit, open conveyances are preferred for collecting and conveying stormwater as they better reflect LID design. Consideration must be given to public safety when designing open conveyances adjacent to traveled ways and when accessible to the public. A vegetated open channel BMP is preferred over the following design standards for open channel conveyance (see Volume V).

Open conveyances shall be designed by one of the following methods:

- Manning's Equation (for uniform flow depth, flow velocity, and constant channel cross-section; see Section 3.4.1).
- Backwater Method (utilizing the energy equation or a computer program; see Section 3.4.2).

Velocities must be low enough to prevent channel erosion based on the native soil characteristics or the compacted fill material. For velocities above 5 feet per second, channels shall have either rock-lined bottoms and side slopes to the roadway shoulder top with a minimum thickness of 8 inches, or shall be stabilized in a fashion acceptable to the County.

Water quality shall not be degraded due to passage through an open conveyance. See Table 3.8.

Table 3.8. Channel Protection

Velocity at Design Flow (fps)		REQUIRED PROTECTION		
Greater than	**Less than or equal to**	**Type of Protection**	**Thickness**	**Minimum Height Above Design Water Surface**
0	5	Grass lining or bioengineered lining	N/A	0.5 foot
5	8	Rock lining [1] or bioengineered lining	1 foot	1 foot
8	12	Riprap [2]	2 feet	2 feet
12	20	Slope mattress gabion, etc.	Varies	2 feet

(1) Rock Lining shall be reasonably well graded as follows:

Maximum stone size: 12 inches

Median stone size: 8 inches

Minimum stone size: 2 inches

(2) Riprap shall be reasonably well graded as follows:

Maximum stone size: 24 inches

Median stone size: 16 inches

Minimum stone size: 4 inches

Note: Riprap sizing is governed by side slopes on channel, assumed to be approximately 3:1

Channels having a slope less than 6 percent and having peak velocities less than 5 feet per second shall be lined with vegetation.

Channel side slopes shall not exceed 2:1 for undisturbed ground (cuts) as well as for disturbed ground (embankments). All constructed channels shall be compacted to a minimum 95 percent compaction as verified by a Modified Proctor test.

Channels shall be designed with a minimum freeboard of 0.5 feet when the design flow is 10 cubic feet per second or less and 1 foot when the design flow is greater than 10 cubic feet per second.

Check dams for erosion and sedimentation control may be used for stepping down channels being used for biofiltration.

3.11 Private Drainage Systems

The engineering analysis for a private drainage system is the same as a County system.

3.11.1 Discharge Locations

Stormwater cannot discharge directly onto County roads or into a County system without prior County approval, with the exception of single family residences. Discharges to a County system shall be into a structure such as an inlet, catch basin, manhole, through an approved sidewalk underdrain or curb drain, or into an existing or created County ditch. Concentrated drainage will not be allowed to discharge across sidewalks, curbs, or driveways.

All buildings are required to have roof downspouts and subsurface drains directed to either an infiltration system, dispersion system, or to the storm drainage system.

3.11.2 Drainage Stub-outs

If drainage outlets (stub outs) are to be provided for each individual lot, the stub outs shall conform to the following requirements:

- Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an approved storm water conveyance system or to an approved outfall location.

- Outlets on each lot shall be located with a 5-foot-high, 2" x 4" stake marked "storm" or "drain." For stub-outs to a surface drainage, the stub-out shall visibly extend above surface level and be secured to the stake.

- The developer and/or contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to the utilities (e.g., power, gas, telephone, television).
- All individual stub-outs shall be privately owned and maintained by the lot home owner including from the property line to the riser on the main line.

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Appendix III-A
Methods for Determining Design Infiltration Rates

This appendix provides details on methods to estimate the design infiltration rate for infiltration facilities. The methods described include:

- Simple Method 1 – Field Testing Procedures
- Simple Method 2 – Soil Property Relationships
- Detailed Method – Based on Massmann (2003).

Simple Method 1 – Field Testing Procedures (In-Situ)

1. Excavate to the bottom elevation of the proposed infiltration facility.

2. Measure the infiltration rate of the underlying soil using either the EPA falling head percolation test procedure as modified for **Thurston County** (described below), the EPA falling head percolation test procedure as modified by Clark County (2008) (refer to Clark County Drainage Manual), the double ring infiltrometer test (ASTM D3385)(not described here, use ASTM procedure), or the Department of Ecology large scale Pilot Infiltration Test (PIT) described below and presented in the *Stormwater Management Manual for Western Washington* (Ecology 2005).

3. Fill test hole or apparatus with water and maintain at depths above the test elevation for saturation periods specific to the appropriate test.

4. Following the saturation period, the infiltration rate shall be determined in accordance with the specified test procedures.

5. Perform the minimum required number of infiltration tests at the proposed infiltration facility location as specified in Volume III, Chapter 2, Section 2.3.3 and by recommendations of the geotechnical professional.

6. Determine a representative infiltration rate.

For all field testing procedures, apply safety factor to obtain design infiltration rate (see next section).

Safety Factor for Field Measurements

The following equation incorporates safety factors to account for uncertainties related to testing, depth to the water table or impervious strata, infiltration receptor geometry, and long-term reductions in permeability due to biological activity and accumulation of fine sediment. This equation estimates the maximum design infiltration rate, I_{design}. Depending on site conditions, additional reduction of the design infiltration rate may be appropriate. **In no case may the design infiltration rate exceed 30 inches/hour**.

$$I_{design} = I_{measured} \times F_{testing} \times F_{geometry} \times F_{plugging}$$

$F_{testing}$ accounts for uncertainties in the testing methods. For the EPA method, the SDI (ASTM D3385) method, or large-scale PIT testing, $F_{testing} = 0.50$.

$F_{geometry}$ accounts for the influence of facility geometry and depth to the water table or impervious strata on the actual infiltration rate. A shallow water table or impervious layer reduces the effective infiltration rate of a large pond, but this would not be reflected in a small scale test. $F_{geometry}$ must be between 0.25 and 1.0 as determined by the following equation: $F_{geometry} = 4\ D/W + 0.05$

Where: D = Depth from the bottom of the proposed facility to the maximum wet season water table or nearest impervious layer, whichever is less

W = Width of facility

If $F_{geometry}$ is calculated as greater than 1, use 1, if calculated value is less than 0.25, use 0.25.

$F_{plugging}$ accounts for reductions in infiltration rates over the long term due to plugging of soils. This factor is:

- 0.7 for loams and sandy loams
- 0.8 for fine sands and loamy sands
- 0.9 for medium sands
- 1.0 for coarse sands or cobbles, or any soil type in an infiltration facility preceded by a water quality facility (not including a pre-treatment unit or forebay for course sediment removal).

Falling Head Percolation Test Procedure (as Modified for Thurston County) (Source: EPA, *On-site Wastewater Treatment and Disposal Systems,* 1980)

1. **Number and Location of Tests**

   A minimum of three tests shall be performed within the area proposed for an infiltration facility. Tests shall be spaced uniformly throughout the area. For larger facilities or if soil conditions are highly variable, more tests may be required (see minimum testing requirements in Volume III).

2. **Preparation of Test Hole** (as modified for Thurston County)

   The diameter of each test hole is 8 inches, dug or bored to the proposed bottom elevation of the infiltration facility or to the most limiting soil horizon. To expose a natural soil surface, the bottom of the hole is scratched with a sharp pointed instrument and the loose material is removed from the test hole. A 6-inch-inner-diameter, 4-foot long, PVC pipe is set into the hole and pressed 6 inches into the soil, then 2 inches of 1/2- to 3/4-inch rock are placed in the pipe to protect the bottom from scouring when water is added.

3. **Soaking Period**

   The pipe is carefully filled with at least 12 inches of clear water. The depth of water must be maintained for at least 4 hours and preferably overnight if clay soils are present. A funnel with an attached hose or similar device may be used to prevent water from washing down the sides of the hole. Automatic siphons or float valves may be employed to automatically maintain the water level during the soaking period. It is extremely important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained.

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

4. **Percolation Rate Measurement**

   Except for sandy soils, percolation rate measurements are made at least 15 hours but no more than 30 hours after the soaking period began. The water level is adjusted to 6 inches above the gravel (or 8 inches above the bottom of the hole). At no time during the test is the water level allowed to rise more than 6 inches above the gravel. Immediately after adjustment, the water level is measured from a fixed reference point to the nearest 1/16th-inch, at 30 minute intervals. The test is continued until two successive water level drops do not vary by more than 1/16th-inch within a 90 minute period. At least three measurements are to be made.

After each measurement, the water level is readjusted to the 6-inch level. The last water level drop is used to calculate the percolation rate.

In sandy soils or soils in which the first 6 inches of water added after the soaking period seeps away in less than 30 minutes, water level measurements are made at 10-minute intervals for a 1-hour period. The last water level drop is used to calculate the percolation rate.

5. **Percolation Rate Calculation**

The percolation rate is calculated for each test site by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in minutes/inch. To calculate the percolation rate for the area, average the rates obtained from each hole. (If tests in the area vary by more than 20 minutes/inch, variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.) The percolation rate in minutes/inch should be converted to infiltration rate in inches/hour and then t**o compute the design infiltration rate (I_{design}), the final infiltration rates must then be adjusted by the appropriate correction factors outlined previously.**

Example: If the last measured drop in water level after 30 minutes is 5/8-inch, then:

percolation rate = (30 minutes)/(5/8 inch) = 48 minutes/inch.
Convert this to inches per hour by inverting & multiplying by 60:
infiltration rate – 1/48*60 = 1.25 inches/hour. (At a minimum, a safety factor "$F_{testing}$" of 0.5 is be applied to all field methods for determining infiltration rates.)

Washington Department of Ecology Infiltration PIT Method

The Pilot Infiltration Test (PIT) consists of a relatively large-scale infiltration test to better approximate infiltration rates for design of stormwater infiltration facilities. The PIT reduces some of the scale errors associated with relatively small-scale tests such as the Modified Falling Head Percolation Test, double ring infiltrometer or "stove-pipe" infiltration tests. It is not a standard test but rather a practical field procedure recommended by Ecology's Technical Advisory Committee. Following is a step-by-step description of the testing procedure.

Infiltration Test

1. Excavate the test pit to the depth of the bottom of the proposed infiltration facility. Lay back the slopes sufficiently to avoid caving and erosion during the test.

2. The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. For small drainages and where water availability is a problem, smaller areas may be considered as determined by the site professional.

3. Accurately document the size and geometry of the test pit.

4. Install a vertical measuring rod (minimum 5 feet long) marked in half-inch increments in the center of the pit bottom.

5. Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.

6. Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

Note: A water level of 3 to 4 feet provides for easier measurement and flow stabilization control. However, the depth must not exceed the proposed maximum depth of water expected in the completed facility.

7. Every 15 to 30 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 3 and 4 feet) on the measuring rod.

8. Add water to the pit until 1 hour after the flow rate into the pit has stabilized (constant flow rate) while maintaining the same pond water level (usually 17 hours).

9. After the flow rate has stabilized, turn off the water and record the rate of infiltration in inches per hour from the measuring rod data, until the pit is empty.

Data Analysis

Calculate and record the infiltration rate in inches per hour in 30 minute or one-hour increments until 1 hour after the flow has stabilized.

Note: Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

To compute the design infiltration rate (I_{design}), apply appropriate correction factors outlined previously.

Example:

The area of the bottom of the test pit is 8.5 feet by 11.5 feet.

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes, the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour. Divide the flow rate by the area of the test pit and convert to inches per hour to get an average of (9.8 + 12.3) / 2 = 11.1 inches per hour.

To compute the design infiltration rate (I_{design}), the infiltration rate must then be adjusted by the appropriate correction factors outlined previously.

Simple Method 2 – Soil Property Relationships

USDA Soil Textural Classification

Infiltration rates may be estimated from soil grain size distribution (gradation) data using the United States Department of Agriculture (USDA) textural analysis approach. Conduct the grain size distribution test in accordance with the USDA test procedure (Soil Survey Manual, USDA, October 1993, page 136). This manual only considers soil passing the #10 sieve (2 mm) (US Standard) to determine percentages of sand, silt, and clay for use in Figure A-1.

Short-term (field) infiltration rates, required correction factors, and design (long-term) infiltration rates based on gradations from soil samples and textural analysis are summarized in Table A.1. With prior acceptance of

Thurston County, the correction factors may be reduced (to a minimum of 2.0) if there is little soil variability, there will be a high degree of long-term facility maintenance, and there is adequate pre-treatment to reduce total suspended solids in influent stormwater.

Table A.1. Recommended Infiltration Rates based on USDA Soil Textural Classification

	*Short-Term Infiltration Rate (in./hr)	Correction Factor, CF	Estimated Design (Long-term) Infiltration Rate (in./hr)
Clean sandy gravels and gravelly sands (i.e., 90% of the total soil sample is retained in the #10 sieve)	20	2	10
Sand	8	4	2
Loamy Sand	2	4	0.5
Sandy Loam	1	4	0.25
Loam	0.5	4	0.13

Source: *Stormwater Management Manual for Western Washington* (Ecology 2005).
*From WEF/ASCE, 1998.

ASTM Gradation Testing

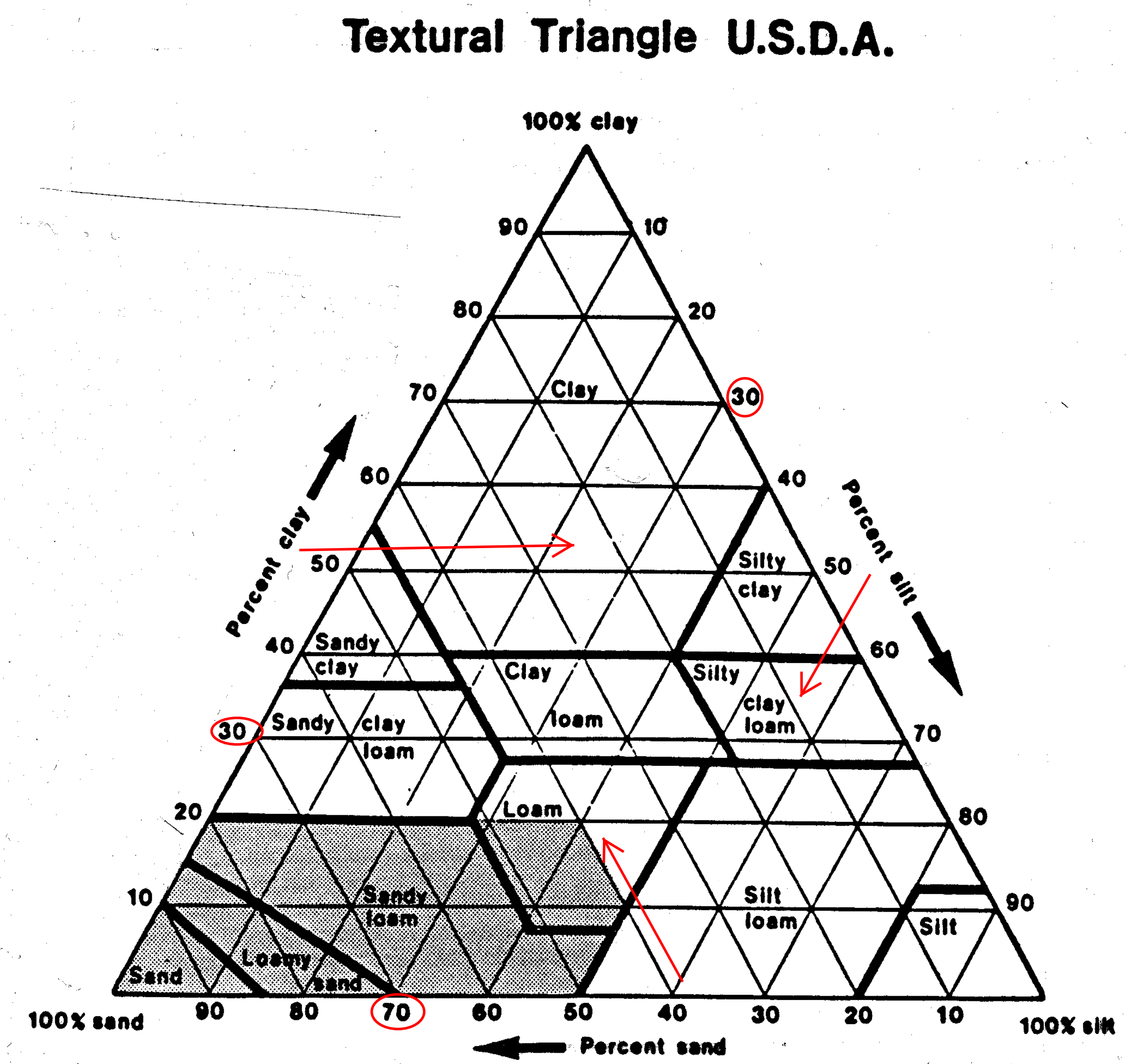
For sites with soils that would be classified as sands or sandy gravels ($D_{10} \geq 0.05$ mm, US Standard Sieve), Table A.2 may be used to estimate design infiltration rates. These rates may need to be reduced if the site is highly variable or if maintenance and influent characteristics are not well controlled.

For finer soils ($D_{10} < 0.05$ mm, US Standard Sieve), consult Volume III of the *Stormwater Management Manual for Western Washington* (Ecology 2005).

Table A.2. Alternative Recommended Infiltration Rates based on ASTM Gradation Testing

D_{10} Size from ASTM D422 Soil Gradation Test (mm)	Estimated Design (Long-Term) Infiltration Rate (in./hr)
$\geq$ 0.4	9
0.3	6.5
0.2	3.5
0.1	2.0
0.05	0.8

Source: *Stormwater Management Manual for Western Washington* (Ecology 2005).



Shaded area is applicable for design of infiltration BMPs
Source: U.S. Department of Agriculture

Figure A-1. USDA Textural Triangle.

Detailed Method

The detailed method described below is based on Massmann (2003).

Determine the Saturated Hydraulic Conductivity

For each defined layer below the pond to a depth below the pond bottom of 2.5 times the maximum depth of water in the pond, but not less than 6 feet, estimate the saturated hydraulic conductivity (K_{sat}) in centimeters per second (cm/s) using the following relationship (see Massmann 2003, and Massmann et al. 2003):

$$\log_{10}\left(K_{sat}\right) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08\,f_{fines} \qquad (1)$$

Where, D_{10}, D_{60} and D_{90} are the grain sizes in millimeters (mm) for which 10 percent, 60 percent and 90 percent of the sample is more fine and f_{fines} is the fraction of the soil (by weight) that passes the number-200 sieve.

If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, soil layers at greater depths must be considered when assessing the site's hydraulic conductivity characteristics. Massmann (2003) indicates that where the water table is deep, soil or rock strata up to 100 feet below an infiltration facility can influence the rate of infiltration. Note that only the layers near and above the water table or low permeability zone (e.g., a clay, dense glacial till, or rock layer) need to be considered, as the layers below the ground water table or low permeability zone do not significantly influence the rate of infiltration.

Also note that this equation for estimating hydraulic conductivity assumes minimal compaction consistent with the use of tracked (i.e., low to moderate ground pressure) excavation equipment. If the soil layer being characterized has been exposed to heavy compaction, or is heavily over consolidated due to its geologic history (e.g., overridden by continental glaciers), the hydraulic conductivity for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt 2003). In such cases, compaction effects must be taken into account when estimating hydraulic conductivity. For clean, uniformly graded sands and gravels, the reduction in K_{sat} due to compaction will be much less than an order of magnitude. For well-graded sands and gravels with moderate to high silt content, the reduction in K_{sat} will be close to an order of magnitude. For soils that contain clay, the reduction in K_{sat} could be greater than an order of magnitude.

For critical designs (facilities that pose a high risk of flooding and property damage in the event of clogging or other failure), the in-situ saturated conductivity of a specific layer can be obtained through field tests such as the packer permeability test (above or below the water table), the piezocone (below the water table), an air conductivity test (above the water table), or through the use of a pilot infiltration test (PIT) as described in Appendix III-A. Note that some field tests provide a direct estimate of infiltration rate, which is the product of hydraulic conductivity and hydraulic gradient (see Equation 5). In this case, the infiltration rate must be divided by the hydraulic gradient to calculate the hydraulic conductivity. This issue will need to be evaluated on a case-by-case basis when interpreting the results of field tests to ensure an accurate estimate of K_{sat}. It is important to recognize that the gradient in the test may not be the same as the gradient likely to occur in the full-scale infiltration facility in the long-term (i.e., when ground water mounding is fully developed).

Once the saturated hydraulic conductivity for each layer has been identified, determine the effective average saturated hydraulic conductivity below the pond. Hydraulic conductivity estimates from different layers can be combined into an equivalent hydraulic conductivity (K_{equiv}) using the harmonic mean:

$$K_{equiv} = \frac{d}{\sum \frac{d_i}{K_i}} \qquad (2)$$

Where:

d is the total depth of the soil column

d_i is the thickness of layer "i" in the soil column

K_i is the saturated hydraulic conductivity of layer "i" in the soil column.

The depth of the soil column, d, typically would include all layers between the pond bottom and the water table. However, for sites with very deep water tables (>100 feet) where ground water mounding to the base of the pond is not likely to occur, it is recommended that the total depth of the soil column in Equation 2 be limited to approximately 20 times the depth of pond. This is to ensure that the most important and relevant layers are included in the hydraulic conductivity calculations. Deep layers that are not likely to affect the infiltration rate near the pond bottom should not be included in Equation 2.

Equation 2 may over-estimate the effective hydraulic conductivity value at sites with low conductivity layers immediately beneath the infiltration pond. For sites where the lowest conductivity layer is within five feet of the base of the pond, it is suggested that this lowest hydraulic conductivity value be used as the equivalent hydraulic conductivity rather than the value from Equation 2.

The harmonic mean given by Equation 2 is the appropriate effective hydraulic conductivity for flow that is perpendicular to stratigraphic layers, and will produce conservative results when flow has a significant horizontal component such as could occur due to ground water mounding.

Calculate the Hydraulic Gradient

The steady state hydraulic gradient (i) is calculated as follows:

$$i = \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} \times CF_{size} \qquad (3)$$

Where:

D_{wt} is the depth from the base of the infiltration facility to the water table in feet

K is the saturated hydraulic conductivity in feet/day

D_{pond} is the depth of water in the facility in feet (see Massmann et al. 2003, for the development of this equation)

CF_{size}, is the correction for pond size. The correction factor was developed for ponds with bottom areas between 0.6 and 6 acres in size. For small ponds (ponds with area equal to 2/3 acre), the correction factor is equal to 1.0. For large ponds (ponds with area equal to 6 acres), the correction factor is 0.2, as shown in Equation 4.

$$CF_{size} = 0.73(A_{pond})^{-0.76} \qquad (4)$$

Where, A_{pond} is the area of pond bottom in acres.

This equation generally will result in a calculated gradient of less than 1.0 for moderate to shallow ground water depths (or to a low permeability layer) below the facility, and conservatively accounts for the development of a ground water mound.

A more detailed ground water mounding analysis using a program such as MODFLOW will usually result in a gradient that is equal to or greater than the gradient calculated using Equation 3. If the calculated gradient is greater than 1.0, the water table is considered to be deep, and a maximum gradient of 1.0 must be used. Typically, a depth to ground water of 100 feet or more is required to obtain a gradient of 1.0 or more using this equation.

Since the gradient is a function of depth of water in the facility, the gradient will vary as the pond fills during the season. The gradient could be calculated as part of the stage-discharge calculation used in the continuous runoff models. As of the date of this update, neither the WWHM or MGSFlood have that capability. However, updates to those models may soon incorporate the capability. Until that time, use a steady-state hydraulic gradient that corresponds with a ponded depth of ¼ of the maximum ponded depth – as measured from the basin floor to the overflow.

Calculate the Infiltration Rate using Darcy's Law

$$f = K\left(\frac{dh}{dz}\right) = Ki \qquad (5)$$

Where:

f is the specific discharge or infiltration rate of water through a unit cross-section of the infiltration facility (L/t)

K is the hydraulic conductivity (L/t)

dh/dz (= "*i*") is the hydraulic gradient (L/L)

Adjustments to Infiltration Rate

Adjustments to the infiltration rate calculated above are required to adjust for biofouling, siltation and pond aspect ratio.

To account for reductions in the rate resulting from long-term siltation and biofouling, take into consideration the degree of long-term maintenance and performance monitoring anticipated, the degree of influent control (e.g., pre-settling ponds biofiltration swales, etc.), and the potential for siltation, litterfall, moss buildup, etc. based on the surrounding environment.

It should be assumed that an average to high degree of maintenance will be performed on these facilities. A low degree of maintenance should be considered only when there is no other option (e.g., access problems). The infiltration rate estimated in the step above is multiplied by the reduction factors summarized in Table A.3.

Table A.3. Infiltration Rate Reduction Factors to Account for Biofouling and Siltation Effects for Ponds (Massmann, 2003)

Potential for Biofouling	Degree of Long-Term Maintenance/Performance Monitoring	Infiltration Rate Reduction Factor, $CF_{silt/bio}$
Low	Average to High	0.9
Low	Low	0.6
High	Average to High	0.5
High	Low	0.2

The values in this table assume that final excavation of the facility to the finished grade is deferred until all disturbed areas in the upgradient drainage area have been stabilized or protected (e.g., construction runoff is not allowed into the facility after final excavation of the facility).

Ponds located in shady areas where moss and litterfall from adjacent vegetation can build up on the pond bottom and sides, the upgradient drainage area will remain in a disturbed condition long-term, and no pretreatment (e.g., pre-settling ponds, biofiltration swales, etc.) is provided, are one example of a situation with a high potential for biofouling.

A low degree of long-term maintenance includes, for example, situations where access to the facility for maintenance is very difficult or limited, or where there is minimal control of the party responsible for enforcing the required maintenance. A low degree of maintenance should be considered only when there is no other option.

Adjustment for Pond Aspect Ratio

Adjust the infiltration rate for the effect of pond aspect ratio by multiplying the infiltration rate determined above by the aspect ratio correction factor CF_{aspect} as shown in the following equation:

$$CF_{aspect} = 0.02A_r + 0.98 \tag{6}$$

Where, A_r is the aspect ratio for the pond (length/width). In no case shall CF_{aspect} be greater than 1.4. The final infiltration rate will therefore be as follows:

$$f = K \times i \times CF_{aspect} \times CF_{silt/bio} \tag{7}$$

The rates calculated based on Equation 7 are long-term design rates. No additional reduction factor or factor of safety is needed.

Appendix III-B
Design Aids

Single Event Model Guidance

The only approved use of a single event model is for the sizing of conveyance systems. Approved continuous simulation runoff models will be used for the design of water quality and quantity BMPs.

SBUH or SCS Methods

The applicant shall use the Western Washington SCS "curve numbers" included in **Table B.4**, not the SCS national curve numbers. Individual curve numbers for a drainage area may be averaged into a "composite" curve number for use with SCS or SBUH methods. The NRCS (formerly SCS) has, for many years, conducted studies of the runoff characteristics for various land types. After gathering and analyzing extensive data, NRCS has identified relationships between land use, soil type, vegetation cover, interception, infiltration, surface storage, and runoff. These relationships have been characterized by a single runoff coefficient called a "curve number." The National Engineering Handbook – Section 4: Hydrology (NEH-4, SCS, August 1972) contains a detailed description of the development and use of the curve number method.

NRCS has developed "curve number" (CN) values based on soil type and land use. They can be found in *Urban Hydrology for Small Watersheds*, Technical Release 55 (TR-55), June 1986, published by the NRCS. The combination of these two factors is called the "soil-cover complex." The soil-cover complexes have been assigned to one of four hydrologic soil groups, according to their runoff characteristics. NRCS has classified over 4,000 soil types into these four soil groups. **Table B.5** shows the hydrologic soil group of most soils in Thurston County and provides a brief description of the four groups. For details on other soil types, the NRCS publication described above (TR-55, 1986).

Isopluvial Maps

National Oceanic and Atmospheric Administration (NOAA) isopluvial maps for western Washington are included below. The design engineer shall use the best engineering judgment in selecting the runoff totals for the project site.

Time of Concentration

Time of concentration (T_c) is the sum of travel times for sheet flow, shallow concentrated flow, and channel flow. For lakes and submerged wetlands, travel time can be determined with storage routing techniques if the stage-storage versus discharge relationship is known or may be assumed to be zero.

Sheet Flow

With sheet flow, the friction value (n_s) is used. This is a modified Manning's effective roughness coefficient that includes the effect of raindrop impact, drag over the plane surface, obstacles such as litter, crop ridges and rocks, and erosion and transportation of sediment. These n_s values are for very shallow flow depths of about 0.1 foot and are used only for travel lengths up to 300 feet. Table B.2 gives Manning's n_s values for sheet flow for various surface conditions.

For sheet flow of up to 300 feet, use Manning's kinematic solution to directly compute T_t.

$$T_t = \frac{0.42\,(n_s L)^{0.8}}{(P_2)^{0.527}(S_o)^{0.4}}$$

Where: T_t = Travel time (min),

n_s = Sheet flow Manning's effective roughness coefficient (Table B.2),

L = Flow length (ft),

P_2 = 2-year, 24-hour rainfall (in), and

s_o = Slope of hydraulic grade line (land slope, ft/ft)

The maximum allowable distance for sheet flow shall be 300 feet. The remaining overland flow distance shall be shallow concentrated flow until the water reaches a channel.

Shallow Concentrated Flow

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow. The average velocity for this flow can be calculated using the k_s values from Table B.2 in which average velocity is a function of watercourse slope and type of channel.

The average velocity of flow, once it has measurable depth, shall be computed using the following equation:

$$V = k\sqrt{s_o}$$

Where: V = Velocity (ft/s)

k = Time of concentration velocity factor (ft/s)

s_o = Slope of flow path (ft/ft)

"k" is computed for various land covers and channel characteristics with assumptions made for hydraulic radius using the following rearrangement of Manning's equation:

$$k = (1.49(R)^{0.667})/n$$

where: R = An assumed hydraulic radius

n = Manning's roughness coefficient for open channel flow (see Table B-3)

Open Channel Flow

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams appear (in blue) on United States Geological Survey (USGS) quadrangle sheets. The k_c values from Table B.2 used in the Velocity Equation above or water surface profile information can be used to estimate average flow velocity.

Lakes or Wetlands

This travel time is normally very small and can be assumed as zero. Where significant attenuation may occur due to storage effects, the flows should be routed using a "level pool routing" technique.

Limitations

The following limitations apply in estimating travel time (T_t).

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet.
- In watersheds with storm drains, carefully identify the appropriate hydraulic flow path to estimate T_c.
- Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. A hydrograph should be developed to this point and a level pool routing technique used to determine the outflow rating curve through the culvert or bridge.

Design Storm Hyetographs

The standard design hyetograph is the SCS Type 1A 24-hour rainfall distribution, resolved into 6-minute time intervals (see Table B.8). Various interpretations of the hyetograph are available and may differ slightly from distributions used in other unit hydrograph based computer simulations. Other distributions such as the hyetograph provided in the 1994 Thurston County Drainage Design and Erosion Control Manual will be accepted with adequate justification.

For project sites with tributary drainage areas above elevation 1,000 feet MSL, an additional total precipitation must be added to the total depth of rainfall for the 25-, 50-, and 100-year design storm events to account for the potential average snow melt which occurs during major storm events.

The MSL "factor" is computed as follows:

$$M_s \text{ (in inches)} = 0.004\ (MB_{el} - 1000)$$

Where: M_s = Rainfall amount to be added to P_r

MB_{el} = The mean tributary basin elevation above sea level (in feet)

Sub-Basin Delineation

Within an overall drainage basin, it may be necessary to delineate separate sub-basins based on similar land uses and/or runoff characteristics or when hydraulically "self-contained" areas are found to exist. When this is necessary, separate hydrographs shall be generated, routed, and recombined, after travel time is considered, into a single hydrograph to represent runoff flows into the quantity or quality control facility.

Hydrograph Routing

All hydrographs shall be routed through retention and/or detention facilities or closed depressions by use of a level pool routing technique. Methods are described in "Handbook of Applied Hydrology", by Chow, V. Te, 1964, and elsewhere.

It is recommended that all such routing be conducted with the use of a computer program.

Hydrograph Phasing Analysis

Where flows from multiple basins or subbasins having different runoff characteristics and/or travel times combine, the design engineer shall sum the hydrographs after shifting each hydrograph according to its travel time to the discharge point of interest. The resultant hydrograph shall be either routed downstream as required in the downstream analysis (see Volume 1 Chapter 3 [Drainage Report section 8]), or routed through the control facility.

Included in this appendix are the 2-, 10-, 25-,and 100-year, 24-hour design storm and mean annual precipitation isopluvial maps for Western Washington. These have been taken from NOAA Atlas 2 "Precipitation - Frequency Atlas of the Western United States, Volume IX, Washington. The Applicant shall use the NOAA Isopluvials for selection of the design storm precipitation.

Rational Method

The only approved use of the Rational Method is for the sizing of conveyance systems. This method is applicable to smaller drainage basins, 25 acres in size or less. This method provides an estimate of peak discharge (Q_p in cubic feet per second [cfs]) using the following formula:

$$Q_p = CIA$$

Where: C = runoff coefficient (unitless),

A = area of watershed (acres), and

I = rainfall intensity (inches per hour) for a chosen frequency expressed as:

$$I = \frac{m}{(T_c)^n}$$

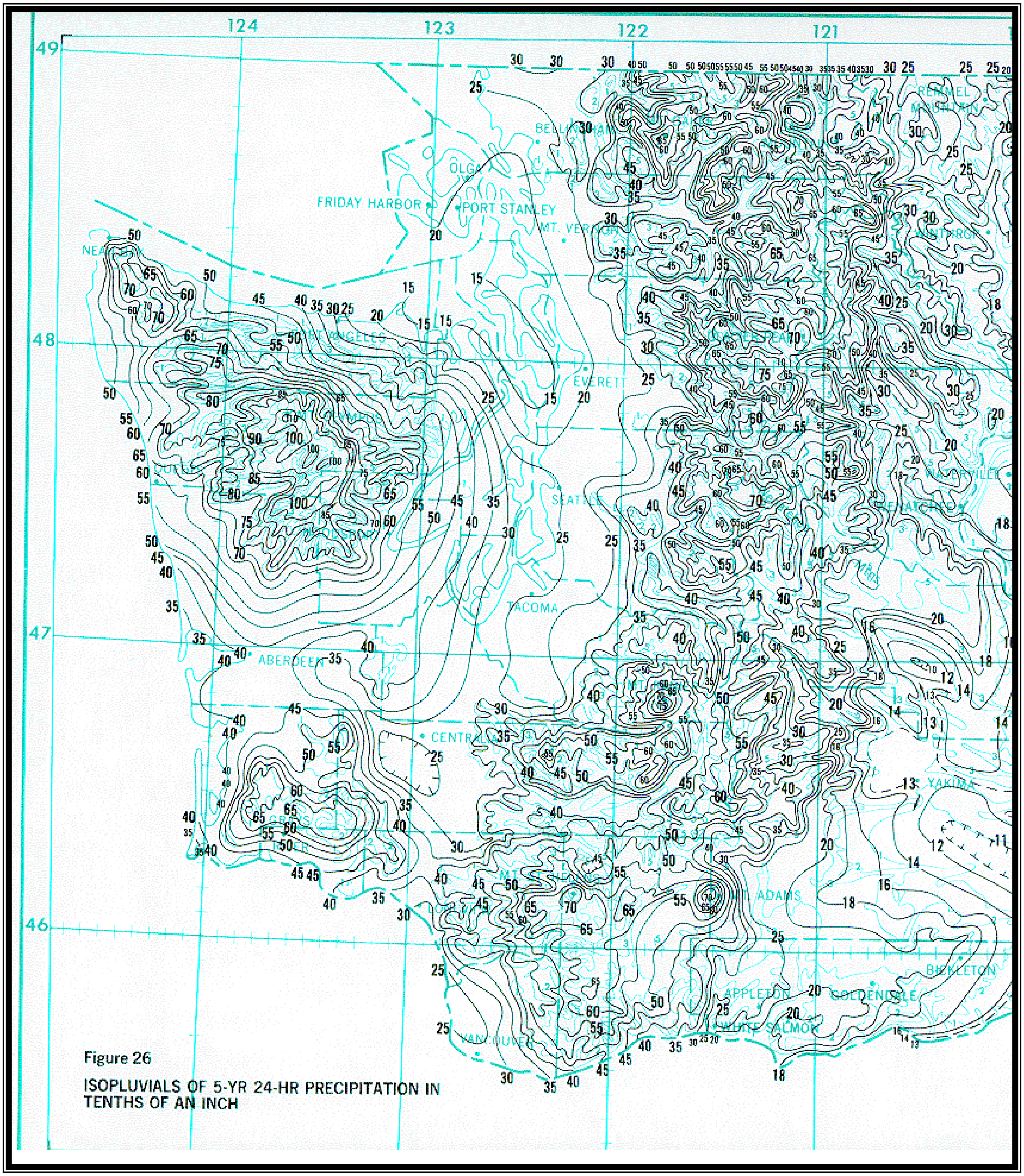
Where: m, n are regression coefficients (unitless), and

T_c = time of concentration (in hours).

Runoff coefficient (C) values are listed in Table B-6 for a range of land cover types. Regression coefficients (m, n) for determining rainfall intensity can be found in Table B-7. Time of concentration (T_c) is calculated as described in the Single Event Model Guidance section above.

Source: NOAA

Western Washington Isopluvial 2-year, 24-hour



Western Washington Isopluvial 5-year, 24-hour

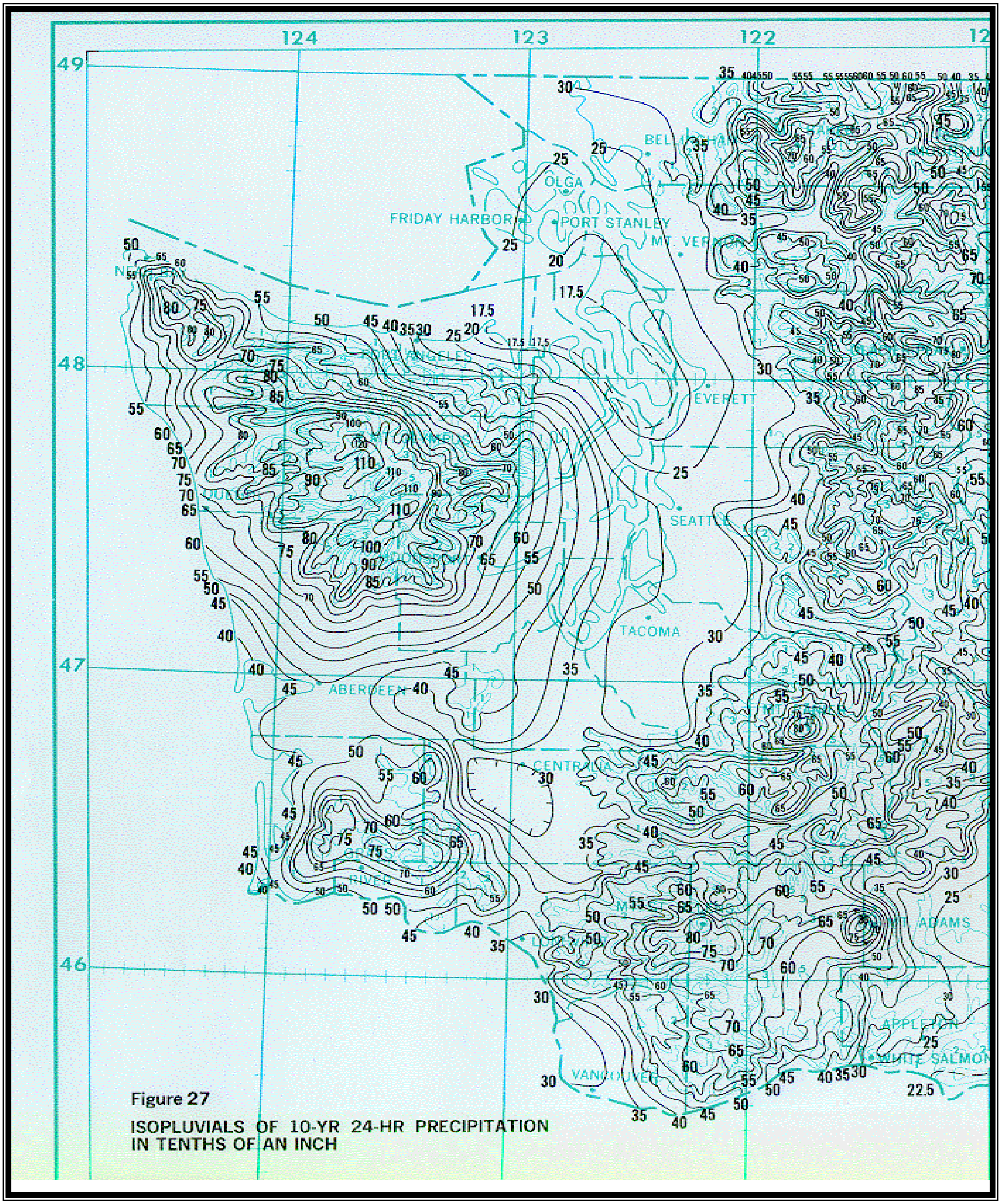
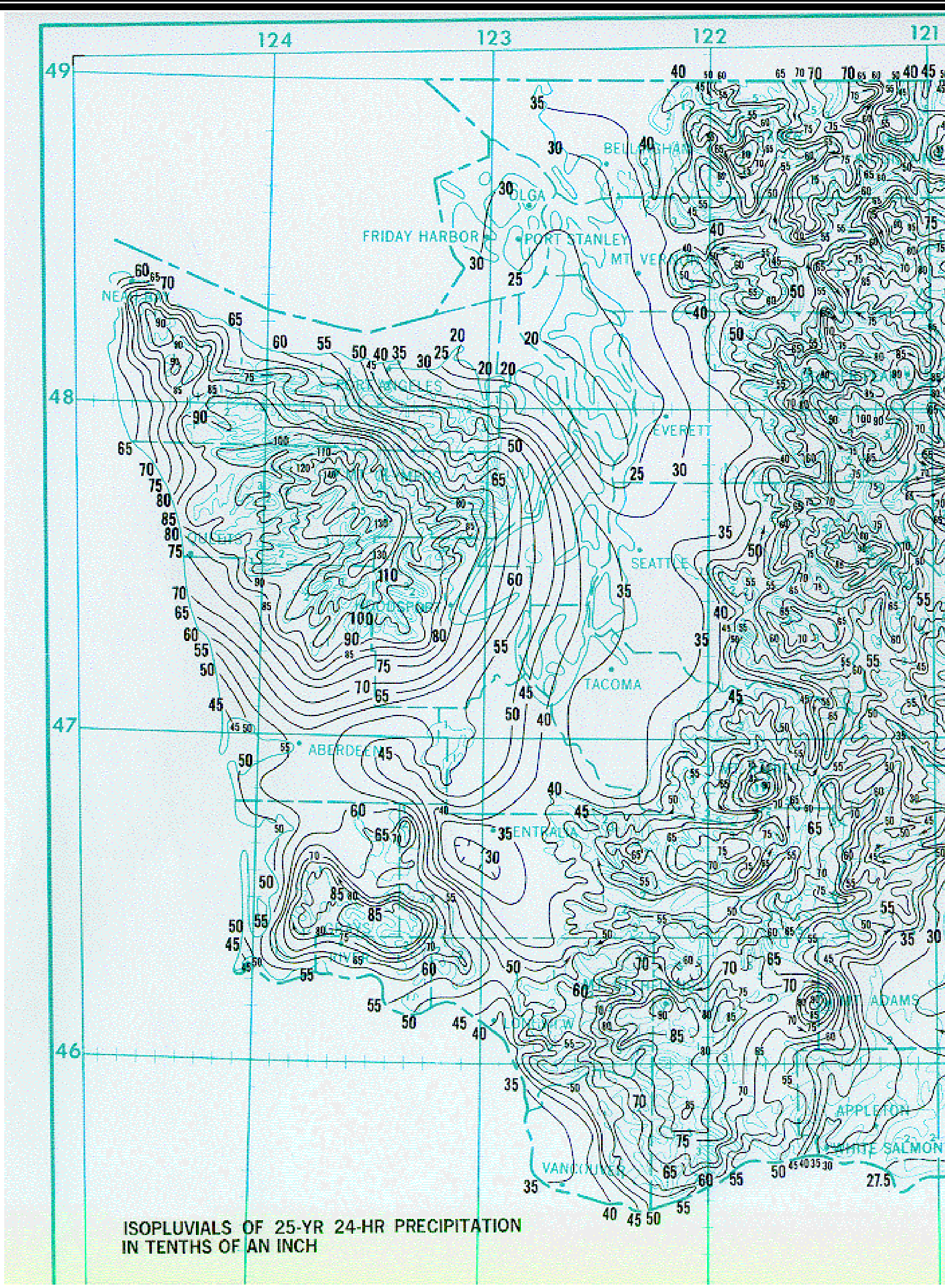


Figure 27

ISOPLUVIALS OF 10-YR 24-HR PRECIPITATION
IN TENTHS OF AN INCH

Western Washington Isopluvial 10-year, 24-hour



Source: NOAA

Western Washington Isopluvial 25-year, 24-hour

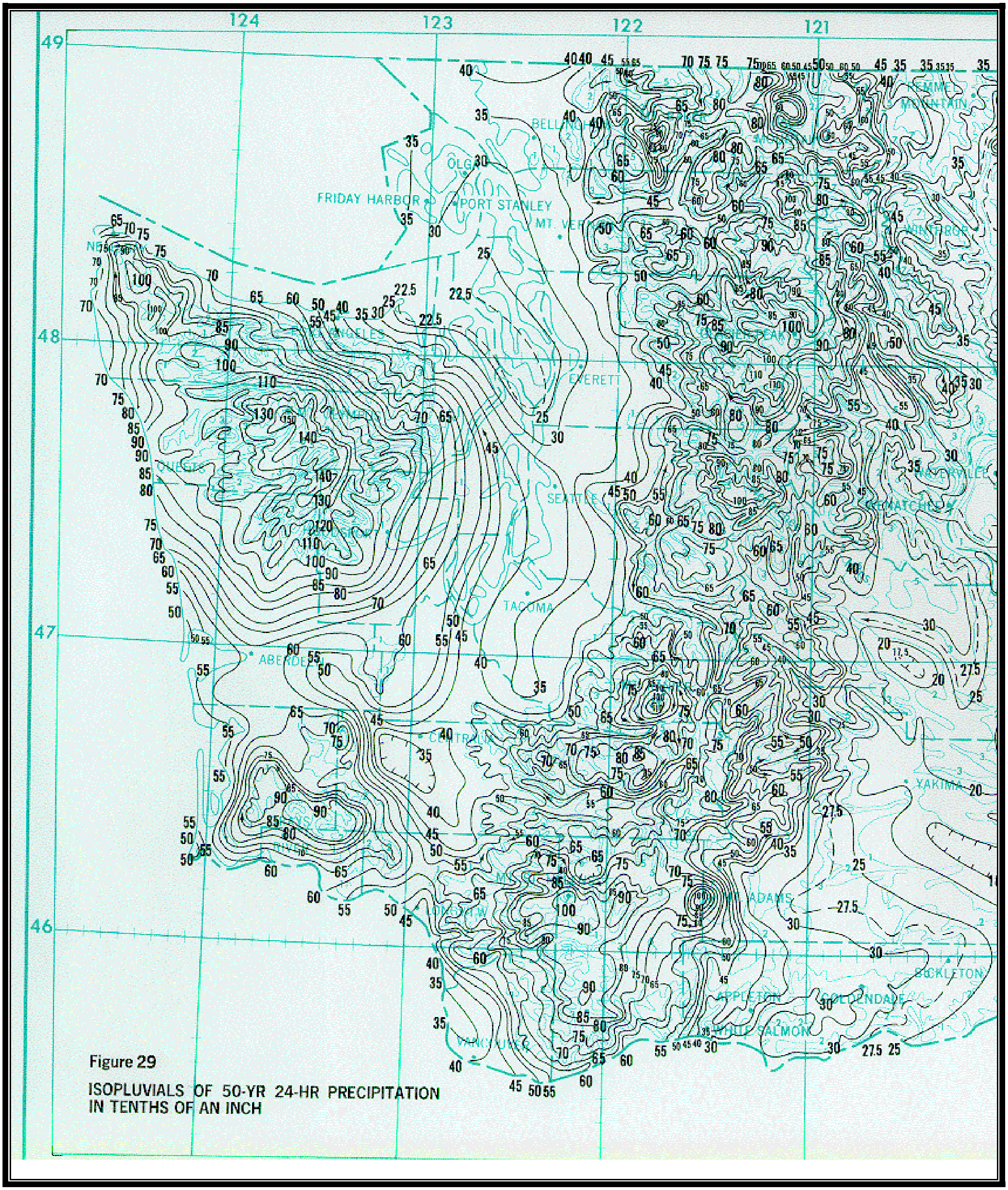
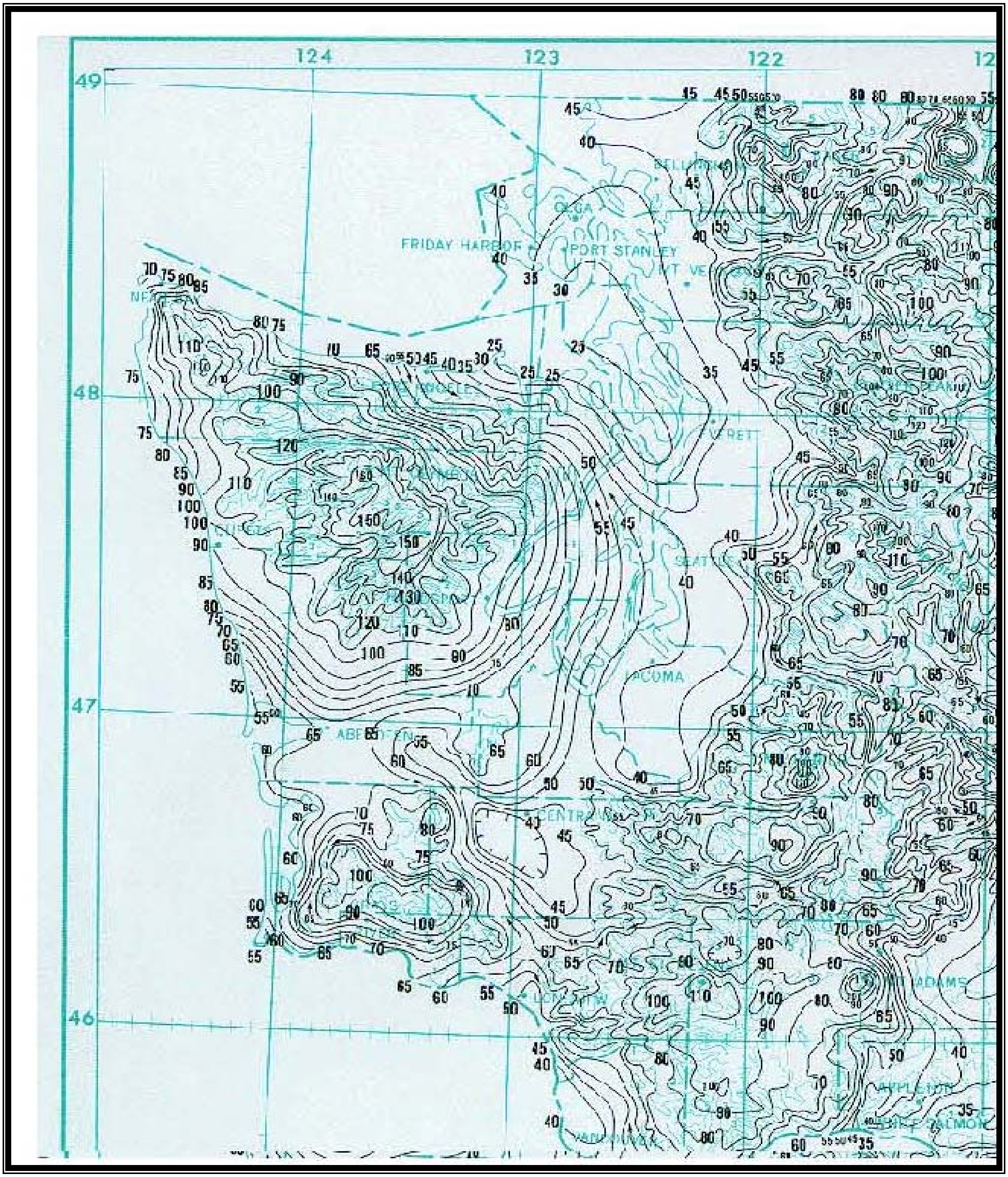


Figure 29
ISOPLUVIALS OF 50-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

Western Washington Isopluvial 50-year, 24-hour



Western Washington Isopluvial 100-year, 24-hour

Table B.2. "n" and "k" Values Used in Time Calculations for Hydrographs

"n_s" Sheet Flow Equation Manning's Values (for the initial 300 ft. of travel)	n_s *
Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover (s≤ 0.20 ft/ft)	0.06
Cultivated soil with residue cover (s> 0.20 ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80

*Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986)

"k" Values Used in Travel Time/Time of Concentration Calculations

	Shallow Concentrated Flow (After the initial 300 ft. of sheet flow, R = 0.1)	k_s
1.	Forest with heavy ground litter and meadows (n = 0.10)	3
2.	Brushy ground with some trees (n = 0.060)	5
3.	Fallow or minimum tillage cultivation (n = 0.040)	8
4.	High grass (n = 0.035)	9
5.	Short grass, pasture and lawns (n = 0.030)	11
6.	Nearly bare ground (n = 0.25)	13
7.	Paved and gravel areas (n = 0.012)	27

	Channel Flow (intermittent) (At the beginning of visible channels R = 0.2)	k_c
1.	Forested swale with heavy ground litter (n = 0.10)	5
2.	Forested drainage course/ravine with defined channel bed (n = 0.050)	10
3.	Rock-lined waterway (n = 0.035)	15
4.	Grassed waterway (n = 0.030)	17
5.	Earth-lined waterway (n = 0.025)	20
6.	CMP pipe (n = 0.024)	21
7.	Concrete pipe (0.012)	42
8.	Other waterways and pipe	0.508/n

	Channel Flow (Continuous stream, R = 0.4)	k_c
9.	Meandering stream with some pools (n = 0.040)	20
10.	Rock-lined stream (n = 0.035)	23
11.	Grass-lined stream (n = 0.030)	27
12.	Other streams, man-made channels and pipe n** determined from Table 6.2	0.807/n**

Ref: DOE Stormwater Management Manual for the Puget Sound Basin, February 1992.

Table B.3. Values of the Roughness Coefficient, "n"

Type of Channel and Description	Manning's "n"
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	0.025
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same as above, highest stage of flow	0.070
4. Dense brush, high stage	0.100
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100 ft.)	
a. Streams on plain	
1. Clean, straight, full stage no rifts or deep pools	0.030
2. Same as above, but more stones and weeds	0.035
3. Clean, winding, some pools and shoals	0.040
4. Same as above, but some weeds	0.040
5. Same as 4, but more stones	0.050
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2 Flood plains	
a. Pasture, no brush	
1. Short grass	0.030
2. High grass	0.035
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as above, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as above, but with flood stage reaching branches	0.120

Ref: DOE Stormwater Management Manual for the Puget Sound Basin, February 1992.

Table B.4. Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas

(Sources: TR 55, 1986, and Stormwater Management Manual, 1992.)				
	CNs for hydrologic soil group			
Cover type and hydrologic condition.	A	B	C	D
Curve Numbers for Pre-Development Conditions				
Pasture, grassland, or range-continuous forage for grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77
Curve Numbers for Post-Development Conditions				
Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.)[1]				
Fair condition (grass cover on 50% - 75% of the area).	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs[2], driveways, etc. (excluding right-of-way)	98	98	98	98
Permeable Pavement (See Volume V to decide which condition below to use)				
Landscaped area	77	85	90	92
50% landscaped area/50% impervious	87	91	94	96
100% impervious area	98	98	98	98
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, grassland, or range-continuous forage for grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning).	45	66	77	83
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77

Single family residential[3]: Dwelling Unit/Gross Acre	Should only be used for subdivisions > 50 acres	Average Percent impervious area[3,4]	
1.0 DU/GA		15	Separate curve number
1.5 DU/GA		20	shall be selected for
2.0 DU/GA		25	pervious & impervious
2.5 DU/GA		30	portions of the site or
3.0 DU/GA		34	basin
3.5 DU/GA		38	
4.0 DU/GA		42	
4.5 DU/GA		46	
5.0 DU/GA		48	
5.5 DU/GA		50	
6.0 DU/GA		52	
6.5 DU/GA		54	
7.0 DU/GA		56	
7.5 DU/GA		58	
PUDs, condos, apartments, commercial businesses, industrial areas & & subdivisions < 50 acres	%impervious must be computed	Separate curve numbers shall be selected for pervious and impervious portions of the site	
For a more detailed and complete description of land use curve numbers refer to chapter two (2) of the Soil Conservation Service's Technical Release No. 55 , (210-VI-TR-55, Second Ed., June 1986).			

[1] Composite CNs may be computed for other combinations of open space cover type.

[2]Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in Volume V, the average percent impervious area may be adjusted in accordance with the procedure described under "Flow Credit for Roof Downspout Infiltration" and "Flow Credit for Roof Downspout Dispersion" .

[3]Assumes roof and driveway runoff is directed into street/storm system.

[4]All the remaining pervious area (lawn) are considered to be in good condition for these curve numbers.

Table B.5. Major Soil Groups in Thurston County

Soil Type *	Hydrologic Soil Group	Soil Type *	Hydrologic Soil Group
ALDERWOOD	C	MUKILTEO	C/D
BALDHILL	B	NEWBERG	B
BAUMGARD	B	NISQUALLY	B
BELLINGHAM	C	NORMA	D
BOISTFORT	B	OLYMPIC	B
BUNKER	B	PHEENEY	C
CAGEY	C	PILCHUCK	C
CATHCART	B	PITS	*
CENTRALIA	B	PRATHER	C
CHEHALIS	B	PUGET	D
DELPHI	B	PUYALLUP	B
DUPONT	D	RAINIER	C
DYSTRIC XEROCHREPTS	C	ROCK OUTCROP	*
ELD	B	RAUGHT	B
EVERETT	A	RIVERWASH	D
EVERSON	D	SALKUM	B
GALVIN	D	SCAMMAN	D
GILES	B	SCHNEIDER	B
GODFREY	D	SEMIAHMOO	C
GROVE	A	SHALCAR	D
HOOGDAL	C	SHALCAR VARIANT	D
HYDRAQUENTS	D	SKIPOPA	D
INDIANOLA	A	SPANA	D
JONAS	B	SPANAWAY	B
KAPOWSIN	D	SULTON	C
KATULAS	C	TACOMA	D
LATES	C	TENINO	C
MAL	C	TISCH	D
MASHEL	B	VAILTON	B
MAYTOWN	C	WILKESON	B
MCKENNA	D	XERORTHENTS	C
MELBOURNE	B	YELM	C

**See the description of the map unit*
Soils Table Notes:
Hydrologic Soil Group Classifications, as Defined by the NRCS (formerly Soil Conservation Service):

A = *(Low runoff potential) Soils having low runoff potential and high infiltration rates, even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr.).*

B = *(Moderately low runoff potential). Soils having moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.3 in/hr.).*

C = *(Moderately high runoff potential). Soils having low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine textures. These soils have a low rate of water transmission (0.05-0.15 in/hr.).*

D = *(High runoff potential). Soils having high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr.).*

** = From NRCS Database for Thurston surveys, SCS, TR-55, Second Edition, June 1986, Exhibit A-1. Revisions made from SCS, Soil Interpretation Record, Form #5, September 1988 and various county soil surveys.*

Table B.6. Runoff Coefficients for Rational Method Calculations.

Type of Cover	Flat	Rolling (2%-10%)	Hilly Over 10%)
Pavement and Roofs	0.90	0.90	0.90
Earth Shoulders	0.50	0.50	0.50
Drives and Walks	0.75	0.80	0.85
Gravel Pavement	0.50	0.55	0.60
City Business Areas	0.80	0.85	0.85
Suburban Residential	0.25	0.35	0.40
Single Family Residential	0.30	0.40	0.50
Multi Units, Detached	0.40	0.50	0.60
Multi Units, Attached	0.60	0.65	0.70
Lawns, Very Sandy Soil	0.05	0.07	0.10
Lawns, Sandy Soil	0.10	0.15	0.20
Lawns, Heavy Soil	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Areas, Turf	0.25	0.30	0.30
Cultivated Land, Clay and Loam	0.50	0.55	0.60
Cultivated Land, Sand and Gravel	0.25	0.30	0.35
Industrial Areas, Light	0.50	0.70	0.80
Industrial Areas, Heavy	0.60	0.80	0.90
Parks and Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland and Forests	0.10	0.15	0.20
Meadows and Pasture Land	0.25	0.30	0.35
Pasture with Frozen Ground	0.40	0.45	0.50
Unimproved Areas	0.10	0.20	0.30

Source: WSDOT Hydraulics Manual (2007)

Table B.7. Regression Coefficients for Rational Method Calculations.

	2-year MRI		5-year MRI		10-year MRI		25-year MRI		50-year MRI		100-year MRI	
Location	**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**
Olympia	3.82	0.466	4.86	0.472	5.62	0.474	6.63	0.477	7.40	0.478	8.17	0.480
Centralia and Chehalis	3.63	0.506	4.85	0.518	5.76	0.524	7.00	0.530	7.92	0.533	8.86	0.537
Tacoma	3.57	0.516	4.78	0.527	5.70	0.533	6.93	0.539	7.86	0.542	8.79	0.545

Source: WSDOT Hydraulics Manual (2007).
MRI: Mean Recurrence Interval (frequency).

Table B.8. SCS Type IA Storm Rainfall Distribution, 6-minute intervals.

Time (hours)	Incremental Rainfall	Cumulative Rainfall	Time (hours)	Incremental Rainfall	Cumulative Rainfall
0	0	0	3.8	0.004	0.109
0.1	0.002	0.002	3.9	0.003	0.112
0.2	0.002	0.004	4	0.004	0.116
0.3	0.002	0.006	4.1	0.004	0.12
0.4	0.002	0.008	4.2	0.003	0.123
0.5	0.002	0.01	4.3	0.004	0.127
0.6	0.002	0.012	4.4	0.004	0.131
0.7	0.002	0.014	4.5	0.004	0.135
0.8	0.002	0.016	4.6	0.004	0.139
0.9	0.002	0.018	4.7	0.004	0.143
1	0.002	0.02	4.8	0.004	0.147
1.1	0.003	0.023	4.9	0.005	0.152
1.2	0.003	0.026	5	0.004	0.156
1.3	0.003	0.029	5.1	0.005	0.161
1.4	0.003	0.032	5.2	0.004	0.165
1.5	0.003	0.035	5.3	0.005	0.17
1.6	0.003	0.038	5.4	0.005	0.175
1.7	0.003	0.041	5.5	0.005	0.18
1.8	0.003	0.044	5.6	0.005	0.185
1.9	0.003	0.047	5.7	0.005	0.19
2	0.003	0.05	5.8	0.005	0.195
2.1	0.003	0.053	5.9	0.005	0.2
2.2	0.003	0.056	6	0.006	0.206
2.3	0.004	0.06	6.1	0.006	0.212
2.4	0.003	0.063	6.2	0.006	0.218
2.5	0.003	0.066	6.3	0.006	0.224
2.6	0.003	0.069	6.4	0.007	0.231
2.7	0.003	0.072	6.5	0.006	0.237
2.8	0.004	0.076	6.6	0.006	0.243
2.9	0.003	0.079	6.7	0.006	0.249
3	0.003	0.082	6.8	0.006	0.255
3.1	0.003	0.085	6.9	0.006	0.261
3.2	0.003	0.088	7	0.007	0.268
3.3	0.003	0.091	7.1	0.007	0.275
3.4	0.004	0.095	7.2	0.008	0.283
3.5	0.003	0.098	7.3	0.008	0.291
3.6	0.003	0.101	7.4	0.009	0.3
3.7	0.004	0.105	7.5	0.01	0.31

Time	Incremental Rainfall	Cumulative Rainfall	Time	Incremental Rainfall	Cumulative Rainfall
(hours)			(hours)		
7.6	0.021	0.331	11.4	0.004	0.641
7.7	0.024	0.355	11.5	0.004	0.645
7.8	0.024	0.379	11.6	0.004	0.649
7.9	0.024	0.403	11.7	0.004	0.653
8	0.022	0.425	11.8	0.004	0.657
8.1	0.014	0.439	11.9	0.003	0.66
8.2	0.013	0.452	12	0.004	0.664
8.3	0.01	0.462	12.1	0.004	0.668
8.4	0.01	0.472	12.2	0.003	0.671
8.5	0.008	0.48	12.3	0.004	0.675
8.6	0.009	0.489	12.4	0.004	0.679
8.7	0.009	0.498	12.5	0.004	0.683
8.8	0.007	0.505	12.6	0.004	0.687
8.9	0.008	0.513	12.7	0.003	0.69
9	0.007	0.52	12.8	0.004	0.694
9.1	0.007	0.527	12.9	0.003	0.697
9.2	0.006	0.533	13	0.004	0.701
9.3	0.006	0.539	13.1	0.004	0.705
9.4	0.006	0.545	13.2	0.003	0.708
9.5	0.005	0.55	13.3	0.004	0.712
9.6	0.006	0.556	13.4	0.004	0.716
9.7	0.005	0.561	13.5	0.003	0.719
9.8	0.006	0.567	13.6	0.003	0.722
9.9	0.005	0.572	13.7	0.004	0.726
10	0.005	0.577	13.8	0.003	0.729
10.1	0.005	0.582	13.9	0.004	0.733
10.2	0.005	0.587	14	0.003	0.736
10.3	0.005	0.592	14.1	0.003	0.739
10.4	0.004	0.596	14.2	0.004	0.743
10.5	0.005	0.601	14.3	0.003	0.746
10.6	0.005	0.606	14.4	0.003	0.749
10.7	0.004	0.61	14.5	0.004	0.753
10.8	0.005	0.615	14.6	0.003	0.756
10.9	0.005	0.62	14.7	0.003	0.759
11	0.004	0.624	14.8	0.004	0.763
11.1	0.004	0.628	14.9	0.003	0.766
11.2	0.005	0.633	15	0.003	0.769
11.3	0.004	0.637	15.1	0.003	0.772

Time	Incremental Rainfall	Cumulative Rainfall	Time	Incremental Rainfall	Cumulative Rainfall
(hours)			(hours)		
15.2	0.004	0.776	19	0.003	0.887
15.3	0.003	0.779	19.1	0.003	0.89
15.4	0.003	0.782	19.2	0.002	0.892
15.5	0.003	0.785	19.3	0.003	0.895
15.6	0.003	0.788	19.4	0.002	0.897
15.7	0.004	0.792	19.5	0.003	0.9
15.8	0.003	0.795	19.6	0.003	0.903
15.9	0.003	0.798	19.7	0.002	0.905
16	0.003	0.801	19.8	0.003	0.908
16.1	0.003	0.804	19.9	0.002	0.91
16.2	0.003	0.807	20	0.003	0.913
16.3	0.003	0.81	20.1	0.002	0.915
16.4	0.003	0.813	20.2	0.003	0.918
16.5	0.003	0.816	20.3	0.002	0.92
16.6	0.003	0.819	20.4	0.002	0.922
16.7	0.003	0.822	20.5	0.003	0.925
16.8	0.003	0.825	20.6	0.002	0.927
16.9	0.003	0.828	20.7	0.003	0.93
17	0.003	0.831	20.8	0.002	0.932
17.1	0.003	0.834	20.9	0.002	0.934
17.2	0.003	0.837	21	0.003	0.937
17.3	0.003	0.84	21.1	0.002	0.939
17.4	0.003	0.843	21.2	0.002	0.941
17.5	0.003	0.846	21.3	0.003	0.944
17.6	0.003	0.849	21.4	0.002	0.946
17.7	0.002	0.851	21.5	0.002	0.948
17.8	0.003	0.854	21.6	0.003	0.951
17.9	0.003	0.857	21.7	0.002	0.953
18	0.003	0.86	21.8	0.002	0.955
18.1	0.003	0.863	21.9	0.002	0.957
18.2	0.002	0.865	22	0.002	0.959
18.3	0.003	0.868	22.1	0.003	0.962
18.4	0.003	0.871	22.2	0.002	0.964
18.5	0.003	0.874	22.3	0.002	0.966
18.6	0.002	0.876	22.4	0.002	0.968
18.7	0.003	0.879	22.5	0.002	0.97
18.8	0.003	0.882	22.6	0.002	0.972
18.9	0.002	0.884	22.7	0.002	0.974

Time	Incremental Rainfall	Cumulative Rainfall			
(hours)					
22.8	0.002	0.976			
22.9	0.002	0.978			
23	0.002	0.98			
23.1	0.002	0.982			
23.2	0.002	0.984			
23.3	0.002	0.986			
23.4	0.002	0.988			
23.5	0.002	0.99			
23.6	0.002	0.992			
23.7	0.002	0.994			
23.8	0.002	0.996			
23.9	0.002	0.998			
24	0.002	1			

Appendix III-C – Nomographs for Culvert Sizing Needs

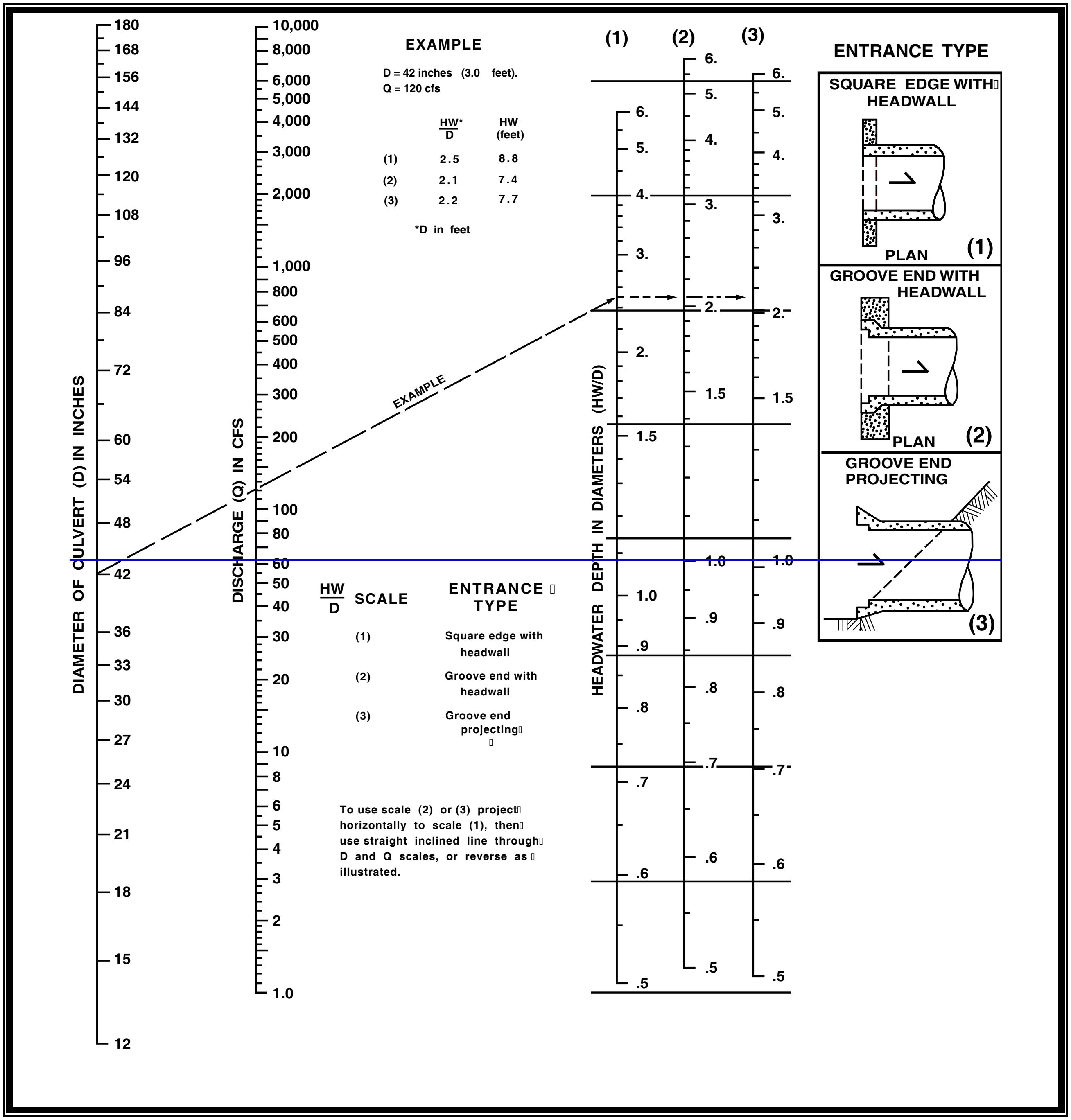


Figure C.1. Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control.

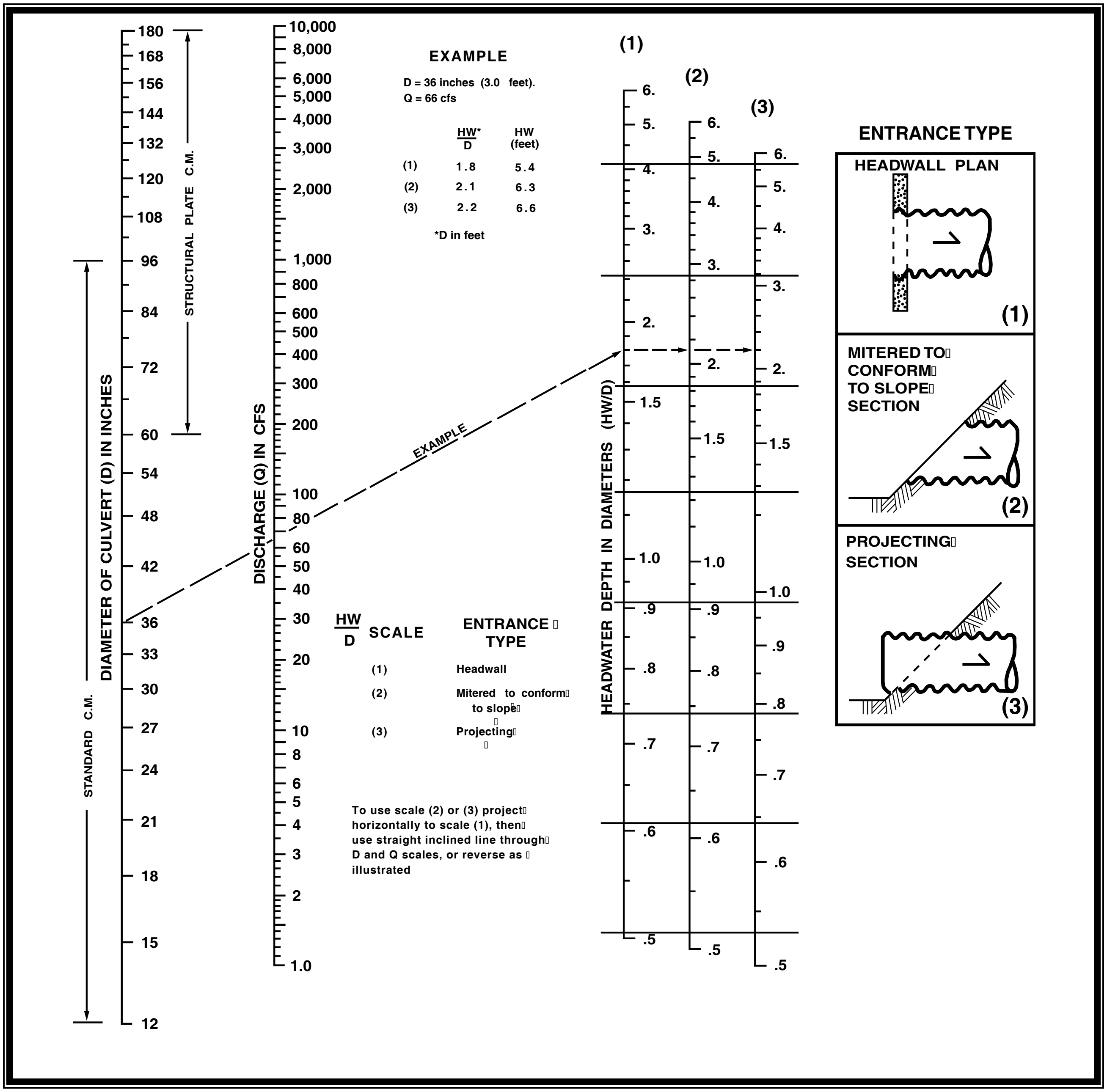


Figure C.2. Headwater Depth for Corrugated Pipe Culverts with Inlet Control.

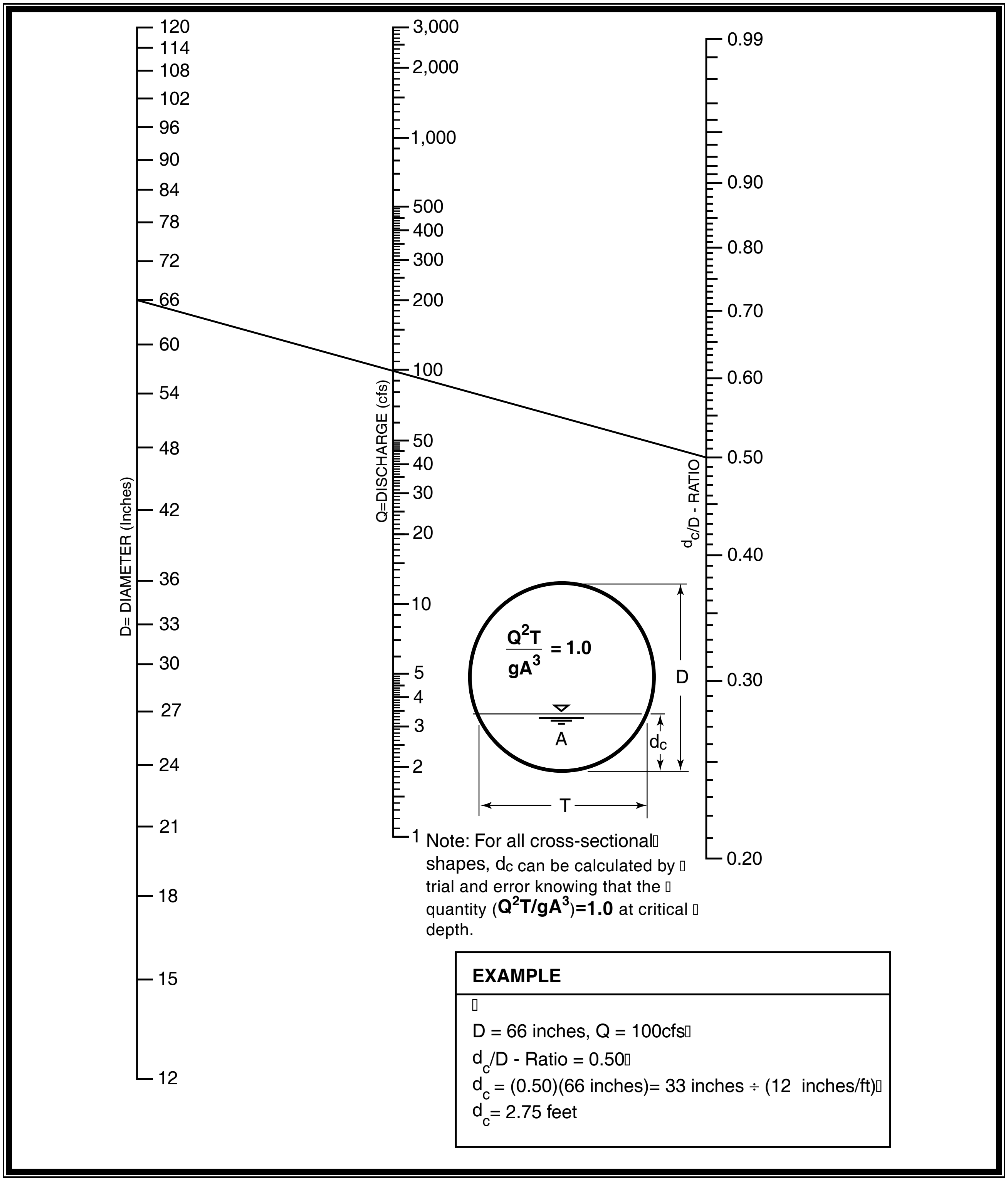


Figure C.3. Critical Depth of Flow for Circular Culverts.

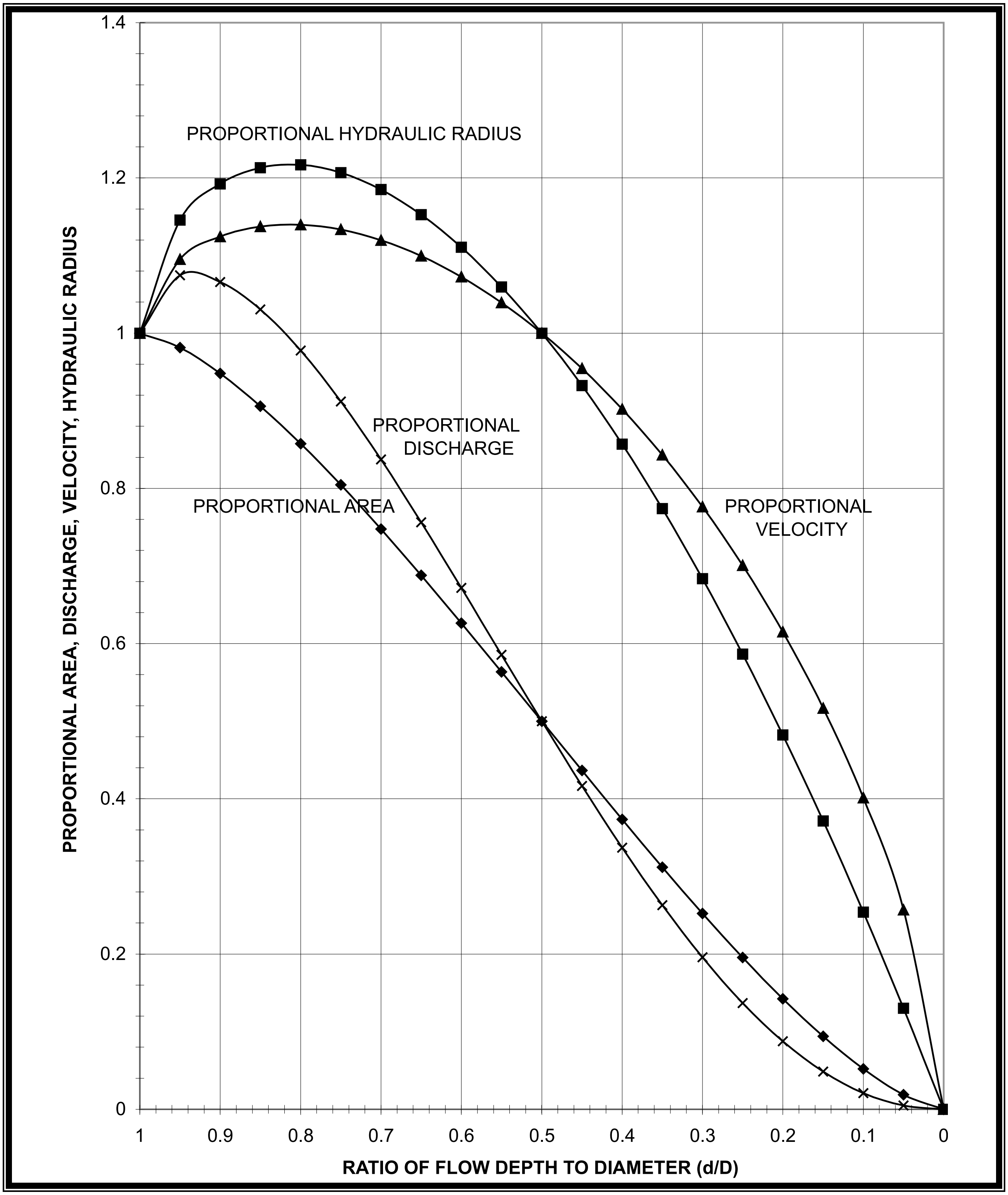


Figure C.4. Circular Channel Ratios.

Thurston County Drainage Design and Erosion Control Manual

Volume IV
Source Control

Prepared for
Thurston County Water Resources Unit,
Department of Resource Stewardship

July 2009

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Figures

Chapter 1 - Introduction to Volume IV

1.1 What is the Purpose of this Volume?

This volume of the *Drainage Design and Erosion Control Manual* provides guidance to businesses, homeowners and public agencies in Thurston County on how to prepare and implement a source control plan for best management practices (BMPs) to prevent pollutants from contaminating stormwater runoff and entering rivers, lakes, and streams.

The source control plan is a stand alone document that included as an element of the Stormwater Maintenance Plan (if one is required). Any structural BMPs required for specific land uses should be shown on the Drainage and Erosion Control Plan drawings and discussed in the Drainage and Erosion Control Report for the project.

The implementation of source control BMPs is required by several programs, which are listed in Section 1.2 below. Every person and business in Thurston County is required to use BMPs as part of their stormwater planning. You need to select BMPs from this volume to prevent stormwater pollution. Refer to Section 1.5 below for introductory information on BMPs. Information on stormwater treatment BMPs can be found in Volume I, Chapter 4 and Volume V.

1.2 How This Volume is Organized

Volume IV is organized into eight chapters and three appendices:

- Chapter 1: Introduction and first steps
- Chapter 2: Principles of pollution prevention
- Chapter 3: Commercial and Industrial Activities Worksheet
- Chapter 4: Industrial and Commercial BMPs
- Chapter 5: Source Control BMPs
- Chapter 6: Single Family Residence BMPs
- Chapter 7: Regulations and Requirements
- Chapter 8: Contact and Reference Information
- Appendix A: Recycling and Disposal of Vehicle Fluids and Other Wastes
- Appendix B: Example of an IPM Program

- Appendix C: Recommendations for Management of Road maintenance materials

1.3 How Do I Know What Applies to My Project?

The source control BMPs included in this Volume apply to all businesses, residences and public agencies in Thurston County that discharge stormwater under the provisions of the federal Clean Water Act (CWA) and Coastal Zone Management Act, the County's National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit, and the Puget Sound Partnership Action Agenda.

The requirements of this Volume apply to all permanent and temporary activities at public facilities, commercial and industrial facilities, agriculture and livestock farms, and residential dwellings. Anyone involved in a particular activity, whether they do so as an employee, supervisor, manager, landlord, tenant, or homeowner, must take part in implementing appropriate BMPs. BMPs need to be selected from this volume. Thurston County complies with the Endangered Species Act and all other relevant federal regulations in this effort.

1.4 When in the Design Process Should I Consult this Volume?

Source control, or preventative measures, is more effective than treating runoff once it has been polluted. It is recommended that you read all relevant sections of this Volume if a potential pollution problem is identified or prior to designing any stormwater treatment facilities. For projects completing the full design process, the "Worksheet for Commercial and Industrial Activities" in Chapter 3 will be submitted with the **Drainage Scoping Report**. Updated submittals and appropriate supplemental materials will be included in the **Preliminary Drainage Report** and **Final Drainage Report**.

1.5 What Pollutants are Addressed in this Volume?

The NPDES permit mentioned above requires Thurston County to show progress in eliminating virtually all non-stormwater discharges to the stormwater drainage system. In other words, **nothing but uncontaminated stormwater may be discharged** to any stormwater drainage system. There are severe state and federal penalties for anyone violating the terms of these permits. See Thurston County Code Chapter 15.05, *Thurston County Stormwater Standards*, for more information.

The pollutant descriptions provided below are brief. You can obtain more information on a particular pollutant by calling one of the information numbers listed in Chapter 8.

1.5.1 pH

pH value is a relative measure of whether a substance is acidic or basic. The pH value of a body of water is vitally important, since most aquatic life can only live within a relatively narrow band of pH values (6 to 8). Some sources that can contribute to a change in pH of stormwater and water bodies are cement in concrete pouring, paving, and recycling operations; solutions from metal plating; chemicals from printing businesses and other industrial processes; and household cleaners such as bleaches and deck washes.

1.5.2 Total Suspended Solids (TSS)

This represents particulate solids such as eroded soil, heavy metal precipitates, and biological solids, which can cause turbidity in receiving waters and sedimentation in streams and lakes. TSS is the most common pollutant present in stormwater runoff. These sediments can destroy the desired habitat for fish and can impact drinking water supplies. The sediment may be carried to streams, lakes, or the Puget Sound where they may be toxic to aquatic life and make dredging necessary.

1.5.3 Oils and Greases

Oils and greases are petroleum-based or food-related. Petroleum-based compounds can be immediately toxic to fish and wildlife and, if they reach drinking water aquifers, make humans sick too. Food-based oils and greases may not be toxic to us, but can coat fish gills and insects, suffocating them as well as using up oxygen in the water.

1.5.4 Oxygen-Demanding Substances

Degradable organic matter, such as yard, food, and pet wastes, and some chemical wastes, can have a drastic effect on water quality if they are allowed to enter stormwater. As these substances are broken down by bacteria, the oxygen in the water is consumed in the process. This stresses and can eventually kill fish and other creatures in the water.

1.5.5 Metals

Metals are utilized in many products important to our daily lives. Certain metals, such as cadmium, copper, lead, and zinc, are known as heavy metals. They wear off of our car brakes, engines, and tires. They come from our paint and moss-killing roof strips. They are found in herbicides we use at our homes. These metals can cause severe health and reproductive problems in fish and animals that live in water and sediments that become contaminated by runoff.

1.5.6 Bacteria and Viruses

Bacteria and viruses from pet wastes, failing septic systems and agricultural areas can contaminate drinking water and close down swimming and shellfish areas. A group of bacteria called **fecal coliform bacteria** are typically used as the indicators for pollution by more serious disease-causing microorganisms called pathogens. The Washington State Department of Ecology (Ecology) has made changes to the State Water Quality Standards that include the use of new bacterial indicators: *E. coli* for fresh water and enterococci for marine water will replace fecal coliform bacteria, except that fecal coliform will still be used for marine waters that contain shellfish beds.

1.5.7 Nutrients

In the context of water quality, nutrients are mainly compounds of nitrogen and phosphorus. When nutrients are allowed to enter water bodies, certain plant species, such as algae, may grow too abundant. As the algae multiplies it can clog shorelines, streams, pipe intakes, and drainage channels. As it decays, the decomposition process depletes the oxygen and fish and animal death can occur. Sources of nutrients can include fertilizers, failing septic systems, and yard and animal wastes.

1.5.8 Toxic Organic Compounds

A number of organic chemicals are toxic when they get into the aquatic environment. Many pesticides, herbicides, rodenticides, and fungicides are deadly to aquatic life. The same is true of compounds such as antifreeze, wood preservatives, cleansers, and a host of other, more exotic organics derived from industries or past practices (such as polychlorinated biphenyls [PCBs], DDT, and chlordane).

1.5.9 Other Chemicals and Substances

There are a host of other chemicals that can cause problems if allowed to enter the aquatic environment. Common household bleach can be deadly to fish and other animals if drained directly to water bodies. Diatomaceous earth backwash from swimming pool filters can clog gills and suffocate fish. Arsenic used in rat and mole killing compounds is also toxic. Even those compounds classified as **biodegradable or environmentally friendly** can have devastating **immediate** effects on aquatic life, often by using up oxygen in the water as they degrade.

1.6 What are Best Management Practices?

Best Management Practices (BMPs) are a set of activities designed to reduce stormwater pollution. BMPs are separated into two broad categories: *source control* and *treatment*.

1.6.1 Source Control BMPs

Source control BMPs prevent contaminants from entering stormwater runoff by controlling them at the source. There are two categories of source control BMPs:

1. **Operational** source control BMPs are non-structural practices that prevent or reduce pollutants from entering stormwater. They include process changes such as raw material/product changes and recycling of wastes. Examples include:
   - Formation of a pollution prevention team
   - Good housekeeping practices
   - Preventive maintenance procedures
   - Spill prevention and clean up
   - Employee training
   - Inspections of pollutant sources
   - Record keeping

2. **Structural** source control BMPs are physical, structural or mechanical devices or facilities intended to prevent pollutants from entering stormwater. Examples of structural source control BMPs include:
   - Enclosing and/or covering the pollutant source, i.e., within a building or other enclosure, a roof over storage and working areas, a temporary tarpaulin, etc.
   - Physically segregating the pollutant source to prevent contact with uncontaminated stormwater that runs onto the site from surrounding areas.
   - Devices that separate contaminated runoff and send it to appropriate treatment instead of discharging into the main stormwater flow. For instance, polluted runoff could be discharged to a sanitary sewer if a permit is first obtained from the sewer service provider. Contact your local sewer service provider to determine what the requirements for industrial pre-treatment are for your location .

1.6.2 Treatment Best Management Practices

Treatment BMPs are used to treat stormwater that is already contaminated. Most treatment BMPs require planning, designing, permitting and construction, but cannot remove 100 percent of contaminants once they enter stormwater. The difficulty of treatment, combined with the typical expense of treatment BMPs, makes source control BMPs the preferred choice. There may be instances where treatment BMPs are required, however. This volume identifies specific treatment BMPs that apply to particular pollutant sources, such as fueling stations, railroad yards, storage and transfer of materials, etc. After identifying the required treatment BMPs, the reader can refer to Volume I, Chapter 4 and Volume V for additional information about treatment BMPs.

1.7 What if I am Already Implementing Best Management Practices?

Businesses already implementing BMPs in accordance with other federal, state, or county programs usually do not have to implement additional BMPs. Persons or businesses qualifying for exemptions include businesses required to obtain a general or individual NPDES permit for stormwater discharges (who must comply with the requirements of that permit). See regulatory requirement R.2 in Chapter 7 of this volume for details.

If you have a stormwater permit, the County assumes you are implementing the appropriate BMPs. If the County finds that you have not implemented your BMPs, or that the BMPs that you have implemented are not effectively addressing the discharge of contaminants, then you will be required to implement additional BMPs, potentially including more expensive treatment BMPs, to meet requirements. **Everyone** must implement BMPs, but how each business accomplishes this may differ.

1.8 How Do I Get Started?

If you are a landlord, tenant, or owner of a single-family residence, proceed to Chapter 2 for General Principles that everyone should implement, and Chapter 5 for BMPs that are recommended for you.

If you own a business or industry, review the General Principles in Chapter 2, and complete the worksheet in Chapter 3. If you checked off any of the activities that are being performed outdoors, use the activity code on the worksheet to find the BMPs recommended for you in Chapter 4.

If you have questions, please contact Thurston County Department of Resource Stewardship, Water Resources Unit (360) 754-4681. They can provide assistance over the phone and at your business site.

1.9 Related Stormwater Requirements

Under current state and county law, if you own commercial property and lease or rent it, you can be held responsible for water quality problems caused by your tenants. Make sure your tenants are informed of their responsibilities under the auspices of this manual and Thurston County Code, Chapter 15.05, *Thurston County Stormwater Standards*.

You need an accidental spill plan if your business has the potential for a spill. If you are currently under a pretreatment permit for discharge to sewers, you can amend it to include stormwater. Please contact Thurston

County Department of Resource Stewardship, Water Resources Unit at (360) 754-4681 for information on developing these plans.

You are responsible for obtaining prior approval for your stormwater discharge to the county system. This means obtaining proper building and environmental permits from the county and state. Please contact the Thurston County Development Services (360) 786-5490 or go to http://www.co.thurston.wa.us/ for more information. For Ecology permits, call (360) 407-6400.

Chapter 2 - Principles of Pollution Prevention

This chapter describes simple pollution prevention principles that every business and homeowner should consider. Most of these are common sense, "housekeeping" types of solutions. With collective action by individuals and businesses throughout the county in implementing each of these principles, the improvement in water quality can be substantial. Although most of these principles are aimed at commercial or industrial activities, many items apply to individual residents as well.

1. Avoid the activity or reduce its occurrence

Avoid a potentially polluting activity or do it less frequently, especially if it takes place outdoors. Do a larger run of a process and reduce the number of times it needs to be repeated? Avoid one solvent-washing step altogether or have raw materials delivered closer to the time of use to avoid stockpiling and exposure to the weather. Apply lawn care chemicals following directions and only as needed. Many lawns are excessively fertilized. Do not apply herbicides right before it rains. Ecology or the Thurston County Department of Public Health and Social Services can provide pollution prevention assistance.

2. Move the activity indoors

Move a potentially polluting activity indoors out of the weather. This prevents runoff contamination, and you provides more control for a cleanup if a spill occurs. For example unload and store chemicals inside a garage area instead of outside. Be aware that moving storage areas indoors may require installation of fire suppression equipment or other building modifications as required by the International Building Code (IBC), applicable fire codes, or local ordinances.

3. Cleanup spills quickly

Promptly contain and cleanup solid and liquid pollutant leaks and spills on any exposed soil, vegetation, or paved area. Commercial spill kits are available, but readily available absorbent such as kitty litter also work well in many cases. Promptly repair or replace all leaking connections, pipes, hoses, valves, etc. which can contaminate stormwater.

4. **Use less material**

Don't buy or use more material than you really need. This not only helps keep potential disposal, storage, and pollution problems to a minimum, but will probably save you money, too.

5. **Use the least toxic materials available**

Investigate the use of materials that are less toxic. For example, replace a caustic-type detergent or a solvent with a more environmentally friendly product. This might allow you to discharge process water to the sanitary sewer instead of paying for expensive disposal. Even if you do switch to a biodegradable product, only uncontaminated water is allowed to enter the stormwater drainage system.

6. **Create and maintain vegetated areas near activity locations**

Vegetation can filter pollutants out of stormwater. Route stormwater through vegetated areas located near your activity. Many low impact development (LID) stormwater BMPs can be used to manage stormwater from small source areas, like bioretention areas designed at depressions in parking lots. These BMPs are described in Volume V.

Wastewater other than stormwater runoff, such as wash water, must be discharged to a wastewater collection system, and may not be discharged to a storm drainage system.

High-use sites may require conveyance of runoff to an oil removal treatment system. For more information on high-use sites, refer to Volume I, Section 4.2, Step 7a.

7. **Locate activities as far as possible from surface drainage paths**

Activities located as far as possible from known drainage paths, ditches, streams, other water bodies, and drains will be less likely to pollute, since it will take longer for material to reach the drainage feature. This gives more time to react to a spill, or if it is a "housekeeping" issue, may protect the local waters long enough for you to cleanup the area around the activity. Don't forget that groundwater protection is important throughout Thurston County, no matter where the activity is located, so the actions taken on your site on a day-to-day basis are always important, even in dry weather.

8. Maintain stormwater drainage systems

Pollutants can concentrate over time in storm drainage facilities such as catch basins, vaults, ditches, and storm drains. When a large storm event occurs, turbulent runoff can mobilize these pollutants and carry them to receiving waters. Develop and implement maintenance practices, inspections, and schedules for treatment devices (e.g., detention ponds, oil/water separators, vegetated swales, etc.). Requirements for cleaning stormwater facilities are discussed in Chapter 5, specifically BMP S.9.

Repair or replace cracked or otherwise damaged pavement in areas used for secondary spill containment, high-intensity parking, and any other drainage areas that are subjected to pollutant material leaks or spills.

Maintenance standards can be found in Volume V, Appendix V-C.

9. Reduce, reuse, and recycle as much as possible

Look for ways to recycle instead of just disposing. This saves money and keeps hazardous and non-hazardous materials out of landfills. You can learn more about other businesses that have made process changes allowing recycling of chemicals by calling Ecology at 1-800-RECYCLE and requesting publication No. 92-45 and No. 90-22.

Another unique recycling opportunity for businesses is available through the Industrial Materials Exchange, which covers the entire Pacific Northwest. This free service acts as a waste or surplus “matchmaker”, turning one company's waste into another company's asset. For instance, waste vegetable oil can become biofuel for another business. Go to the Industrial Materials Exchange web site to list your potentially usable solid or chemical waste in their publication:

<http://www.govlink.org/hazwaste/business/imex/submit.cfm>

10. Be an advocate for stormwater pollution prevention

Help friends, neighbors, and business associates find ways to reduce stormwater pollution in their activities. Most people want clean water and do not pollute intentionally. Share your ideas and the BMPs in this volume to get them thinking about how their everyday activities affect water quality.

11. Report problems

We all must do our part to protect water, fish, wildlife, and our own health by implementing proper BMPs, and reporting water quality problems that we observe. In Thurston County, call the Department of Public Works at (360) 754-4581 to report dumping to sewers and to report incidents involving storm drains or ditches.

12. Provide oversight and training

Assign one or more individuals at your place of business to be responsible for stormwater pollution control. Hold regular meetings to review the overall operation of BMPs. Establish responsibilities for inspections, operation and maintenance (O&M), documentation, and availability for emergency situations. Train all team members in the operation, maintenance, and inspection of BMPs and reporting procedures.

13. Dust control

Sweep paved material handling and storage areas regularly as needed, to collect and dispose of dust and debris that could contaminate stormwater. Do not hose down pollutants from any area to the ground, storm drain, conveyance ditch, or receiving water unless necessary for dust control purposes to meet air quality regulations and unless the pollutants are conveyed to a treatment system approved by the County.

14. Eliminate illicit connections

A common problem with the stormwater drainage system for most communities is the existence of illicit connections of wastewater to the storm drainage system. Many businesses and residences have internal building drains, sump overflows, process wastewater discharges, and even sanitary sewer and septic system pipes that were connected to the nearby storm drainage system in the past as a matter of course.

All businesses and residences in Thurston County must examine their plumbing systems to determine if illicit connections exist. Any time it is found that toilets, sinks, appliances, showers and bathtubs, floor drains, industrial process waters, and/or other indoor activities are connected to the stormwater drainage system, these connections must be immediately rerouted to the sanitary or septic system, holding tanks, or process treatment system. Methods to eliminate illicit connections are described in detail in Chapter 5, BMP S.1.

15. Dispose of waste properly

Every business and residence in Thurston County must dispose of solid and liquid wastes and contaminated stormwater properly. There are generally four options for disposal depending on the type of materials. These options include:

- Sanitary sewer and septic systems
- Recycling facilities
- Municipal solid waste disposal facilities
- Hazardous waste treatment, storage, and disposal facilities.

Additional information on disposal is described in Chapter 5, BMP S.2.

Chapter 3 - Commercial and Industrial Activities Worksheet

This worksheet and the associated BMPs are organized by business activity. The goal of BMPs is to ensure that **only uncontaminated stormwater is discharged** into any stormwater drainage system.

Complete the entire worksheet by checking the appropriate boxes for all activities that occur at your work place. If you checked off any of the activities **that are being performed outdoors or can drain to the stormwater drainage system**, use the activity code on the worksheet to find the BMPs recommended for you in Chapter 4. If you perform an activity indoors and control all discharges from the activity (e.g., process water, washwater, lubricants, solvents, fugitive dust, granular material, blow down waste) so that no stormwater exposure occurs, you do not have to institute BMPs for that activity.

If you have checked activities as occurring indoors, the County may require you to demonstrate how your facility qualifies as 'indoors' or not exposed to the elements. No indoor drains or process water discharges can connect to the storm drainage system without a permit. You must ensure that liquids, powders, dusts, and fine granular materials stay confined indoors; otherwise, you will be subject to all of the BMP requirements. For discharges to the sanitary sewer, permits must be obtained from your sewer service provider.

If you checked off any of these activities as occurring outdoors at your business, use the activity code to find the appropriate BMPs described in Chapter 4.

If you have questions, please contact Thurston County Department of Resource Stewardship, Water Resources Unit at (360) 754-4681. They can provide assistance over the phone and also at your business site.

Activity Code	Type of Activity	Check if You Are Involved in This	
		Indoor	Outdoor
A1.1	Cleaning or Washing of Tools, Engines, and Manufacturing Equipment • Includes parts washers and all types of manufactured equipment components.		
A1.2	Cleaning or Washing of Cooking Equipment • Includes vents, filters, pots and pans, grills, and related items.		
A1.3	Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures • Includes cleaning and washing at all types of establishments, including fleet vehicle yards, car dealerships, car washes, and maintenance facilities.		
A1.4	Collection and Disposal of Wastewater from Mobile Interior Washing Operations • Includes carpet cleaners, upholstery cleaners, and drapery cleaners.		
A2.1	Loading and Unloading Areas for Liquid or Solid Material • Includes raw materials, intermediate products, finished products, waste, or fuel.		
A2.2	Fueling at Dedicated Stations • Includes gas stations, pumps at fleet vehicle yards or shops, and other privately owned pumps.		
A2.3	Engine Repair and Maintenance • This covers oil changes and other engine fluids.		
A2.4	Mobile Fueling of Vehicles and Heavy Equipment • Includes fleet fueling, wet fueling, and wet hosing.		
A3.1	Concrete and Asphalt Mixing and Production at Stationary Sites • Applies to mixing of raw materials on site to produce concrete or asphalt.		
A3.2	Concrete Pouring, Concrete Cutting, and Asphalt Application at Temporary Sites • Includes construction sites, and driveway and parking lot resurfacing.		
A3.3	Manufacturing and Postprocessing of Metal Products • Includes machining, grinding, soldering, cutting, welding, quenching, rinsing, etc.		
A3.4	Wood Treatment Areas • Includes wood treatment using pressure processes or by dipping or spraying.		
A3.5	Commercial Composting • Includes commercial composting facilities operating outside.		
A3.6	Landscaping and Vegetation Management Activities, Including Vegetation Removal, Herbicide and Insecticide Application, Fertilizer Application, Irrigation, Watering, Gardening, and Lawn Care • Includes businesses involved in landscaping, applying pesticides and managing vegetation.		

Activity Code	Type of Activity	Check if You Are Involved in This	
		Indoor	Outdoor
A3.7	Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and Equipment • Includes surface preparation and the applications of paints, finishes, and/or coatings.		
A3.8	Commercial Printing Operations • Includes materials used in the printing process.		
A3.9	Manufacturing Activities – Outside • Includes outdoor manufacturing areas.		
A3.10	Agricultural Crop Production • Includes commercial scale farming.		
A3.11	Application of Pesticides, Herbicides, Fungicides and Rodenticides for purposes other than landscaping • Includes moss removal and outdoor insect extermination.		
A4.1	Storage or Transfer (Outside) of Solid Raw Materials, By-products, or Finished Products		
A4.2	Storage and Treatment of Contaminated Soils • This applies to contaminated soils that are excavated and left on site.		
A4.3	Temporary Storage or Processing of Fruits or Vegetables • Includes processing activities at wineries, fresh and frozen juice makers, and other food and beverage processing operations.		
A4.4	Storage of Solid Wastes and Food Wastes • Includes regular garbage and all other discarded non-liquid items.		
A4.5	Recyclers and Scrap Yards • Includes scrapped equipment, vehicles, empty metal drums, and assorted recyclables.		
A4.6	Treatment, Storage, or Disposal of Dangerous Wastes • Refer to Ecology and the Thurston County Health Department for more information, see Chapter 7.		
A4.7	Storage of Liquid, Food Waste, or Dangerous Waste Containers • Includes containers located outside a building and used for temporary storage.		
A4.8	Storage of Liquids in Permanent Aboveground Tanks • Includes all liquids in aboveground tanks.		
A4.9	Parking and Storage for Vehicles and Equipment • Includes public and commercial parking lots		
A4.10	Storage of Pesticides, Fertilizers, or other products that can leach pollutants		
A5.1	Demolition of Buildings • Applies to removal of existing buildings and subsequent clearing of the rubble.		
A5.2	Building Repair, Remodeling, and Construction • Applies to construction of buildings, general exterior building repair work and remodeling of buildings.		

Activity Code	Type of Activity	Check if You Are Involved in This	
		Indoor	Outdoor
A6.1	Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots		
A6.2	Dust Control at Manufacturing Sites • Includes grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash.		
A6.3	Soil Erosion and Sediment Control (ESC) at Industrial Sites • Includes industrial activities that take place on soil.		
A7.1	Commercial Animal Handling Areas • Includes kennels, fenced pens, veterinarians, and businesses that board animals.		
A7.2	Keeping Livestock in Stables, Pens, Pastures or Fields • Applies to all types of livestock.		
A7.3	Log Sorting and Handling • Applies to log yards typically located at sawmills, ports, and pulp mills.		
A7.4	Boat Building, Mooring, Maintenance, and Repair • Includes all types of maintenance, repair, and building operations.		
A7.5	Logging • Applies to logging activities that fall under Class IV general forest practices.		
A7.6	Mining and Quarrying of Sand, Gravel, Rock, Minerals, Peat, Clay, and Other Materials • This does not include excavation at construction sites.		
A7.7	Swimming Pool and Spa Cleaning and Maintenance • Includes every swimming pool and spa not at a single family residence. Commercial pool cleaners are included here for all pools.		
A7.8	De-icing and Anti-icing Operations for Airports and Streets • Includes aircraft, runways/taxiways, streets and highways.		
A7.9	Roof and Building Drains at Manufacturing and Commercial Buildings • These sites will be referred to ORCAA.		
A7.10	Urban Streets • BMPs for addressing pollutants found on paved surfaces, including street sweeping.		
A7.11	Railroad Yards		
A7.12	Maintenance of Public and Private Utility Corridors and Facilities • Includes public and private utility maintenance activities.		
A7.13	Maintenance of Roadside Ditches		
A7.14	Maintenance of Stormwater Drainage and Treatment Facilities		
A7.15	Spills of Oil and Hazardous Substances		

Chapter 4 - Best Management Practices for Commercial and Industrial Activities

This chapter coordinates with the worksheet in Chapter 3. That worksheet and the BMPs are organized by the different activities that businesses perform. If you perform the listed activity indoors, controlling all discharges from the activity (e.g., process water, washwater, lubricants, solvents, fugitive dust, granular material, blow down waste, etc.) such that no exposure to stormwater occurs, then you do not have to institute new BMPs for that activity. However, if you checked the column for activities performed outdoors, match the number from the worksheet to the activities listed in this chapter to find the suggested BMPs you should implement.

4.1 Explanation of Required BMPs

Every business in Thurston County is required to use the BMPs described in this manual to control stormwater pollution. In some instances, there are BMPs mandated by various federal, state, or county laws. If you are subject to those laws and regulations via another permit or formal regulatory approval, you are encouraged, but not required to use additional BMPs to further protect our water quality. Developers are responsible for ensuring that discharges from their BMPs meet water quality requirements.

Some businesses are (or will be) required to obtain a NPDES permit for stormwater discharges. These permits are issued and regulated by Ecology. Types of businesses (listed by Standard Industrial Classification code) that must obtain this type of permit are listed in Chapter 7. Businesses regulated under the NPDES stormwater program may be exempt from implementing some BMPs outlined in this volume, since they will be implementing BMPs required by the state. Refer to Volume I, Section 1.3 and Section 7 of this volume for more information about NPDES permits for industries.

The BMPs outlined in this volume are focused on source control: that is, methods to prevent pollution from reaching stormwater in the first place. The use of source control BMPs is always the first line of defense in stormwater pollution prevention efforts for several reasons:

- In many cases, source control BMPs are adequate to correct stormwater pollution problems.
- Most source control BMPs are relatively inexpensive and easy to implement.

- Treatment BMPs are used after pollution has entered stormwater. These BMPs are more expensive, and can never remove 100 percent of stormwater pollution. This source control volume identifies specific treatment BMPs that apply to particular pollutant sources, such as fueling stations, railroad yards, storage and transfer of materials, etc.

- NOTE: At times, the type of pollutants present or the condition of a site could mean treatment BMPs are required. Information about treatment BMPs are found in Volume V of this manual.

Minimum requirements for stormwater source control are contained in Volume I, Section 2.4.3 Minimum Requirement #3: Source Control of Pollution. In accordance with this minimum requirement, all known, available and reasonable source control BMPs shall be applied to all projects. Chapter 5 of this volume contains details on types of source control BMPs, with references to appropriate documents for others.

Stormwater treatment may also be required for certain types of businesses, based on the information provided in this volume and in Volume I, Section 2.4.6 Minimum Requirement #6: Runoff Treatment and in Volume V, Runoff Treatment BMPs. Volume V contains detailed information about stormwater treatment BMPs.

Section A1

Cleaning and Washing Activities

A1.1 Cleaning or Washing of Tools, Engines, and Manufacturing Equipment

This activity applies to businesses and public agencies that clean manufacturing equipment such as saws, grinders, screens, and other processing devices outside of buildings, and businesses engaged in pressure washing of engines, equipment, and portable objects.

Description of Pollutant Sources: Pollutant sources include toxic hydrocarbons, organic compounds, oils and greases, nutrients, heavy metals, pH, suspended solids, biochemical oxygen demand (BOD), and chemical oxygen demand (COD).

Pollutant Control Approach: The preferred approach is to cover and/or contain the cleaning activity, or conduct the activity inside a building. Washwater must be conveyed to a sanitary sewer after approval by your sewer service provider, temporarily stored before proper disposal, or recycled, with no discharge to the ground, a storm drain, or surface water. Washwater may be discharged to the ground after proper treatment in accordance with *Ecology guidance WQ-R-95-56, "Vehicle and Equipment Washwater Discharges," Revised 9/2007*. The quality of any discharge to the ground after proper treatment (gravity separation followed by media filtration) must comply with Ecology's Ground Water Quality Standards, Chapter 173-200 WAC. Contact the Ecology Southwest Regional Office for an NPDES permit application for discharge of washwater to surface water or to a storm drain after onsite treatment.

Required BMPs

The following BMPs (or equivalent measures) are required of all businesses and public agencies that clean or wash tools, engines, equipment, and portable objects:

- Illicit connections to the stormwater drainage system must be eliminated. See BMP S.1 in Chapter 5 for detailed information.
- Train employees to control washing operations to prevent stormwater contamination.
- All washwater must discharge to a holding tank, process treatment system, or sanitary sewer--never to the stormwater drainage system. See BMP S.3 in Chapter 5 for instructions.
- Pressure washing must be performed in a designated area (such as a wash pad) provided with a sump drain and stormwater run-on prevention (Figures 4.1 and 4.2). See BMPs S.6 and S.7 in Chapter 5 for information on sumps (or holding tanks) and run-on prevention. Contact your sewer service provide for pre-treatment requirements and for washing operation policy.

(Photo courtesy of Seattle Public Utilities)

Figure 4.1. Wash Pad for Tool and Equipment Washing.

Figure 4.2. Uncovered Washing Area for Tools, Engines, Equipment, and Portable Objects, with Drains to a Sanitary Sewer, Process Treatment, or a Dead-End Sump.

Suggested BMPs

The following BMPs are not required but can provide additional pollution control:

- If soaps or detergents are used, use the least toxic cleaner capable of doing the job. Use non-phosphate detergent, if possible, to reduce loadings at your local wastewater treatment plant.
- Limit the amount of water used in washing activities to reduce the potential of runoff carrying pollutants beyond the designated wash pad or capture system.
- Recycle washwater for subsequent washings.
- Implement one or more of the stormwater treatment BMPs found in Volume V.

NOTE: For discharging washwaters containing soaps and detergents, the use of infiltration, biofiltration, wet ponds, and wetlands must not result in the violation of groundwater quality standards.

A1.2 Cleaning or Washing of Cooking Equipment

This activity applies to businesses that clean cooking equipment such as vent filters, grills, and grease traps outside of buildings.

Description of Pollutant Sources: Pollutants of concern consist of oil and grease, nutrients, suspended solids, biochemical oxygen demand (BOD) and chemical oxygen demand (COD).

Pollutant Control Approach: Businesses engaged in this activity that cannot connect discharges to a sanitary sewer, holding tank, or process water treatment system must contact Ecology and obtain a NPDES wastewater permit.

Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in cleaning or washing of cooking equipment:

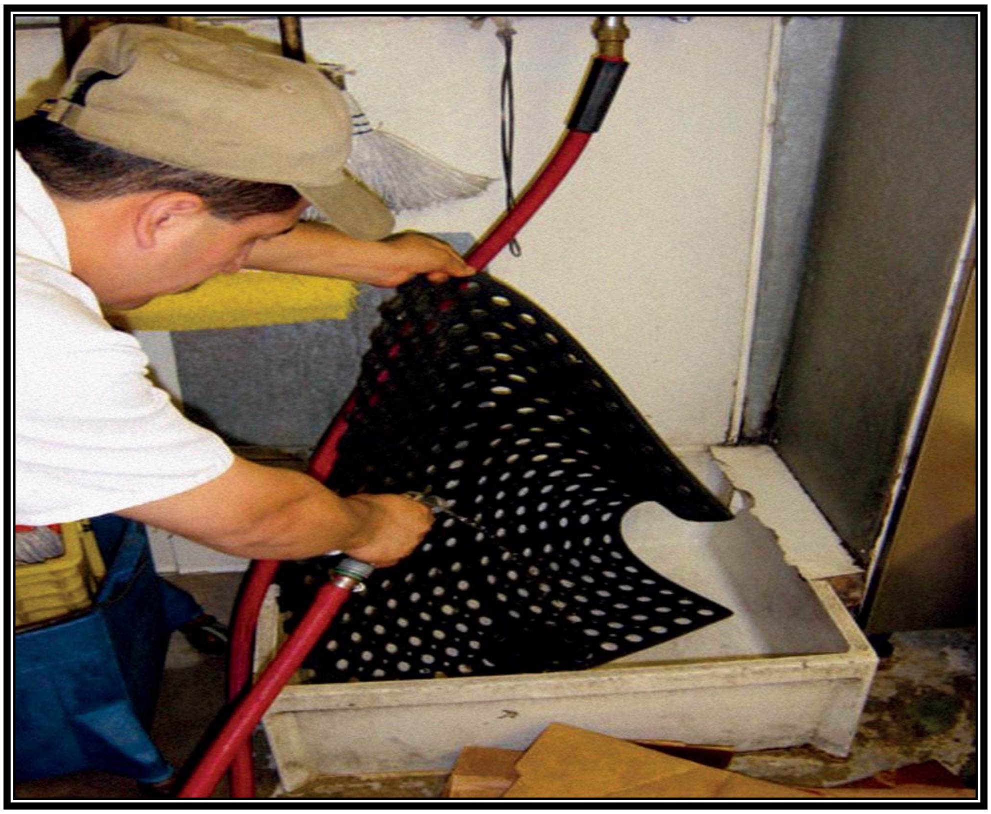
- Illicit connections to the stormwater drainage system must be eliminated. See BMP S.1 in Chapter 5 for detailed requirements.
- Employees must be educated about the need to prevent stormwater contamination from washing operations.
- Washwater cannot be discharged to the stormwater drainage system.
- Paved washing areas must be swept daily to collect loose solid materials for proper disposal.
- Greasy buildup on cooking equipment must be removed and properly disposed of prior to washing to reduce the amount of material that can potentially contaminate runoff.
- Move the activity indoors, into either an existing building or a newly constructed building or shed, with drainage to a sanitary sewer, holding tank, or process treatment system (Figure 4.3). See BMP S.3 in Chapter 5 for further information on drainage alternatives. Any connection to the sanitary sewer requires the approval of the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your sewer service provider, if your site is not within the LOTT service area.

  OR

  Use a tub or similar device to contain washwater. This water must be recycled for subsequent washing, or disposed of in a holding tank or sanitary sewer.

OR

If the washing activity cannot be moved indoors or contained in a tub, then the washing area must drain to a sanitary sewer, holding tank, or process treatment system, and provisions must be made to prevent stormwater run-on onto the washing area. See BMP S.3 in Chapter 5 for detailed drainage requirements and BMP S.7 for run-on prevention schemes. If discharging to a sanitary sewer, permits must be obtained from the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider if your site is not within the LOTT service area.



(Photo courtesy of Seattle Public Utilities)

Figure 4.3. Cleaning and Washing Cooking Equipment Indoors.

- If a holding tank is used for storage of washwater, the contents must be pumped out before it is full and disposed of appropriately to a sanitary sewer or wastewater treatment system.

Suggested BMPs

The following BMPs are not required but can provide additional pollution protection:

- A cover should be placed over a designated wash area to keep rain from falling on dirty equipment and producing contaminated runoff.
- Implement one or more of the treatment BMPs found in Volume V.

For discharging washwaters containing soaps and detergents, the use of infiltration, biofiltration, wet ponds, and wetlands must not result in the violation of groundwater quality standards.

A1.3 Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures

Description of Pollutant Sources: Vehicles, aircraft, vessels, carpets, industrial equipment, and large buildings may be commercially cleaned with low or high pressure water or steam. This includes "charity" car washes at gas stations and commercial parking lots. The cleaning can include hand washing, scrubbing, sanding, etc. Washwater from cleaning activities can contain oil and grease, suspended solids, heavy metals, soluble organics, soaps, and detergents that can contaminate stormwater.

Pollutant Control Approach: The preferred approach is to cover and/or contain the cleaning activity, or conduct the activity inside a building, to separate the uncontaminated stormwater from the pollutant sources. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for advice and consultation on appropriate treatment and for approvals to discharge to sanitary sewer. Washwater must be conveyed to a sanitary sewer after approval by the LOTT Alliance Industrial Pretreatment Program, temporarily stored before proper disposal or recycling, with no discharge to the ground, a storm drain, or surface water.

Washwater may be discharged to the ground after proper treatment in accordance with *Ecology guidance WQ-R-95-56, "Vehicle and Equipment Washwater Discharges," Revised 9/2007*. The quality of any discharge to the ground after proper treatment (gravity separation followed by media filtration) must comply with Ecology's Ground Water Quality Standards, Chapter 173-200 WAC. Contact the Ecology Southwest Regional Office for an NPDES permit application for discharge of washwater to surface water or to a storm drain after onsite treatment.

Required BMPs

Conduct vehicle and equipment washing in one of the following locations:

- At a commercial washing facility in which the washing occurs in an enclosure and drains to the sanitary sewer, or
- In a building constructed specifically for washing of vehicles and equipment, which drains to a sanitary sewer.

Conduct outside washing operation in a designated wash area with the following features:

- In a paved area, constructed as a spill containment pad to prevent the run-on of stormwater from adjacent areas. Slope the spill containment area so that washwater is collected in a containment pad drain system with perimeter drains, trench drains, or catchment drains. Size the containment pad to extend out a minimum of four feet on all sides of the vehicles and/or equipment being washed.

- Convey the washwater to a sump (like a grit separator) and then to a sanitary sewer (if allowed by the Thurston County Sewer Utility), or other appropriate wastewater treatment or recycle system. An NPDES permit may be required for any washwater discharge to a storm drain or receiving water after treatment. Contact the Ecology Southwest Regional Office for NPDES permit requirements.

- Any discharge to the sanitary sewer requires the approval of the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider. Contact the utility for details on approved systems.

Suggested BMPs

- The wash area should be well marked at gas stations, multifamily residences, and any other business where non-employees wash vehicles.

- For uncovered wash pads, the positive control outlet valve may be manually operated, but a pneumatic or electric valve system is preferable. The valve may be on a timer circuit where it is opened upon completion of a wash cycle. The timer would then close the valve after the sump or separator is drained.

Note that the purpose of the valve is to convey only washwater and contaminated stormwater to a treatment system.

- Use phosphate-free biodegradable detergents when practicable.

- Consider recycling the washwater.

- Because soluble/emulsifiable detergents can be used in the wash medium, the selection of soaps and detergents and treatment BMPs should be considered carefully. Oil/water separators are ineffective in removing emulsified or water soluble detergents.

- At commercial parking lots, where it is not possible to discharge the washwater to a sanitary sewer, a temporary plug or a temporary sump pump can be used at the storm drain to collect the washwater for offsite disposal.

Charity car washes are not allowed to discharge washwater to the county stormwater drainage system. For optional fund-raiser information, contact the Puget Sound Car Wash Association at (800) 509-9274. Online, visit: www.charitycarwash.org.

- New and used car dealerships may wash vehicles in the parking stalls without soap, or if an approved treatment system for the washwater is in place.

At industrial sites, contact the Ecology Southwest Regional Office for NPDES permit requirements even if soaps, detergents, and/or other chemical cleaners are not used in washing trucks.

A1.4 Collection and Disposal of Wastewater in Mobile Interior Washing Operations

This activity applies to businesses that wash carpets and other interior items on a mobile site-to-site basis. The typical fleet washing process includes use of machines that spray the washwater solution onto the carpet or upholstery and then vacuums the dirty solution up into a portable tank with limited capacity.

Description of Pollutant Sources: Pollutants of concern are nutrients, suspended solids, organic compounds (such as pesticides and chemicals used for flea and odor control), biochemical oxygen demand (BOD), and chemical oxygen demand (COD).

Pollutant Control Approach: Previously, common practice was to discharge the dirty solution to the ground or to a drain connected to the stormwater drainage system between site visits. **These practices are now illegal.** This point must be made clear to all employees. Wastewater from mobile washing operations may be permitted for sanitary sewer disposal if it does not contain high concentrations of toxic materials.

Required BMPs

The following BMPs are required of all businesses doing mobile interior wash activities:

- Wastewater from mobile washing operations must be poured into a sanitary sewer drain at the site of collection, the business office, or at another proper location. If discharging to a sanitary sewer, permits must be obtained from the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider.
- Absolutely no wastewater from mobile interior wash activities can be disposed of outdoors, or to a drain connected to the stormwater drainage system.
- Some chemicals used for flea and odor control are listed by U.S. Environmental Protection Agency (U.S. EPA) as toxics. The LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider will need to know the type of chemicals and amount of water you intend to discharge. If the discharge is approved, they will then issue a permit for your activity.

- If sanitary sewer disposal is not available or not allowed, the collected wastewater must be returned to the business site for process treatment or transfer to a holding tank. See BMP S.3 in Chapter 5 for details on these drainage/disposal alternatives.

Suggested BMPs

The following BMPs are not required, but can provide additional pollution protection:

- Use the least toxic detergents and cleaners that will get the job done. Select non-phosphate detergents when possible.

- Limit the amount of water used in interior washing operations. This will save you time, money, and effort when it comes to proper disposal.

- Recycle washwater for more than one use.

Section A2

Transfer of Liquid or Solid Materials

A2.1 Loading and Unloading Areas for Liquid or Solid Material

Description of Pollutant Sources: Loading and unloading of liquid and solid materials at industrial and commercial facilities is typically conducted at shipping and receiving, outside storage, and fueling areas. Transferred materials can include raw materials, waste materials, fuels, and scrap metals. Leaks and spills of fuels, oils, powders, organics, heavy metals, salts, acids, alkalis, and other chemicals during transfer are potential causes of stormwater contamination. Spills from hydraulic line breaks are a common problem at loading docks.

Pollutant Control Approach: Cover and contain the loading/ unloading area where necessary to prevent run-on of stormwater and runoff of contaminated stormwater.

Required BMPs

At All Loading/Unloading Areas:

- A significant amount of debris can accumulate at outside, uncovered loading/unloading areas. Sweep these surfaces frequently to remove material that could be washed off by stormwater. Sweep outside areas that are covered for a period of time by containers, logs, or other material after the areas are cleared.

- Place drip pans, storm drain covers or other temporary containment devices at locations where leaks or spills may occur such as hose connections, hose reels, and filler nozzles. Drip pans shall always be used when making and breaking connections (Figure 4.4). Check loading/unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed.

    - Consistent with applicable fire code requirements and to the extent practicable, conduct unloading or loading of solids and liquids in a manufacturing building or under a roof, lean-to, or other appropriate cover.

    - Berm, dike, and/or slope the loading/unloading area to prevent run-on of stormwater and to prevent the runoff or loss of any spilled material from the area.

    - Large loading areas frequently are not curbed along the shoreline. As a result, stormwater passes directly off the paved surface into surface water. Place curbs along the edge, or slope the edge such that the stormwater can flow to an internal stormwater drainage system that leads to an approved treatment BMP.

- Pave and slope loading/unloading areas to prevent the pooling of water. The use of catch basins and drain lines within the interior of the paved area must be minimized as they will frequently be covered by material, or they should be placed in designated "alleyways" that are not covered by material, containers, or equipment.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.4. Drip Pan for Connections at Loading and Unloading Areas for Liquid Material.

- To minimize the risk of accidental spillage, prepare an "Operations Plan" that describes procedures for loading/unloading. Train the employees, especially fork lift operators, in its execution and post it or otherwise have it readily available to employees and regulatory officials.
- Report spills of reportable quantities to Ecology Southwest Regional Office (refer to Chapter 7 for telephone number).
- Prepare and implement an emergency spill cleanup plan for the facility (BMP A7.14 Spills of Oil and Hazardous Substances) which includes the following BMPs:

- Ensure cleanup of liquid/solid spills in the loading/unloading area immediately if a significant spill occurs, upon completion of the loading/unloading activity, or at the end of the working day.
- Retain and maintain an appropriate oil spill cleanup kit on site for rapid cleanup of material spills (see BMP A7.14 Spills of Oil and Hazardous Substances).
- Ensure that an employee trained in spill containment and cleanup is present during loading/unloading.

At Rail Transfer Areas to Above/Below-ground Storage Tanks:

- Install a drip pan system as illustrated (Figure 4.4) within the rails to collect spills/leaks from tank cars and hose connections, hose reels, and filler nozzles.

Loading/Unloading from/to Marine Vessels:

- Facilities and procedures for the loading or unloading of petroleum products must comply with Coast Guard requirements.

Transfer of Small Quantities from Tanks and Containers:

- Refer to BMPs A4.8 Storage of Liquids in Permanent Aboveground Tanks and A4.7 Storage of Liquid, Food Waste, or Dangerous Waste Containers for requirements on the transfer of small quantities from tanks and containers, respectively.

Suggested BMPs

- For the transfer of pollutant liquids in areas that cannot contain a catastrophic spill, install an automatic shutoff system in case of unanticipated off-loading interruption (e.g., coupling break, hose rupture, overfill, etc.).

At Loading and Unloading Docks:

- Install/maintain overhangs or door skirts that enclose the trailer end (Figures 4.5 and 4.6) to prevent contact with rainwater.
- Design the loading/unloading area with berms, sloping, etc. to prevent the run-on of stormwater.
- Retain on site the necessary materials for rapid cleanup of spills.

Figure 4.5. Loading Docks with an Overhang to Prevent Material Contact with Rainwater.

Figure 4.6. Door Skirts to Enclose the Trailer End of a Truck to Prevent Material Contact with Rainwater.

At Tanker Truck Transfer Areas to Above/Below-Ground Storage Tanks:

- Pave the area on which the transfer takes place. If any transferred liquid, such as gasoline, is reactive with asphalt, pave the area with Portland cement concrete.

- Slope, berm, or dike the transfer area to a dead-end sump, spill containment sump, spill control oil/water separator, or other spill control device. The minimum spill retention time should be 15 minutes at the highest fuel dispenser nozzle through-put rate or the peak flow rate of the 6-month, 24-hour storm event over the surface of the containment pad, whichever is greater. The volume of the spill containment sump shall be a minimum of 50 gallons with an adequate grit sedimentation volume.

A2.2 Fueling at Dedicated Stations

Description of Pollutant Sources: A fueling station is a facility dedicated to the transfer of fuels from a stationary pumping station to mobile vehicles or equipment. It includes above or under-ground fuel storage facilities. In addition to general service gas stations, fueling may also occur at 24-hour convenience stores, construction sites, warehouses, car washes, manufacturing establishments, port facilities, and businesses with fleet vehicles. Typically, stormwater contamination at fueling stations is caused by leaks/spills of fuels, lube oils, radiator coolants, and vehicle washwater.

Pollutant Control Approach: New or substantially remodeled fueling stations must be constructed on an impervious concrete pad under a roof to keep out rainfall and stormwater run-on. Substantial remodeling includes replacing the canopy or relocating or adding one or more fuel dispensers in such a way that the Portland cement concrete (or equivalent) paving in the fueling area is modified. A treatment BMP must be used for contaminated stormwater and wastewaters in the fueling containment area.

Required BMPs

For New or Substantially Remodeled Fueling Stations:

- Prepare an emergency spill response and cleanup plan (per BMP A7.14 Spills of Oil and Hazardous Substances) and have designated trained person(s) available either on site or on call at all times to promptly and properly implement that plan and immediately cleanup all spills. Keep suitable cleanup materials, such as dry adsorbent materials, on site to allow prompt cleanup of a spill.

- Train employees on the proper use of fuel dispensers. Post signs in accordance with fire codes. Post “No Topping Off” signs (topping off gas tanks causes spillage and vents gas fumes to the air). Make sure that the automatic shut off on the fuel nozzle is functioning properly.

- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer, particularly at unattended or self-serve stations.

- Keep drained oil filters in a suitable container or drum.

- Design the fueling island to control spills (dead-end sump or spill control separator in compliance with the applicable fire codes) and to treat collected stormwater and/or wastewater to required levels. Slope the concrete containment pad around the fueling island toward drains: trench drains, catch basins, and/or a dead-end sump. The slope of the drains shall not be less than 1 percent. Drains to treatment shall have a shutoff valve, which must be closed in the event of a spill. The spill control sump must be sized in compliance with the applicable fire code.

OR

- Design the fueling island as a spill containment pad with a sill or berm raised to a minimum of 4 inches or in accordance with the applicable fire code) to prevent the runoff of spilled liquids and to prevent run-on of stormwater from the surrounding area. Raised sills are not required at the open-grate trenches that connect to an approved drainage-control system.

- The fueling pad must be paved with Portland cement concrete, or equivalent. Asphalt is not considered an equivalent material.

- The fueling island must have a roof or canopy to prevent the direct entry of precipitation onto the spill containment pad (Figure 4.7). The roof or canopy shall, at a minimum, cover the spill containment pad (within the grade break or fuel dispensing area) and preferably extend several additional feet to reduce the introduction of windblown rain. Convey all roof drains to storm drains outside the fueling containment area.

Figure 4.7. Roof at Fueling Island to Prevent Stormwater Runon.

- Stormwater collected on the fuel island containment pad must be conveyed to a sanitary sewer system, if approved by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider; or to an approved treatment system such as an oil/water separator and a basic treatment BMP (basic treatment BMPs are listed in Volume V and include media filters and biofilters). Discharges from treatment systems to storm drains or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain greater than a significant amount of oil and grease.

- Alternatively, stormwater collected on the fuel island containment pad may be collected and held for proper offsite disposal.
- Conveyance of any fuel-contaminated stormwater to a sanitary sewer must comply with pretreatment regulations (WAC 173-216-060) and the LOTT Alliance Industrial Pretreatment Program. Contact the LOTT Alliance at (360) 528-5708 or your local sewer service provider.
- Transfer the fuel from the delivery tank trucks to the fuel storage tank in impervious contained areas and ensure that appropriate overflow protection is used. Alternatively, cover nearby storm drains during the filling process and use drip pans under all hose connections.

Additional BMP for Vehicles 10 Feet in Height or Greater:

A roof or canopy may not be practicable at fueling stations that regularly fuel vehicles that are 10 feet in height or greater, particularly at industrial or WSDOT sites. At those types of fueling facilities, the following BMPs apply, as well as all of the other required BMPs and fire prevention requirements.

- If a roof or canopy is impractical, the concrete fueling pad must be equipped with emergency spill control, which includes a shutoff valve for the drainage from the fueling area. The valve must be closed in the event of a spill. An electronically actuated valve is preferred to minimize the time lapse between spill and containment. Spills must be cleaned up and disposed of off site in accordance with BMP A7.14 Spills of Oil and Hazardous Substances.
- The valve may be opened to convey contaminated stormwater to a sanitary sewer, if approved by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider, or to oil removal treatment such as an American Petroleum Institute (API) or coalescent plate oil/water separator, or equivalent treatment, and then to a basic treatment BMP. See Volume V for more information. Discharges from treatment systems to storm drains or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain greater than a significant amount of oil and grease.

A2.3 Engine Repair and Maintenance

Description of Pollutant Sources: This activity applies to businesses and public agencies where fuel filters, engine oil, and other fluids such as battery acid, coolants, and transmission and brake fluids are removed and replaced in vehicles and equipment. It also applies to mobile vehicle maintenance operations, such as at construction sites. Related vehicle maintenance activities are covered under the following activity headings in this volume, and other BMPs provided in this volume:

A1.3 Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures

A2.1 Loading and Unloading Areas for Liquid or Solid Material

A2.2 Fueling at Dedicated Stations

A2.4 Mobile Fueling of Vehicles and Heavy Equipment

A3.7 Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and Equipment

A4.9 Parking and Storage for Vehicles and Equipment

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, pH, and heavy metals.

Pollutant Control Approach: Control of leaks and spills of fluids using good housekeeping and cover and containment BMPs.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and agencies engaged in engine and vehicle repair:

- Employees must be educated about the need for careful handling of automotive fluids. Employees at businesses or agencies who routinely change or handle these fluids must be trained in spill response and cleanup procedures. Inspect all incoming vehicles, parts, and equipment stored temporarily outside for leaks.

- Remove batteries and liquids from vehicles and equipment in designated areas designed to prevent stormwater contamination. Store cracked batteries in a covered non-leaking secondary containment system.

- Empty fuel filters before disposal.

- Spill cleanup materials, such as rags and absorbent materials, must always be kept close at hand when changing oil and other fluids. You can comply more easily with sewer and stormwater requirements by running a 'dry shop', thereby reducing your consumption/discharge of liquids. Soiled rags and other cleanup material must be properly disposed of or cleaned and reused. Contact Thurston County Waste Management at (360) 754-4581 or your local solid waste hauler for proper disposal options.

- No drains inside maintenance buildings may connect to the sanitary sewer without prior written approval of your sewer service provider. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider. Interior drains will not be allowed to be connected to the stormwater drainage system.

- Do not hose down the maintenance/repair area. Instead, sweep the area weekly to collect dirt, and wipe up spills with rags and other absorbent materials.

- If the work is done at a mobile location, such as a construction site, a tarpaulin, ground cloth, or drip pans must be used beneath the vehicle or equipment to capture all spills and drips (Figure 4.8). The collected drips and spills must be recycled or disposed of properly. See BMP S.2 in Chapter 5 for disposal options.

Figure 4.8. Drip Pan for Use at Mobile Sites.

- If this activity occurs at a stationary business location, the activity area must be moved indoors. An exception to this requirement would be equipment that is too large to fit under a roofed area. In this case, the outdoor area must be paved, provided with a sump drain, and provision made for stormwater run-on prevention. See BMP S.6 and S.7 in Chapter 5 for more on paving, sump drains and holding tanks, and run-on prevention. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for information on requirements for disposal to sewer. If you are on a septic tank, sump contents will need to be pumped and disposed of by an oil recycler or hazardous waste company.

- Recycle oil, antifreeze, batteries, and air conditioning coolant.
- Contaminated stormwater runoff from vehicle staging and maintenance areas must be conveyed to an API or coalescing plate oil and water separator followed by a basic treatment BMP (see Volume V), applicable filter, or other equivalent oil treatment system.

Suggested BMPs

- Drain all fluids from wrecked vehicles and 'parts' cars/equipment upon arrival. Recover air conditioning gases.
- Use reusable cloth rags to cleanup drips and small spills instead of disposables: these can be professionally laundered and reused. Do not attempt to launder these at home or at a coin-op laundry.
- Use absorbent pillows or booms in or around storm drains and catch basins to absorb oil and fuel.

A2.4 Mobile Fueling of Vehicles and Heavy Equipment

Description of Pollutant Sources: Mobile fueling, also known as fleet fueling, wet fueling, or wet hosing, is the practice of filling fuel tanks of vehicles by tank trucks that are driven to the yards or sites where the vehicles to be fueled are located. Mobile fueling is only conducted using diesel fuel, as mobile fueling of gasoline is prohibited. Diesel fuel is considered a Class II Combustible Liquid, whereas gasoline is considered a Flammable Liquid.

Historically mobile fueling has been conducted for off-road vehicles that are operated for extended periods of time in remote areas. This includes construction sites, logging operations, and farms. Mobile fueling of on-road vehicles is also conducted commercially in the State of Washington.

Note that some local fire departments may have restrictions on mobile fueling.

Pollutant Control Approach: Proper training of the fueling operator, and the use of spill/drip control and reliable fuel transfer equipment with backup shutoff valving are typically needed.

Required BMPs

Organizations and individuals conducting mobile fueling operations must implement the following BMPs. The operating procedures for the driver/operator should be simple, clear, effective and their implementation verified by the organization that will potentially be liable for environmental and third party damage.

- Ensure that all mobile fueling operations are approved by the Thurston County Fire District and comply with applicable fire codes.
- In fueling locations that are in close proximity to sensitive aquifers, designated wetlands, wetland buffers, or other waters of the state, Thurston County acceptance is necessary to ensure compliance with additional local requirements.
- Ensure the compliance with all 49 CFR 178 requirements for DOT 406 cargo tanker. Documentation from a U.S. Department of Transportation Registered Inspector shall be proof of compliance.
- Ensure the presence and the constant observation/monitoring of the driver/operator at the fuel transfer location at all times during fuel transfer and ensure that the following procedures are implemented at the fuel transfer locations:

  - Locating the point of fueling at least 25 feet from the nearest storm drain or inside an impervious containment with a volumetric holding capacity equal to or greater than 110 percent of the fueling tank volume, or covering the storm drain to ensure no inflow of spilled or leaked fuel. Cover storm drains except those that convey the inflow to a spill control separator approved by Thurston County, including the Thurston County Fire Marshal. Potential spill/leak conveyance surfaces must be impervious and in good repair.

  - Placing a drip pan or an absorbent pad under each fueling location prior to and during all dispensing operations. The pan (must be liquid tight) and the absorbent pad must have a capacity of 5 gallons. Spills retained in the drip pan or the pad need not be reported.

  - Handling and operating of fuel transfer hoses and nozzle, drip pan(s), and absorbent pads as needed to prevent spills/leaks of fuel from reaching the ground, storm drains, and receiving waters.

  - Not extending the fueling hoses across a traffic lane without fluorescent traffic cones, or equivalent devices, conspicuously placed so that all traffic is blocked from crossing the fuel hose.

  - Removing the fill nozzle and cessation of filling when the automatic shut-off valve engages. Do not allow automatic shutoff fueling nozzles to be locked in the open position.

  - Not “topping off” the fuel receiving equipment.

- Provide the driver/operator of the fueling vehicle with:

  - Adequate flashlights or other mobile lighting to view fill openings with poor accessibility. Consult with the Thurston County Fire Marshal for additional lighting requirements.

  - Two-way communication with his/her home base.

- Train the driver/operator annually in spill prevention and cleanup measures and emergency procedures. Make all employees aware of the significant liability associated with fuel spills.

- The fueling operating procedures should be properly signed and dated by the responsible manager, distributed to the operators, retained in the organization files, and made available in the event an authorized government agency requests a review.

- In the event of any spill entering the surface water or groundwater, immediately notify the local fire district (or fire department) and the Ecology Southwest Regional Office. Establish a "call down list" to ensure the rapid and proper notification of management and government officials should any significant amount of product be lost off site. Keep the list in a protected but readily accessible location in the mobile fueling truck. The "call down list" should also identify spill response contractors available in the area to ensure the rapid removal of significant product spillage into the environment.

- Maintain a minimum of the following spill cleanup materials in all fueling vehicles, that are readily available for use:
  - Non-water absorbents capable of absorbing 15 gallons of diesel fuel
  - A storm drain plug or cover kit
  - A non-water absorbent containment boom of a minimum 10 feet in length with a 12-gallon absorbent capacity (Figure 4.9)
  - A non-metallic shovel; and
  - Two, 5-gallon buckets with lids.

Figure 4.9. Spill Containment Boom.

- Use automatic shutoff nozzles for dispensing the fuel. Replace automatic shut-off nozzles as recommended by the manufacturer.

- Maintain and replace equipment on fueling vehicles, particularly hoses and nozzles, at established intervals to prevent failures.

- Include the following fuel transfer site components:

    - Automatic fuel transfer shut-off nozzles; and
    - An adequate lighting system at the filling point.

Section A3

Production and Application Activities

A3.1 Concrete and Asphalt Mixing and Production at Stationary Sites

Description of Pollutant Sources: This activity applies to businesses and agencies that mix raw materials onsite to produce concrete or asphalt. It also applies to subsequent uses such as pouring concrete structures and making other concrete or asphalt products. Mobile concrete pouring and asphalt application are covered under **Activity A3.2** in this section. Requirements for stockpiling of raw materials are covered under **Activity A4.1 Storage or Transfer (Outside) of Solid Raw Materials, By-products or Finished Products.**

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, heavy metals, and pH.

Pollutant Control Approach: Cover and contain processes where possible and prevent stormwater run-on and contamination, where feasible.

Any facility categorized under SIC Code 2951 (asphalt paving mixtures and blocks) or SIC Code 3273 (ready-mix concrete) may need to comply with Ecology's sand and gravel general permit. Contact Ecology at (360) 407-6400 for additional information.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and public agencies active in concrete and asphalt mixing and production:

- Eliminate all illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for a detailed discussion on identifying and eliminating these connections.

- All process water from production, pouring, and equipment cleaning must be discharged to a dead-end sump, process water treatment system, or sanitary sewer (subject to approval by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider if outside of the LOTT service area), or recycled. Never wash fresh concrete or concrete mixer washout into streets, stormwater drainage systems, streams, or other water bodies.

- A BMP maintenance schedule must be established, and employees educated about the need to prevent stormwater contamination through the use and proper maintenance of BMPs.

Suggested BMPs

- The production and pouring area should be swept at the end of each workday to collect loose chunks of aggregate and raw materials for recycling or proper disposal. See BMP S.2 in Chapter 5 for disposal options.

- Sweep all driveways and gutters that show accumulation of materials to minimize the amount that could be carried offsite by rain and enter the stormwater drainage system.

- Asphalt plants should use an oil/water separator to treat stormwater runoff. See Volume V of this manual, Runoff Treatment BMPs, for more information.

- Production and pouring areas shall be protected from stormwater run-on. See BMP S.7 in Chapter 5 for methods of run-on protection.

- Use absorbent materials in and around storm drains and catch basins to filter out contaminants. See Volume V of this manual, Runoff Treatment BMPs, for more information.

- Pave the mixing, production, and pouring areas. A sump drain in these areas is probably not advisable due to potential clogging problems, but could be used in a curing area. Sweep these areas to remove loose aggregate and recycle or dispose of properly.

- Use storm drain covers or similarly effective containment devices to prevent runoff from entering the stormwater drainage system. Accumulations of dirty runoff must be disposed of properly.

Contact the Thurston County Storm and Surface Water Utility at (360) 754-4681 for information about water quality treatment BMPs for these types of operations. Visit Ecology's Web site for accepted water quality treatment at:
<http://www.ecy.wa.gov/programs/wq/stormwater/index.html>.

The use of any treatment BMP must not result in the violation of groundwater or surface water quality standards.

A3.2 Concrete Pouring, Concrete Cutting, and Asphalt Application at Temporary Sites

Description of Pollutant Sources: This activity applies to businesses and public agencies that apply asphalt or pour or cut concrete for building construction and remodeling, road construction, sidewalk, curb and gutter repairs and construction, sealing of driveways and roofs, and other applications. These activities are typically done on a temporary site-to-site basis where permanent BMP measures do not apply. Concrete pouring activities can severely alter the pH of receiving waters slurry from aggregate washing can harden in storm pipes, reducing capacity and creating flooding problems. Concrete cutting uses water for cooling and the fine particulates suspended in the resulting slurry are particularly hard to treat.

Pollutants of concern include toxic hydrocarbons, toxic organic compounds, oils and greases, heavy metals, suspended solids, and pH.

Pollutant Control Approach: Train employees on proper procedures, sweep or shovel aggregate chunks, collect accumulated runoff and solids, and wash equipment in designated areas.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and agencies doing concrete pouring and asphalt application at temporary sites:

- Employees must be educated on the pollution hazards of concrete and asphalt application and cutting.

- Loose aggregate chunks and dust must be swept or shoveled and collected (not hosed down a storm drain) for recycling or proper disposal at the end of each workday, especially at work sites such as streets, driveways, parking lots, sidewalks, curbs, and gutters where rain can readily pick up the loose material and carry it to the nearest stormwater conveyance. Small amounts of excess concrete, grout, and mortar can be disposed of in the trash.

- Storm drain covers or similarly effective containment devices must be placed over all nearby drains at the beginning of each day. Shovel or vacuum slurry and remove from the site. All accumulated runoff and solids must be collected and properly disposed of (see BMP S.2 in Chapter 5 for disposal options) at the end of each workday, or more often if necessary.

- Exposed aggregate washing (where the top layer of unhardened concrete is hosed or scraped off to leave a rough finish) must be done with a mechanism for containment and collection of the discarded concrete slurry (such as the storm drain covers mentioned above).

- Cleaning of concrete application and mixing equipment or concrete vehicles on the work site must be done in a designated area where the rinse water is controlled to prevent any runoff to surface water features. The rinse water must either be collected for proper disposal or disposed of on site, only where depth to groundwater and soil conditions will ensure that the water can percolate away and the solids can be captured by the soil matrix and later covered with soil or recovered and disposed of or recycled. If soils are very porous (outwash sands and gravels) with shallow (<15-ft) depth to groundwater, the rinsate area shall be lined and rinsate collected for disposal at a wastewater treatment facility.

The use of any treatment BMP must not result in the violation of groundwater or surface water quality standards.

Suggested BMPs

- Avoid the activity when rain is occurring or expected.

- If possible, portable asphalt mixing equipment should be covered by an awning, a lean-to, or another simple structure to avoid contact with rain. See BMP S.4 in Chapter 5 for further details on cover structures.

- Recycle broken concrete and asphalt. Look under Recycling Services in the Yellow Pages of the phone book to find the recycler nearest you.

A3.3 Manufacturing and Postprocessing of Metal Products

Description of Pollutant Sources: This activity applies to businesses such as mills, foundries, and fabricators that manufacture or postprocess metal products. A variety of activities such as machining, grinding, soldering, cutting, welding, quenching, cooling, and rinsing may take place. These businesses may be required to obtain a NPDES permit from Ecology. See Chapter 7 for a discussion of NPDES requirements. Note: Painting, finishing and coating of metal products is covered under **A3.7 Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and Equipment.**

Pollutants of concern include toxic organic compounds, heavy metals, oils and greases, pH, suspended solids, and chemical oxygen demand (COD).

Pollutant Control Approach: Cover and contain operations. Apply good housekeeping practices such as sweeping and avoid storage where metals are exposed to rain.

Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in metals manufacturing or postprocessing:

- Eliminate illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for detailed information on identifying and eliminating illicit connections.
- Process wastewater including contact cooling water, filter backwash, cooling tower blow down, and stormwater runoff from activity areas, must discharge to a sanitary sewer, holding tank, or process treatment system. Such systems require an Ecology NPDES permit for discharge to surface water or storm drain. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider if outside the LOTT service area to obtain permits for discharge to the sewer. See BMP S.3 in Chapter 5 for detailed requirements.
- Employees must be educated in proper handling to control their work with metal products to minimize pollution.
- The activity area must be swept at the end of each workday to collect and dispose of metal fragments and product residues properly. See BMP S.2 in Chapter 5 for disposal alternatives.

Suggested BMPs

- Limit the amount of water used in quenching and rinsing. Recycle used water where possible.
- Cover the activity area to prevent rain from contacting the process and reduce the amount of runoff that has to be detained or treated. See BMP A3.9.
- Implement a program to track purchase and consumption of lubricants, solvents, and additives. Check with operating managers for an explanation if consumption increases. Recommend action if significant equipment leaks or spills are identified.
- Refer to the BMPs under sections A2 Transfer of Liquid Materials and A4 Storage and Stockpiling Activities, and utilize those BMPs which are applicable for materials storage and maintenance activities in your shop.

A3.4 Wood Treatment Areas

Description of Pollutant Sources: Wood treatment includes both anti-staining and wood preserving using pressure processes or by dipping or spraying. Wood preservatives include creosote, creosote/coal tar, pentachlorophenol, copper naphthenate, arsenic trioxide, malathion, or inorganic arsenicals such as chromated copper arsenate, acid copper chromate, chromate zinc chloride, and fluor-chrome-arsenate-phenol. Anti-staining chemical additives include iodo-prophenyl-butyl carbamate, dimethyl sulfoxide, didecyl dimethyl ammonium chloride, sodium azide, 8-quinolinol, copper (II) chelate, sodium ortho-phenylphenate, 2-(thiocyanomethylthio)-benzothiazole (TCMTB) and methylene bis-(thiocyanate), and zinc naphthenate.

Pollutant sources include drips of condensate or preservative after pressurized treatment, product washwater (in the treatment or storage areas), spills and leaks from process equipment and preservative tanks, fugitive emissions from vapors in the process, blowouts and emergency pressure releases, and kick-back from lumber (phenomenon where preservative leaks as it returns to normal pressure). Potential pollutants typically include the wood treating chemicals, BOD, suspended solids, oil and grease, benzene, toluene, ethylbenzene, phenol, chlorophenols, nitrophenols, heavy metals, and PAH, depending on the chemical additive used.

Pollutant Control Approach: Cover and contain all wood treating areas and prevent all leaching of and stormwater contamination by wood treating chemicals. All wood treating facilities in Washington State are required to be covered under an Individual NPDES permit.

Required BMPs

- Equipment that is used for treatment activities should be dedicated to that use only to prevent the tracking of treatment chemicals to other areas on the site.

- Eliminate non-process traffic on the drip pad. Scrub down non-dedicated lift trucks on the drip pad.

- Immediately remove and properly dispose of soils with visible surface contamination (green soil) to prevent the spread of chemicals to groundwater and/or surface water via stormwater runoff.

- If any wood is observed to be contributing chemicals to the environment in the treated wood storage area, relocate it on a concrete chemical containment structure until the surface is clean and until it is drip free and surface dry.

- Cover and/or enclose, and contain with impervious surfaces, all wood treatment areas. Slope and drain areas around dip tanks, spray booths, retorts, and any other process equipment in a manner that allows return of treatment chemicals to the wood treatment process.

- Cover storage areas for freshly treated wood to prevent contact of treated wood products with stormwater. Segregate clean stormwater from process water. Ensure that all process water is conveyed to an approved treatment system.

- Seal any holes or cracks in the asphalt areas that are subject to wood treatment chemical contamination.

- Elevate stored, treated wood products to prevent contact with stormwater run-on and runoff.

- Place dipped lumber over the dip tank or on an inclined ramp for a minimum of 30 minutes to allow excess chemical to drip back to the dip tank.

- Place treated lumber either from dip tanks or retorts in a covered paved storage area for at least 24 hours before placement in outside storage. Use a longer storage period during cold weather unless the temporary storage building is heated. The wood shall be drip free and surface dry before it is moved outside.

Suggested BMP

- Consider using preservative chemicals that do not adversely impact receiving surface water and groundwater.

A3.5 Commercial Composting

Description of Pollutant Sources: Commercial compost facilities operating outside without cover require large areas to decompose wastes and other feedstocks. These facilities should be designed to separate stormwater from leachate (i.e., industrial wastewater) to the greatest extent possible. When stormwater is allowed to runoff after contacting any active composting areas, including waste receiving and processing areas, it becomes leachate. Pollutants in leachate include nutrients, biochemical oxygen demand (BOD), organics, coliform bacteria, acidic pH, color, and suspended solids. Stormwater at a compost facility consists of runoff from areas at the facility that are not associated with active processing and curing, such as product storage areas, vehicle maintenance areas, and access roads.

NPDES Permit Requirements: Discharge of leachate from a compost facility will require a state or NPDES permit from Ecology, depending on the disposal method chosen for managing leachate at the facility. (See Chapter 2 in "Compost Facility Resource Handbook, Guidance for Washington State," November 1998. Publication No. 97-502.) An additional alternative, zero discharge, is possible by containing all leachate from the facility (in tanks or ponds) or preventing production of leachate (by composting under a roof or in an enclosed building).

The Thurston County Public Health and Social Services Department regulates solid waste facilities in accordance with WAC 173-304. The Health & Social Services Department should be contacted at (360) 786-5581 to obtain permits and requirements for composting and recycling facilities.

Pollutant Control Approach: Consider the leachate control specified in publication No. 97-502 or zero leachate discharge.

Required BMPs

- Ensure that the compost feedstocks do not contain dangerous wastes regulated under Chapter 173-303 WAC or hazardous products of a similar nature or solid wastes that are not beneficial to the composting process. Employees must be trained to screen these materials in incoming wastes.

- Contact other federal, state, and Thurston County agencies with environmental or zoning authority for applicable permit and regulatory information. The Thurston County Public Health and Social Services Department is responsible for issuing solid waste handling permits for commercial compost facilities.

- Apply for coverage under the general permit to Discharge Stormwater Associated with Industrial Activities if the facility discharges stormwater to surface water or a municipal stormwater system. If all stormwater from the facility infiltrates into the surrounding area, the general permit is not required.

- Develop a plan of operations as outlined in the Compost Facility Resource Handbook, publication No. 97-502.

Refer to the "Compost Facility Resource Handbook, Guidance for Washington State," November 1998, publication No. 97-502, for additional design criteria and information.

- Store finished compost in a manner to prevent contamination of stormwater.

- Compost pads are required for all uncovered facilities in areas of the state with wet climates (per water quality regulations).

- Provide curbing for all compost pads to prevent stormwater run-on and leachate run-off.

- Slope all compost pads sufficiently to direct leachate to the collection device.

- Provide one or more sumps or catch basins capable of collecting all leachate generated by the design storm and conveying it to the leachate holding structure for all compost pads.

- Convey all leachate from composting operations to a sanitary sewer, holding tank, or onsite treatment system designed to treat the leachate and total suspended solids. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local service provider for permits and information.

- Ponds used to collect, store, or treat leachate and other contaminated waters associated with the composting process must be lined to prevent groundwater contamination. Apply all known available and reasonable methods of prevention and treatment (AKART) to all pond liners, regardless of the construction materials.

Suggested BMPs

- Cleanup debris from yard areas regularly.

- Locate stored residues in areas designed to collect leachate.

- Limit storage times of residues to prevent degradation and generation of leachate.

- Consider using leachate as make-up water in early stages of the composting process. Since leachate can contain pathogenic bacteria, care should be taken to avoid contaminating finished product or nearly finished product with leachate.

A3.6 Landscaping and Lawn/Vegetation Management

Description of Pollutant Sources: Landscaping can include grading, soil transfer, vegetation removal, pesticide and fertilizer application, and watering. Stormwater contaminants include toxic organic compounds, heavy metals, oils, total suspended solids, coliform bacteria, fertilizers, and pesticides.

Lawn and vegetation management can include control of objectionable weeds, insects, mold, bacteria, and other pests with chemical pesticides and is conducted commercially at commercial, industrial, and residential sites. Examples include weed control on golf course lawns, access roads, and utility corridors and during landscaping; sap stain and insect control on lumber and logs; rooftop moss removal; killing nuisance rodents; fungicide application to patio decks; and residential lawn/plant care. Toxic pesticides such as pentachlorophenol, carbamates, and organometallics can be released to the environment by leaching and dripping from treated parts, container leaks, product misuse, and outside storage of pesticide contaminated materials and equipment. Poor management of the vegetation and poor application of pesticides or fertilizers can cause appreciable stormwater contamination.

Pollutant Control Approach: Control fertilizer and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater.

Develop and implement an integrated pest management plan and use pesticides only as a last resort. Refer to Appendix IV-B Example of an Integrated Pest Management Program for more information. If pesticides/herbicides are used they must be carefully applied in accordance with label instructions on U.S. EPA registered materials. Maintain appropriate vegetation, with proper fertilizer application where practicable, to control erosion and the discharge of stormwater pollutants. Where practicable, grow plant species appropriate for the site, or adjust the soil properties of the subject site to grow desired plant species.

Required BMPs for Landscaping

- Do not dispose of grass clippings and other collected vegetation into waterways or stormwater drainage systems.
- Use mulch or other erosion control measures when soils are exposed for more than 1 week during the dry season or 2 days during the rainy season.
- If oil or other chemicals are handled, store and maintain appropriate oil and chemical spill cleanup materials in readily accessible locations. Ensure that employees are familiar with proper spill cleanup procedures.

Suggested BMPs for Landscaping

- Conduct mulch-mowing whenever practicable.
- Install engineered soil/landscape systems to improve the infiltration and regulation of stormwater in landscaped areas.
- Dispose of grass clippings, leaves, sticks, or other collected vegetation by composting, if feasible.
- Till fertilizers into the soil rather than dumping or broadcasting onto the surface. Determine the proper fertilizer application for the types of soil and vegetation encountered.
- Till a topsoil mix or composted organic material into the soil to create a well-mixed transition layer that encourages deeper root systems and drought-resistant plants.
- Use manual and/or mechanical methods of vegetation removal rather than applying herbicides, where practical.

Required BMPs for the Use of Pesticides

- Develop and implement an IPM plan (see section on integrated pest management below) and use pesticides only as a last resort.
- Implement a pesticide-use plan and include at a minimum: a list of selected pesticides and their specific uses; brands, formulations, application methods, and quantities to be used; equipment use and maintenance procedures; safety, storage, and disposal methods; and monitoring, record keeping, and public notice procedures. All procedures shall conform to the requirements of Chapter 17.21 Revised Code of Washington (RCW) and Chapter 16-228 WAC.
- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. The pesticide should readily degrade in the environment and/or have properties that strongly bind it to the soil. Any pest control used should be conducted at the life stage when the pest is most vulnerable. For example, if it is necessary to use a Bacillus thuringiensis (Bt) application to control tent caterpillars, it must be applied before the caterpillars cocoon or it will be ineffective. Any method used should be site-specific and not used wholesale over a wide area.
- Apply the pesticide according to label directions. Under no conditions shall pesticides be applied in quantities that exceed manufacturer's instructions.

- Mix the pesticides and clean the application equipment in an area where accidental spills will not enter surface or groundwater, and will not contaminate the soil.

- Store pesticides in enclosed areas or in covered impervious containment. Ensure that pesticide contaminated stormwater or spills/leaks of pesticides are not discharged to storm drains. Do not hose down paved areas to a storm drain or conveyance ditch. Store and maintain appropriate spill cleanup materials in a location known to all near the storage area.

- Cleanup any spilled pesticides and ensure that the pesticide contaminated waste materials are kept in designated covered and contained areas.

- The pesticide application equipment must be capable of immediate shutoff in the event of an emergency.

- Do not spray pesticides within 100 feet of open waters including wetlands; ponds; and streams, sloughs, and any drainage ditch or channel that leads to open water, except when approved by Ecology or by Thurston County. All sensitive areas including wells, creeks, and wetlands must be flagged prior to spraying.

- As required by Thurston County or by Ecology, complete public posting of the area to be sprayed prior to the application.

- Spray applications should only be conducted during weather conditions as specified in the label direction and applicable local and state regulations. Do not apply during rain or immediately before expected rain.

Suggested BMPs for the Use of Pesticides

- Consider alternatives to the use of pesticides such as covering or harvesting weeds, substitute vegetative growth, and manual weed control/moss removal.

- Consider the use of soil amendments, such as compost, that are known to control some common diseases in plants, such as Pythium root rot, ashy stem blight, and parasitic nematodes. The following are three possible mechanisms for disease control by compost addition (USEPA publication 530-F-9-044):

    - Successful competition for nutrients by antibiotic production
    - Successful predation against pathogens by beneficial microorganism; and
    - Activation of disease-resistant genes in plants by composts.

Installing an amended soil/landscape system can preserve both the plant system and the soil system more effectively. This type of approach provides a soil/landscape system with adequate depth, permeability, and organic matter to sustain itself and continue working as an effective stormwater infiltration system and a sustainable nutrient cycle.

- Once a pesticide is applied, its effectiveness should be evaluated for possible improvement. Records should be kept showing the applicability and inapplicability of the pesticides considered.

- An annual evaluation procedure should be developed including a review of the effectiveness of pesticide applications, impact on buffers and sensitive areas (including potable wells), public concerns, and recent toxicological information on pesticides used/proposed for use. If individual or public potable wells are located in the proximity of commercial pesticide applications, contact the regional Ecology hydrogeologist to determine if additional pesticide application control measures are necessary.

- Rinsate from equipment cleaning and/or triple-rinsing of pesticide containers should be used as product or recycled into product.

For more information, contact the WSU Extension Home-Assist Program at (253) 445-4556; Bio-Integral Resource Center (BIRC), P.O. Box 7414, Berkeley, CA 94707; or Ecology to obtain "Hazardous Waste Pesticides" (publication No. 89-41); contact U.S. EPA to obtain a publication entitled "Suspended, Canceled and Restricted Pesticides" which lists all restricted pesticides and the specific uses that are allowed. Valuable information from these sources may also be available on the Internet.

Suggested BMPs for Vegetation Management

- Use at least an 8-inch "topsoil" layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium. Amending existing landscapes and turf systems by increasing the percent organic matter and depth of topsoil can substantially improve the permeability of the soil, improve the disease and drought resistance of the vegetation, and reduce fertilizer demand. This reduces the demand for fertilizers, herbicides, and pesticides. Organic matter is the least water-soluble form of nutrients that can be added to the soil. Composted organic matter generally releases only between 2 and 10 percent of its total nitrogen annually, and this release corresponds closely to the plant growth cycle. If natural plant debris and mulch are returned to the soil, this system can continue recycling nutrients indefinitely.

- Select the appropriate turfgrass mixture for your climate and soil type. Certain tall fescues and rye grasses resist insect attack because the symbiotic endophytic fungi found naturally in their tissues repel or kill common leaf and stem-eating lawn insects. The fungi do not, however, repel root-feeding lawn pests such as Crane Fly larvae, and are toxic to ruminants such as cattle and sheep. They cause no known adverse effects to the host plant or to humans. Endophytic grasses are commercially available and can be used in areas such as parks or golf courses where grazing does not occur. The local Cooperative Extension office can offer advice on which types of grass are best suited to the area and soil type.

- Use the following seeding and planting BMPs in Volume II, or equivalent BMPs, to obtain information on grass mixtures: C120 temporary and permanent seeding procedures, C121 mulching, C122 nets and blankets, and C124 sodding.

- The numbers of desired plant species can be increased by adjusting the soil properties of the subject site. For example, a constructed wetland can be designed to resist the invasion of reed canary grass by layering specific strata of organic matters (e.g., compost forest product residuals) and creating a mildly acidic pH and carbon-rich soil medium. Consult a soil restoration specialist for site-specific conditions.

- Aerate lawns regularly in areas of heavy use, where the soil tends to become compacted. Aeration should be conducted while the grasses in the lawn are growing most vigorously. Remove layers of thatch greater than 3/4-inch deep.

- Mowing is a stress-creating activity for turfgrass. When grass is mowed too short, its productivity is decreased and there is less growth of roots and rhizomes. The turf becomes less tolerant of environmental stresses, more disease prone, and more reliant on outside means such as pesticides, fertilizers, and irrigation to remain healthy. Set the mowing height at the highest acceptable level and mow at times and intervals designed to minimize stress on the turf. Generally mowing only one-third of the grass blade height will prevent stressing the turf.

Suggested BMPs for Irrigation

- The depth from which a plant normally extracts water depends on the rooting depth of the plant. Appropriately irrigated lawn grasses normally root in the top 6 to 12 inches of soil; lawns irrigated on a daily basis often root only in the top 1 inch of soil. Improper irrigation can encourage pest problems, leach nutrients, and make a lawn completely dependent on artificial watering. The amount of water applied depends on the normal rooting depth of the turfgrass species used, the available water holding capacity of the soil, and the efficiency of the irrigation system. Consult with your local water purveyor, the Thurston Conservation District (360-754-3588), or a Cooperative Extension office to help determine optimum irrigation practices.

Suggested BMPs for Fertilizer Management

- Turfgrass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site depending on plant, soil, and climatic conditions. Evaluate soil nutrient levels through regular testing to determine how much nutrients the soil needs, if any, which also saves money. For details on soils testing, contact the Thurston Conservation District or Cooperative Extension Service.

- Fertilizers should be applied in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and groundwater. Do not fertilize during a drought or when the soil is dry. Plants need moisture to take up fertilizer and avoid fertilizer “burn”. Alternatively, do not apply fertilizers within 3 days prior to predicted rainfall. The longer the period between fertilizer application and either rainfall or irrigation, the less fertilizer runoff occurs. After a rain, but well before the next storm is a good time for application.

- Use slow release fertilizers such as methylene urea, IDBU, or resin coated fertilizers when appropriate, generally in the spring. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.

- Time the fertilizer application to periods of maximum plant uptake. Generally fall and spring applications are recommended, although WSU turf specialists recommend four fertilizer applications per year.

Properly trained persons should apply all fertilizers. At commercial and industrial facilities, fertilizers should not be applied to grass swales, filter strips, or buffer areas that drain to sensitive water bodies unless approved by the County.

Suggested BMPs for IPM

An integrated pest management program might consist of the following steps:

Step 1 Correctly identify problem pests and understand their life cycle.

Step 2 Establish tolerance thresholds for pests.

Step 3 Monitor to detect and prevent pest problems.

Step 4 Modify the maintenance program to promote healthy plants and discourage pests.

Step 5 Use cultural, physical, mechanical, or biological controls first if pests exceed the tolerance thresholds.

Step 6 Evaluate and record the effectiveness of the control and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

For an elaboration of these steps refer to Appendix IV-B, Example of an IPM Program.

A3.7 Painting, Finishing, and Coating of Vehicles, Boats, Buildings, and Equipment

Description of Pollutant Sources: Surface preparation and the application of paints, finishes, and/or coatings to vehicles, boats, buildings, and/or equipment outdoors can be sources of pollutants. Potential pollutants include organic compounds, oils and greases, heavy metals, and suspended solids.

Pollutant Control Approach: Cover and contain painting and sanding operations and apply good housekeeping and preventive maintenance practices to prevent the contamination of stormwater with painting oversprays and grit from sanding.

Required BMPs

- Train employees in the careful application of paints, finishes, and coatings to reduce misuse and overspray. Use ground or drop cloths underneath outdoor painting, scraping, sandblasting work, and properly clean and temporarily store collected debris daily.

- Do not conduct spraying, blasting, or sanding activities over open water or where wind may blow paint or waste into water.

- Wipe up spills with rags and other absorbent materials immediately. Do not hose down the area to a storm drain, receiving water, or conveyance ditch to receiving water.

- On marine dock areas, sweep rather than hose down debris. Collect any hose water generated and convey to appropriate treatment and disposal.

- Use a storm drain cover, filter fabric, or similarly effective runoff control device if dust, grit, washwater, or other pollutants may escape the work area and enter a catch basin. The containment device(s) must be in place at the beginning of the workday. Collect contaminated runoff and solids and properly dispose of such wastes before removing the containment device(s) at the end of the workday.

- Use a ground cloth, pail, drum, drip pan, tarpaulin, or other protective device for activities such as paint mixing and tool cleaning outside or where spills can contaminate stormwater.

- Properly dispose of all wastes and prevent all uncontrolled releases to the air, ground, or water.

- Clean brushes and tools covered with non-water-based paints, finishes, or other materials in a manner that allows collection of used solvents, turpentine, or paint thinners for recycling or proper disposal.

- Store toxic materials under cover (tarpaulin, etc.) during precipitation events and when not in use to prevent contact with stormwater.

- Enclose or contain all work while using a spray gun or conducting sand blasting and in compliance with applicable Olympic Region Clean Air Agency (ORCAA), Occupational Safety and Health Administration (OSHA), and Washington Industrial Safety and Health Act (WISHA) requirements. Do not conduct outside spraying, grit blasting, or sanding activities during windy conditions which render containment ineffective.

Suggested BMPs

- Incidental cleaning of paintbrushes and tools covered with water-based paints in sinks connected to sanitary sewers or in portable containers that can be dumped into a sanitary sewer drain. Oil-based paints should not be washed down the drain.

- Recycle paint, paint thinner, solvents, pressure washwater, and any other recyclable materials.

- Use efficient spray equipment such as electrostatic, air-atomized, high volume/low pressure, or gravity feed spray equipment.

- Purchase recycled paints, paint thinner, solvents, and other products if feasible.

A3.8 Commercial Printing Operations

Description of Pollutant Sources: Materials used in the printing process include inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include waste inks and ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, zinc, lead, spent formaldehyde, silver, plasticizers, and used lubricating oils. As the printing operations are conducted indoors, the only likely points of potential contact with stormwater are the outside temporary waste material storage area and area where chemicals are offloaded at external unloading bays. Pollutants can include total suspended solids, pH, heavy metals, oil and grease, and COD.

Pollutant Control Approach: Ensure appropriate disposal and NPDES permitting of process wastes. Cover and contain stored raw and waste materials.

Required BMPs

- Discharge process wastewaters to a sanitary sewer (if approved by LOTT Alliance Industrial Pretreatment Program (360) 528-5708 or to an approved process wastewater treatment system).
- Do not discharge process wastes or wastewaters into storm drains or surface water.
- Determine whether any of these wastes qualify for regulation as dangerous wastes and dispose of them accordingly.
- Store raw materials or waste materials that could contaminate stormwater in covered and contained areas.

Suggested BMPs

- Train all employees in pollution prevention, spill response, and environmentally acceptable materials handling procedures.
- Store materials in proper, appropriately labeled containers. Identify and label all chemical substances.
- All stormwater management devices should be inspected regularly and maintained as necessary.
- Try to use press washes without listed solvents, and with the lowest VOC content possible. Don't evaporate ink cleanup trays to the outside atmosphere.

- Place cleanup sludges into a container with a tight lid and dispose of as hazardous waste. Do not dispose of cleanup sludges in the garbage or in containers of soiled towels.

For additional information on pollution prevention the following Ecology publications are recommended: A Guide for Screen Printers, publication No. 94-137 and A Guide for Lithographic Printers, publication No. 94-139.

A3.9 Manufacturing Operations (Outside)

Description of Pollutant Sources: Manufacturing pollutant sources include outside process areas, stack emissions, and areas where manufacturing activity has taken place in the past and significant pollutant materials remain and are exposed to stormwater.

Pollution Control Approach: Cover and contain outside manufacturing and prevent stormwater run-on and contamination, where feasible.

Required BMPs

- Sweep paved areas regularly, as needed, to prevent contamination of stormwater. Do not wash down areas into storm drains.
- Eliminate or minimize the contamination of stormwater by altering the activity.
- Enclose the activity (Figure 4.10). If possible, enclose the manufacturing activity in a building.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.10. Commercially Available Bermed Workspace.

- Cover the activity and connect floor drains to a sanitary sewer (Figure 4.11), if approved by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider if outside of the LOTT service area. Berm or slope the floor as needed to prevent drainage of pollutants to outside areas.

- Isolate and segregate pollutants, as feasible. Convey the segregated pollutants to a sanitary sewer, process treatment, or dead-end sump, depending on available methods and applicable permit requirements.

(Photo courtesy of Seattle Public Utilities)

Figure 4.11. Structure Used to Cover Manufacturing Operations.

A3.10 Agricultural Crop Production

This activity applies to farming of crops on a commercial scale. Crop farming practices can cause a large variety of pollution problems in receiving waters. Many of these practices can be altered without adversely affecting the farmers' ability to produce the same crops.

One of the most effective BMPs for stormwater pollution prevention the farmer can pursue is education. Contact the Thurston County Conservation District at (360) 754-3588. They will help develop a farm plan that covers all aspects of the farming operation, with particular care and attention to soil conservation and water resource protection. Conservation tillage and many other measures can help save money. The agencies also have access to grants to pay for conservation plantings and stream corridor fencing.

Pollutants of Concern: Toxic organic compounds, oils, heavy metals, nutrients, Biochemical oxygen demand (BOD), suspended solids (e.g., sediments), fecal bacteria.

Crop farms should implement agricultural practices proven to limit erosion. Several farming techniques aimed at reducing erosion have been proven successful. Individual farms should implement the combination of the following BMPs that best suits conditions present:

Suggested BMPs

- Maintain ground cover. Cover bare areas with material such as mulch or green manure during times when land is not in production.
- Practice conservation tillage. Implement tillage or planting systems in which at least 30 percent of the soil surface is covered by plant residue after planting.
- Practice conservation cover. Establish and maintain perennial vegetation cover to protect soil and water resources on land retired from agricultural production.
- Utilize contour farming. Plow, prepare, plant and cultivate land on contours perpendicular to the slope of the land in a terrace-like fashion, so that runoff cannot proceed directly along a row but rather is impeded by rows in its path, thus allowing for more infiltration.
- Plant critical areas. Plant vegetation such as trees, shrubs, vines, grasses, and legumes on highly erodible or critical areas to stabilize the soil.

- Plant and maintain vegetated buffers and filter strips. Maintain a strip of permanent vegetation downslope of crop fields so that sediments and associated pollutants in surface water runoff can be filtered out. These filter strips are especially important along stream banks, shorelines, and drainage ditches. Contact the Thurston County Conservation District at (360) 754-3588 and the Natural Resources Conservation Service at (360) 704-7740 for more information. In some instances, these organizations may be able to provide plant materials for such work free or for a low cost.

- Practice conservation irrigation. Replace flood irrigation systems with sprinkler head or drip irrigation systems that use less water. These irrigation methods reduce the amount of crop field runoff and thereby reduce erosion and pollutant transport.

Some other suggested BMPs to consider for your farm include the following:

- Use an IPM plan and reduce reliance on pesticides. Information on integrated pest management is available from the Washington State University/Thurston County Cooperative Extension Service. BMP S.8 in Chapter 5 provides some details on integrated pest management and in Appendix IV-B for an example. See Activity 3.6 for information on BMPs for pesticide and fertilizer use.

- If possible, fertilized crops should be planted as far as possible from surface drainages. This will help keep nutrients out of water bodies.

- Contact the Natural Resources Conservation Service (formerly the Soil Conservation Service) at (360) 704-7740 for information on developing specific fertilization schedules. Applying fertilizers at the right time and in the right quantity can help minimize pollution.

If possible, crop cultivation should be avoided on steep slopes.

A3.11 Application of Pesticides, Herbicides, Fungicides, and Rodenticides for Purposes Other than Landscaping

This activity applies to businesses and government agencies using pesticides, herbicides, fungicides and rodenticides for purposes such as removing moss from rooftops or decks, killing nuisance rodents and some insects (such as termites and carpenter ants) that live outdoors but can invade the home if left unchecked. Businesses and government agencies involved in these activities must comply with Thurston County Public Health and Social Services Department regulations and Washington State Department of Agriculture pesticide regulations. See Chapter 7 for more information on these regulations. The BMPs listed are intended to complement other regulations. Application of pesticides for landscaping purposes must follow the BMPs discussed under **A3.6 Landscaping and Lawn/Vegetation Management.**

Pollutants of Concern: Toxic organic compounds, oils, heavy metals, Chemical oxygen demand (COD)

Required BMPs

The following BMPs or equivalent measures are required of all businesses and agencies applying pesticides, herbicides, fungicides and rodenticides for non-landscaping purposes:

- Proper application practices must be used to avoid excessive application. Follow the manufacturers' guidelines and directions carefully.
- Never apply pesticides, herbicides, fungicides or rodenticides when rain is expected, or during rain events.
- Do not apply chemicals when it is windy. Early morning is typically the calmest time of day.
- Employees must be educated regarding the pollution potential of misusing the chemicals they are working with.
- Manage residues properly. Triple rinse or pressure rinse empty containers and mixing and application equipment. Collect all rinse water, and use it for diluting the next batch.

Suggested BMPs

- Use manual pest control measures, such as scraping or using high-pressure sprayers to remove moss from roofs and decks, before resorting to chemicals. Rodent traps can also be highly effective, without endangering pets and children as chemical baits can.

- IPM is a comprehensive approach to the use of pesticides. Integrated pest management minimizes pesticide application and stresses selection of proper products and tailored application rates. It is a sensible long-term strategy rather than a hit-and-run operation, and as such is probably the most effective BMP measure that can be utilized under this activity. See BMP S.8 in Chapter 5 for more details on integrated pest management and in Appendix IV-B for an example.

Section A4

Storage and Stockpiling Activities

A4.1 Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, or Finished Products

Description of Pollutant Sources: Solid raw materials, by-products, or products such as gravel, sand, salts, topsoil, compost, logs, sawdust, wood chips, lumber and other building materials, concrete, and metal products are often stored outside in large piles or stacks at commercial or industrial establishments. Bulk materials stored outside may leach or erode when contacted by stormwater. Contaminants include total suspended solids, BOD, organics, and dissolved metals or salts (sodium, calcium, magnesium chloride, etc).

Pollutant Control Approach: Provide impervious containment with berms, dikes, etc. and/or cover to prevent run-on and discharge of leachate pollutant(s) and total suspended solids.

Required BMPs

- Do not hose down the contained stockpile area to a storm drain or a conveyance to a storm drain or receiving water.
- Choose one or more of the source control BMP options listed below for stockpiles greater than 5 cubic yards of erodible or water soluble materials such as soil, road de-icing salts, compost, unwashed sand and gravel, or sawdust. Also included are outside storage areas for solid materials such as logs, bark, lumber, and metal products:
  - Store in a building or paved and bermed covered area as shown in Figure 4.12;
  - Place temporary plastic sheeting (polyethylene, polypropylene, hypalon, or equivalent) over the material (Figure 4.13); or
  - Pave the area and install a stormwater drainage system. Place curbs or berms along the perimeter of the area to prevent the run-on of uncontaminated stormwater and to collect and convey runoff to treatment. Slope the paved area in a manner that minimizes the contact between stormwater (e.g., pooling) and leachable materials in compost, logs, bark, wood chips, or other materials.
- For large stockpiles that cannot be covered, implement containment practices at the perimeter of the site and at any catch basins as needed to prevent erosion and discharge of the stockpiled material offsite or to a storm drain. Ensure that contaminated stormwater is not discharged directly to catch basins without being conveyed through a treatment BMP.

- Convey contaminated stormwater from the stockpile area to a wet pond, wet vault, settling basin, media filter, or other appropriate treatment system, depending on the contamination.

Figure 4.12. Covered and Secured Storage Area for Bulk Solids.

Figure 4.13. Temporary Plastic Sheeting Covering Raw Materials Stored Outdoors.

Suggested BMPs

- Maintain drainage areas in and around storage of solid materials with a minimum slope of 1.5 percent to prevent pooling and minimize leachate formation. Areas should be sloped to drain stormwater to the perimeter where it can be collected or to internal drainage “alleyways” where material is not stockpiled.

- Sweep paved storage areas regularly for collection and disposal of loose solid materials.
- If and when feasible, collect and recycle water-soluble materials (leachates) to the stockpile.
- Stock cleanup materials such as brooms, dustpans, and vacuum sweepers near the storage area.

A4.2 Storage and Treatment of Contaminated Soils

Description of Pollutant Sources: This activity applies to businesses and agencies that store and treat soils contaminated with toxic organic compounds, petroleum products, or heavy metals. Such contamination typically comes to light when an environmental audit is done or old underground tanks are removed. The soils are usually excavated and taken off site for treatment via aeration and perhaps chemical stabilization. Stormwater runoff that comes in contact with contaminated soil can carry those contaminants along with loose dirt into receiving waters.

Pollutants of concern include toxic organic compounds, oils and greases, and heavy metals.

Pollutant Control Approach: The Thurston County Public Health and Social Services Department at (360) 786-5581 regulates and permits businesses treating contaminated soil. In addition, a permit from ORCAA is required if the treatment method for removing soil contaminants involves forcing air through, or extracting air from, the soil. Contact these agencies for additional information regarding the appropriate pollutant control approach.

Required BMPs

The BMPs included here are intended as a supplement to other toxics regulations. The following BMPs or equivalent measures are required of all businesses engaged in storage and treatment of contaminated soils:

- The storage area for contaminated soils must be enclosed indoors, covered, or contained by a curb, dike, or berm constructed around the material storage area. If the contaminated soils are covered, stormwater run-on protection must also be provided. BMP S.7 in Chapter 5 provides further details on containment and run-on prevention.
- Employees must be educated on methods to prevent contamination from leaving the site.
- Cleanup materials must be stocked near the storage area.
- Gutters, storm drains, catch basins, and other drainage system features on the site must be cleaned following the completion of site work, or at least once per year, whichever comes first. Sediments from such cleaning must be disposed of properly. See BMPs S.9 and S.2 for details on catch basin cleaning and disposal options.

Suggested BMPs

- If feasible, the storage area should be swept weekly for collection of stray soil, which can be added back to the piles or properly disposed of. See BMP S.2 in Chapter 5 for information on disposal options.

- Implement one of the following treatment BMPs from Volume V in conjunction with a runoff containment plan:

    - Vegetated biofilter
    - Wet vault
    - Equivalent BMP (see Volume V).

The use of any treatment BMP must not result in the violation of groundwater or surface water quality standards.

A4.3 Temporary Storage or Processing of Fruits or Vegetables

Description of Pollutant Sources: This activity applies to businesses that temporarily store fruits and vegetables outdoors prior to processing or sale, or that crush, cut, or shred fruits or vegetables for wines, frozen juices, and other food and beverage products. Nutrients and soil washing off of fruit can have a detrimental effect on receiving waters.

Pollutants of concern include nutrients, suspended solids, biochemical oxygen demand (BOD), and color.

Pollutant Control Approach: Store and process fruits and vegetables indoors or under cover whenever possible. Educate employees about proper procedures. Eliminate illicit connections to the stormwater drainage system. Cover and contain operations and apply good housekeeping and preventive maintenance practices to prevent the contamination of stormwater.

Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in *storage* of fruits or vegetables:

- Employees must be educated on benefits of keeping a clean storage area.
- Eliminate illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for details on detecting and eliminating these connections.
- No untreated water used to clean produce can enter the stormwater drainage system. Minimize the use of water when cleaning produce to avoid excess runoff.
- Cleanup materials, such as brooms and dustpans, must be kept near the storage area.
- Gutters, storm drains, and catch basins on the property must be cleaned as needed. See BMP S.9 in Chapter 5 for details on catch basin cleaning requirements.

The following BMPs or equivalent measures are required of all businesses that *process* fruits or vegetables:

- Eliminate illicit connections to the stormwater drainage system. See BMP S.1 in Chapter 5 for details on detecting and eliminating these connections.

- Employees must be educated on benefits of keeping a clean processing area.
- Cleanup materials, such as brooms, dustpans, and shovels, must be kept near the storage area.
- The processing area must be swept or shoveled daily to collect dirt and fruit and vegetable fragments for proper disposal.
- The processing area must be enclosed in a building or shed, or covered with provisions for stormwater run-on prevention. See BMPs S.4, S.5, and S.7 in Chapter 5 for more on covering and run-on prevention.

OR

- The processing area must be paved and sloped to a sanitary sewer drain, holding tank, or process treatment system collection drain, and stormwater run-on prevention must be provided for the processing area. Call LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 for information on discharging to the sanitary sewer or your local sewer provider if not located within the LOTT service area. See BMPs S.6 and S.3 in Chapter 5 for details on paving and drainage.

Suggested BMPs

The following BMPs are not required but can provide additional pollution protection:

- Cover storage areas for fruits and vegetables. See BMPs S.4 and S.5 in Chapter 5 for more details on coverings.
- A containment curb, dike, or berm can be used to prevent offsite runoff from storage or processing areas and also to prevent stormwater run-on. See BMP S.7 in Chapter 5 for more information. Note that run-on prevention is required for processing areas, but not for storage areas.
- The storage area should be swept or shoveled daily to collect dirt and fruit and vegetable fragments for proper disposal. Keep hosing to a minimum.
- Use an approved or equivalent treatment BMPs for any run off (see Volume V).

A4.4 Storage of Solid Wastes and Food Wastes

Description of Pollutant Sources: This activity applies to businesses and public agencies that store solid wastes and food wastes outdoors. This includes ordinary garbage. If improperly stored, these wastes can contribute a variety of different pollutants to stormwater. Requirements for handling and storing solid waste may include a permit from the Thurston County Public Health and Social Services Department. For more information, call the Waste Management Section at (360) 786-5461.

NOTE: Dangerous solid wastes must be stored and handled under special guidelines. Businesses and agencies that store dangerous wastes must follow specific regulations outlined by Ecology and, in some cases, the county health department. Ecology regulations are outlined in Chapter 7. Please contact Ecology at (360) 407-6300 and the Thurston County Public Health and Social Services Department at (360) 786-5581 for the specific requirements and permitting information.

Pollutants of concern include toxic organic compounds, oils and greases, heavy metals, nutrients, suspended solids, chemical oxygen demand (COD), and biochemical oxygen demand (BOD).

Pollutant Control Approach: Store wastes in suitable containers with leak proof lids. Sweep or shovel loose solids. Educate employees about the need to check for and replace leaking containers.

Required BMPs

The following BMPs are required of all businesses and public agencies engaged in storage of non-dangerous solid wastes or food wastes:

- All solid and food wastes must be stored in suitable containers. Piling of wastes without any cover is not acceptable.
- Storage containers must be checked for leaks and replaced if they are leaking, corroded, or otherwise deteriorating.
- Storage containers must have leak-proof lids or be covered by some other means (Figure 4.14). Lids must be kept closed at all times. This is especially important for dumpsters, as birds can pick out garbage and drop it, promoting rodent, health, and stormwater problems.

OR

- If lids cannot be provided for the waste containers, or they cannot otherwise be covered, there is another option: a designated waste storage area must be provided with a containment berm, dike, or curb, and the designated area must drain to a sanitary sewer (contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider prior to any connections) or holding tank for further treatment. See BMP S.7 and S.3 in Chapter 5 for more information.

Figure 4.14. Solid Waste Dumpsters with Properly Sealed Lids.

- Employees must be trained to frequently check storage containers for leaks and to ensure that the lids are on tightly.
- The waste storage area must be swept or otherwise cleaned frequently to collect all loose solids for proper disposal in a storage container. Do not hose the area to collect or clean solids.
- If you clean your containers, all rinse water from cleaning must be disposed of in a sanitary sewer or septic system.
- Clean out catch basins on your property that receive drainage from your waste storage area. See BMP S.9 in Chapter 5 for details on catch basin cleaning.

Suggested BMPs

- If the amount of waste accumulated appears to frequently exceed the capacity of the storage container, then another storage container should be obtained and utilized.
- Store containers such that wind will not be able to knock them over.

- Designate a storage area, pave the area, and slope the drainage to a holding tank to prevent stormwater run-on or run-off. If a holding tank is used, the contents must be pumped out before the tank is full and properly disposed of. See BMP S.2 in Chapter 5 for more information on disposal options.

- Compost appropriate wastes. Contact Thurston County Waste Management at (360) 754-4581 for more information on composting.

- Recycle your solid wastes. The Industrial Materials Exchange program facilitates the transfer of excess materials and wastes to those who can use them. Industrial Materials Exchange can be reached at (206) 296-4899, toll free 1-888-TRY-IMEX or on the Web at: <www.govlink.org/hazwaste/business/imex/index.html>.

A4.5 Recyclers and Scrap Yards

Description of Pollutant Sources: This activity applies to businesses and public agencies that salvage and store scrap metal, scrap equipment, junk appliances and vehicles, empty metal drums, and recyclable items such as cans, bottles, paper products, construction materials, metals, and beverage containers. This does not apply to businesses and agencies that store these items for less than 2 weeks. Businesses engaged in these activities may be required to obtain an NPDES permit for industrial stormwater discharges from Ecology. See the discussion of NPDES requirements in Chapter 7 for more information. For these permit holders, the BMPs listed below should be used to complement NPDES requirements.

Potential sources of pollutants include paper, plastic, metal scrap debris, engines, transmissions, radiators, batteries, and other materials that contain fluids or are contaminated with fluids. Other pollutant sources include leachate from metal components, contaminated soil, and the erosion of soil. Activities that can generate pollutants include the transfer, dismantling, and crushing of vehicles and scrap metal; the transfer and removal of fluids; maintenance and cleaning of vehicles, parts, and equipment; and storage of fluids, parts for resale, solid wastes, scrap parts, and materials, equipment and vehicles that contain fluids, generally in uncovered areas.

Potential pollutants typically found at these facilities include: toxic hydrocarbons, polychlorinated biphenyls (PCBs), other toxic organic compounds, heavy metals, oils and greases, suspended solids, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), ethylene and propylene glycol, and acidic pH.

Required BMPs

For facilities subject to Ecology's industrial stormwater general permit refer to BMP Guidance Document No. 94-146, "Best Management Practices to Prevent Stormwater Pollution at Vehicle Recycler Facilities," Ecology, September 1994 for selection of BMPs. The BMPs in that guidance document can also be applied to scrap material recycling facilities (depending on the pollutant sources existing at those facilities) and to non-permitted facilities.

- Gasoline, engine fluids, freon and other contaminated liquids must be drained from scrapped items in a designated area and disposed of or recycled properly before the items are placed in the scrap storage area. See BMP S.2 in Chapter 5 for acceptable disposal options. The designated fluid draining area must be covered and paved, or if not covered, must be paved and sloped to a drain and holding tank. See BMP S.3 in Chapter 5 for drainage alternatives.

Batteries must also be removed and recycled properly prior to storage.

- Employees must be educated about the need for stormwater pollution protection, and proper maintenance of BMPs. They also must have training in spill cleanup procedures, and appropriate cleanup materials must be stocked near the fluid draining area.

- Catch basins on the property must be cleaned as needed. See BMP S.9 in Chapter 5 for more details.

- If the storage area is small, the scrap or recycling materials must be covered. See BMPs S.4 and S.5 in Chapter 5 for further details on coverings.

OR

- If the storage area cannot be covered, an enhanced stormwater treatment system capable of removing dissolved metals must be used. See the BMP selection process in Volume I for more information.

Suggested BMPs

- The material storage area can be paved and sloped to a drain and holding tank. See BMP S.6 in Chapter 5 for details on this drainage strategy.

- Use of a containment dike, curb, or berm can help prevent contaminated runoff from leaving the site, and can function to direct runoff to one of the treatment methods mentioned under the Required BMPs. See BMP S.7 in Chapter 5 for more details.

- Recycle, reuse, or let others use your scrap materials.

- Chemicals can be added to enhance settling or adjust pH in a wet pond/vault or filtration system. However, this is usually a more complex and expensive way to deal with contaminated runoff. See BMP T.2 and T.4 in Chapter 5 for details on these systems.

A4.6 Treatment, Storage, or Disposal of Dangerous Wastes

This activity applies to businesses and public agencies that are permitted by Ecology to treat, store, or dispose of dangerous wastes. DOE regulates these facilities with specific requirements, which include the need for a NPDES permit. Detailed BMPs are not included in this volume since site requirements for these facilities are well beyond the level of typical BMP applications. See Chapter 7 for reference information.

The Thurston County Public Health and Social Services Department also administers some aspects of dangerous waste treatment, storage, and disposal. Call (360) 786-5581 for more information.

A4.7 Storage of Liquid or Dangerous Waste Containers

Description of Pollutant Sources: Steel and plastic drums with volumetric capacities of 55 gallons or less are typically used at industrial facilities for container storage of liquids and powders. The BMPs specified below apply to container(s) located outside a building and used for temporary storage of accumulated food wastes, vegetable or animal grease, used oil, liquid feedstock or cleaning chemicals, or Dangerous Wastes (liquid or solid), unless the business is permitted by Ecology to store the wastes. Leaks and spills of pollutant materials during handling and storage are the primary sources of pollutants. Oil and grease, acid/alkali pH, BOD, and COD are potential pollutant constituents.

Pollutant Control Approach: Store containers in impervious containment under a roof or other appropriate cover, or inside a building. For roll-containers (for example, dumpsters) that are picked up directly by the collection truck, a filet can be placed on both sides of the curb to facilitate moving the dumpster. If a storage area is to be used on site for less than 30 days, a portable temporary secondary system can be used in lieu of a permanent system as described above.

Required BMPs

- Place tight-fitting lids on all containers.
- Place drip pans beneath all mounted container taps and at all potential drip and spill locations during filling and unloading of containers.
- Inspect container storage areas regularly for corrosion, structural failure, spills, leaks, overfills, and failure of piping systems. Check containers daily for leaks/spills. Replace containers, and replace and tighten bungs in drums, as needed.
- Businesses accumulating Dangerous Wastes that do not contain free liquids need only to store these wastes in a sloped designated area with the containers elevated or otherwise protected from stormwater run-on.
- Drums stored in an area where unauthorized persons may gain access must be secured in a manner that prevents accidental spillage, pilferage, or any unauthorized use (Figure 4.15).
- If the material is a Dangerous Waste, the business owner must comply with any additional Ecology requirements as specified in Chapter 7, Section 7.2, R.2.
- Storage of reactive, ignitable, or flammable liquids must comply with the applicable fire codes.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.15. Outdoor Drum Storage Unit with Locking Doors.

- Cover dumpsters or keep them under cover, such as a lean-to, to prevent the entry of stormwater. Replace or repair leaking garbage dumpsters.

- Drain dumpsters and/or dumpster pads to sanitary sewer. Dumpster drains must not discharge to stormwater systems. Keep dumpster lids closed. Install waterproof liners.

- Keep containers with Dangerous Waste, food waste, or other potential pollutant liquids inside a building unless this is impracticable due to site constraints or applicable fire code requirements.

- Store containers in a designated paved area that is covered, bermed, or diked to contain leaks and spills. The secondary containment shall be sloped to drain into a dead-end sump for the collection of leaks and small spills.

- For liquid wastes, surround the containers with a dike as illustrated in Figure 4.16. The dike must be of sufficient height to trap a volume of either 10 percent of the total enclosed volume of the stored containers or 110 percent of the volume contained in the largest container, whichever is greater. If the liquid wastes are in a single container, the dike must trap 110 percent of the volume of that container.

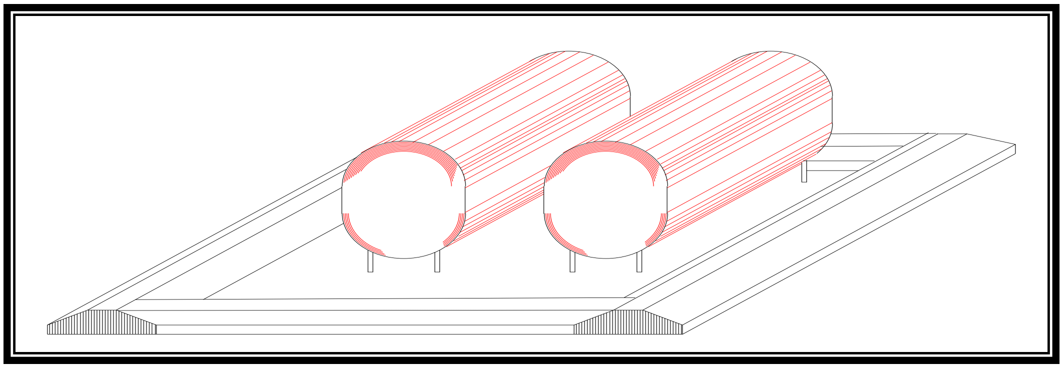


Figure 4.16. Containment Berm Used to Control Liquid-Material Leaks or Spills.

- Where material is temporarily stored in drums, a containment system can be used, as illustrated, in lieu of the above system (Figure 4.17).

(Photo courtesy of Seattle Public Utilities)

Figure 4.17. Temporary Secondary Containment.

- Place containers mounted for direct removal of a liquid chemical for use by employees inside a containment area as described above. Use a drip pan during liquid transfer (Figure 4.18).

- For contaminated stormwater in the containment area, connect the sump outlet to a sanitary sewer, if approved by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider, or to appropriate treatment such as an API or coalescent plate oil/water separator, or other appropriate system (see Volume V). Equip the sump outlet with a normally closed valve to prevent the release of spilled or leaked liquids, especially flammables (in compliance with fire codes), and dangerous liquids. This valve may be opened only for the conveyance of contaminated stormwater to treatment.

Figure 4.18. Mounted Containers with Drip Pans.

- Another option for discharge of contaminated stormwater is to pump it from a dead-end sump or catchment to a tank truck or other appropriate vehicle for offsite treatment and/or disposal.

A4.8 Storage of Liquids in Permanent Aboveground Tanks

Description of Pollutant Sources: Aboveground tanks containing liquids (excluding uncontaminated water) may be equipped with a valved drain, vent, pump, and bottom hose connection. They may be heated with steam heat exchangers equipped with steam traps. Leaks and spills can occur at connections and during liquid transfer. Oil and grease, organics, acids, alkalis, and heavy metals in tank water and condensate drainage can also cause stormwater contamination at storage tanks.

Pollutant Control Approach: Install secondary containment or a double-walled tank. Slope the containment area to a drain with a sump. Stormwater collected in the containment area may need to be discharged to treatment such as an **API** or **coalescent plate** oil/water separator, or equivalent BMP. Add safeguards against accidental releases including protective guards around tanks to protect against vehicle or forklift damage, and tag valves to reduce human error. *Tank water and condensate discharges are process wastewater that may need an NPDES permit.*

Required BMPs

- Inspect the tank containment areas regularly to identify problem components such as fittings, pipe connections, and valves for leaks/spills, cracks, corrosion, etc.
- Place adequately sized drip pans beneath all mounted taps and drip/spill locations during filling/unloading of tanks. Valved drain tubing may be needed in mounted drip pans.
- Sweep and clean the tank storage area regularly, if paved.
- Replace or repair tanks that are leaking, corroded, or otherwise deteriorating.
- All installations shall comply with the applicable fire and electric codes.
- Locate permanent tanks in impervious (Portland cement concrete or equivalent) secondary containment surrounded by dikes as illustrated in Figure 4.19, or Underwriters Laboratory approved double-walled facilities. Any dike must be of sufficient height to trap a volume of either 10 percent of the total enclosed volume of the tank or 110 percent of the volume contained in the largest tank, whichever is greater. If the liquid wastes are in a single tank, the dike must trap 110 percent of the volume of that tank.

(Photo courtesy of Seattle Public Utilities)

Figure 4.19. Aboveground Storage Tanks with Secondary Containment.

- Slope the secondary containment to drain to a dead-end sump (optional), or equivalent, for the collection of small spills.

- Include a tank overfill protection system to minimize the risk of spillage during loading.

- If the tank containment area is uncovered, equip the outlet from the spill-containment sump with a shutoff valve, which is normally closed and may be opened, manually or automatically, only to convey contaminated stormwater to approved treatment or disposal or convey uncontaminated stormwater to a storm drain. Evidence of contamination can include the presence of visible sheen, color, or turbidity in the runoff, or existing or historical operational problems at the facility. Simple pH measurements with litmus or pH paper can be used for areas subject to acid or alkaline contamination.

- At petroleum tank farms, convey stormwater contaminated with floating oil or debris in the contained area through an API or coalescent plate type oil/water separator (Volume V, Treatment BMPs) or other approved treatment prior to discharge to storm drain or surface water.

A4.9 Parking and Storage for Vehicles and Equipment

Description of Pollutant Sources: Parked vehicles at public and commercial parking lots, such as retail store, fleet vehicle (including rent-a-car lots and car dealerships), equipment sale and rental parking lots, and parking lot driveways, can be sources of toxic hydrocarbons and other organic compounds, oils and greases, metals, and suspended solids.

Required BMPs

- If washing of a parking lot is conducted, discharge the washwater to a sanitary sewer (if allowed by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708) or other approved wastewater treatment system, or collect it for offsite disposal.

- Do not hose down the area to a storm drain or receiving water. Sweep parking lots, storage areas, and driveways regularly to collect dirt, waste, and debris.

- An oil removal system such as an API or coalescent plate oil and water separator, or equivalent BMP (see Volume V), approved by Thurston County, is applicable for parking lots meeting the threshold vehicle traffic intensity level of a high-use site. For more information on high-use sites, refer to Volume I, Section 4.2.5, and Volume V, Section 3.2.

A4.10 Storage of Pesticides, Fertilizers, or Other Products That Can Leach Pollutants

This activity applies to businesses, public agencies and farms that store non-liquid pesticides, fertilizers, or a variety of other products, such as treated lumber, metal building materials, and metal tools, that have the potential to leach pollutants into underlying soil or stormwater runoff. The main problem with the potential pollutants from these sources is their solubility. Once dissolved, they are difficult or impossible to filter out of runoff. If there is any question as to whether materials on your site have the potential to leach pollutants into stormwater runoff or underlying soil, call Thurston County Public Works at (360) 754-4581 and ask to speak to a water quality person. The storage of liquid pesticides is covered under activity **A4.7 Storage of liquid chemicals, waste oils, solvents or petroleum products in portable containers.**

Pollutants of Concern: Toxic organic compounds, oils, heavy metals, Chemical oxygen demand (COD), nutrients, fecal bacteria, Biochemical oxygen demand (BOD), suspended solids.

Required BMPs

The following BMPs or equivalent measures are required of all businesses, public agencies and farms engaged in storage of pesticides, fertilizers or finished products that can leach pollutants:

- Employees must be trained on the proper storage, handling, application and disposal of fertilizers and pesticides, from keeping bags intact to storing in a covered or contained area.

- Outdated or banned pesticides must be disposed of at an approved hazardous waste facility. Do not hose storage areas to a storm drain or conveyance ditch.

Suggested BMPs

- Contained storage areas should drain to a sump or a holding tank. Note that this only applies to finished products other than treated lumber. The sump should have an outlet pipe for discharges to the stormwater drainage system. The sump must be cleaned at least once per year, and solid materials and residues collected in the bottom of the sump must be properly disposed of. See BMP S.2 in Chapter 5 for information on disposal options.

- Storage areas for pesticides, fertilizers, and finished products that can leach pollutants should be covered. See BMPs S.4 and S.5 in Chapter 5 for further information on coverings. Stormwater runon prevention must be provided for the covered area, or the stored materials must be raised off the ground. See BMP S.7 in Chapter 5 for more information on runon prevention options.

- Storage areas for treated lumber should be paved, and either covered or sloped to drain to a dead-end sump or treatment system. Material collected from the sump must be disposed of as a hazardous waste (it may be economical to install an evaporation system for the uncovered area). Stormwater runon must be prevented from entering the covered area if the lumber is not elevated off the ground. See BMPs S.4 and S.7 in Chapter 5 for more information on roof covers and runon prevention.

- Paved storage areas for finished products should be swept weekly and collected materials disposed of properly. Small amounts of fertilizers can be disposed of in the regular garbage after double wrapping in plastic.

- Use less pesticide or fertilizer, or store less finished product, so that the size of the designated storage areas can be smaller and stormwater contamination potential is reduced.

- If it is not feasible to use the source-control BMPs listed above, use one or more of the following stormwater treatment BMPs (described in Volume V) :

  - IN-01,02,03: Infiltration with underdrains to prevent groundwater contamination
  - MF-01,02,03,04: Filtration
  - WP-03: Wet pond with nutrient control, for fertilizer storage only
  - WP-01: Constructed wetland
  - BF-01,02,03: Vegetated biofilter.

Section A5

Construction and Demolition Activities

A5.1 Demolition of Buildings

Description of Pollutant Sources: This activity applies to removal of existing buildings by controlled explosions, wrecking balls, or manual methods, and subsequent clearing of the rubble. The loose debris can contaminate stormwater.

Pollutants of concern include toxic organic compounds, heavy metals, and suspended solids. Waste from concrete sawing is of particular concern due to its effect on aquatic organisms and because it is extremely hard to settle out.

Pollutant Control Approach: Regularly cleanup debris that can contaminate stormwater. Protect the stormwater drainage system from dirty runoff and loose particles. Sweep paved surfaces daily.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and public agencies engaged in building demolition:

- Storm drain covers or a similarly effective containment device must be placed on all nearby drains to prevent dirty runoff and loose particles from entering the stormwater drainage system (Figure 4.20). Covers shall be placed at the beginning of the workday and the accumulated materials collected and disposed of before removing the covers at the end of the workday. If storm drains are not present, dikes, berms, or other methods must be used to protect overland discharge paths from runoff. See BMPs S.2 and S.7 in Chapter 5 for more information on runoff control and disposal options.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 4.20. Commercially Available Gutter Guard Being Replaced.

- Street gutters, sidewalks, driveways, and other paved surfaces in the immediate area of the demolition must be swept at the end of each workday to collect and properly dispose of loose debris and garbage.

- Contact Thurston County Development Services at (360) 786-5490 to obtain required permits. Additional information is available at the following web site: <www.co.thurston.wa.us/permitting/index.htm>.

Suggested BMPs

- Water should be sprayed throughout the site to help control wind blowing of fine materials such as soil, concrete dust, and paint chips. The amount of water must be controlled so that runoff from the site does not occur, yet dust control is achieved. Oils must never be used for dust control.

- If possible, a wall should be constructed to prevent stray building materials and dust from escaping the area during demolition.

- Schedule demolition to take place at a dry time of the year.

A5.2 Building Repair, Remodeling, Painting, and Construction

Description of Pollutant Sources: This activity refers to activities associated with construction of buildings and other structures, remodeling of existing buildings and houses, and general exterior building repair work. Work done on docks, piers, bridges, or other structures over water are of particular concern. Concrete pouring is covered under **A3.2 Concrete Pouring and Asphalt Application at Temporary Sites**.

Pollutants of concern include toxic hydrocarbons, toxic organics, suspended solids, heavy metals, pH, oils, and greases.

Pollutant Control Approach: Employees must be educated about the need to control site activities. Control leaks, spills, and loose material. Utilize good housekeeping practices.

Required BMPs

The following BMPs or equivalent measures are required of all businesses engaged in building repair, remodeling, and construction:

- Employees must be educated about the need to control site activities to prevent stormwater pollution, and also trained in spill cleanup procedures.
- Spill cleanup materials, appropriate to the chemicals being used on site, must be available at the work site at all times.
- The work site must be cleaned up at the end of each workday, with materials such as solvents put away indoors or covered and secured so that vandals will not have access to them.
- The area must be swept daily to collect loose litter, paint chips, grit, and dirt.
- Absolutely no substance can be dumped on pavement, on the ground, or in or toward storm drains, regardless of its content, unless it is water only.
- For wood treating activities drop cloths must be placed where space and access permit before the work begins. Additional drip pans must be used in areas where drips are likely to occur that cannot be protected with a drop cloth.
- Ground or drop cloths must be used underneath scraping, sandblasting work. Ground cloths, buckets, or tubs must also be used anywhere that work materials are laid down.

- Incidental cleaning of paint brushes and other tools that are covered with water-based paints must be cleaned in sinks connected to sanitary sewers or in portable containers that can subsequently be dumped into a sanitary sewer drain. Brushes and tools covered with non-water-based finishes or other materials must be cleaned in a manner that enables collection of used solvents for recycling or proper disposal and cannot be discharged to the sanitary sewer. See BMP S.2 in Chapter 5 for disposal options.

- Storm drain covers or similarly effective devices must be used if dust, grit, washwater, or other pollutants may escape the work area. This is particularly necessary on rainy days. The cover or containment device shall be placed over the storm drain at the beginning of the workday, and accumulated dirty runoff and solids must be collected and disposed of before removing the cover at the end of the day.

Suggested BMPs

The following BMPs are not required, but can provide additional pollution protection:

- Recycle materials whenever possible.

- Light spraying of water on the work site can control some of the dust and grit that can blow away. Oils must never be used for dust control. Never spray to the point of runoff from the site.

- Activities such as tool cleaning should occur over a ground cloth or within a containment device such as a tub.

Section A6

Dust Control and Soil and Sediment Control

A6.1 Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots

Description of Pollutant Sources: Dust can cause air and water pollution problems particularly at demolition sites, disturbed land areas, and unpaved roadways and parking lots.

Pollutant Control Approach: Minimize dust generation and apply environmentally friendly and government approved dust suppressant chemicals, if necessary.

Required BMPs

- Sprinkle or wet down soil or dust with water as long as it does not result in a wastewater discharge (Figure 4.21).

Figure 4.21. Dust Suppression by Water Spray.

- Use in the recommended manner, only local and/or state government approved dust suppressant chemicals such as those listed in Ecology publication No. 96-433, "Techniques for Dust Prevention and Suppression." See BMP C126, Polyacrylamide for Soil Erosion Protection, in Volume II of this manual.

- Avoid excessive and repeated applications of dust suppressant chemicals. Time the application of dust suppressants to avoid or minimize their wash-off by rainfall or human activity such as irrigation.

- Avoid driving over treated areas as this will break the crust formed by the dust suppressant, rendering it less effective.

- Apply stormwater containment to prevent the conveyance of sediments and or dust suppressant chemicals into storm drains or receiving waters.

- The use of motor oil for dust control is prohibited. Care should be taken when using lignin derivatives and other high BOD chemicals in excavations or areas easily accessible to surface water or groundwater.

- Consult with the Ecology Southwest Regional Office on discharge permit requirements if the dust suppression process results in a wastewater discharge to the ground, groundwater, storm drain, or surface water.

Suggested BMPs for Roadways and Other Trafficked Areas

- Consider limiting use of off-road recreational vehicles on dust generating land.

- Consider paving unpaved permanent roads and other trafficked areas at municipal, commercial, and industrial areas.

- Consider paving or stabilizing shoulders of paved roads with gravel, vegetation, or Thurston County approved chemicals.

- Encourage use of alternate paved routes, if available.

- Vacuum or wet sweep fine dirt and skid control materials from paved roads soon after winter weather ends or when needed.

- Consider using traction sand that is prewashed to reduce dust emissions.

Suggested BMPs for Dust Generating Areas

- Prepare a dust control plan. Helpful references include: Control of Open Fugitive Dust Sources (EPA-450/3-88-088) and Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures (EPA-450/2-92-004).

- Limit exposure of soil (dust source) as much as feasible.

- Stabilize dust-generating soil by growing and maintaining vegetation, mulching, topsoiling, and/or applying stone, sand, or gravel.

- Apply windbreaks in the soil such as trees, board fences, tarpaulin curtains, bales of hay, etc.

- Cover dust-generating piles with wind-impervious fabric, or equivalent material.

Additional information on dust control can be found in Volume II of this manual.

A6.2 Dust Control at Manufacturing Sites

Description of Pollutant Sources: Industrial material handling activities can generate considerable amounts of dust that is typically removed using exhaust systems. This can generate air emissions that can contaminate stormwater. Dusts can be generated at cement and concrete product mixing facilities, and wherever powdered materials are handled. Particulate materials that are of concern to air pollution control agencies include grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash. The objective of this BMP is to reduce the stormwater pollutants caused by dust generation and control.

Pollutant Control Approach: Prevent dust generation and emissions where feasible, regularly cleanup dust that can contaminate stormwater, and convey dust contaminated stormwater to proper treatment.

Required BMPs

- Clean powder material handling equipment and vehicles that can be sources of stormwater pollutants as needed to remove accumulated dust and residue.

- Regularly sweep dust accumulation areas that can contaminate stormwater. Sweeping should be conducted using vacuum filter equipment to minimize dust generation and to ensure optimal dust removal.

- Use in the recommended manner, approved dust suppressants such as those listed in Ecology publication "Techniques for Dust Prevention and Suppression," No. 96-433 (Ecology 1996). Application of some products may not be appropriate in close proximity to receiving waters or conveyances close to receiving waters. For more information, check with the Ecology Southwest Regional Office or Thurston County.

Suggested BMPs

- In manufacturing operations, train employees to carefully handle powders to prevent generation of dust.

- Use dust filtration/collection systems such as bag house filters, cyclone separators, etc. to control vented dust emissions that could contaminate stormwater. Control of zinc dusts in rubber production is one example.

- Use water spray to flush dust accumulations to sanitary sewers where allowed by Thurston County or to other appropriate treatment system. Contact LOTT Alliance Industrial Pretreatment

Program at (360) 528-5708 or your local sewer service provider for details.

- For removal of total suspended solids in stormwater, use sedimentation basins, wet ponds, wet vaults, vegetated filter strips, or equivalent sediment removal BMPs. Refer to Volume V Runoff Treatment BMPs for more information about these BMPs.

- Additional information on dust control can be found in Volume II of this manual.

A6.3 Soil Erosion and Sediment Control at Industrial Sites

Description of Pollutant Sources: Industrial activities on soil areas, exposed and disturbed soils, steep grades, etc. can be sources of sediments that can contaminate stormwater runoff.

Pollutant Control Approach: Limit the exposure of erodible soil, stabilize or cover erodible soil where necessary to prevent erosion, and/or provide treatment for stormwater contaminated with total suspended solids caused by eroded soil.

Required BMPs

- Apply one or more of the following cover practices:
  - Vegetative cover such as grass, trees, or shrubs on erodible soil areas
  - Covering with mats such as clear plastic, jute, or synthetic fiber; and/or
  - Preservation of natural vegetation including grass, trees, shrubs, and vines.
- Control sediment through installing a vegetated swale, dike, silt fence, check dam, gravel filter berm, and/or sedimentation basin and properly grading. For design information refer to Volume II, Standards and Specifications for BMPs.

Section A7

Other Activities

A7.1 Commercial Animal Handling Areas

Description of Pollutant Sources: Animals at racetracks, kennels, fenced pens, veterinarians, and businesses that provide boarding services for horses, dogs, cats, etc. can generate pollutants from the following activities: manure deposits, animal washing, grazing, and any other animal handling activity that could contaminate stormwater. Pollutants can include coliform bacteria, nutrients, and total suspended solids.

Pollutant Control Approach: To prevent, to the maximum extent practicable, the discharge of contaminated stormwater from animal handling and keeping areas.

Required BMPs

- Regularly sweep and clean animal keeping areas to collect and properly dispose of droppings, uneaten food, and other potential stormwater contaminants.
- Do not hose down to storm drains or to receiving water those areas that contain potential stormwater contaminants.
- Do not allow any washwaters to be discharged to storm drains or to receiving water without proper treatment.
- If animals are kept in unpaved and uncovered areas, the ground must either have vegetative cover or some other type of ground cover, such as mulch.
- If animals are not leashed or in cages, the area where animals are kept must be surrounded by a fence or other means that prevents animals from moving away from the controlled area where BMPs are used.

A7.2 Keeping Livestock in Stables, Pens, Pastures, or Fields

This activity applies to management of all types of livestock. Manure from livestock can pollute stormwater and local water bodies. Animals that are not fenced off from creeks and streams can also cause severe erosion of stream banks, which in turn can silt up fish spawning areas. Certain areas of Thurston County require the filing of a livestock management plan. Contact the Thurston County Conservation District at (360) 754-3588 for more information and assistance in preparing such a plan. Thurston County/WSU Cooperative Extension at (360) 786-5445 also has literature to help you more effectively manage your pastures and livestock. Feedlots containing more than 100 animals may require an NPDES permit for Concentrated Animal Feeding Operations.

Pollutants of Concern: Nutrients, suspended solids, Biochemical oxygen demand (BOD), fecal bacteria.

Required BMPs

The following BMPs or equivalent measures are required of all businesses and citizens keeping livestock in stables, pens, pastures, or fields:

- Restrict animal access to creeks and streams, preferably by fencing. There are ways to fence and still allow animals drinking access to the stream, without allowing bank trampling and minimizing fecal inputs into the stream. Contact the Thurston County Conservation District for more information on fencing, including how to get money to provide such fencing. They can also help you with replanting the stream banks to prevent further erosion. A minimum setback of 20 feet from the center of the streambed will be required on each side. Major tributaries and large farm ditches should be fenced as well.

- Dispose of manure from stables and pens properly. Do not pile it where rain will wash nutrients into constructed or natural stormwater drainage systems that leave your land. Place it within a bermed area to contain runoff, or cover it with a tarpaulin. It may also be placed in a grassy area as far from watercourses as possible, so that any seepage has a chance to be filtered and absorbed by the grasses before reaching a creek or stream.

Suggested BMPs

- On fields where animals are pastured, a rotational grazing system should be developed. This would mean that a field would need to be divided into a minimum of four equal units, and the stock rotated from one unit to another. The stock should not be allowed onto the pastures until the grass reaches a minimum height of 6 inches. They should be moved to the second field when the grass height is down to approximately 3 inches. Each field should be allowed to recover for a period of 21 to 28 days prior to regrazing.

- Monitor grazing carefully. If 90 percent of the plants' leaves are removed, the roots will stop growing for at least 18 days. If only 40 percent or less of the leaves are removed, the roots will continue to grow. Not only will overgrazing or overstocking limit pasture production, but the pastures become vulnerable to the invasion of unpalatable or poisonous weed species such as tussock, moss, buttercup, tansy ragwort, and thistle.

- Grazing should be discontinued starting in early October. Neither the animals nor the fields benefit from grazing during the winter. Since the plants are basically dormant, the protein content is extremely low. The fields become compacted and rutted, thus reducing soil tilth, which in turn reduces summer grass yields. Fence off a small portion of your pasture to sacrifice during winter, and feed hay and grain instead of grazing.

- Proper pasture management should also include the practices of clipping and harrowing the fields after the stock has been removed. This is done to assure uniform growth and to avoid excessive damage to the stand and a consequent reduction in yields. This would also be the optimum time to apply fertilizer, such as manure, to the fields in a manner which does not contribute to runoff.

- Weed control is very important for maintaining highly productive pastures. If you follow the practices described above, you will go a long way toward effective weed control. You may occasionally need to apply herbicides, but do so judiciously. Remember that it is much easier to take care of a few thistles early on than it is to get rid of a field full.

A7.3 Log Sorting and Handling

Description of Pollutant Sources: Log yards are areas where logs are transferred, sorted, debarked, cut, and stored to prepare them for shipment or for the production of dimensional lumber, plywood, chips, poles, or other products. Log yards are generally maintained at sawmills, shipping ports, and pulp mills. Typical pollutants include oil and grease, BOD, settleable solids, total suspended solids (including soil), high and low pH, heavy metals, pesticides, wood-based debris, and leachate.

The following are pollutant sources:

1. Log storage, rollout, sorting, scaling, and cutting areas
2. Log and liquid loading areas
3. Log sprinkling
4. Debarking, bark bin, and conveyor areas
5. Bark, ash, sawdust and wood debris piles, and other solid wastes
6. Metal salvage areas
7. Truck, rail, ship, stacker, and loader access areas
8. Log trucks, stackers, loaders, forklifts, and other heavy equipment
9. Maintenance shops and parking areas
10. Cleaning areas for vehicles, parts, and equipment
11. Storage and handling areas for hydraulic oils, lubricants, fuels, paints, liquid wastes, and other liquid materials
12. Pesticide usage for log preservation and surface protection
13. Application of herbicides for weed control
14. Contaminated soil resulting from leaks or spills of fluids.

Ecology's Baseline General Permit Requirements

Industries with log yards are required to obtain coverage under the Baseline General Permit for discharges of stormwater associated with industrial activities to surface water. The permit requires preparation and onsite retention of Stormwater Pollution Prevention Plans (SWPPP). The SWPPP must identify operational, source control, ESC, and, if necessary, treatment BMPs. Required and Suggested operational, source control, and treatment BMPs are presented in detail in Ecology's Guidance Document: Industrial Stormwater General Permit Implementation Manual for Log Yards, publication No. 0410-031. It is recommended that all log yard facilities obtain a copy of this document.

A7.4 Boat Building, Mooring, Maintenance, and Repair

Description of Pollutant Sources: Sources of pollutants at boat and ship building, repair, and maintenance facilities at boatyards, shipyards, ports, and marinas include pressure washing, surface preparation, paint removal, sanding, painting, engine maintenance and repairs, and material handling and storage, if conducted outdoors. Potential pollutants include spent abrasive grits, solvents, oils, ethylene glycol, washwater, paint over-spray, cleaners/detergents, anti-corrosive compounds, paint chips, scrap metal, welding rods, resins, glass fibers, dust, and miscellaneous trash. Proper application of anti-fouling paints is of particular concern in marine environments. Pollutant constituents include total suspended solids, oil and grease, organics, copper, lead, tin, and zinc. Related activities are covered under the following activity headings in this volume, and other BMPs provided in this volume:

A1.3 Washing, Pressure Washing, and Steam Cleaning of Vehicles/Equipment/Building Structures

A2.2 Fueling at Dedicated Stations

A7.15 Spills of Oil and Hazardous Substances

Pollutant Control Approach: Apply good housekeeping, preventive maintenance, and cover and contain BMPs in and around work areas.

Required BMPs

The following BMPs or equivalent measures are required of all businesses, public agencies, and private boat owners engaged in boat building, mooring, maintenance and repair that are not covered by the NPDES permit for boatyards:

- Maintenance and repair activities that can be moved on-shore must be moved accordingly. This action reduces some of the potential for direct pollution impact on water bodies.
- Blasting and spray painting activities must be sheltered by hanging tarps to block the wind and prevent dust and overspray from escaping. Move the activity indoors if possible. See Chapter 7 for details on Olympic Region Clean Air Agency (ORCAA) limitations.
- Ground cloths must be used for collection of drips and spills in painting and finishing operations, and paint chips and used blasting sand from sand blasting (Figure 4.22).
- Collect spent abrasives regularly and store under cover to await proper disposal.

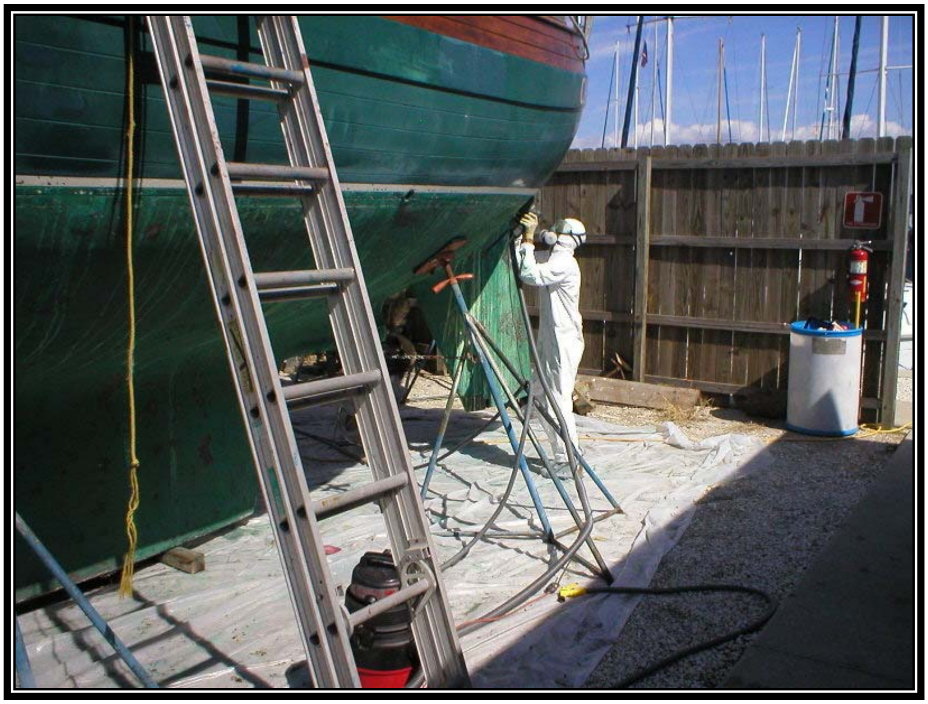


Figure 4.22. Drop Cloth Used During Hull Sanding.

- Dispose of greasy rags, oil filters, air filters, batteries, spent coolant, and degreasers properly.
- Drain oil filters before disposal or recycling.
- Bilge water must be collected for proper disposal rather than discharged on land or water. See BMP S.2 in Chapter 5 for detail on disposal options. Several companies are available for bilge pumpout services. The problem can be avoided if oil-absorbent pads are used to capture the oil in the bilge water before or during pumping. If pads are used, they must be recycled or properly disposed of.
- Ballast water that has an oily sheen on the surface must be collected for proper disposal rather than discharged on land or water. See BMP S.2 in Chapter 5 for details on disposal options.
- Maintenance yard areas must be swept and cleaned, without hosing down the area, at least once per week or as needed. This prevents sandblasting materials, scrapings, paint chips, oils, and other loose debris from being carried away with stormwater. The collected materials must be disposed of properly. See BMP S.2 in Chapter 5 for disposal options.

- Docks and boat ramps must be swept at least once per week or as needed, and the collected materials must be disposed of properly. Drydocks must be swept before flooding.

- Paint and solvent mixing, fuel mixing and similar handling of liquids shall be performed on shore, or such that no spillage can occur directly into surface water bodies.

- Routine cleanup materials such as oil-absorbent pads, brooms, dustpans, mops, buckets, and sponges must be stocked near docks.

- When washing your boat in the water, use no soaps or detergents. Brush the hull with water only.

- Comply with BMP A2.3 and A4.2 if engine repair and maintenance are conducted.

- In the event of an accidental discharge of oil or hazardous material into waters of the state or onto land with a potential for entry into state waters, immediately notify the yard, port, or marina owner or manager, Ecology, and the National Response Center at 1-800-424-8802 (24-hour). If the spill can reach or has reached marine waters, contact the U.S. Coast Guard at (206) 217-6232.

Suggested BMPs

- Boat construction and structural repair activities should be covered with drop cloths or other protection to avoid grit, paint, or other materials from contaminating stormwater.

- Materials such as paints, tools, and ground cloths should be stored indoors or in a covered area when not in use.

- Select the least toxic anti-fouling paint available.

- Boat interiors should be routinely cleaned, with proper disposal of collected materials, so that accumulations of water drained from them are not contaminated.

- Use sanders that have dust containment bags and avoid sanding in windy conditions.

- All used oil should be recycled if feasible. Most marinas now offer used oil recycling services. To dispose of filters, let drain 24 hours, then double wrap in plastic and dispose of in the regular garbage, or take them to the Thurston County Waste and Recovery Center, HazoHouse for disposal and recycling. Pending state legislation may make disposal in the garbage illegal, so contact the HazoHouse at (360) 786-5494 for current information.

- Check with marinas for other BMPs they have developed.
- Use one of the following treatment BMPs when paint chips or blasting grit are prevalent in the work area:
    - IN-01: Infiltration basin
    - WP-02: Wet pond or WP-03 wet vault
    - WP-01: Constructed wetland
    - BF-01,02,03: Vegetated biofilter
    - MF-04: Filtration with media designed for the pollutants that are present
    - Equivalent BMP (see Volume V).

A7.5 Logging

Description of Pollutant Sources: This activity covers logging activities that fall under the Washington State Forest Practices Act category of Class IV general forest practices. These are situations where timber harvesting is done in the process of converting forest lands into other land uses, such as home and business construction. Stormwater runoff from bare ground exposed during logging contains large amounts of dirt and other pollutants. This material can clog ditches and stream channels, thus reducing carrying capacity and increasing flooding, as well as smothering spawning beds for fish. Simply controlling runoff and not allowing it to leave the site will prevent these harmful effects. Clearing and grading activities are covered in detail in Volume II of this manual, Construction Stormwater Pollution Prevention.

Coverage under Ecology's construction stormwater general permit is required for construction sites that result in the disturbance of one acre or more of land. Compliance with the Construction Stormwater Pollution Prevention requirements in Ecology's manual is required, as applicable. Virtually all logging operations will require a permit from the Washington State Department of Natural Resources (WDNR). Sensitive/critical areas and wetlands ordinances for Thurston County also contain requirements for logging activities in the vicinity of water bodies.

Pollutants of concern include suspended solids, oils and greases, biochemical oxygen demand (BOD), nutrients, toxic organic compounds, and heavy metals.

Pollutant Control Approach: Maintain required buffers adjacent to critical areas, including streams and wetlands. Keep sediments out of water bodies and off paved areas.

Required BMPs

- Vegetation along stream corridors, and adjacent to other water bodies and wetlands, must be preserved. Maintenance of a vegetated buffer enables filtration of most of the pollutants of concern for this activity. The above-mentioned ordinances contain specific requirements for buffer setbacks.

- Logging access roads must have a crushed rock or spall apron construction entrance where they join the pavement to prevent sediments from being tracked onto the pavement.

- On-site fueling and maintenance operations must follow the required BMPs as outlined in A2.4 Mobile Fueling; A2.3 Engine Repair and Maintenance; and A.4.2 Storage of Liquid Chemicals, Waste Oils, Solvents, or Petroleum Products in Portable Containers.

Suggested BMPs

- Erosion potential can be reduced by avoiding logging on steep slopes.
- If access roads are constructed for logging, they should be provided with drainage ditches that divert runoff into vegetated areas or stormwater treatment systems.
- Plant vegetated buffers in areas where they are already lost downslope of proposed logging areas, with sufficient lead time to allow for effective growth.

A7.6 Mining and Quarrying of Sand, Gravel, Rock, Minerals, Peat, Clay, and Other Materials

Description of Pollutant Sources: This activity applies to surface excavation and onsite storage of sand, gravel, and other materials that are mined. All mining operations that have stormwater runoff from the site are required to apply for a NPDES permit with Ecology. Ecology has specific BMPs required by the permit. Some additional BMPs to help meet Ecology's discharge performance standards are listed below.

Pollutants of concern are suspended solids, nutrients, pH, and metals.

Pollutant Control Approach: Provide containment and or cover for any onsite storage areas to prevent run-on and discharge of suspended solids and other pollutants.

Suggested BMPs

- If the material is appropriate, use excavated spoil material to form compacted berms along downslope sides of the site to contain runoff. Berms should be seeded to promote growth of grass or other vegetation to limit erosion from the berms. Safety considerations must be examined to prevent flooding due to berm failure.

- Semi-permanent stockpiles should be seeded to promote vegetation growth to limit erosion from the stockpiles.

- Use detention ponds to promote settling of suspended solids, or infiltration basins to filter suspended solids, to cleanup runoff before it leaves the site. See Chapter 5 for a further discussion of treatment BMPs.

- Use anchored tarps to cover stockpiles at small-scale mining operations if there is a potential for contaminated stormwater to leave the site.

A7.7 Swimming Pool and Spa Cleaning and Maintenance

Description of Pollutant Sources: This activity applies to all municipal and commercial swimming pools and spas, including county health department—regulated facilities. Pools and spas at hotels, motels, and apartment and condominium complexes are covered here. Pools at single-family residences are covered in Chapter 3 of this volume. Commercial pool and spa cleaning services must follow these required BMPs for all pools they service.

Pollutants of concern include nutrients, suspended solids, chlorine, pH, and chemical oxygen demand (COD).

Pollutant Control Approach: Dispose of pool or spa water to the sanitary sewer after getting preapproval from the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider.

Required BMPs

- The preferred method of pool or spa water disposal is to the sanitary sewer. If a sanitary sewer is available, all county health department—regulated facilities are required to connect for draining and backwash. Contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for specific instructions on allowable flow rates and timing before starting to drain the pool. Never discharge pool water to a septic system, as it will cause the system to fail.

- If discharge to the sanitary sewer is not possible, pool and spa water may be discharged to a ditch or stormwater drainage system. The discharges shall be dechlorinated to a concentration of 0.1 ppm or less, pH-adjusted if necessary, reoxygenated, and volumetrically and velocity controlled to prevent resuspension of sediments. Swimming pool cleaning wastewater and filter backwash shall not be discharged to the Thurston County stormwater system. You are required to contact Thurston County Department of Resource Stewardship, Water Resources Unit at (360) 754-4681 prior to discharge for instructions on allowable flow rates for the system or ditch that is being discharged to. Neutralizing chemicals are available for dechlorinating water. Letting the pool or spa "sit" may also reduce chlorine levels. Use a test kit to determine if the concentration has reached zero.

- State law may allow discharges of pool water to the ground. However, the water must not cross property lines or impact neighboring properties, and a satisfactory means for distributing the water to the ground must be used so there is no runoff. Check with Ecology prior to release.

- Diatomaceous earth used in pool filters cannot be discharged to surface waters, stormwater drainage systems, or septic systems, or on the ground.

Suggested BMPs

- Hire a professional pool-draining service to collect all pool water for offsite disposal.

A7.8 De-icing and Anti-icing Operations for Airports and Streets

Description of Pollutant Sources: De-icing and/or anti-icing compounds are used on highways, streets, airport runways, and on aircraft to control ice and snow. Typically ethylene glycol and propylene glycol are de-icing chemicals used on aircraft. De-icing chemicals commonly used on highways and streets include calcium magnesium acetate (CMA), calcium chloride, magnesium chloride, sodium chloride, urea, and potassium acetate. The de-icing and anti-icing compounds become pollutants when they are conveyed to storm drains or to surface water after application where they deplete oxygen in the receiving water. Leaks and spills of these chemicals can also occur during their handling and storage.

BMPs for Airport De/anti-icing Operations

U.S. EPA is currently studying airport de-icing as part of the pretreatment regulations (40 CFR 403). These regulations are not expected to be promulgated for several years.

Pollutant Control Approach for Aircraft: Spent glycol discharges in aircraft application areas are process wastewaters that are regulated under Ecology's Industrial Stormwater General Permit. (Contact the Ecology Southwest Regional Office for details.) BMPs for aircraft anti-icing chemicals must be consistent with aviation safety and the operational needs of the aircraft operator.

Required BMPs for Aircraft:

- Conduct aircraft de-icing or anti-icing applications in impervious containment areas. Collect aircraft de-icing spent chemicals, such as glycol, draining from aircraft in de-icing or anti-icing application areas and convey to a sanitary sewer, treatment, or other approved disposal or recovery method. Contact the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 to obtain permit for discharges to sanitary sewer. Divert de-icing runoff from paved gate areas to appropriate collection areas or conveyances for proper treatment or disposal.

- Do not allow spent de-icing chemicals or stormwater contaminated with aircraft de-icing chemicals to be discharged from application areas including gate areas, to surface water or groundwater, directly or indirectly.

- Transfer de-icing and anti-icing chemicals on an impervious containment pad, or equivalent spill/leak containment area, and store in secondary containment areas (see Storage of Liquids in Aboveground Tanks).

Suggested BMPs for Aircraft:

> *Note the applicable containment BMP of aircraft de/anti-icing applications, and applicable treatment BMPs for anti-icing spent chemicals such as glycols.*

- Establish a centralized aircraft de/anti-icing facility, if feasible and practicable, or in designated areas of the tarmac equipped with separate collection drains for the spent de-icing liquids.

- Consider installing an aircraft de/anti-icing chemical recovery system, or contract with a chemical recycler, if practicable.

Required BMPs for Airport Runways/Taxiways:

- Avoid excessive application of all de/anti-icing chemicals, which could contaminate stormwater.

- Store and transfer de/anti-icing materials on an impervious containment pad or an equivalent containment area and/or under cover in accordance with BMP Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products in this volume. Other material storage and transfer approaches may be considered if it can be demonstrated that stormwater will not be contaminated with the anti-icing material or the material cannot reach surface or groundwater.

Suggested BMPs for Airport Runways/Taxiways:

- Include limits on toxic materials and phosphorous in the specifications for de/anti-icing chemicals, where applicable.

- Consider using anti-icing materials rather than de-icing if it will result in less adverse environmental impact.

- Select cost-effective de/anti-icing chemicals that cause the least adverse environmental impact.

BMPs for Streets/Highways

Required BMPs for Streets/Highways:

- Select de and anti-icing chemicals that cause the least adverse environmental impact. Apply only as needed using minimum quantities.

- Where feasible and practicable, use roadway de-icing, such as calcium magnesium acetate, potassium acetate, or similar materials that cause less adverse environmental impact than urea and sodium chloride.

- Store and transfer de/anti-icing materials on an impervious containment pad in accordance with BMP Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products in this volume.

- Sweep/cleanup accumulated de/anti-icing materials and grit from roads as soon as possible after the road surface clears.

Suggested BMPs for Streets/Highways:

- Intensify roadway cleaning in early spring to help remove particulates from road surfaces.

- Include limits on toxic metals in the specifications for anti-icing chemicals.

A7.9 Roof and Building Drains at Manufacturing and Commercial Buildings

Description of Pollutant Sources: Stormwater runoff from roofs and sides of manufacturing and commercial buildings can be sources of pollutants caused by leaching of roofing materials, building vents, and other air emission sources. Vapors and entrained liquid and solid droplets/particles have been identified as potential pollutants in roof/building runoff. Metals, solvents, acidic/alkaline pH, BOD, and organics are some of the pollutant constituents identified.

Pollutant Control Approach: Evaluate the potential sources of stormwater pollutants and apply source control BMPs where feasible.

Required BMPs

- If leachates and/or emissions from buildings are suspected sources of stormwater pollutants, then sample and analyze the stormwater draining from the building.
- If a roof/building stormwater pollutant source is identified, implement appropriate source control measures such as air pollution control equipment, selection of materials, operational changes, material recycle, process changes, etc.
- Bare galvanized metal shall not be used for materials that convey stormwater, such as roofs, canopies, siding, gutters, downspouts, roof drains, and pipes. Any galvanized materials shall have an inert, non-leachable finish, such as baked enamel, fluorocarbon paint (such as Kynar or Hylar), factory-applied epoxy, pure aluminum, or asphalt coating. Acrylic paint, polyester paint, field-applied, and Galvalume coatings are not acceptable.

A7.10 Urban Streets

Description of Pollutant Sources: Streets can be the sources of vegetative debris, paper, fine dust, vehicle liquids, tire wear residues, heavy metals (lead and zinc), soil particles, ice control salts, domestic wastes, lawn chemicals, and vehicle combustion products. Street surface contaminants have been found to contain significant concentrations of particle sizes less than 250 microns (Sartor and Boyd 1972).

Pollutant Control Approach: Conduct efficient street sweeping where and when appropriate to minimize the contamination of stormwater. Do not wash street debris into storm drains.

Suggested BMPs

- For maximum stormwater pollutant reductions on curbed streets and high volume parking lots, use efficient vacuum sweepers (refer to Volume V, Chapter 11 for information about an emerging high-efficiency vacuum sweeper technology).

  Note: High-efficiency street sweepers utilize strong vacuums and the mechanical action of main and gutter brooms combined with an air filtration system that only returns clean air to the atmosphere (i.e., filters very fine particulates). They sweep dry and use no water since they do not emit any dust.

  It has been reported that high-efficiency vacuum sweepers have the capability of removing, from pavements under good condition, 80 percent or more of the accumulated street dirt particles whose diameters are less than 250 microns (Sutherland 1998). This assumes pavements under good condition and reasonably expected accumulation conditions.

- For moderate stormwater pollutant reductions on curbed streets, use regenerative air sweepers or tandem sweeping operations.

  Note: A tandem sweeping operation involves a single pass of a mechanical sweeper followed immediately by a single pass of a vacuum sweeper or regenerative air sweeper.

  - *A regenerative air sweeper blows air down on the pavement to entrain particles and uses a return vacuum to transport the material to the hopper.*
  - *These operations usually use water to control dust. This reduces their ability to pick up fine particulates.*

  It has been reported that these types of sweepers have the capability of removing approximately 25 to 50 percent of the *accumulated street dirt particles whose diameters are less than 250 microns (Sutherland 1998). This assumes pavements under good conditions and typical accumulation conditions.*

- For minimal stormwater pollutant reductions on curbed streets, use mechanical sweepers.
  - *Note: Mechanical sweepers are referred to as broom sweepers and use the mechanical action of main and gutter brooms to throw material on a conveyor belt that transports it to the hopper.*
  - *These sweepers usually use water to control dust. This reduces their ability to pick up fine particulates.*

  It has been reported that mechanical sweepers have the capability of removing only 10 to 20 percent of the accumulated street dirt particles whose diameters are less than 250 microns (Sutherland 1998). This assumes pavements under good condition and the most favorable accumulation conditions.

- Conduct sweeping at optimal frequencies. Optimal frequencies are those scheduled sweeping intervals that produce the most cost-effective annual reduction of pollutants normally found in stormwater and can vary depending on land use, traffic volume, and rainfall patterns.

- Train operators in those factors that result in optimal pollutant removal. These factors include controlling sweeper speed, brush adjustment and rotation rate, sweeping pattern, maneuvering around parked vehicles, and interim storage and disposal methods.

- Consider the use of periodic parking restrictions in low to medium density single-family residential areas to ensure the sweeper's ability to sweep along the curb unimpeded by parked vehicles.

- Establish programs for prompt sweeping, removal, and disposal of debris from special events that will generate higher than normal loadings. This includes leaf-fall during the autumn.

- Disposal of street sweeping solids must comply with "Recommendations for Management of Road maintenance materials" described in Appendix IV-C of this volume.

- Inform citizens about the importance of eliminating yard debris, oil, and other wastes in street gutters in order to reduce street pollutant sources.

A7.11 Railroad Yards

Description of Pollutant Sources: Pollutant sources can include drips/leaks of vehicle fluids onto the railroad bed; human waste disposal; litter; locomotive/railcar/equipment cleaning ; fueling; outside material storage; the erosion and loss of soil particles from the railroad bed; maintenance and repair activities at railroad terminals, switching yards, and maintenance yards; and herbicides used for vegetation management. Waste materials can include waste oil, solvents, degreasers, antifreeze solutions, radiator flush, acids, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludges, machine chips with residual machining oil, and toxic fluids/solids lost during transit. Potential pollutants include oil and grease, total suspended solids, BOD, organics, pesticides, and metals.

Pollutant Control Approach: Apply good housekeeping and preventive maintenance practices to control leaks and spills of liquids in railroad yard areas.

Required BMPs

- Implement the applicable BMPs in this chapter depending on the pollution generating activities/sources at a railroad yard facility.
- Do not allow discharge to outside areas from toilets while a train is in transit. Pumpout facilities should be used to service these units.
- Use drip pans at hose/pipe connections during liquid transfer and other leak-prone areas (BMP A2.1).
- During maintenance do not discard debris or waste liquids along the tracks or in railroad yards.

<u>In areas subjected to leaks/spills of oils or other chemicals, convey the contaminated stormwater to appropriate treatment</u> such as a sanitary sewer (if approved by LOTT Alliance Industrial Pretreatment Program at (360) 528-5708), to an API or coalescent plate oil/water separator for floating oils, or other appropriate treatment BMP (as approved by Thurston County). See Volume V.

A7.12 Maintenance of Public and Utility Corridors and Facilities

Description of Pollutant Sources: Passageways and equipment at petroleum product, natural gas, and water pipelines and electrical power transmission corridors and rights-of-way can be sources of pollutants, such as herbicides used for vegetation management and eroded soil particles from unpaved access roads. At pump stations, waste materials generated during maintenance activities may be temporarily stored outside. Additional potential pollutant sources include the leaching of preservatives from wood utility poles, PCBs in older transformers, water that is removed from underground transformer vaults, and leaks/spills from petroleum pipelines. The following are potential pollutants: oil and grease, total suspended solids, BOD, organics, PCB, pesticides, and heavy metals.

Pollutant Control Approach: Control of fertilizer and pesticide applications, soil erosion, and site debris that can contaminate stormwater.

Required BMPs

- Implement BMPs included in Chapter 4, A.9 Landscaping and Lawn/Vegetation Management and in Chapter 7, Section 7.2, R.6 Pesticide Regulations.

- When water or sediments are removed from electric transformer vaults, determine whether contaminants might be present before disposing of the water and sediments. This includes inspecting for the presence of oil or sheen, and determining from records or testing if the transformers contain PCBs. If records or tests indicate that the sediment or water are contaminated above applicable levels, manage these media in accordance with applicable federal and state regulations, including the federal PCB rules (40 CFR 761) and the state MTCA cleanup regulations (Chapter 173-340 WAC). Water removed from the vaults can be discharged in accordance with the federal 40 CFR 761.79, and state regulations (Chapter 173-201A WAC and Chapter 173-200 WAC), or via the sanitary sewer if the requirements, including applicable permits, for such a discharge are met. (See also Chapter 7, Section 7.2-R2.)

- Within utility corridors, consider preparing maintenance procedures and an implementation schedule that provides for vegetative, gravel, or equivalent cover that minimizes bare or thinly vegetated ground surfaces within the corridor to prevent the erosion of soil.

- Provide maintenance practices to prevent stormwater from accumulating and draining across and/or onto roadways.

Stormwater should be conveyed through roadside ditches and culverts. The road should be crowned, outsloped, water barred, or otherwise left in a condition not conducive to erosion. Appropriately maintaining grassy roadside ditches discharging to surface waters is an effective way of removing many pollutants associated with sediments carried by stormwater.

- Maintain ditches and culverts at an appropriate frequency to ensure that plugging and flooding across the roadbed, with resulting overflow erosion, does not occur.

- Apply the appropriate BMPs from Section A4 of this volume, Storage Activities, for the storage of waste materials that can contaminate stormwater.

Suggested BMPs

- When selecting utility poles for a specific location, consideration should be given to the potential environmental effects of the pole or poles during storage, handling, and end-use, as well as its cost, safety, efficacy, and expected life. If a wood product treated with chemical preservatives is used, it should be made in accordance with generally accepted industry standards such as the American Wood Preservers Association Standards. If the pole or poles will be placed in or near an environmentally sensitive area, such as a wetland or a drinking water well, alternative materials or technologies should be considered. These include poles constructed with material(s) other than wood, such as fiberglass composites, metal, or concrete. Other technologies and materials, such as sleeves or caissons for wood poles, may also be considered when they are determined to be practicable and available.

- As soon as practicable, remove all litter from wire cutting/replacing operations, etc.

- Implement temporary erosion and sediment control in areas where clear-cuts are conducted and new roads are constructed.

A7.13 Maintenance of Roadside Ditches

Description of Pollutant Sources: Common road debris including eroded soil, oils, vegetative particles, and heavy metals can be sources of stormwater pollutants.

Pollutant Control Approach: Roadside ditches should be maintained to preserve the condition and capacity for which they were originally constructed, and to minimize bare or thinly vegetated ground surfaces. Maintenance practices should provide for ESC (refer to Activity A3.6 Landscaping and Lawn/Vegetation Management).

Required BMPs

- Inspect roadside ditches regularly, as needed, to identify sediment accumulations and localized erosion.

- Clean ditches on a regular basis, as needed. Ditches should be kept free of rubbish and debris.

- Vegetation in ditches often prevents erosion and cleanses runoff waters. Remove vegetation only when flow is blocked or excess sediments have accumulated. Conduct ditch maintenance (seeding, fertilizer application, harvesting) in late spring and/or early fall, where possible. This allows vegetative cover to be re-established by the next wet season, thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter.

- In the area between the edge of the pavement and the bottom of the ditch, commonly known as the “bare earth zone,” use grass vegetation, wherever possible. Vegetation should be established from the top of the slope of the ditch as long as it does not block the sightlines required for safety.

- Diversion ditches on top of cut slopes that are constructed to prevent slope erosion by intercepting surface drainage must be maintained to retain their diversion shape and capability.

- Ditch cleanings are not to be left on the roadway surfaces. Sweep dirt and debris remaining on the pavement at the completion of ditch cleaning operations.

- Roadside ditch cleanings not contaminated by spills or other releases and not associated with a stormwater treatment system such as a bioswale may be screened to remove litter and separated into soil and vegetative matter (leaves, grass, needles, branches, etc.). The soil fraction may be handled as ‘clean soils’ and the vegetative matter can be composted or disposed of in a municipal waste landfill. For more information, please see "Recommendations for Management of Road maintenance material," in Appendix IV-C of this volume.

- Roadside ditch cleanings contaminated by spills or other releases known or suspected to contain dangerous waste must be handled following the Dangerous Waste Regulations (Chapter 173-303 WAC) unless testing determines it is not dangerous waste.

- Inspect culverts on a regular basis for scour or sedimentation at the inlet and outlet, and repair as necessary. Give priority to those culverts conveying perennial and/or salmon-bearing streams and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.

Suggested BMPs

- Install biofiltration swales, bioinfiltration swales and filter strips to treat roadside runoff wherever practicable and use engineered topsoils wherever necessary to maintain adequate vegetation (CH2M Hill 2000). Consider using the Ecology Embankment BMP where adequate slope and level of traffic permit it. These systems can improve infiltration and stormwater pollutant control upstream of roadside ditches. See Volume V of this manual, *Runoff Treatment BMPs*, for additional information about biofiltration swales, bioinfiltration swales, filter strips, and ecology embankments.

A7.14 Maintenance of Stormwater Drainage and Treatment Facilities

Description of Pollutant Sources: Facilities include roadside catch basins on arterials and within residential areas, conveyance systems, detention facilities such as ponds and vaults, oil and water separators, biofilters, settling basins, infiltration systems, and all other types of stormwater treatment systems presented in Volume V. Roadside catch basins can remove from 5 to 15 percent of the pollutants present in stormwater. When catch basins are about 60 percent full of sediment, they cease removing sediments. Oil and grease, hydrocarbons, debris, heavy metals, sediments, and contaminated water are found in catch basins, oil and water separators, settling basins, etc.

Pollutant Control Approach: Provide maintenance and cleaning of debris, sediments, and oil from stormwater collection, conveyance, and treatment systems to obtain proper operation.

Required BMPs

Maintain stormwater treatment facilities according to the O&M procedures presented in Volume V, Appendix V-C, in addition to the following BMPs:

- Inspect and clean treatment BMPs, conveyance systems, and catch basins (Figure 4.23) as needed, and determine whether improvements or maintenance are needed.
- Promptly repair any deterioration threatening the structural integrity of the facilities. These include replacement of clean-out gates, catch basin lids, and rock in emergency spillways.
- Ensure that storm sewer capacities are not exceeded and that heavy sediment discharges to the storm sewer system are prevented, by methods like those found in C-220, Storm Drain Inlet Protection.
- Regularly remove debris and sludge from BMPs used for peak-rate control, treatment, etc. and truck to a local or state government approved disposal site.
- Clean catch basins in accordance with the information provided in Volume V, Appendix V-C. Additional information is also included in Chapter 5 of this volume, BMP S.9 Cleaning Catch Basins.
- Clean woody debris in a catch basin as frequently as needed to ensure proper operation of the catch basin.

- Install monuments on storm drain inlet rims that state: "Dump No Waste - Drains to Groundwater," "Streams," "Lakes," *where possible* (Figure 4.24).

Figure 4.23. Catch Basin Cleaning with a Vacuum Truck.

Figure 4.24. "No Dumping" Storm Drain Stencil.

- Disposal of sediments and liquids from the catch basins must comply with "Recommendations for Management of Road maintenance materials" described in Appendix IV-C of this volume.

- Select additional applicable BMPs from this chapter depending on the pollutant sources and activities conducted at the facility. Those BMPs include:

  - A4.7 – Storage of Liquid, Food Waste, or Dangerous Waste Containers
  - A6.3 – Soil ESC at Industrial Sites
  - A7.10 – Urban Streets
  - A7.15 – Spills of Oil and Hazardous Substances.

A7.15 Spills of Oil and Hazardous Substances

Description of Pollutant Sources: Owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, transferring, distributing, refining or consuming oil and/or oil products are required by Federal Law to have a Spill Prevention and Control Plan if the storage capacity of the facility, which is not buried, is 1,320 gallons or more of oil, or any single container with a capacity in excess of 660 gallons and which, due to their location, could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines {40 CFR 112.1(b)}. Onshore and offshore facilities, which, due to their location, could not reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines are exempt from these regulations {40 CFR 112.1(1)(i)}. Owners of businesses that produce dangerous wastes are also required by state law to have a spill control plan. These businesses should refer to Chapter 7, Section 7.2, R-2. The federal definition of oil is oil of any kind or any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.

Pollutant Control Approach: Maintain, update, and implement an oil spill prevention/cleanup plan.

Required BMPs

- Prepare an Emergency Spill Control Plan (SCP), which includes:
  - A description of the facility including the owner's name and address.
  - The nature of the activity at the facility.
  - The general types of chemicals used or stored at the facility.
  - A site plan showing the location of storage areas for chemicals, the locations of storm drains, the areas draining to them, and the location and description of any devices to stop spills from leaving the site such as positive control valves.
  - Cleanup procedures.
  - Notification procedures to be used in the event of a spill, such as notifying key personnel. Agencies such as Ecology, Thurston County Fire Marshal, the local Fire District (call 911), Washington State Patrol, Thurston County, U.S. Coast Guard, and the U.S. EPA shall be notified.

  - The name of the designated person with overall spill cleanup and notification responsibility.

- Train key personnel in the implementation of the Emergency SCP. Prepare a summary of the plan and post it at appropriate points in the building, identifying the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill.

- Update the SCP regularly.

- Immediately notify Ecology and Thurston County if a spill may reach sanitary or storm sewers, groundwater, or surface water, in accordance with federal and Ecology spill reporting requirements.

- Immediately cleanup spills. Do not use emulsifiers for cleanup unless an appropriate disposal method for the resulting oily wastewater is implemented. Absorbent material shall not be washed down a floor drain or storm sewer.

- Locate emergency spill containment and cleanup kit(s) in high potential spill areas. The contents of the kit shall be appropriate for the type and quantities of chemical liquids stored at the facility (Figure 4.25).

(Photo courtesy of Seattle Public Utilities)

Figure 4.25. Example of Spill Kit Contents.

Suggested BMP

- Spill kits should include appropriately lined drums, absorbent pads, and granular or powdered materials for neutralizing acids or alkaline liquids where applicable. In fueling areas: absorbent should be packaged in small bags for easy use and small drums should be available for storage of absorbent and/or used absorbent. Spill kits should be deployed in a manner that allows rapid access and use by employees.

Chapter 5 - General Source Control Best Management Practices

This chapter describes source control BMPs recommended in Chapters 2 and 4, organized by BMP type.

This chapter describes BMPs common to several activities described in Chapters 2 and 4. This chapter organizes BMPs by general activity—for example, BMP S.2 describes proper waste disposal applicable to several activities, such as engine repair (A 2.3), concrete mixing (A 3.1), and building demolition (A 5.1).

5.1 Index of BMP Descriptions

BMP	BMP Categories
S.1	Eliminate Illicit Stormwater Drainage System Connections
S.2	Dispose of Collected Runoff and Waste Materials Properly
S.3	Connect Process Water Discharges to a Sanitary Sewer, Holding Tank, or Water Treatment System
S.4	Cover the Activity with a Roof or Awning
S.5	Cover the Activity with an Anchored Tarpaulin or Plastic Sheet
S.6	Pave the Activity Area and Slope to a Sump or Holding Tank
S.7	Surround the Activity Area with a Curb, Dike, or Berm or Elevate the Activity
S.8	Implement IPM Measures
S.9	Clean Catch Basin

5.2 Source Control BMPs

S.1 Eliminate Illicit Storm Drain Connections

A common problem with Thurston County's stormwater drainage system is illegal hook-ups to the system. Many businesses and residences hooked internal building drains, sump overflows, process wastewater discharges, and even sanitary sewer and septic system pipes to the storm drain in the past, allowing a variety of pollutants to flow directly to receiving waters instead of the sanitary sewer or septic system. Frequently, these connections are unknown to the current owner, and do not appear on any plans for the site. Because of the pollution potential these connections represent, the Environmental Protection Agency, under the mandate of the NPDES stormwater permits, has made elimination of illegal connections a top priority.

All businesses and residences in Thurston County must examine their plumbing systems to determine if illegal connections exist. We recommend starting with site plans, to better understand what piping systems were initially installed, making piping that does not appear on the plan a priority for investigation. Wherever toilets, sinks, appliances, showers and bathtubs, floor drains, industrial process waters, or other indoor activities are connected to the stormwater drainage system, immediately reroute them to the sanitary or septic system, holding tanks, or process treatment system.

Industries and businesses that have been issued an NPDES Baseline General Permit by Ecology, and are allowed specific discharges under that permit are exceptions to this requirement. Please refer to R.4 in Chapter 7 to determine if your type of business is required to have a NPDES permit.

If sanitary facilities (such as toilets) are connected to the stormwater drainage system, you must obtain a permit from your local sewer utility and reroute them to the sanitary sewer. If sanitary service is not available, contact the Thurston County Public Health and Social Services Department at (360) 786-5581 for septic permits.

Dye testing with a non-toxic dye is one way to determine where a pipe or structure drains if not obvious by observations or on plans. The dye is put into the structure and flushed with some water. Observations are then made at ends-of-pipes, drainage ditches, catch basins, and manholes to look for the color coming through. Contact Thurston County Department of Resource Stewardship, Water Resources Unit (360) 754-4681 if you need assistance in locating structures adjacent to your property.

Smoke testing can also help detect illegal connections and is best done by qualified personnel. To conduct smoke testing, shut off all indoor discharges, place a smoke bomb or other smoke-generating device in a storm drain manhole, and force air in after it. Station personnel at each suspect drain location to observe if smoke is coming out. Identify smoking drains for future rerouting.

Drains which are found to connect to the stormwater drainage system must either be permanently plugged or disconnected and rerouted as soon as possible. Plug unused drains with concrete or similar permanent materials. If a drain pipe is to be rerouted and a sanitary sewer services the property, then the local sewer provider must be contacted. Restrictions on certain types of discharges, particularly industrial process waters, may require pretreatment of discharges before entering the sanitary sewer. It is the responsibility of the property owner or business operator to follow through on rerouting illicit storm drainage connections to the sanitary sewer.

If the property is not served by a sanitary sewer, alternate measures will be necessary. If the discharge is simply domestic waste, a septic system may be feasible. If it is necessary to install a septic system, the proper permits will need to be obtained from the Thurston County Public Health and Social Services Department at (360) 786-5581. If the discharge is anything other than domestic waste, then a holding tank or onsite treatment will be necessary. Contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for specific directions for installation and disposal.

S.2 Dispose of Collected Runoff and Waste Materials Properly

Every business and residence in Thurston County must dispose of solid and liquid wastes and contaminated stormwater properly. There are generally four options for disposal depending on the type of materials. These options include:

- Sanitary sewer and septic systems
- Recycling facilities
- Municipal solid waste disposal facilities
- Hazardous waste treatment, storage, and disposal facilities.

Many liquid wastes and contaminated stormwater (depending on the pollutants and associated concentrations present) may be put into the sanitary sewer, subject to approval by the LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider.

If wastes cannot be legally discharged to a sanitary sewer or septic system, one of the other three disposal options must be used. Sumps or holding tanks may be useful for storing liquid wastes temporarily. The contents must be disposed of in the sanitary sewer or at a dangerous waste facility depending on the nature of the waste.

Recycling facilities are a recommended option for many commercial and household items, including used oils, used batteries, old equipment, glass, some plastics, metal scrap materials, solvents, paints, wood and land clearing wastes, and various other solid wastes. Solid wastes that cannot be recycled and that are not hazardous must be disposed of at a licensed municipal solid waste disposal facility. The list in Chapter 8 of this volume has the phone numbers and addresses of these facilities in Thurston County.

Dangerous and hazardous wastes must be properly transported to an appropriate hazardous waste treatment, storage, and disposal facility. Included in Chapter 8 is a list of companies dealing in these activities.

Costs of disposal vary considerably from option to option. Especially in the case of dangerous wastes, different types of wastes should be kept segregated. Disposal costs are usually determined by the most hazardous or difficult to dispose of waste present, so you can keep your costs down by not mixing wastes. The Thurston County Department of Public Works (360) 754-4581 can help you determine the best disposal options for your waste.

S.3 Connect Process Water Discharges to a Sanitary Sewer, Holding Tank, or Wastewater Treatment System

This BMP is a minimum requirement for all industrial and commercial activities that generate contaminated process wastewater, such as washing activities, composting activities, and production and processing activities. The water used in these activities cannot drain to surface waters or groundwater untreated. Process water must drain to a sanitary sewer, holding tank, or wastewater treatment system, or it can be recycled.

The first priority for these businesses is discharge of process water to a sanitary sewer via a new or existing plumbing connection. In order to connect to the sewer, you must contact LOTT Alliance Industrial Pretreatment Program at (360) 528-5708 or your local sewer service provider for information on permits for the connection. Pretreatment of industrial wastewaters will often be necessary before it is allowed to discharge to the sewer, and more information can be obtained by calling the number above.

If a sanitary sewer is not available, or if it is determined that a discharge connection is not allowed, the only remaining options are holding tanks or an onsite wastewater treatment facility. Consideration should be given to using a holding tank for used process water if the volume of process water generated by the activity is not excessive. The contents of the holding tank must be pumped out or drained before the tank is full and disposed of properly (see BMP S.2 in this chapter for information on disposal options). If a sanitary sewer connection cannot be made and a holding tank is not used, a wastewater treatment facility must be constructed on the site. This treatment facility must be designed to receive and effectively treat all discharges of process water from the business. Ecology must be contacted for approval of such a facility, since discharges from the treatment facility will enter surface waters or be spread on land. See Chapter 7 for Ecology's requirements for discharges of process waters.

For all types of process water discharges the following measures are required if the activity is to remain uncovered. Define a designated area for the activity and provide a mechanism for prevention of stormwater run-on into the activity area. This can be a curb, dike, or berm (see BMP S.7 in this chapter for more information) or similar effective means to prevent run-on. In this manner, only the precipitation that falls within the activity area is discharged and/or treated along with the activity process water. The designated area should be paved and sloped to a central collection drain. The collection drain must connect to the sanitary sewer (with pretreatment if required), the onsite holding tank, or the onsite treatment facility, whichever method is selected.

This process water BMP can be made more effective if the activity is covered, thus reducing the total amount of water to be treated.

S.4 Cover the Activity with a Roof or Awning

Not every activity can or needs to be located inside a building. In many cases, a simple roof or awning will protect the activity from coming into contact with stormwater, and usually at a lower cost than a complete building. If you do decide to build one of these structures, you will need to obtain permits from Thurston County Development Services (360) 786-5490. They will also be able to help you with fire code requirements and zoning code provisions.

The roof structure can be designed in several ways. One option is a lean-to type of structure, where sheets of corrugated steel, fiberglass, aluminum, or similar impermeable material are attached to the wall of a building and are supported by sturdy poles. Similarly, if there is no building to attach to, roofing materials can be sufficiently supported at all four corners as a stand alone cap, or a waterproof tent canopy can be used.

The area of the roof cover should be sufficient to prevent any precipitation from reaching the covered materials. An example of this type of structure is provided in Figure 5.1.

(Photo courtesy of Seattle Public Utilities)

Figure 5.1. Structure Used to Cover Manufacturing Operations.

Another option for covering an activity is to use an overhanging awning of sufficient size to prevent rain from reaching the materials. Many of the building permit, fire code, and zoning requirements will also apply to these structures. An example of an awning cover is shown in Figure 5.2.

Figure 5.2. Loading Docks with an Overhang to Prevent Material Contact with Rainwater.

Activities such as fueling operations may be more conveniently covered by an island-type overhanging roof. This type of roof is supported by columns along the center of the structure rather than at the corners, enabling vehicles easy access underneath while still providing sufficient protection from rain. An example of this type of roof structure is shown in Figure 5.3.

Figure 5.3. Roof at Fueling Island to Prevent Stormwater Runon.

Note that floating fuel stations (such as some used for refueling boats) cannot be covered, according to the fire code.

The particular roof cover option used at a given site is subject to the site layout and available space, affordability, and limitations imposed by other regulations. Structural cover options other than those given above can be used if they perform the same function. This BMP should usually be implemented in conjunction with sump or sanitary sewer drains and provisions for prevention of stormwater run-on into the covered area. BMPs S.6 and S.7 in this chapter present information on sump installation and run-on prevention.

S.5 Cover the Activity with an Anchored Tarpaulin or Plastic Sheet

Some activities, such as stockpiling of raw materials, can be effectively covered with a sturdy tarpaulin or heavy plastic sheet made of impermeable material. Weights such as bricks, tires, or sandbags should be used to anchor the cover in place. Care should be taken to ensure that the tarpaulin or sheet covers the activity completely and that stormwater run-on does not penetrate significantly under the cover. If several sheets are used to form a cover, the sheets should be tethered together or laid in an overlapping manner. If necessary, pins or stakes should be used to anchor the tarpaulin to the ground. The tarpaulin must be inspected daily to ensure that no holes or gaps are present in the tarpaulin coverage. An example of this type of cover is shown in Figure 5.4.

Figure 5.4. Temporary Plastic Sheeting Anchored over Raw Materials Stored Outdoors.

The tarpaulin covering will be easier to keep in place and will last longer if some form of wind protection is possible. Attempts should be made to locate stockpiles adjacent to buildings where winds are reduced, but not in between buildings where a wind tunnel effect can occur.

Tarpaulins are an inexpensive and cost effective BMP for many activities. This BMP can be combined with runoff containment/run-on prevention curbs, dikes, and berms for better effectiveness (see BMP S.7 for more information).

S.6 Pave the Activity Area and Slope to a Sump or Holding Tank

This BMP applies to several activities that cannot be covered effectively. It is particularly suited to activities with the potential for leaks and spills, but that otherwise do not generate excessive amounts of polluted runoff. Examples are storage of liquid chemicals, waste oils, and solvents in portable containers such as drums; loading and unloading of liquids from trucks; and painting, finishing, and coating activities. A sump or holding tank serves to provide spill containment until the liquids can be pumped out and properly disposed of. If the activity produces large amounts of runoff, this BMP will not be very effective because the stray contaminants will overflow the sump or pass through the sump before collection and disposal are possible. To prevent run-on, the area should be enclosed with a berm, curb, or dike. The following implementation information is intended for situations where this BMP can be effective.

A designated activity area should be paved and sloped to drain to a central collection point. A sump, vault, or holding tank should be installed underneath this collection drain. Some materials, such as gasoline, can react with asphalt pavement and break it down, releasing additional pollutants. If the area is not yet paved and materials are present which may react with asphalt, the area must be paved with concrete. If the area is already paved with asphalt, an asphalt sealant can be applied which can aid in preventing pavement degradation. Whichever paving material is used, the paved surface must be free of gaps and cracks.

The sump or holding tank should have a capacity large enough to contain the entire volume of a potential spill. An example of a paved activity area with a sump drain is shown in Figure 5.5.

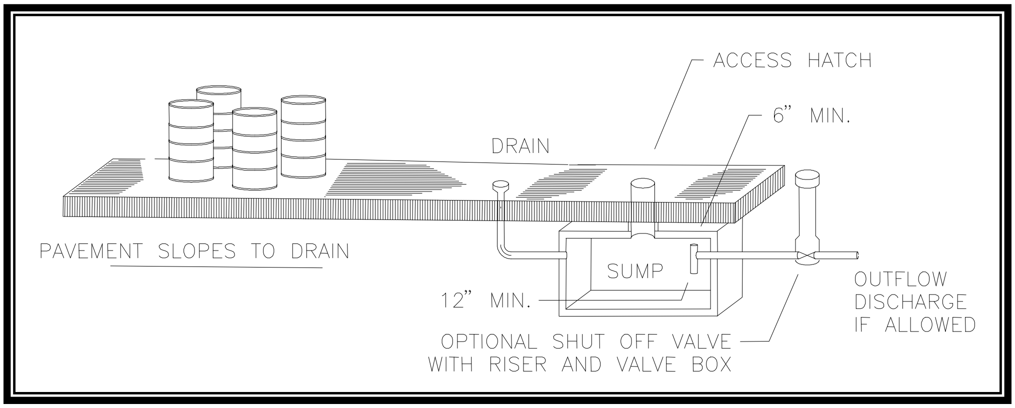


Figure 5.5. Paved Area With Sump Drain.

Wash pads may frequently need to use a sump arrangement like this. To keep disposal costs down, a drain cover, plug, or shutoff valve upstream of the sump should be used at times when the activity is not occurring.

The cost of constructing a sump and the disposal of accumulated contents can be high, so businesses should consider whether other allowable alternative BMPs can be used.

Commercial services that pump sumps and holding tanks are listed in the Yellow Pages of the phone directory under Environmental and Ecological Services.

BMPs S.4, S.5, and S.7 in this chapter present information on covering activities and run-on prevention.

S.7 Surround the Activity Area with a Curb, Berm, or Dike, or Elevate the Activity

This set of BMP options can be an effective means for prevention of stormwater run-on to an activity area. In addition, a curb, berm, or dike can be used for containment of spills in the activity area, or for containment of contaminated activity runoff. Generally, a containment BMP is most applicable to spill control situations; that is, sites where runoff is relatively clean, but occasional spills may occur. This BMP may be less expensive to implement than paving the activity area and providing proper drainage collection, but can also be more difficult to maintain if stormwater ponding occurs inside a containment dike.

If a curb, dike, or berm is used to prevent stormwater run-on to a covered activity area, and the activity area is paved or otherwise impermeable, the berm should be placed underneath the covering so that rain will not pond inside it. Stormwater run-on can also be prevented by elevating the activity with a platform or other type of pedestal.

Containment may be achieved with concrete curbing, an earthen berm, a tub such as a plastic wading pool, or some other dike material, depending on the activity, its size, and resources available. Activities that require more space and therefore cannot be contained with a tub may need to be surrounded by a curb, dike, or berm. Aboveground storage tanks of liquids, storage of chemicals or wastes in numerous drums, and stockpiling of fertilizer are examples of activities that can be contained effectively in this manner. As the activity area gets larger, containment with an earthen berm can probably be provided less expensively than concrete curbing.

If a curb, berm, or dike is used for runoff containment, and other containment sizing regulations (such as fire codes, Ecology or Thurston County Environmental Health restrictions) do not apply, it should function so that all stormwater runoff from rain events up to the 6-month storm is contained in the immediate activity area until it infiltrates into the ground or is properly disposed of later. This approach is applicable for activities that involve liquid material storage, and that may consequently incur spills. It is also applicable to stockpile areas where runoff is typically polluted with suspended solids. If a stormwater treatment system is presently on site, a valve should be installed in the containment dike so that excess stormwater can be drained out of the activity area and directed to the treatment system. This valve should always be kept closed unless excess stormwater is being discharged, so that any spills that occur within the activity area can be effectively contained.

Difficulties in maintenance may arise with disposal of the captured water on sites without stormwater treatment capability. The collected rainwater may need to be treated before discharge. If the activity is located on impermeable ground, then potentially contaminated water will accumulate within the containment area. If contaminated, this accumulated water cannot simply be drained from the area; it must be collected and disposed of at a licensed disposal facility. During the wet season, this course of action can lead to frequent draining that may prove costly. In addition, some type of monitoring would be needed to determine if ponded water is contaminated. Depending on the monitoring requirements, this can also be very costly.

For storage of small items, the simplest containment device is a tub or wading pool. A plastic child's wading pool may be sufficient for some activities that do not require a lot of space, such as storing painting materials, and temporary storage of wastes in drums. An example of this is shown in Figure 5.6. Make sure the material you are using does not react with the plastic.

(Photo courtesy of Mark Dilley, Interstate Products, Inc.)

Figure 5.6. Temporary Spill Containment.

For larger areas, a containment curb, dike, or berm may be necessary. If an earthen berm is used, it must be seeded with grass or other vegetation so that it does not erode. Sketches of a containment berm are shown in Figure 5.7.

The volume of the containment area shall be the greater of either 110 percent of the volume of the largest tank, or 10% of volume of all tanks if there are multiple tanks

It should be noted that neglect and poor maintenance can render the containment useless. Other BMPs should be considered before containment is. Commercial products are available that are a combination containment box/elevated pedestal. These effective devices prevent stormwater run-on by elevating containers off the ground, and allow for collection of spills and drips inside the pedestal box. Similar arrangements can be constructed by hand as well.

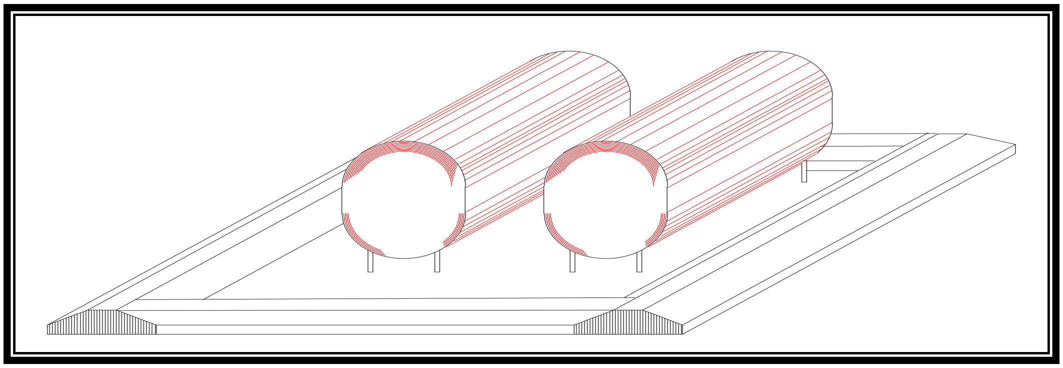


Figure 5.7. Containment Berm Used to Control Liquid-Material Leaks or Spills.

BMPs S.4, S.5, and S.6 in this chapter provide information on covering activities and sump installation.

S.8 Implement IPM Measures

Use of herbicides, fungicides, and rodenticides should always be done with extreme caution, not only because of the potential harm to humans and pets, but also because of the potential harm to fish, wildlife, and our water resources. In light of the toxic nature of these compounds, special attention should be given to pesticide usage in all applications. The discussion below applies more to large-scale pesticide users, but should be considered for backyard applications as well.

Commercial, agricultural, municipal, and other large scale pesticide users, such as golf courses and parks, should adhere to the principles of integrated pest management, a decision-making process for pest management that strives for intelligent, environmentally sound control of pests. It is a systems approach to pest management that combines agronomic, biological, chemical, and genetic information for educated decisions on the type of control to use, the timing and extent of chemical application, and whether non-chemical means can attain an acceptable level of pest control.

Integrated pest management is a preventive measure aimed at knowing the exact pests being targeted for control, the locations and times when pests will pose problems, the level of pest-induced damage that can be tolerated without taking action, the most vulnerable life stage, and control actions that are least damaging to the environment. The major components of integrated pest management are as follows:

- Monitoring and inventory of pest populations
- Determination of pest-induced injury and action levels
- Identification of priority pest problems
- Selection and timing of least toxic management tools
- Site-specific treatment with minimized chemical use
- Evaluation and adjustment of pesticide applications.

Monitoring of pest populations is a key to successful integrated pest management implementation. Pest problems are universally easier to control if the problem can be discovered early. With integrated pest management pesticides are used only as a last resort. Maximization of natural controls, including biological controls and removal of pests by hand, is always the first choice.

More information on integrated pest management is available from the Washington State Department of Agriculture and from the Washington State University Extension Service. Refer to Appendix IV-B for an example of an Integrated Pest Management Program.

S.9 Cleaning Catch Basins

Cleaning catch basins regularly (Figure 5.8) is one of the most important stormwater source control measures that a business can take as they are a last line of defense before runoff enters the stormwater conveyance system.

Figure 5.8. Catch Basin Cleaning with a Vacuum Truck.

Catch basins are typically located under low spots in parking lots, along curbs and road edges, and where storm drain pipes combine flows. Catch basins on the surface collect runoff for storm drains that are typically located directly underneath them. Most catch basins have some storage in the bottom that never drains to an outflow pipe. This permanent storage area is intended to trap sediments, debris, and other particles that can settle out of stormwater, thus preventing clogging of downstream pipes and washing of these solids into receiving waters.

For additional information on the maintenance of catch basins, refer to Volume V, Appendix V-C.

Several companies offer catch basin cleaning services. Pertinent equipment dealers and cleaning services can be found in the telephone Yellow Pages under headings like "Sewer Cleaning Equipment and Supplies" and "Sewer Contractors". All of the solids and stagnant water collected from catch basin sumps must be disposed of properly. None of the sump contents can be flushed into the catch basin outflow pipe. Depending on the nature of the pollutants in the sump, and the associated types of activities taking place on the site, the sump contents may need to be disposed of as hazardous waste. Contractors who perform catch basin cleanout services will be required to follow specified disposal requirements.

It should be apparent that use of other BMPs, such as frequent sweeping of activity areas, covering activity areas, reducing activity occurrence, and containing runoff from activity areas will help reduce catch basin cleaning frequency, thus saving time and money. All businesses and agencies should set up maintenance schedules for all of their BMPs so that coordinated BMP maintenance efforts result in reduced catch basin cleaning frequencies.

Chapter 6 - Best Management Practices for Single-Family Residences

The actions we take each day in and around our homes have a profound effect on surface water quality and fish habitat in this region. Stormwater goes directly to our groundwater, lakes, streams, and to Puget Sound. It does not go to the wastewater treatment plant. Any pollutants that get into the stormwater go directly to surface or groundwater. Small amounts of pollution from many different sources can significantly affect our waterways. Yard maintenance, waste storage, car washing and maintenance, and pool cleaning are some of the activities that can adversely impact water quality. Stormwater BMPs) discussed in this section are practical ways to keep stormwater from becoming polluted in the first place. It is recommended that all residents in Thurston County use these BMPs. **Please note that some of these procedures are required by various state, or county laws, and are noted as required BMPs.**

Below is a general list of BMPs for Thurston County residents. The list includes brief information on applicability. For more information on the following BMPs, refer to the information in Sections 3.1 through 3.7 of this chapter. Additionally, BMPs addressing maintenance of roof runoff systems and onsite stormwater management features are described in Volumes III and V.

6.1 Automobile Washing

Many residents wash their cars in the driveway or on the street. Washwaters typically flow to a storm drain or ditch, which discharges stormwater directly to the underlying groundwater or to the nearest stream, lake, or Puget Sound. Soaps and detergents, even the biodegradable ones, can have immediate and long-term effects on aquatic life in water bodies. The grime washed off the car also contains a variety of pollutants that can harm fish and wildlife.

6.1.1 Suggested BMPs

At Home:

- Wash your car directly over your lawn or make sure the washwater drains to a vegetated area. This allows the water and soap to soak into the ground instead of running off into a local water body.

- Ideally, no soaps or detergents should be used, but if you do use one, select one without phosphates.

- Commercial products are available that allow you to clean a vehicle without water. These were developed for areas where water is scarce, so a water saving benefit is realized, as well as reduced pollution.
- Use a hose nozzle with a shut-off valve to save water.
- Do not wash your car if rain is expected.
- Pour the bucket of soapy, dirty washwater down your sink. This way the water doesn't pollute surface water. Instead, it's treated at the wastewater treatment plant or by your septic system.

Away from Home:

- Consider not washing your car at home. Take it to a commercial car wash that has a recycle system and discharges wastewater to the sanitary sewer for treatment.

6.2 Automobile Maintenance

Many of us are "weekend mechanics". We enjoy the cost savings of changing our own oil and antifreeze, topping off the battery with water, and generally making our car perform its' best. There is a lot of potential for stormwater pollution associated with these activities; however, the following BMPs will help you minimize pollution while servicing your car, truck, van, or RV.

6.2.1 Required BMPs

- Recycle all oils, antifreeze, solvents, and batteries. Many local car parts dealers and gas stations accept used oil and oil filters. The Household Hazardous Waste facilities at the Thurston County Waste and Recovery Center accept oil, oil filters, antifreeze, and solvents.
- Never dump new or used automotive fluids or solvents on the ground, in a storm drain or street gutter, or in a water body. Eventually, it will make its way to local surface waters or groundwater, including the water we drink.
- Do not mix wastes. The chlorinated solvents in some carburetor cleaners can contaminate a huge tank of used oil, rendering it unsuitable for recycling. Always keep your wastes in separate containers which are properly labeled and store them out of the weather.

6.2.2 Suggested BMPs

- Fix all leaks, to keep the leaky material off streets and out of surface water.

- To dispose of oil filters, punch a hole in the top and let drain for 24 hours. This is where a large funnel in the top of your oil storage container will come in handy. After draining, wrap in 2 layers of plastic and dispose of in your regular garbage or recycle by taking it to the Thurston County Waste and Waste and Recovery Center. Call the Thurston County Department of Public Works at (360) 754-4581 for up-to-date information on the appropriate disposal of consumer products.

- Use care in draining and collecting antifreeze to prevent accidental spills. Spilled antifreeze tastes sweet and can be deadly to animals that ingest it.

- Perform your service activities on concrete or asphalt or over a plastic tarpaulin to make spill cleanup easier. Keep a bag of kitty litter on hand to absorb spills. If there is a spill, sprinkle a good layer on the spill, let it absorb for a little while and then sweep it up. Place the contaminated litter in a plastic bag, tie it up, and dispose of it in your regular garbage. Take care not to leave kitty litter out in the rain; it will form a sticky goop that is hard to clean up.

- If you are doing body work outside, be sure to use a tarpaulin to catch material resulting from grinding, sanding, and painting. Dispose of this waste by double bagging in plastic and placing in your garbage.

6.3 Storage of Solid Wastes and Food Wastes

Improper storage of food and solid waste at residences can lead not only to water pollution problems, but problems with neighborhood pets and vermin as well. Following the BMPs listed below can help keep your property a clean and healthy place to live.

6.3.1 Suggested BMPs

- Recycle as much as you can. Most Thurston County residents have access to curbside pickup for yard waste and recyclable materials. Also, look under “recycling” in the phone book for firms which take other recyclables.

- All waste containers kept outside should have lids (Figure 6.1). If your lid is damaged, please call your local solid waste hauler to get the lid repaired or replaced. The Thurston County web site lists haulers for your neighborhood: <www.co.thurston.wa.us/wwm/>

Figure 6.1. Waste Dumpster with Properly Sealed Lid.

- Leaking waste containers should be replaced. If your container is damaged, please call your local solid waste hauler.
- Store waste containers under cover if possible, or on grassy areas.
- Inspect the storage area regularly to pick up loose scraps of material and dispose of them properly.
- Purchase products which have the least amount of packaging materials.
- Compost biodegradable materials such as grass clippings and vegetable scraps instead of throwing them away. Your flowerbeds will love the finished compost, and you'll be helping to conserve limited landfill space. Call Thurston County Department of Public Works at (360) 754-4581 for more information on composting or information on yard waste collections. See the section on composting for BMPs relating to that activity.
- A fun alternative to traditional composting is worm composting. You can let worms do all the work for you by keeping a small vermiculture box just outside your kitchen. For more information on getting started with worms, call the number listed above.

6.4 Composting

Composting is an earth-friendly activity as long as some common sense rules outlined below are followed. If you choose to compost, the following BMPs should be utilized. More information can be found on-line at: <www.co.thurston.wa.us/wwm/>

6.4.1 Suggested BMPs

- Compost piles must be located on an unpaved area where runoff can soak into the ground or be filtered by grass and other vegetation. Compost piles should be located in an area of your yard not prone to water ponding during storms, and should be kept well away from wetlands, streams, lakes, and other drainage paths.

- Compost piles must be maintained and turned over regularly to work properly. Large piles of unattended compost may create odor and vermin problems.

- Avoid putting hazardous, inorganic, plastics or metal waste in the pile.

- Cover the compost pile (Figure 6.2) for two reasons:

    1. To keep stormwater from washing nutrients into waterways.

    2. To keep excess water from cooling down the pile, which will slow down the rate of decomposition.

(photo courtesy of Green Culture)

Figure 6.2. Covered Compost Bin.

Build bins of wood, chicken wire, or fencing material to contain compost so it can't be washed away. You can purchase reduced price compost bins through Thurston County's web-site or find information on building your own bins. Call Thurston County Department of Public Works at (360) 754-4581 to get free composter designs and materials lists or see: <www.co.thurston.wa.us/wwm/>.

- Building a small earthen dike around your compost pile is an effective means of preventing nutrient-rich compost drainage from reaching stormwater paths.

6.5 Yard Maintenance and Gardening

This section deals with the normal yard maintenance activities we all perform at our homes. Over watering, over fertilizing, improper herbicide application, and improper disposal of trimmings and clippings can all contribute to serious water pollution problems. Following the BMPs listed below will help alleviate pollutant runoff.

6.5.1 Required BMPs

- Follow the manufacturer's directions exactly for mixing and applying herbicides, fungicides, and pesticides, and use them sparingly. Never apply when it is windy or when rain is expected. Never apply over water, within 100 feet of a well-head, or adjacent to streams, wetlands, or other water bodies. Triple-rinse empty containers, using the rinsate for mixing your next batch of spray, and then double-bag and dispose of the empty container in your regular garbage. Never dispose of grass clippings or other vegetation in or near storm drains, streams, lakes, or Puget Sound.

6.5.2 Suggested BMPs

- Use natural, organic soil amendments when possible. The excellent soil conditioning properties of the organic matter aid water retention in lighter soils and help to break up and aerate heavier soils, so roots can grow better and less watering is needed. It contains both readily available and long term nitrogen and other nutrients commonly lacking in Northwest soils. The slow release of nitrogen better matches the needs of plants. Thus, there is much less potential for nitrates to leach into surface or groundwater due both to less "excess nitrogen" and less water use. Better vegetative growth can also reduce erosion and runoff.

- Follow manufacturer's directions when applying fertilizers. More is not better, either for your lawn or for local water bodies. Never apply fertilizers over water or adjacent to ditches, streams, or other water bodies. Remember that organic fertilizers have a slow release of nitrogen, and less potential to pollute then synthetic fertilizers.

- Save water and prevent pollution problems by watering your lawn sensibly. Lawns and gardens typically need the equivalent of 1 inch of rainfall per week. You can check on how you're doing by putting a wide mouth jar out where you're sprinkling, and measure the water with a small plastic ruler. Overwatering to the point of runoff can carry polluting nutrients to the nearest water body.

- Consider planting a vegetated buffer zone adjacent to streams or other water bodies on your property. Call the Thurston County Conservation District at (360) 754-3588 for advice and assistance in developing a planting plan. The Stream Team program (360) 754-4681 at the County may even be able to help you plant it!

- Reduce the need for pesticides and fertilizers on lawns by improving the health of the soil. Aerating, thatching, and topdressing with compost will improve soil health and help desired grasses compete with weeds and moss.

- Make sure all fertilizers and pesticides are stored in a covered location. Rain can wash the labels off of bottles and convert 50 pounds of boxed fertilizer into either a solid lump or a river of nutrients.

- Use a mulching mower and mow higher to improve soil/grass health and reduce or eliminate pesticide use.

- Compost all yard clippings, or use them as mulch to save water and keep down weeds in your garden. See Composting section for more information.

- Practice organic gardening and virtually eliminate the need to use pesticides and fertilizers. Contact Thurston County Cooperative Extension at (360) 786-5445 for information and classes on earth-friendly gardening.

- Pull weeds instead of spraying and get some healthy exercise, too. If you must spray, use the least toxic formulations that will get the job done. The Master Gardener program listed above can help advise you on which spray to use.

- Work fertilizers into the soil instead of letting them lie on the ground surface exposed to the next rain storm.

- Plant native vegetation which is suited to Northwest conditions, they require less water and little to no fertilizers and pesticides.

- Contact your local waste disposal company for curbside pickup and recycling of yard waste.

6.6 Swimming Pool and Spa Cleaning and Maintenance

Despite the fact that we immerse ourselves in it, the water from pools and spas is far from chemically clean. Nutrients, pH, and chlorine can adversely affect fish and wildlife in water bodies. Following these BMPs will ensure the cleanliness of your pool and the environment.

6.6.1 Required BMPs

- Pool and spa water must be dechlorinated to 0.1 mg/L if it is to be emptied into a ditch or to the stormwater drainage system. Contact your pool chemical supplier to obtain the neutralizing chemicals you will need. The rate of flow into the ditch or drainage system must be regulated so that it does not cause problems such as erosion, surcharging, or flooding. Water discharged to the ground or a lawn must not cross property lines and must not produce runoff.

- If pool and spa water cannot be dechlorinated, it must be discharged to the sanitary sewer. Prior to draining, your local sewer provider must be notified to ensure they are aware of the volume of discharge and the potential effects of chlorine levels. A pool service company can help you determine the frequency of cleaning and backwash of filters.

- Diatomaceous earth used in pool filters cannot be disposed of in surface waters, on the ground, or into stormwater drainage systems or septic systems. Dry it out as much as possible, bag it in plastic, and dispose of at the landfill.

6.6.2 Suggested BMPs

- Hire a professional pool service company to collect all pool water for proper disposal. Make sure to ask them where they will dispose of it and the kind of permits they hold to do so.

6.7 Household Hazardous Material Use, Storage, and Disposal

Once we really start looking around our houses, the amount of hazardous materials we have on site is a real eye-opener. Oil-based paints and stains, paint thinner, gasoline, charcoal starter fluid, cleaners, waxes, pesticides, fingernail polish remover, and wood preservatives are just a few hazardous materials that most of us have around the house.

When products such as these are dumped on the ground or in a storm drain, they can be washed directly to receiving waters where they can harm fish and wildlife. They can also infiltrate into the ground and contaminate drinking water supplies. The same problem can occur if they are disposed of with your regular garbage; the containers can leak at the landfill and contaminate groundwater. The same type of contamination can also occur if hazardous products are poured down a sink or toilet into a septic system. Don't pour them down the drain if you're on municipal sewers, either. Many compounds can “pass through” the wastewater treatment plant without treatment and contaminate receiving waters, or they can harm the biological process used at the treatment plant, reducing overall treatment efficiency.

With such a diversity of hazardous products present in all homes in Thurston County, a large potential for serious environmental harm exists if improper methods of storage, usage, and disposal are employed. Using the following BMPs will help keep these materials out of our soils, sediments, and waters.

6.7.1 Required BMPs

- Hazardous Materials must be used in accordance with the manufacturer recommendation or guidelines as shown on the label.

- Always store hazardous materials in properly labeled containers, never in food or beverage containers which could be misinterpreted by a child as something to eat or drink.

- Dispose of hazardous materials and their containers properly. Never dump products labeled as *poisonous*, *corrosive*, *caustic*, *flammable*, *inflammable*, *volatile*, *explosive danger*, *warning*, *caution*, or *dangerous* outdoors, in a storm drain, or into sinks, toilets or drains. Call the Thurston County Department of Public Works at (360) 754-4581 for information on disposal methods, collection events, and alternative products. Household hazardous wastes from Thurston County residents and non-residents are accepted at the HazoHouse, at the Thurston County Waste and Recovery Center in Hawks Prairie at 2418 Hogum Bay Road NE.

6.7.2 Suggested BMPs

- Check hazardous material containers frequently for signs of leakage. If a container is rusty and has the potential of leaking soon, place it in a secondary container before the leak occurs and prevent a cleanup problem.

- Hazardous materials should be stored out of the reach of children.

- Store hazardous materials containers under cover and off the ground. Keep them out of the weather to avoid rusting, freezing, cracking, labels being washed off, etc.

- Keep appropriate spill cleanup materials on hand. Kitty litter is good for many oil-based spills.

- Ground cloths and drip pans must be used under any work outdoors which involves hazardous materials such as oil-based paints, stains, rust removers, masonry cleaners, and others bearing label warnings as outlined above (Figure 6.3).

Figure 6.3. Drip Pan for Capturing Spills and Drips During Engine Repair and Maintenance.

- Latex paints are not a hazardous waste, but are not accepted in liquid form at the landfill. To dispose of, leave uncovered in a protected place until dry, then place in the garbage. If your can is at least half full, you can take it to the HazoHouse to be placed in Swap Shop area. If you wish to dry waste paint quickly, mix kitty litter or sawdust in the can to absorb the paint. Once paint is dry, leave the lid off when you place it in the garbage so your garbage collector can see that it is no longer liquid.

- Use less toxic products whenever possible. Ecology maintains a hotline at 1-800-RECYCLE, or see information online at https://fortress.wa.gov/ecy/recycle/

- If an activity involving the use of a hazardous material can be moved indoors out of the weather, then do so. Make sure you can provide proper ventilation, however.

- Follow manufacturers' directions in the use of all materials. Over-application of yard chemicals, for instance, can result in the washing of these compounds into receiving water bodies. Never apply pesticides when rain is expected.

- When hazardous materials are in use, place the container inside a tub or bucket to minimize spills and store materials above the local base flood elevation (BFE).

6.8 Pet Waste Management

Pet waste that washes into lakes, streams or Puget Sound begins to decay, using up oxygen and releasing ammonia. Low oxygen levels and ammonia combined with warm water can kill fish. Pet waste also contains nutrients that encourage weed and algae growth in waters we use for swimming, boating and fishing. Most importantly, in many urban areas, pet waste is the largest source of bacterial loading to streams. It can carry diseases that could make water unsafe for contact and lead to beach closures or affect shellfish harvest. These include:

- Campylobacteriosis—bacterial infection
- Salmonellosis—bacterial infection
- Toxocariasis—roundworm infection
- Toxoplasmosis—protozoan parasite infection
- Giardiasis—protozoan parasite infection
- Fecal Coliform—bacteria in feces, indicates contamination
- *E. coli*—bacteria in feces, may cause disease.

Cleaning up after your pet can be as simple as taking a plastic bag or pooper scooper along on your next walk. Then choose one of the following:

6.8.1 Suggested BMPs

- **Bag it –** Put waste in a securely closed bag and deposit it in the trash. Do not put it in your yard waste container because pet waste may carry diseases, and yard waste treatment may not kill disease organisms.

- **Bury it –** Bury waste at least 1 foot deep and cover with soil in your yard or garden (not in food-growing areas).

- **Flush it** – Only flush pet wastes if your home is served by a sanitary sewer which goes to a sewage treatment plant. Water from your toilet goes through a treatment process that removes pollutants before it is discharged into the environment.

  To prevent plumbing problems, don't flush debris or cat litter. Cat feces may be flushed, but used litter should be put in a securely closed bag in the trash. Septic systems are not designed to accommodate the high pollutant load of pet waste. To prevent premature failure or excessive maintenance costs do not flush pet wastes to your septic system.

- **Compost it** – waste from small animals **other than dogs and cats** (rabbits, rodents, etc.), can be put in your compost bin.

6.9 On-Site Sewage Maintenance and Operation

Thurston County is responsible for ensuring that stormwater discharged from stormwater management systems we operate does not harm or impair the use of the receiving waters (creeks, rivers, lakes, groundwater or Puget Sound). Sample tests of stormwater discharges and receiving water occasionally indicate high levels of fecal coliform bacteria.

One potential source of bacteria is malfunctioning onsite sewage systems (septic systems). Septic tank failures have been documented on private property in Thurston County.

Septic systems vary widely in their design and complexity. Owners of septic systems should contact the Thurston County Department of Public Health and Social Services (Environmental Health Division) at (360) 754-4111 to request an as-built of their system. As-built requests are also available at the Development Review counter at 2000 Lakeridge Drive SW, Olympia. More information is available at: <www.co.thurston.wa.us/permitting>.

In its simplest design the septic tank is the first stage of a private sewage disposal system. The septic tank is a water-tight tank below ground that is usually made of concrete but may be fiberglass, plastic or steel. Septic tanks have one or two access ports for inspection and maintenance which are usually buried a few inches below the ground.

The tank receives household wastewater through an inlet pipe at one end, settles out larger material to the bottom, breaks down waste material with bacteria present in the tank and delivers the partially treated wastewater out another pipe on the opposite end of the tank to the disposal field.

The disposal field is the second stage of the private sewage disposal system and completes the final breakdown of wastewater with organisms in the soil.

The disposal field consists of narrow trenches filled with gravel and perforated pipes that distribute the wastewater to the field. With proper maintenance, a well designed system can last a long time; however, disposal fields will clog if forced to handle large particles that should settle out in the bottom of the septic tank.

6.9.1 Required BMPs

Owners of septic systems must follow all of the requirements of the Thurston County Department of Public Health and Social Services, Environmental Health Division. They can be contacted at Thurston County Health Department at (360) 754-3355 extension 6518 for further information and specific requirements applicable to your system.

6.9.2 Suggested BMPs

Regular Inspection and Maintenance

Septic tanks require regular inspection and maintenance. Inspections should be done to measure accumulated sludge every 3 to 5 years. Pumping frequency can vary depending on tank size, family size and garbage disposal use. Failure to remove sludge periodically will result in reduced settling capacity and eventual overloading of the disposal field, which can be difficult and expensive to remedy. Maintenance is required on complex systems, those serving more than one single family residence, and commercial establishments.

Eliminate or Restrict Garbage Disposal Use

Eliminating or restricting garbage disposals can significantly reduce the loading of solids to the septic tank thus reducing the pumping frequency.

Reduce and Spread Water Use Out Over the Day

Septic tanks are limited in their ability to handle rapid large increases in the amount of water discharged into them. Excess wastewater flow can cause turbulence in the tank flushing accumulated solids into the disposal field. Over time this will impair the ability of the disposal field to function. Limit water using appliances to one at a time. Do one load of clothes a day rather than several in one day. Practice water conservation at home.

Chemical Use

Septic systems are to be used for the disposal of household wastewater only. Never dispose of excess or unwanted chemicals into the septic system. Occasional use of household cleaners in accordance with the manufacturers' recommendations should not harm your septic system. There is little evidence that products advertised for use as septic system cleaners and substitutes for pumping actually work as advertised.

For additional information on proper operation of your septic system or to report a failing septic system in your neighborhood, contact Thurston County Environmental Health at (360) 786-5490 or at: <www.co.thurston.wa.us/health/ehoss/index.html>.

6.10 Activities in Wetlands and Wetland Buffers

Wetlands and associated buffers are vegetated ecosystems through which water passes. These areas characteristically have a high water table and are often subject to periodic flooding. Wetlands can be very effective in removing sediments, nutrients and other pollutants from stormwater.

Maintaining wetlands and associated buffers helps to slow stormwater runoff, trap sediments and other pollutants and reduce the volume of runoff by allowing infiltration to occur. Reducing the velocity of runoff reduces soil erosion and increases contact time with soil and vegetation. Increasing contact of stormwater with soils and vegetation in a wetland or riparian area can be effective in removing sediments, nutrients and other pollutants from stormwater runoff.

Buffer areas are important to both the wetland and the upland areas as habitat for aquatic wetland-dependant wildlife and as buffers during extreme weather events. Other functions of buffer areas that contribute to water quality include shading, flood attenuation and shoreline stabilization.

Persons responsible for maintenance of wetland areas are encouraged to call Thurston County Development Services at (360)786-5490 prior to performing work in wetlands or their buffers.

6.10.1 Required BMPs

- Removal by hand of manmade litter and control of noxious weeds that are included on the state noxious weed list (Washington Administrative Code [WAC] 16-750) or invasive plant species as identified by Thurston County. Control may be conducted by clipping, pulling, over-shading with native tree and shrub species, or non-mechanized digging. Alternative methods such as mechanical excavation, barrier installation, or herbicide use may be allowed if acceptable to the Department of Resource Stewardship and acquisition of any necessary permits, per Thurston County Code Title 17 *Environment*, 17.15 - *Critical Areas.*

- Check with Thurston County Development Services and Planning on guidelines for vegetation and hazardous tree removal in critical areas.

6.10.2 Suggested BMPs

- To prevent possible contamination limit fertilizer and herbicide around wetlands and their buffers.

- Limit access to wetlands and their buffers. To avoid compaction do not establish trails within the wetland areas.

Chapter 7 - Regulations and Requirements

The information in this chapter is provided to help you comply with additional Thurston County and Washington State water quality regulations that may apply to your project, industry, or business. Applicable state regulations are summarized for your convenience. Relevant regulations are listed but it is your responsibility to obtain the current version of any ordinances, statutes, or regulations that apply to your project.

7.1 Thurston County Codes and Ordinances

The following is a list of selected Thurston County codes and ordinances, which may apply to land development and stormwater management in Thurston County. A complete list of all Thurston County ordinances is available at: www.thurston.wa.us.

Title 8 Health and Sanitation

- 8.12 Sanitary Landfill Operations
- 8.20 Out-of-County Waste
- 8.24 Solid Waste Management-Reduction and Recycling
- 8.30 LOTT Discharge and Industrial PreTreatment Regulations

Title 13 Roads and Bridges

- 13.28 Construction and Permits
- 13.52 Trees and Vegetation

Title 14 Buildings and Construction

- 14.20 Thurston County Building Code
- 14.28 Uniform Plumbing Code
- 14.32 International Fire Code
- 14.37 International Building Code Appendix J, Grading
- 14.38 Development in Floor Hazard Areas
- 14.40 Construction in Mudslide Hazard Areas
- 14.44 Mobile Homes
- 14.48 Building Permits

Title 15 Public Works

15.40 Standards Adoption

15.05 Thurston County Stormwater Standards

15.09 Sewer Systems

15.16 Right-of-Way Acquisition and Relocation Assistance

Title 16 Waterways and Vessels

16.04 Regulations and Restrictions on the Use of County Waters

Title 17 Environment

17.09 State Environmental Policy Act

17.12 Black Lake Stormwater Control Area

17.15 Critical Areas

PART 100 Purpose

PART 200 Definitions.

PART 300 Review Standards

PART 400 Administrative Action

PART 500 Aquifer Recharge Areas

PART 600 Geologic Hazard Areas

PART 700 Important Habitats and Species

PART 800 Special Management Areas

PART 900 Floodplains, Streams and Wetlands

17.20 Mineral Extraction Code

17.25 Thurston County Forest Lands Conversion Ordinance

Title 18 Platting and Subdivisions

18.04 General Provisions

18.12 Preliminary Plat

18.16 Final Plat

18.20 Dedications – Plats and Short Plats

18.24 Agreement and Bond for Improvements

18.28 Large Lot Subdivisions

18.32 Short Plats

18.40 Street Requirements

18.42 Thurston County Road Standards

18.44 Drainage Requirements

18.46 Utility Requirements

18.47 Open Space Standards

Title 19 Shoreline Master Program

Title 20 Zoning

20.04 Minimum Requirements

20.07 Lot, Yard, Use and Structure Regulations

20.30 Planned Rural Residential Development (PRRD)

20.31 Mobile Home Park Standards and Regulations

20.32 Open Space

20.37 Site Plan Review

20.44 Parking and Loading

20.45 Landscaping and Screening

20.54 Special Use

Title 21 Lacey Urban Growth Area Zoning

Title 22 Tumwater Urban Growth Area Zoning

Title 23 Olympia Urban Growth Area Zoning

7.2 State, Federal, and Other Regulations and Requirements

R.1 Ecology requirements for the discharge of process wastewaters directly to surface waters

R.2 Ecology requirements for generators of dangerous (hazardous) wastes

R.3 Ecology stormwater NPDES permit requirements

R.4 Ecology requirements for underground and aboveground storage tanks.

R.5 U.S. EPA and Ecology requirements for spill-control and prevention plans

R.6 Washington State Department of Agriculture (WSDA) pesticide regulations

R.7 Puget Sound Air Pollution Control Agency (PSAPCA) air quality regulations

R.8 Requirements of Native American Tribes

R.1 Washington State Department of Ecology Requirements for the Discharge of Process Wastewaters Directly to Surface Waters

If a public sanitary sewer is not available, process wastewater may be discharged, after suitable treatment, to a surface water body like a lake or stream, or to a drainage field. If the discharge is to a surface water body, Ecology must be contacted to obtain approval of the type and design of the treatment system, as well as the design and location of the outfall and the need for an NPDES permit. If a septic tank and drainfield are used for treatment, requirements of the Thurston County Environmental Health Division will also apply; contact the On-Site Sewage Program directly at (360) 357-2490 for more information.

Ecology's requirements can be found at WAC Chapter 173-240. Some of the specific requirements include:

1. An engineering report must be prepared describing the proposed project. The general contents of the engineering report are specified by Ecology (WAC Chapter 173-240). The report is reviewed and approved by Ecology.

2. The treatment system must be designed in accordance with *Criteria for Sewage Works Design*, August 2008, by Ecology.

3. The outfall must be designed in accordance with specific dilution zone dimensions (WAC Chapter 173-201A-100).

4. The quality of the discharge into the receiving water must be treated and diluted (according to the dilution criteria noted above) so as to not result in a violation of water quality standards (WAC Chapter 173-201A).

5. The treatment plant must be properly maintained and operated by a certified operator (WAC Chapter 173-230).

R.2 Ecology Requirements for Dangerous Waste Generators

The state dangerous waste regulations (WAC Chapter 173-303) cover accumulation, storage, transportation, treatment, and disposal. Of interest to this volume is the temporary accumulation of waste until taken from the site to a permitted disposal site. Only portions of those regulations that apply to temporary storage are summarized here.

Permitted Generators

Businesses that generate 220 pounds or more of dangerous waste, either per batch or in the aggregate, over 1 month must comply with the storage specifications outlined below:

If placed in containers:

1. If the container is not in good condition (for example, severe rusting or apparent structural defects) or if it begins to leak, the owner must replace the container.
2. The container must be labeled as to its contents.
3. The container must be lined with a material that does not react with the waste.
4. The container must be kept closed except when adding or removing waste.
5. The container must not be opened, handled, or stored in a manner which may cause a rupture or leak.
6. At least weekly examine the containers for leakage.
7. Containers storing reactive or ignitable waste must meet fire code requirements.
8. Incompatible wastes must be stored separately.
9. Ecology may require secondary containment of the storage area. Specifically, the storage area must:
    a. Be capable of collecting and holding spills and leaks.
    b. If uncovered, be capable of handling a 25-year recurrence interval storm.
    c. Have a base that is free of cracks or gaps and is sufficiently impervious to leaks, spills, and rainfall.

d. Be sloped or designed so that liquids can drain to a point for removal.

e. Have positive drainage control (e.g., a valve) to ensure containment until any liquid is removed, which must occur in a timely manner.

f. Have a holding capacity equal to 10 percent of the volume of all containers or the volume of the largest container, whichever is greater.

g. Not allow run-on of rainfall from areas adjacent to the storage area.

If the waste does not contain free liquids, the above requirements need not be met, provided that the area is sloped or the containers are elevated.

If placed in tanks:

1. The tank must be lined with a material that does not react with the waste.

2. The tank, tank area, and its ancillary equipment must be inspected according to a written schedule.

3. If retired, the tank is to be cleaned of all contents, and those contents properly disposed of.

4. Tanks storing reactive or ignitable waste must meet applicable fire codes.

5. Incompatible wastes must be stored separately.

The generators must have a designated employee on site or on call with the responsibility for coordinating all emergency response measures. Spills are to be contained and cleaned up as soon as practicable.

Small-Quantity Waste Generators

These are businesses that generate less than 220 pounds of dangerous waste per month or per batch (or 2.2 pounds of extremely hazardous waste). Small-quantity generators still fall under Ecology regulations to the extent that the materials must be properly stored on site until shipment. The wastes must be moved from the property whenever the accumulated quantity equals or exceeds 220 pounds or whenever the material has resided on site for 180 days. The waste must be disposed of at an approved facility. If the business is in compliance with these requirements, they are also considered solid waste generators, and are regulated by Thurston County Department of Public Health and Social Services, Environmental Health Division. For technical assistance and site visits, contact Thurston County Environmental Health (360) 786-5461 or the Thurston County Department of Resource Stewardship, Water Resources Unit at (360) 754-4681. Regulations governing small-quantity generators are currently being reviewed to possibly raise the accumulation limit. Call the Hazardous Waste Line at 1-800-287-6429 for the most up-to-date information.

Dangerous Waste Spill Plans

A recent state law established the requirement that generators of dangerous wastes in excess of 220 lbs/month (2,640 lbs/year) prepare a waste reduction plan, called a spill plan, not to be confused with the SWPPP (see R.4). The required content of the plan is set forth in *Pollution Prevention Planning - Guidance Manual*, January 1992, publication No. 91-2, for WAC Chapter 173-307.

Many of the actions described in these plans may benefit stormwater quality and thus should be integrated into any decisions about the selection of the BMPs described in Chapters 4 and 5 of this volume.

See WAC Chapters 173-303 and -307 for further details, as well as the above-named publication.

R.3 Ecology Stormwater NPDES Permit Requirements

The NPDES program requires industries or industrial-type activities to obtain permits for stormwater discharge.

Coverage is under Ecology's general permit for stormwater discharges associated with industrial or construction activities for each regulated facility. A business must obtain permit coverage if its primary activity falls under one of the categories listed in the permit or its fact sheet. The permit and fact sheet may be viewed on Ecology's Web site at: <www.ecy.wa.gov/programs/wq/permits/index.html>.

Examples of types of industrial facilities required to be covered under the General Permit for Industrial activities include the following business types if they discharge stormwater to surface water from their sites:

1. Lumber & Wood Products Industries
2. Paper and Allied Products Industries
3. Primary Metals Industries
4. Mining and gas/oil extraction industries (Note: Gravel Mines have a separate NPDES permit and would be required to be covered under that General Permit).
5. Hazardous waste treatment, storage and disposal facilities.
6. Landfills, land application sites and dumps
7. Recycling facilities including salvage yards, automobile junkyards, and metal scrap yards.
8. Transportation facilities including railway stations, airports, ferry terminals, petroleum bulk stations and terminals.
9. Industries involved in food products, printing, painting, glass products industrial and commercial machinery, transportation equipment, warehousing and storage.

The NPDES Stormwater Permit program requires the preparation of a SWPPP and compliance with the general permit conditions. Alternatively a site can apply for an individual permit if special circumstances would warrant it. A NPDES permit is also required for certain activities such as gravel mining not included under the industrial permit and municipalities for discharge to surface water, or a storm drain that discharges to surface water or to surface water and groundwater.

R.4 Ecology Requirements for Underground and Aboveground Storage Tanks

Underground Storage Tanks

Underground storage tanks (UST) that contain fuel and other petroleum products are regulated by Ecology under **WAC Chapter 173-360 Underground Storage Tank Regulations.** This law applies to USTs that have a capacity of greater than 110 gallons. USTs which store federally listed or otherwise regulated hazardous waste, heating fuel on the premises where used, farm or residential USTs less than 1,100 gallons in size and other types are exempt from these regulations (WAC Chapter 173-360-110).

The state UST regulations require permits for USTs in use after July 1991. Specific performance criteria such as design, integrity testing, inventory control, UST performance monitoring, spill control, and reporting for new USTs are outlined in this regulation. USTs in existence prior to adoption of this regulation in 1990 must meet the upgrade criteria or new UST requirements by 1998 or complete closure of the system.

USTs that have been closed or taken out of service after December 1988 must complete closure (removal or in-place closure) in accordance with WAC Chapter 173-360. Requirements for UST closure with Ecology include submittal of a 30-day notice of closure, site assessment, and completion of any applicable cleanup actions. A report of the closure actions must be submitted to Ecology.

Aboveground Storage Tanks

Aboveground storage tanks (AST) which store dangerous wastes are regulated under **WAC Chapter 173-303 Dangerous Waste Regulations**, which is administered by Ecology. Underground storage tanks which store dangerous wastes must also meet the criteria for tanks in this regulation. Businesses which store, handle or generate dangerous wastes are regulated under this regulation based on the volume of dangerous waste generated. The Dangerous Waste Regulations have specific requirements for AST integrity, corrosion protection, secondary containment, leak detection, and use and management criteria, in addition to general requirements for businesses that have dangerous wastes.

For ASTs which contain other types of materials such as petroleum products or raw materials, Ecology guidance document ***Guidelines to Prevent, Control, and Contain Spills from the Bulk Storage of Petroleum Products*** is available for technical guidance.

Inquiries about business-specific requirements and permitting for USTs and ASTs should be directed to Ecology, Southwest Regional Office at (360) 407-6300.

R.5 U.S. EPA and Washington State Department of Ecology Emergency Spill Cleanup Requirements

USEPA – Spill Prevention Control and Cleanup Plans (40 CFR 112)

This federal regulation requires that owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, or consuming oil and oil products are required to have a Spill Prevention and Control and Cleanup Plan (SPCC), provided that the facility is not transportation related; and, that the aboveground storage of a single container is in excess of 660 gallons, or an aggregate capacity greater than 1,320 gallons, or a total below ground capacity in excess of 42,000 gallons.

The plan must:

1. Be well thought out in accordance with good engineering.
2. Achieve three objectives - prevent spills, contain spills that occur, cleanup spills.
3. Identify name, location, owner, and type of facility.
4. Have date of initial operation and oil spill history.
5. Designate the person responsible.
6. Be approved and certified by the person in authority.
7. Contain a facility analysis.
8. Tanks must have secondary containment and leak detection.

Ecology Dangerous Wastes (WAC 173-303-350)

The regulations state that generators must have a contingency plan that must include:

1. Actions taken in the event of a spill.
2. Descriptions of arrangements with local agencies.
3. Identification of the owner's emergency coordinator.
4. List of emergency equipment.
5. Evaluation plan for business personnel.

See Federal Regulation 40 CFR 112 and WAC 173-303-350 for further information.

R.6 Washington State Department of Agriculture Pesticide Regulations

The State of Washington encourages integrated pest management (IPM) when possible. IPM makes use of physical, biological, and selective chemical methods to control pests, helping to protect the environment. IPM techniques for schools and homeowners can be found on Ecology's website:

http://www.ecy.wa.gov/programs/swfa/upest/

Pesticide laws for agricultural operations are administered by the state's Department of Agriculture, under the Washington Pesticide Control Act (RCW Chapter 15.58), Washington Pesticide Application Action (RCW Chapter 17.21), and regulations in WAC Chapter 16.228. The requirements relevant to water quality protection are:

1. Persons who apply pesticides are required to be licensed **except**:

    a. People who use general-use pesticides on their own or their employer's property.

    b. Grounds maintenance people using only general use pesticides on an occasional basis not amounting to a regular occupation.

    c. Governmental employees who apply general use pesticides without utilizing any kind of motorized or pressurized apparatus.

    d. Employees of a commercial applicator or a government agency who are under direct onsite supervision by a licensed applicator.

2. Licensed applicators must undergo 40 hours of continuing education to keep the license.

3. No person shall pollute streams, lakes, and other water supplies in pesticide loading, mixing, and application.

4. No person shall transport, handle, store, load, apply, or dispose of any pesticide, pesticide container, or apparatus in such a manner as to pollute water supplies or waterways, or cause damage or injury to land, human beings, desirable plants, or animals.

See WAC Chapter 16.228 for further details.

R.7 Olympia Region Clean Air Agency Air Quality Regulations

Thurston County is under the jurisdiction of regional air quality authorities who in turn must function under Washington State and federal air quality regulations. The Olympic Region Clear Air Agency (ORCAA) is the regulatory agency for air quality in Thurston County.

The air authority requires registration of and regulates sources of air emissions, including:

1. Spray painting
2. Asphalt plants
3. Rock crushers
4. Non-road engines
5. Incinerators
6. Fuel storage tanks and reservoirs
7. Dry-cleaners
8. Soil and groundwater remediation
9. Composters
10. Auto body repair and painting
11. Outdoor burning
12. Building demolition and asbestos removal

Other air emission sources are exempt from registration but are still required to comply with applicable air pollution requirements. A list of these sources can be found in the ORCAA regulations.

ORCAA requires that reasonable and appropriate precautions be taken to prevent fugitive particulate material from becoming airborne when handling, loading, transporting, or storing particulate material or when constructing, altering, repairing or demolishing a building, road, or untreated open area. Reasonable precautions include: the paving of parking lots and storage areas; housekeeping measures to minimize the accumulation of mud and dust and prevent its tracking onto public roads; and stabilizing storage piles with water spray, chemical stabilizers, tarps, or enclosure.

ORCAA regulations prohibit the release of an air contaminant or water vapor, including an air contaminant whose emission is not otherwise prohibited if the air contaminant or water vapor causes detriment to the health, safety, or welfare of any person, or causes damage to property or business. It also prohibits installation of any device which would conceal or mask an emission of an air contaminant which would otherwise violate ORCAA's Regulations or WAC 173-400.

ORCAA regulations may be viewed on the agency's Web site at: <www.orcaa.org>.

R.8 Requirements of Native American Tribes

Two tribes are located in Thurston County—the Nisqually Indian Tribe and the Confederated Tribes of the Chehalis Reservation (with reservation boundaries that also cross into neighboring Grays Harbor County). Tribal staff review federal, state, and local permits for projects on tribal lands or projects on non-tribal lands that may affect treaty-reserved resources or areas. Both tribes have lands and continuing treaty interests in natural resources. Check with the respective tribes for more information on the treaty rights and the permit review role of the tribe.

Chapter 8 - Quick Reference Phone Numbers and Web Sites

Environmental Protection Agency (U.S. EPA) – Region X	800-424-4372
Thurston County:	
Water Resources Unit, Department of Resource Stewardship	360-754-4681
Department of Public Works	360-754-4581
After-hours water and sewer emergencies (paging service)	800-926-7761
Thurston County Waste Line (automated information)	360-786-5494
LOTT Alliance Industrial Pretreatment Program	360-528-5708
Development Services – Permits	360-786-5490
Weed Control/ Noxious Chemical Use	360-786-5576
Thurston County Public Health and Social Services Department:	
On-Site Sewage	360-754-3355 x 6518
Asbestos Removal	360-786-5461
Hazardous Waste Section	360-786-5457
Solid Waste	360-786-5461
University of Washington Center for Urban Water Resources	206-543-6272
Washington State Department of Agriculture	360-902-2010
	877-301-4555
Washington State Department of Ecology	360-407-6000
Southwest Regional Office	360-407-6300
Dangerous/Hazardous Waste	360-407-6300
NPDES Stormwater or Wastewater Permits	360-407-6400
Spill Reporting	800-424-8802
Recycling	800-732-9253
Groundwater Quality and Protection	360-407-6400
Underground and Aboveground Storage Tanks	360-407-7170
Washington State University/Thurston County Cooperative Extension	360-867-2151
Industrial Materials Exchange	206-296-4899
Nisqually Tribe	360-456-5221
Confederated Tribes of the Chehalis	360-273-5911
Olympic Region Clean Air Agency (ORCAA)	800-422-5623
Underground Utility Locate “Call Before You Dig”	800-424-5555

Washington State Departments:

Washington State Department of Health
<http://www.doh.wa.gov/>

Washington Department of Fish and Wildlife
<http://wdfw.wa.gov/>

Washington State Government Information and Services
<http://www.access.wa.gov/>

Washington State Department of Ecology – Flood Information
<http://www.ecy.wa.gov/programs/sea/floods/>

Washington State Department of Ecology - Digital Coastal Atlas
<http://www.ecy.wa.gov/programs/sea/SMA/atlas_home.html>

Washington State Department of Ecology - Stormwater Home Page
<http://www.ecy.wa.gov/programs/wq/stormwater/index.html>

Salmon and Watershed Information Management (SWIM) Team
<http://www.swim.wa.gov/>

Federal Departments:

Federal Emergency Management Agency (FEMA)
<http://fema.gov/>

U.S. EPA Office of Water, Academy 2000
<http://epa.gov/watertrain/>

U.S. Geological Survey (USGS) Departments:

USGS Historical Water Resource Data
<http://wa.water.usgs.gov/realtime/historical.html>

USGS National Water Information System (NWISWeb)
<http://water.usgs.gov/nwis/>

TerraServer (zoom in on USGS aerial photos anywhere in the USA)
<http://terraserver-usa.com/>

Water Quality and NPDES:

Natural Resources Conservation Service (NRCS) and U.S. Department of Agriculture (USDA)
<http://www.nrcs.usda.gov/>

National Climatic Data Center Data Archive
<http://www.ncdc.noaa.gov/>

National Weather Service Hydrologic Forecasts (River Flooding)
<http://ahps2.wrh.noaa.gov/ahps2/index.php?wfo=sew>

USGS Real Time Gauging Info
<http://wa.water.usgs.gov/realtime/current.html>

U.S. Army Corps of Engineers Real Time Gauge Info
<http://www.nwd-wc.usace.army.mil/nws/hh/basins/puy.html>

The Central Puget Sound Water Suppliers' Forum
<http://www.ci.seattle.wa.us/Forum>

Thurston County:

Thurston County Homepage
<http://www.co.Thurston.wa.us/>

Thurston County Water Resources Unit

< http://www.co.thurston.wa.us/stormwater/Water_Resources_home.htm>

Thurston County Mapping
<http://www.geodata.org>

Thurston Conservation District
<http://www.Thurstoncountycd.org/>

Other Agencies:

Thurston County Public Health and Social Services
<http://www.co.thurston.wa.us/health/ehadm/index.html>

NWS River Forecast Center - Flood Outlook
<http://www.nwrfc.noaa.gov/river/fop.cgi>

NOAA Tide and Current Predictions
<http://co-ops.nos.noaa.gov/tp4days.html>

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Ecology, Interim TPH Policy, publication N. ECY 97-600, 1997.

Ecology, Analytical Methods for Petroleum Hydrocarbons, publication No. ECY 97-602, June 1997.

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Ecology, Discussion Draft - Recommendations for Management of Street Waste, June 1999.

Ecology, Guidance for Remediation of Petroleum Contaminated Soils, pub. 91-30, 1994.

Ecology, Model Toxics Control Act (MTCA) Cleanup Regulations, Chapter 173-340 WAC.

Ecology, Solid Waste Handling Standards, Chapter 173-350 WAC.

Ecology, Vehicle and Equipment Washwater Discharges, Best Management Practices Manual pub. WQ-R-95-56, June 1995, Revised 9/2007.

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Hazardous Waste Management Act of 1976, Chapter 70.105 RCW.

Herrera Environmental Consultants, Inc., King County Maintenance Waste Disposal Characterization Study, prepared for King County Surface Water Management Division, January 1995 Draft.

Herrera Environmental Consultants, Inc., Street Truck Operations and Disposal Practices, 1991.

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Pitt, R., 1985, Characterizing and Controlling Urban Runoff through Street and Sewer Cleaning, EPA/600/2-85/038.

Pond, Rodney, South Base Pond Report - The Response of Wetland Plants to Stormwater Runoff From a Transit Base, Municipality of Metropolitan Seattle publication 775, 1993.

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Schueler, Thomas R., Pollutant Dynamics of Pond Muck, Wat. Prot. Techniques, 1 (2), Summer 1994.

Serdar, Dave, Ecology, Contaminants in Vactor Truck Wastes, April 1993.

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Thurston County Environmental Health Division, (Environmental Health Division-Unpublished data), 1993.

Thurston County Environmental Health Division, Report on Street Facility Monitoring, Grant Tax No. 91-129, April 1993.

TYMCO, Inc., Best Management Practices - Street Sweeping, Waco, Texas, 1993.

U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Wastes, (SW-846), 3rd Edition, 1986.

W&H Pacific, Inc., Street and Street Sweeping Waste Characteristics Snohomish County, Washington, February 1994.

Appendix IV-A –Recycling and Disposal of Vehicle Fluids and Other Wastes*

	Recommended Management
Antifreeze	Store separately for resale. Separate ethylene glycol from propylene glycol for offsite recycling. If not recyclable, send to Treatment, Storage, and Disposal Facility (TSDF) for disposal.
Batteries	INTACT: Accumulate under cover prior to sale, deliver to recycler or, return to manufacturer. BROKEN: Accumulate acid from broken batteries in resistant containers with secondary containment. Send to TSDF for disposal.
Brake fluid	Accumulate in separate, marked, closed container. Do not mix with waste oil. Recycle.
Fuel	Store gasoline, and diesel separately for use or resale. Mixtures of diesel, gasoline, oil, and other fluids may not be recyclable and may require expensive disposal.
Fuel filters	Drain fluids for use as product. With approval of local landfill operator, dispose of in dumpster, if needed.
Oil filters	Puncture the filter dome and drain it for 24 hours. Put oil drained from filters into your “USED OIL ONLY” container. Keep drained filters in a separate container marked “USED OIL FILTERS ONLY.” Locate a scrap metal dealer who will pick up and recycle your filters. With approval of local landfill operator, dispose of drained filters to dumpster.
Paint	Accumulate oil-based and water-based paints separately for use or resale. If not recyclable, send accumulations to TSDF for disposal.
Power steering fluid	Same as for used oils.
Shop towels/oily rags	Use cloth towels that can be laundered and reused. Accumulate used shop towels in a closed container. Sign up with an industrial laundry service that can recycle your towels.
Solvents	Consider using less hazardous solvents or switching to a spray cabinet that doesn't use solvent. Accumulate solvents separately. Consider purchasing your own solvent still and recycling solvent on site. Do not mix with used oil. Do not evaporate as a means of disposal.
Transmission oil, differential and rear end fluids	Accumulate in your “USED OIL ONLY” container. Arrange for pickup for offsite recycling.
Used oils; including, crankcase oil, transmission oil, power steering fluid and differential/rear end oil	Keep used oil in a separate container marked “USED OIL ONLY.” Do not mix with brake fluid, or used antifreeze. Do not mix with any other waste if you plan to burn it in your shop for heating. Arrange for pickup for offsite recycling.
Windshield washer fluid	Accumulate separately for use or resale. Discharge to onsite sewage disposal, or, if acceptable by the Industrial Pretreatment Program ((253) 798-3013) discharge to sanitary sewer.

* This information was obtained from Ecology’s Hazardous Waste Program.
For a copy of “Hazardous Waste Services Directory,” publication No. 91-12s, Revised December 1994, listing facilities which recycle/dispose of wastes, solvents, paints, photographic wastes, refrigerants, oils, oil filters, and silver; provide spill assistance, oil/water separator cleanout service, and drum disposal/recycling; TSD facilities; and waste brokers; call Ecology’s Hazardous Waste and Toxic Reduction Program at (360) 407-6721.

Appendix IV-B – Example of an IPM Program

Integrated Pest and Vegetation Management (IPM) is a natural, long-term, ecologically-based systems approach to controlling pest populations. IPM is used to reduce pest populations, maintain them at levels below those causing health concerns or economic damage. The goals of IPM are to both encourage optimal selective pesticide use (away from prophylactic, broad spectrum use), and to maximize natural controls to minimize environmental side effects.

For more information on Thurston County's IPM policy, visit the County web site at: < http://www.co.thurston.wa.us/health/ehhw/IPM.html>.

Introduction

True integrated pest and vegetation management is a powerful approach that anticipates and prevents most problems through appropriate cultural practices and careful observation. Knowledge of the life cycles of host plants and both beneficial and pest organisms is also important. The integrated pest management section of this study guide is adapted from *Least Toxic Pest Management for Lawns* by Sheila Daar. Following the integrated pest management process gives you the information you need to minimize damage by weeds, diseases, and pests and to treat those problems with the least toxic approaches.

The IPM Process

Step One: Correctly identify problem pests and understand their life cycle.

Learn more about the pest. Observe it and pay attention to any damage that may be occurring. Learn about the life cycle. Many pests are only a problem during certain seasons, or can only be treated effectively in certain phases of the life cycle.

Step Two: Establish tolerance thresholds for pests.

Every landscape has a population of some pest insects, weeds, and diseases. This is good because it supports a population of beneficial species that keep pest numbers in check. Beneficial organisms may compete with, eat, or parasitize disease or pest organisms. Decide on the level of infestation that must be exceeded before treatment needs to be considered. Pest populations under this threshold should be monitored but don't need treatment. For instance, European crane flies usually don't do serious damage to a lawn unless there are between 25 to 40 larvae per square foot feeding on the turf in February (in normal weather years).

Also, most people consider a lawn healthy and well maintained even with up to 20 percent weed cover, so treatment, other than continuing good maintenance practices, is generally unnecessary.

Step Three: Monitor to detect and prevent pest problems.

Regular monitoring is a key practice to anticipate and prevent major pest outbreaks. It begins with a visual evaluation of the lawn or landscape's condition. Take a few minutes before mowing to walk around and look for problems. Keep a notebook, record when and where a problem occurs, then monitor for it at about the same time in future years. Specific monitoring techniques can be used in the appropriate season for some potential problem pests, such as European crane fly.

Step Four: Modify the maintenance program to promote healthy plants and discourage pests.

A healthy landscape is resistant to most pest problems. Lawn aeration and overseeding along with proper mowing height, fertilization, and irrigation will help the grass out-compete weeds. Correcting drainage problems and letting soil dry out between waterings in the summer may reduce the number of crane-fly larvae that survive.

Step Five: If pests exceed the tolerance thresholds …

Use cultural, physical, mechanical, or biological controls first. If those prove insufficient, use the chemical controls described below that have the least non-target impact. When a pest outbreak strikes (or monitoring shows one is imminent), implement integrated pest management then consider control options that are the least toxic, or have the least non-target impact. Here are two examples of an integrated pest management approach:

1. **Red thread disease** is most likely under low nitrogen fertility conditions and most severe during slow growth conditions. Mow and bag the clippings to remove diseased blades. Fertilize lightly to help the grass recover, then begin grasscycling and change to fall fertilization with a slow-release or natural-organic fertilizer to provide an even supply of nutrients. Chemical fungicides are not recommended because red thread cannot kill the lawn.

2. **Crane fly damage** is most prevalent on lawns that stay wet in the winter and are irrigated in the summer. Correct the winter drainage and/or allow the soil to dry between irrigation cycles; larvae are susceptible to drying out, so these changes can reduce their numbers. It may also be possible to reduce crane fly larvae numbers by using a power de-thatcher on a cool, cloudy day when feeding is occurring close to the surface. Studies are being

conducted using beneficial nematodes that parasitize the crane fly larvae; this type of treatment may eventually be a reasonable alternative.

Only after trying suitable non-chemical control methods, or determining that the pest outbreak is causing too much serious damage, should chemical controls be considered. If chemical controls prove necessary, determine what products are available and choose a product that is the least toxic and has the least non-target impact. Refer to the operational BMPs for the use of pesticides below for guidelines on choosing, storing, and using lawn and garden chemicals.

Step Six: Evaluate and record the effectiveness of the control, and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

Keep records! Note when, where, and what symptoms occurred, or when monitoring revealed a potential pest problem. Note what controls were applied and when, and the effectiveness of the control. Monitor next year for the same problems. Review your landscape maintenance and cultural practices to see if they can be modified to prevent or reduce the problem.

A comprehensive integrated pest management program should also include the proper use of pesticides as a last resort, and vegetation/fertilizer management to eliminate or minimize the contamination of stormwater.

Appendix IV-C – Recommendations for Management of Material Generated from Road Maintenance Activities

Introduction

This appendix is a summary, taken from the June 1999 draft Ecology publication titled Recommendations for Management of Street Waste (publication WQ 99-09). The guidance document addresses materials generated from stormwater maintenance activities such as street sweeping and the cleaning of catch basins and, to a limited extent, other stormwater conveyance and treatment facilities. Limited information is available on the characteristics of materials from maintenance of detention/retention ponds, bioswales, and similar stormwater treatment facilities. The recommendations provided here may be generally applicable to these facilities, with extra diligence given to material characterization.

These recommendations do not constitute rules or regulations, but are suggestions for road maintenance materials handling, reuse, and disposal using current regulations and the present state of knowledge of road maintenance materials constituents. The recommendations are intended to address the liquid and solid materials collected during routine maintenance of stormwater catch basins, detention/retention ponds and ditches and similar stormwater treatment and conveyance structures, and street and parking lot sweeping. In addition to these recommendations, end users and other authorities may have their own requirements for road maintenance materials reuse and handling.

"Road Maintenance Materials" include liquid and solid materials collected during maintenance of stormwater catch basins and detention/retention ponds and ditches and similar stormwater treatment and conveyance structures, and materials collected during street and parking lot sweeping.

"Road Maintenance Materials," as defined here, does not include solids and liquids from street washing using detergents, cleaning of electrical vaults, vehicle wash sediment traps, restaurant grease traps, industrial process waste, sanitary sewage, mixed process, or combined sewage/stormwater wastes. Wastes from oil/water separators at sites that load fuel are not included as road maintenance materials. Road maintenance material also does not include flood debris, land slide debris, and chip seal gravel.

Road maintenance materials do not ordinarily classify as dangerous waste. The owner of the stormwater facility and/or collector of road maintenance materials is considered the waste generator and is responsible for determining whether or not the waste designates as dangerous waste. Sampling to date has shown that material from routine maintenance of streets and stormwater facilities does not classify as dangerous waste (see Table C.6 below). However, it is possible that road maintenance materials from spill sites could classify as dangerous waste. Road maintenance materials from areas with exceptionally high average daily traffic counts may contain contaminants – such as heavy metals, total petroleum hydrocarbons (TPH), and carcinogenic polycyclic aromatic hydrocarbons(c-PAH) – at levels that limit reuse options.

Road Maintenance Materials Solids

Road maintenance materials is solid waste. While road maintenance materials from normal street and highway maintenance is not dangerous waste, it is solid waste, as defined under The Solid Waste Management Act (Chapter 70.95 RCW) and under Solid Waste Handling Standards (Chapter 173-350 WAC). Under the Solid Waste Management Act, local health departments (Thurston County Environmental Health Division of Department of Public Health and Social Services) have primary jurisdiction over solid waste management. Road maintenance materials solids may contain contaminants at levels too high to allow unrestricted reuse. There are currently no specific references in the Solid Waste Handling Standards to facilities managing road maintenance materials solids. These facilities will typically fit under the section dealing with Piles Used for Storage and Treatment (Section 320 of the regulation). There are no specific references for reuse and disposal options for road maintenance materials in the Solid Waste Handling Standards, although the Solid Waste Handling Standards do not apply to clean soils. In the rule, clean soils are defined as ‘soils that do not contain contaminants at concentrations which could degrade the quality of air, waters of the state, soils, or sediments; or pose a threat to the health of humans or other living organisms’ (WAC 173-350-100). Whether or not a soil is a clean soil depends primarily upon the level of contaminants and, to a lesser degree, on the background level of contaminants at a particular location and the exposure potential to humans or other living organisms. Therefore, both the soil and potential land application sites must be evaluated to determine if a soil is a clean soil. Thurston County Environmental Health should be contacted to determine if a road maintenance material meets the definition of “clean soil” when it will be reused as a soil.

There is no simple regulatory mechanism available to classify road maintenance materials solids as “clean” for uncontrolled reuse or disposal. Local health districts have historically used the Model Toxics Control Act (MTCA) Cleanup Regulation Method A residential soil cleanup levels to approximate “clean” and to make decisions on land application proposals. These regulations were amended in February 2001. The MTCA regulation is not intended to be directly applied to setting contaminant concentration levels for land application proposals. However, they may provide human health and environmental threat information and a useful framework for such decisions, when used in conjunction with other health and environmental considerations. Thurston County Environmental Health should be contacted to determine local requirements for making this determination.

Using the old MTCA regulations, many local health departments have set a criteria of 200 mg/Kg Total Petroleum Hydrocarbons (TPH) for diesel and heavy fuel oils as a threshold level for clean soil. Using the new MTCA terrestrial ecological evaluation procedures, allowable TPH levels for land application could range from 200 to 460, depending on site characteristics and intended land use. Road maintenance materials sampling has historically yielded TPH values higher than 200 mg/kg for hydrocarbons in the diesel and heavy oil range. These values typically reflect interference from natural organic material and, to a lesser extent, relatively immobile petroleum hydrocarbons. The mobile hydrocarbons that are of concern for groundwater protection are generally not retained with road maintenance materials solids. Ecology's Manchester Lab has developed an analytical method to reduce the problem of natural organic material being included in the TPH analysis for diesel and heavier range hydrocarbons. This new method, called NWTPH-Dx, reduces the background interference associated with vegetative matter by as much as 85 percent to 95 percent. However, even with the new methodology, TPH test results for road maintenance materials may still be biased by the presence of natural vegetative material and may still exceed 200 mg/kg. Where the laboratory results report no ‘fingerprint’ or chromatographic match to known petroleum hydrocarbons, the soils should not be considered to be petroleum contaminated soils.

Road maintenance materials solids frequently contain levels of carcinogenic PAHs (c-PAH) that make unrestricted use inappropriate. This is complicated further by analytical interference caused by organic matter that raises practical quantitation or reporting limits. To greatly reduce the level of interference, the use of U.S. EPA Test Method 8270, incorporating the silica gel cleanup step, is recommended. The calculated c-PAH value can vary greatly depending upon how non-detect values are handled. The new MTCA Method A criterion for c-PAH is 0.1 mg/kg (the sum of all seven c-PAH parameters multiplied by the appropriate toxicity equivalency factor) for unrestricted land uses. The MTCA criteria for soil cleanup levels for industrial properties is 2.0 mg/kg. Following this guidance, most sites where road maintenance materials could be reused as soil will be commercial or industrial sites, or sites where public exposure will be limited or prevented.

Permitting of road maintenance materials treatment and storage facilities as solid waste handling facilities by the Thurston County Environmental

Health Division is required. Under the Solid Waste Management Act, local health departments have primary jurisdiction over solid waste management.

Road maintenance materials handling facilities are subject to the requirements of the Solid Waste Handling Standards. The specific requirements will depend upon the manner in which the waste is managed. Most facilities will probably be permitted under the section dealing with Piles Used for Storage and Treatment (Section 320 of the regulation).

For most facilities, permit requirements include a plan of operation, sampling, record keeping and reporting, inspections, and compliance with other state and local requirements. The plan of operation should include a procedure for characterization of the waste and appropriate reuse and disposal options, consistent with the recommendations in this document and applicable federal, state, and local requirements.

A road maintenance materials site evaluation (see sample at end of this appendix) is suggested for all road maintenance materials as a method to identify spill sites or locations that are more polluted than normal. The disposal and reuse options listed below are based on characteristics of routine road maintenance materials and are not appropriate for more polluted wastes. The collector of road maintenance materials should evaluate it both for its potential to be classified as dangerous waste and to not meet end users requirements.

Road maintenance materials that are suspected to be dangerous waste should not be collected with other road maintenance materials. Material in catch basins with obvious contamination (unusual color, staining, corrosion, unusual odors, fumes, and oily sheen) should be left in place or segregated until tested. Testing should be based on probable contaminants. Road maintenance materials that is suspected to be dangerous waste should be collected and handled by someone experienced in handling dangerous waste. If potential dangerous waste must be collected because of emergency conditions, or if the waste becomes suspect after it is collected, it should be handled and stored separately until a determination as to proper disposal is made. Road maintenance materials treatment and storage facilities should have separate “hot load” storage areas for such waste. **Dangerous Waste** includes road maintenance materials known and suspected to be dangerous waste. This waste must be handled following the Dangerous Waste Regulations (Chapter 173-303 WAC) unless testing determines it is not dangerous waste.

Spills should be handled by trained specialists. Public works maintenance crews and private operators conducting street sweeping or cleaning catch basins should have written policies and procedures for dealing with spills or suspected spill materials. Emergency Spill Response telephone numbers should be immediately available as part of these operating policies and procedures.

The end recipient of road maintenance materials must be informed of its source and may have additional requirements for its use or testing that are not listed here. This document is based primarily on average road maintenance materials' chemical constituents and their potential affect on human health and the environment. There are physical constituents (for example, broken glass or hypodermic needles) or characteristics (for example, fine grain size) that could also limit reuse options. Additional treatment such as drying, sorting, or screening may also be required, depending on the needs and requirements of the end user.

Road maintenance materials treatment and storage facilities owned or operated by governmental agencies should be made available to private waste collectors and other governmental agencies on a cost recovery basis. Proper road maintenance materials collection and disposal reduces the amount of waste released to the environment. The operators of road maintenance materials facilities should restrict the use of their facilities to certified and/or licensed waste collectors who meet their training and liability requirements.

The use of road maintenance materials solids under this guidance should not lead to designation as a hazardous waste site, requiring cleanup under MTCA. Exceeding MTCA Method A unrestricted land use cleanup levels in road maintenance materials and products made from road maintenance materials, does not automatically make the site where road maintenance materials is reused a cleanup site. A site is reportable only if “a release poses a threat to human health or the environment” (Model Toxic Control Act). The reuse options proposed below are designed to meet the condition of not posing a threat to human health or the environment.

Testing of road maintenance materials solids will generally be required as part of a plan of operation that includes procedures for characterization of the waste. Testing frequency, numbers of samples, parameters to be analyzed, and contaminant limit criteria should all be provided as part of an approved plan of operation. Tables C.4 and C.5 below provide some recommended parameters and sampling frequencies for piles of road maintenance materials solids from routine street maintenance. These are provided as guidance only, and are intended to assist the county and the Thurston County Public Health and Social Services Department in determining appropriate requirements. Sampling requirements may be modified, over time, based on accumulated data. When the material is from a road maintenance materials facility or an area that has never been characterized by testing, the test should be conducted on a representative sample before co-mingling with other material. Testing in these instances would be to demonstrate that the waste does not designate as dangerous waste and to characterize the waste for reuse. At a minimum, the parameters in Table C.4 are recommended for these cases. Note that it will generally not be necessary to conduct TCLP analyses when the observed values do not exceed the recommended values in Table C.4. Table C.6 illustrates some observed relationships between total metals and TCLP metals values.

For further information on testing methods and sampling plans, refer to:

- SW 846 (U.S. EPA, Office of Solid Waste, Test Methods for Evaluating Solid Wastes, 3rd Edition); and
- Standard Methods for the Examination of Water and Wastewater (American Public Health Association, et al., 18th Edition, 1992).

For road maintenance materials not exceeding the suggested maximum values in Table C.4, the following road maintenance materials solids reuse and disposal options are recommended:

- Street sweepings that consist primarily of leaves, pine needles and branches, and grass cuttings from mowing grassy swales can be composted. Litter and other foreign material must be removed prior to composting or the composting facility must provide for such removal as part of the process. The screened trash is solid waste and must be disposed of at an appropriate solid waste handling facility.
- Coarse sand screened from street sweeping after recent road sanding may be reused for street sanding, providing there is no obvious contamination from spills. The screened trash is solid waste and must be disposed of at an appropriate solid waste handling facility.
- Roadside ditch cleanings, not contaminated by a spill or other release and not associated with a stormwater treatment system such as a bioswale, may be screened to remove litter and separated into soil and vegetative matter (leaves, grass, needles, branches, etc.). The soils from these activities are not generally regulated as solid waste. Ditching material that may be contaminated must be stored, tested, and handled in the same manner as other road maintenance materials solids. It is the generator's responsibility to visually inspect and otherwise determine whether the materials may be contaminated.
- Construction road maintenance materials – solids collected from sweeping or in stormwater treatment systems at active construction sites – may be placed back onto the site that generated it, or

managed by one on the methods listed below, provided that it has not been contaminated as a result of a spill. For concrete handling at construction site, refer to BMP C151 in Volume II, Construction Stormwater Pollution Prevention.

- Screened road maintenance materials soils may be used as feedstock materials for topsoil operations. This option should be reserved for road maintenance materials soils with very low levels of contaminants. Diluting road maintenance materials soils with clean soils or composted material must not be used as a substitute for treatment or disposal. There may be physical contaminants (for example, glass, metal, nails, etc.) in road maintenance materials that cannot be entirely screened from the waste. Where present, these contaminants in road maintenance materials could preclude its use as feedstock material for topsoil operations.

- Fill in parks, play fields, golf courses, and other recreational settings, where direct exposure by the public is limited or prevented. One way to accomplish is to cover the fill with sod, grass, or other capping material to reduce the risk of soil being ingested. The level of contaminants in the road maintenance materials must be evaluated to ensure that the soils meet the definition of clean soils when used in this manner.

- Fill in commercial and industrial areas, including soil or top dressing for use at industrial sites, roadway medians, airport infields, and similar sites where there is limited direct human contact with the soil and the soils will be stabilized with vegetation or other means. The level of contaminants in the road maintenance materials must be evaluated to ensure that the soils meet the definition of clean soils when used in this manner.

- Top dressing on roadway slopes, road or parking lot construction material, road or parking lot subgrade, or other road fill. The level of contaminants in the road maintenance materials must be evaluated to ensure that the soils meet the definition of clean soils when used in this manner.

- Daily cover or fill in a permitted municipal solid waste landfill, provided the road maintenance materials solids have been dewatered. Road maintenance materials solids may be acceptable as final cover during a landfill closure. Thurston County Environmental Health and the landfill operator should be consulted to determine conditions of acceptance.

- Treatment at a permitted contaminated soil treatment facility.

- Recycling through incorporation into a manufactured product, such as Portland cement, prefab concrete, or asphalt. The facility operator should be consulted to determine conditions of acceptance.
- Other end-use as approved by the Thurston County Department of Public Health and Social Services.
- Disposal at an appropriate solid waste handling facility.

For road maintenance materials that exceed the suggested maximum values in Table C.4, the following road maintenance materials solids reuse and disposal options are recommended:

- Treatment at a permitted contaminated soil treatment facility.
- Recycling through incorporation into a manufactured product, such as Portland cement, prefab concrete, or asphalt. The facility operator should be consulted to determine conditions of acceptance.
- Other end-use as approved by the Thurston County Department of Public Health and Social Services.
- Disposal at an appropriate solid waste handling facility.

Road Maintenance Materials Liquids

Road maintenance materials collection should emphasize solids in preference to liquids. Road maintenance materials solids are the principal objective in road maintenance materials collection and are substantially easier to store and treat than liquids.

Road maintenance materials liquids require treatment and/or must follow location limitations before their discharge. Road maintenance materials liquids usually contain high amounts of suspended and total solids and adsorbed metals. Treatment requirements depend on the discharge location.

Discharges to sanitary sewer and storm sewer systems must be approved by the Industrial Pretreatment Program responsible for O&M of the system. Ecology will not generally require waste discharge permits for discharge of stormwater decant to sanitary sewers or to stormwater treatment BMPs constructed and maintained in accordance with Ecology's *Stormwater Management Manual for Western Washington* (see Volume V for further detail).

The following disposal options are recommended, in order of preference, for catch basin decant liquid and for water removed from stormwater treatment facilities.

Under the municipal general permit, municipalities are required to use this guidance in determining appropriate means of dealing with road maintenance materials from stormwater maintenance activities. Ecology Southwest Regional Office water quality staff can help you with treatment standards and permit requirements for your particular situation.

Discharge of catch basin decant liquids to the municipal sanitary sewer is the preferred disposal option. Discharge to a municipal sanitary sewer requires the approval of the Industrial Pretreatment Program of your sewer service provider. Road maintenance materials liquids discharged to a POTW may be treated at a combined road maintenance materials liquid and solid facility (decant facility) or at separate liquids only facilities. These liquid only facilities may consist of modified type 2 catch basins (with a flow restrictor or oil/water separator) or water quality vaults, strategically located through the sanitary collection system. These should provide 24-hour detention for the expected volumes and should be constructed and operated to ensure that the decant discharge does not resuspend sediments. Sewer authorities should require periodic sampling and decant facility operators should test their waste effluent on a regular basis, but road maintenance materials decant liquid should meet the most restrictive local limits with 24 hours of undisturbed gravity settling. Overnight settling is more practical and will likely meet most local pretreatment requirements. (See Table C.9 *Catch Basin Decant Values Following Settling* for typical catch basin decant values from King County's decant facility at Renton.)

State and local regulations generally prohibit discharge of stormwater runoff into sanitary sewers to avoid hydraulic overloads and treatment performance problems. The volume of stormwater discharged from catch basins and small stormwater treatment facilities is generally not sufficient to be a problem, provided the discharge point is properly selected and designed.

Stormwater removed from catch basins and stormwater treatment wet vaults may be discharged into a basic or enhanced stormwater treatment BMP.

Decant liquid collected from cleaning catch basins and stormwater treatment wet vaults may be discharged back into the storm sewer system under the following conditions:

- The preferred disposal option of discharge to sanitary sewer is not reasonably available, **and**

- The discharge is to a basic or enhanced stormwater treatment facility (see Volume V), **and**

- The storm sewer system owner/operator has granted approval and has determined that the treatment facility will accommodate the increased loading.

Pretreatment may be required to protect the treatment BMP.

Reasonably available will be determined by the stormwater utility and by the circumstances, including such factors as distance, time of travel, load restrictions, and capacity of the stormwater treatment facility. Some jurisdictions may choose not to allow discharge back to the storm sewer system.

Discharge back into the storm sewer is an acceptable option, under certain conditions:

- Other practical means are not reasonably available, **and**

- Pretreatment is provided by discharging to a modified type 2 catch basin (with a flow restrictor or oil/water separator) or water quality vault, **and**

- The discharge is upstream of a basic or enhanced stormwater treatment BMP, **and**

- The storm sewer system owner/operator has granted approval.

Other practical means includes the use of decanting facilities and field decant sites that discharge to sanitary sewers or discharge to an approved stormwater treatment BMP.

Limited field testing of flocculent aids has been conducted. While the use of flocculent aids is promising, sufficient testing has not been conducted to allow approval of any specific product or process. In general, the following conditions must be met for flocculent use to be approved:

- The flocculent must be non-toxic under circumstances of use and approved for use by Ecology.

- The decant must be discharged to an approved basic or enhanced stormwater treatment BMP, with sufficient capacity and appropriate design to handle the anticipated volume and pollutant loading.

- The discharge must be approved by the storm sewer system owner/operator.

Water removed from stormwater ponds, vaults, and oversized catch basins may be returned to storm sewer system. Stormwater ponds, vaults, and oversized catch basins contain substantial amounts of liquid, which hampers the collection of solids and poses problems if the removed waste must be hauled away from the site. Water removed from these facilities may be discharged back into the pond, vault, or catch basin provided:

- Clear water removed from a stormwater treatment structure may be discharged directly to a downgradient cell of a treatment pond or into the storm sewer system.
- Turbid water may be discharged back into the structure it was removed from if:
    - The removed water has been stored in a clean container (eductor truck, Baker tank, or other appropriate container used specifically for handling stormwater or clean water); and
    - There will be no discharge from the treatment structure for at least 24 hours.
- The discharge must be approved by the storm sewer system owner/operator.

Vegetation management and structural integrity concerns sometimes require that the ponds be refilled as soon after solids removal as possible. For ponds and other systems relying on biological processes for waste treatment, it is often preferable to reuse at least some portion of the removed water.

Site Evaluation

A site evaluation is suggested to identify spill sites or locations that are more polluted than normal.

The site evaluation will aid in determining if waste should be handled as dangerous waste and in determining what to test for if dangerous waste is suspected. The site evaluation will also help to determine if the waste does not meet the requirements of the end users.

There are three steps to a site evaluation:

1. An **historical review** of the site for spills, previous contamination, and nearby toxic cleanup sites and dangerous waste and materials.

    The historical review will be easier if done on an area wide basis prior to scheduling any waste collection. The historical review should be more thorough for operators who never collected waste at a site before. At a minimum, the historical review should include operator knowledge of the area's collection history or records kept from previous waste collections.

Private operators should ask the owner of the site for records of previous contamination and the timing of the most recent cleaning. Ecology’s Hazardous Substance Information Office maintains a Toxic Release Inventory and a “Facility Site” Web page, tracking more than 15,000 sites. This information is available through the Internet at <http://www.wa.gov/ecology/iss/fsweb/fshome.html> or by calling a toll-free telephone number (800-633-7585). The Web page allows anyone with Internet access to search for facility information by address, facility name, town, zip code, and SIC code, etc. It lists why Ecology is tracking each one (NPDES, TSCA, RCRA, Clean Air Act, etc.), as well as who to call within Ecology to find out more about the given facility.

2. An **area visual inspection** for potential contaminant sources such as a past fire, leaking tanks and electrical transformers, and surface stains.

   The area around the site should be evaluated for contaminant sources prior to collection of the waste. The area visual inspection may be done either as part of multiple or as single site inspections. If a potential contaminant source is found, the waste collection should be delayed until the potential contaminant is assessed.

   A second portion of the area visual inspection is a subjective good housekeeping evaluation of the area. Locations with poor housekeeping commonly cut corners in less obvious places and should be inspected in greater detail for illegal dumping and other contamination spreading practices.

3. **A waste and container inspection** before and during collection.

   The inspection of the waste and catch basin or vault is the last and perhaps most critical step in the site evaluation.

   For example, if the stormwater facility has an unusual color in or around it, then there is a strong possibility that something could have been dumped into it. Some colors to be particularly wary of are yellow-green from antifreeze dumping and black and/or rainbow sheen from oil and/or grease dumping. In addition, if any staining or corrosion is observed, then a solvent may have been dumped.

   Fumes are also good indicators of potential dangerous or dangerous waste. Deliberate smelling of catch basins should be avoided for worker safety, but suspicious odors may be encountered from catch basins thought to be safe. Some suspicious odors are rotten eggs (hydrogen sulfide is present), gasoline or diesel fumes, or solvent odors. If unusual odors are noted, contact a dangerous waste inspector before cleaning the basin.

Finally, operator experience is the best guide to avoid collection of contaminated waste.

Table C.1. Typical TPH Levels in Street Sweeping and Catch Basin Solids.

Reference	Street Sweeping (mg/kg)	Catch Basin Solid (mg/kg)
Snohomish County (1) (Landau 1995)	390 – 4,300	
King County (1) (Herrera 1995)		123 – 11,049 (Median 1,036)
Snohomish County and Selected Cities (1) (W & H Pacific, 1993)	163 – 1,500 (Median 760)	163 – 1,562 (Median 760)
City of Portland (2) (Bresch)		MDL – 1,830 (Median 208)
Oregon (1) (Collins; ODOT 1998) Oregon (3) (Collins; ODOT 1998)	1,600 – 2,380 98 – 125	

(1) Method WTPH 418.1; does not incorporate new methods to reduce background interference due to vegetative material
(2) Method NWTPH-Dx.
(3) Method WTPH – HCID.

Table C.2. Typical c-PAH Values in Road maintenance materials Solids and Related Materials.

Sample Source	City of Everett					WSDOT	
Analyte	Street Sweepings	Soil	3-Way Topsoil	Vactor Solids	Leaf & Sand	Sweepings Fresh	Sweepings Weathered
Benzo(a)anthracene	0.1U	0.076U	0.074U	0.21	0.45	0.56	0.40
Chrysene	0.14	0.09	0.074U	0.32	0.53	0.35	0.35
Benzo(b)fluoranthene	0.11	0.076U	0.074U	0.27	0.52	0.43	0.51
Benzo(k)fluoranthene	0.13	0.076U	0.074U	0.25	0.38	0.39	0.40
Benzo(a)pyrene	0.13	0.076U	0.074U	0.26	0.5	0.41	0.33U
Indeno(1,2,3-cd)pyrene	0.1U	0.076U	0.074U	0.19	0.39	NR	NR
Dibenzo(a,h)anthracene	0.1U	0.076U	0.074U	0.081	0.12	0.39	0.33U
Revised MTCA Benzo(a)pyrene [ND=PQL]	0.215	0.134	0.134	0.388	0.727	0.708	0.597
Benzo(a)pyrene [ND=½ PQL]	0.185	0.069	0.067	0.388	0.727	0.708	0.366
Benzo(a)pyrene [See * below]	0.185	0.069	0	0.388	0.727	0.708	0.366
Benzo(a)pyrene [ND=0]	0.155	0.001	0	0.388	0.727	0.708	0.135

* If the analyte was not detected for any PAH, then ND=0; If analyte was detected in at least 1 PAH, then ND=½PQL; if the average concentration (using ND=½ PQL) is greater than the maximum detected value, then ND=Maximum value.

The new Method A soil cleanup level for unrestricted land use is 0.1 mg/Kg for BAP. (WAC 173-340-900, Table 740-1).

The new Method A soil cleanup level for industrial properties is 2 mg/Kg for BAP. (WAC 173-340-900, Table 745-1).

Table C.3. Typical Metals Concentrations in Catch Basin Sediments.

Parameter	Ecology 1993	Thurston 1993	King County 1995	King County 1995
Metals; Total (mg/kg)	(Min – Max)	(Min – Max)	(Min – Max)	Mean
As	<3 – 24	0.39 – 5.4	4 – 56	0.250
Cd	0.5 – 2.0	<0.22 – 4.9	0.2 – 5.0	0.5
Cr	19 – 241	5.9 – 71	13 – 100	25.8
Cu	18 – 560	25 – 110	12 – 730	29
Pb	24 – 194	42 – 640	4 – 850	80
Ni	33 – 86	23 – 51	14 – 41	23
Zn	90 – 558	97 – 580	50 – 2,000	130
Hg	0.04 – 0.16	0.024 – 0.193		

Table C.4. Recommended Parameters and Suggested Values for Determining Reuse and Disposal Options.

Parameter	Suggested Maximum Value
Arsenic, Total	20.0 mg/kg (a)
Cadmium, Total	2.0 mg/kg (b)
Chromium, Total	42 mg/kg (c)
Lead, total	250 mg/kg (d)
Nickel	100 mg/kg (e)
Zinc	270 mg/kg (e)
Mercury (Inorganic)	2.0 mg/kg (f)
PAHs (Carcinogenic)	0.1 – 2.0 mg/kg (see Note at (g) below)
TPH (Heavy Fuel Oil)	200 – 460 mg/kg (see Note at (h) below)
TPH (Diesel)	200 – 460 mg/kg (see Note at (h) below)
TPH (Gasoline)	100 mg/kg (i)
Benzene	0.03 mg/kg (i)
Ethylbenzene	6 mg/kg (i)
Toluene	7 mg/kg (i)
Xylenes (Total)	9 mg/kg (i)

(a) Arsenic: from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses
(b) Cadmium: from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses.
(c) Chromium; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses
(d) Lead; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses
(e) Nickel and Zinc; from MTCA Table 749-2: Protection of Terrestrial Plants and Animals
(f) Mercury; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses
(g) PAH-Carcinogenic; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses and Table 745-1, industrial properties, based on cancer risk via direct contact with contaminated soil (ingestion of soil) in residential land use situations and commercial/industrial land uses. Note: The Thurston County Environmental Health may permit higher levels as part of a Plan of Operation, where they determine that the proposed end use poses little risk of direct human contact or ingestion of soil.
(h) TPH: from MTCA Tables 749-2 and 749-3: Protection of Terrestrial Plants and Animals. Values up to 460 mg/kg may be acceptable where the soils are capped or covered to reduce or prevent exposure to terrestrial plants and animals. Where the laboratory results report no ‘fingerprint’ or chromatographic match to known petroleum hydrocarbons, the soils will not be considered to be petroleum contaminated soils.
(i) BETX; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses.

Table C.5. Recommended Sampling Frequency for Road Maintenance Materials Solids.

Cubic Yards of Solids	Minimum Number of Samples
0 – 100	3
101 – 500	5
501 – 1,000	7
1,001 – 2,000	10
>2,000	10 + 1 for each additional 500 cubic yards

Modified from Ecology's Interim Compost Guidelines.

Table C.6. Pollutants in Catch Basin Solids – Comparison to Dangerous Waste Criteria.

Parameter	Range of Values in Catch Basin Waste	Range of Values in Catch Basin Waste	Dangerous Waste Criteria
Metals	**Total Metals (mg/kg)**	**TCLP Metals (mg/kg)**	**TCLP values (mg/l)**
Arsenic	<3 – 56	<0.02 – 0 .5	5.0
Cadmium	<0.22 – 5	0.0002 – 0.03	1.0
Chromium	5.9 – 241	0.0025 – 0.1	5.0
Copper	12 – 730	0.002 – 0.88	none
Lead	4 – 850	0.015 – 3.8	5.0
Nickel	23 – 86	<0.01 – 0.36	none
Zinc	50 – 2,000	0.04 – 6.7	none
Mercury	0.02 – 0.19	0.0001 – 0.0002	0.2

Data from Thurston County (Thurston County 1993), King County (Herrera 1995) and Ecology (Serdar; Ecology 1993).

Table C.7. Typical Catch Basin Decant Values Compared to Surface Water Quality Criteria.

Parameter	State Surface Water Quality Criteria		Range of Values Reported	Range of Values Reported
Metals	Freshwater Acute (ug/l – dissolved metals)	Freshwater Chronic (ug/l – dissolved metals)	Total Metals (ug/l)	Dissolved Metals (ug/l)
Arsenic	360	190	100 – 43,000	60 – 100
Cadmium*	2.73	0.84	64 – 2,400	2 – 5
Chromium (total)			13 – 90,000	3 – 6
Chromium (III)*	435	141		
Chromium (VI)	0.5	10		
Copper*	13.04	8.92	81 – 200,000	3 – 66
Lead*	47.3	1.85	255 – 230,000	1 – 50
Nickel*	1114	124	40 – 330	20 – 80
Zinc*	90.1	82.3	401 – 440,000	1,900 – 61,000
Mercury	2.10	0.012	0.5 – 21.9	

*Hardness dependent; hardness assumed to be 75 mg/l

Table C.8. Typical Values for Conventional Pollutants in Catch Basin Decant.

Parameter (values as mg/l; except where stated)	Ecology 1993 Mean	(Min – Max)	King County 1995 Mean	(Min – Max)
PH	6.94	6.18 – 7.98	8	6.18 – 11.25
Conductivity (umhos/cm)	364	184 – 1110	480	129 – 10,100
Hardness (mg/l CaCO3)	234	73 – 762		
Fecal Coliform (MPN/100 ml)	3,000			
BOD	151	28 – 1,250		
COD	900	120 – 26,900		
Oil and Grease	11	7.0 – 40	471	15 – 6,242
TOC	136	49 – 7,880	3,670	203 – 30,185
Total Solids	1,930	586 – 70,400		
Total Dissolved Solids	212	95 – 550		
Total Suspended Solids	2,960	265 – 111,000		
Settleable Solids (ml/l/hr)	27	2 – 234	57	1 – 740
Turbidity (ntu)	1,000	55 – 52,000	4,673	43 – 78,000

Table C.9. Catch Basin Decant Values Following Settling.[1]

Parameter: Total Metals in mg/l	Portland – Inverness Site Min – Max	King County – Renton Min – Max	METRO Pretreatment Discharge Limits
Arsenic	0.0027 – 0.015	< MDL – 0.12	4
Cadmium	0.0009 – 0.0150	< MDL – 0.11	0.6
Chromium	0.0046 – 0.0980	0.017 – 0.189	5
Copper	0.015 – 0.8600	0.0501 – 0.408	8
Lead	0.050 – 6.60	0.152 – 2.83	4
Nickel	0.0052 – 0.10	0.056 – 0.187	5
Silver	0.0003 – 0.010	< MDL	3
Zinc	0.130 – 1.90	0.152 – 3.10	10
Settleable Solids; ml/L	No Data	0.02 – 2	7
Nonpolar fat, oil and grease	5.7 – 25	5 – 22	100
Ph (std)	6.1 – 7.2	6.74 – 8.26	5.0 – 12.0
Total Suspended Solids	2.8 – 1,310		
Recorded Total Monthly Flow; Gallons	Data not available	31,850 – 111,050	
Recorded Max. Daily Flow; Gallons	Data not available	4,500 – 18,600	25,000 GPD
Calculated Average Daily Flow; GPD	Data not available	1,517 – 5,428	

[1] Data from King County's Renton Facility (data from 1998 – 199) and the City of Portland's Inverness Site (data from 1999 – 2001); detention times not provided.

Thurston County
Drainage Design and Erosion Control Manual

Volume V
Stormwater BMPs

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Chapter 1 - Introduction to Volume V

1.1 What is the Purpose of this Volume?

This volume of the *Drainage Design and Erosion Control Manual* provides best management practices (BMPs) for designing and maintaining permanent stormwater management facilities.

BMPs are schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts to waters of Washington State. As described in Volume I, BMPs for long-term stormwater management at developed sites can be divided into three categories:

1. **Flow control**: BMPs that address the volume and timing of stormwater flows
2. **Source control**: BMPs that address prevention of pollution from potential sources
3. **Runoff treatment**: BMPs that address treatment of runoff to remove sediment and other pollutants

This volume addresses flow control and runoff treatment, and includes BMPs considered to be low impact development (LID). Source control BMPs are described in Volume IV. Temporary BMPs for erosion and sediment control are found in Volume II.

BMPs included in this volume are summarized in Table 1.1.

The check mark (√) in the column(s) next to each BMP indicates the BMP type (low impact development, flow control, or runoff treatment) and the level of treatment (basic, enhanced, phosphorus, or oil control). The BMP selection process, which explains each of these categories in detail and helps the manual user to select BMPs depending on project and site characteristics, is provided in Volume I.

Where a BMP type or level of runoff treatment has been indicated with an asterisk (*), the standard BMP meeting minimum design criteria does not provide the level of runoff treatment noted, but the standard design may be modified to provide the additional treatment indicated. Refer to the individual BMP design guidelines for more information.

Many of the BMP design guidelines have been adapted from design criteria from *Low Impact Development: Technical Guidance Manual for Puget Sound* (PSAT 2005), the *King County, Washington Surface Water Design Manual* (King County DNRP 2009), and the *Pierce County Stormwater Management and Site Development Manual* (Pierce County Surface Water Management 2008).

Table 1.1. Thurston County Stormwater BMPs.

BMP No.	Title	Type of BMP					
				Runoff Treatment			
		LID	Flow Control	Basic	Enhanced	Phosphorus	Oil Control
LID Stormwater Management BMPs							
LID.01	Native Vegetation Protection, Reforestation, and Maintenance	√					
LID.02	Post-Construction Soil Quality and Depth	√					
LID.03	Reduce Effective Impervious Areas Associated with Roads, Shared Accesses, Alleys, Sidewalks, Driveways, and Parking Areas	√					
LID.04	Downspout Infiltration Systems	√					
LID.05	Downspout Dispersion Systems	√					
LID.06	Sheet Flow Dispersion	√					
LID.07	Concentrated Flow Dispersion	√					
LID.08	Bioretention Facilities	√	√	√	√		
LID.09	Alternative Paving Surfaces	√					
LID.10	Vegetated Roofs	√					
LID.11	Full Dispersion	√					
LID.12	Rural Roads Natural Dispersion	√					
LID.13	Rural Roads Engineered Dispersion	√					
Infiltration BMPs							
IN.01	Infiltration Basins		√	*	*	*	
IN.02	Infiltration Trenches		√	*	*	*	
IN.03	Infiltration Vault		√	*	*	*	
IN.04	Bio-Infiltration Swale		√	*	*	*	
Detention BMPs							
D.01	Detention Ponds		√				
D.02	Detention Tanks		√				
D.03	Detention Vaults		√				
D.04	Use of Parking Lots for Detention		√				
Biofiltration BMPs							
BF.01	Basic Biofiltration Swale			√			
BF.02	Wet Biofiltration Swale			√			
BF.03	Continuous Inflow Biofiltration Swale			√			
BF.04	Vegetated Filter Strip/CAVFS			√	*		*
BF.05	Narrow Area Filter Strip			√			

Table 1.1 (continued). Thurston County Stormwater BMPs.

BMP No.	Title	Type of BMP					
				Runoff Treatment			
		LID	Flow Control	Basic	Enhanced	Phosphorus	Oil Control
Wet Pool BMPs							
WP.01	Stormwater Treatment Wetland			√	√		
WP.02	Wet Pond			√		*	
WP.03	Wet Vault			√			*
WP.04	Combined Detention/Wet Pool Facilities		√	√	*	*	
WP.05	Presettling Basin						
Media Filtration BMPs							
MF.01	Sand Filter Basin			√	*	*	
MF.02	Sand Filter Vault			√	*	*	
MF.03	Linear Sand Filter			√	*	*	√
MF.04	Media Filter Drain			√	√	√	
Oil and Water Separation BMPs							
OW.01	API (Baffle type) Separator Bay						√
OW.02	Coalescing Plate (CP) Separator Bay						√
OW.03	Oil Containment Booms						√

√ Meets criteria
* Design option allows BMP to meet criteria

1.2 How This Volume is Organized

Volume V is organized as follows:

- **Chapter 1**: Introduction
- **Chapter 2**: Low Impact Development (LID)
- **Chapter 3**: Infiltration BMPs
- **Chapter 4**: Detention BMPs
- **Chapter 5**: Biofiltration BMPs
- **Chapter 6**: Wet pool BMPs
- **Chapter 7**: Media filtration BMPs
- **Chapter 8**: Oil and water separation BMPs
- **Chapter 9**: Emerging Technologies
- **Appendix V-A**: Control structures, including flow control structures, bypass/diversion manholes, and emergency overflows
- **Appendix V-B**: Facility liner design guidance
- **Appendix V-C**: Maintenance guidelines
- **Appendix V-D**: Access roads and ramps
- **Appendix V-E**: Site design elements, including setbacks, landscaping, fencing, and signage.

1.3 How Do I Get Started?

First, consult Chapter 2 of Volume I to determine minimum requirements for flow management (Minimum Requirements #4 through #8) and selection of stormwater BMPs. After determining minimum requirements for your project and selecting BMPs, use this volume (V) to design BMPs. Consult Volume III (Hydrologic Analysis and Stormwater Conveyance) for guidance on methods to appropriately size flow management facilities. These facilities can then be included in any required stormwater submittals (see Volume I, Chapter 3).

Chapter 2 - Low Impact Development (LID)

Low Impact Development (LID) is a development approach that seeks to minimize the stormwater impacts of development by mimicking natural hydrologic processes.

The LID BMPs in this chapter can help you comply with Minimum Requirement #5 (Onsite Stormwater Management), #6 (Runoff Treatment), and #7 (Flow Control). Minimum Requirement #5 requires the use of onsite stormwater BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible, without causing flooding or erosion impacts. For more information about Minimum Requirement #5, see Volume I.

2.1 LID Site Design BMPs

Site design plays an important role in the amount of stormwater runoff generated by a project site. Reductions in impervious areas result in smaller runoff treatment and flow control facilities, thereby reducing stormwater control and treatment requirements and management costs.

This section describes LID site design practices that can reduce impervious areas and improve infiltration and treatment capacity of soils. LID planning and design considerations are also described in Volume I of this manual and in the *Low Impact Development: Technical Guidance Manual for Puget Sound* (PSAT 2005).

The following BMPs are described in this section:

- **LID.01**: Native Vegetation Protection, Reforestation, and Maintenance
- **LID.02**: Post-Construction Soil Quality, and Depth
- **LID.03**: Reduce Effective Impervious Areas Associated with Roads, Shared Accesses, Alleys, Sidewalks, Driveways, and Parking Areas.

2.1.1 LID.01 Native Vegetation Protection, Reforestation, and Maintenance

Preserving native vegetation and soils is an effective and efficient tool for managing stormwater quantity and quality. Puget Sound area research found that preserving native vegetation and reducing the development envelope were the most effective LID strategies in terms of reducing storm flows (AHBL 2002).

The goal of preserving and restoring native vegetation in low impact development is to promote infiltration for overland flow generated in adjacent developed portions of the site and more closely mimic the site's natural hydrologic function. This BMP can be highly effective when used in conjunction with BMP LID.03, reducing effective impervious areas.

In areas where development or disturbance has occurred, the goal is to restore the hydrologic functions of a native forested site, including infiltration, evapotranspiration, and canopy interception.

Applicability

Preserving existing native vegetation shall be the first priority whenever feasible. Preserving vegetation is much easier than restoring it. Restoring native vegetation may be used in situations where an applicant wishes to convert a previously developed surface to a native vegetated surface for purposes of meeting dispersion requirements or code requirements for forest retention. Restoring native vegetation may also be required in cases where an area designed for native vegetation preservation such as a critical area buffer has been disturbed and requires restoration.

Native vegetation preservation and restoration areas should be incorporated to the maximum extent possible, and where most effective (i.e., where there is intact native vegetation and soils and/or unconcentrated flow from developed areas). Where possible, the goal for native vegetation preservation or restoration shall be as follows:

- Rural and large lot development: 65 percent minimum
- Medium density (4 to 6 dwelling units per acre): 50 percent minimum
- High density (more than 6 dwelling units per acre): Protect or restore native vegetation to the maximum extent practical.

Native vegetation retention areas may be required as part of a plan of development for any of the following reasons:

- Stormwater dispersion areas reserved for stormwater quality and quantity treatment as part of on-site measures

- Wetland and other critical area buffers required by Code
- Riparian areas and buffers and habitat areas
- Minimum native vegetation areas required by zoning codes (for example in the Green Cove Basin).

Limitations

Preserving or restoring native vegetation depends heavily on establishing optimal soil and moisture conditions for the vegetation. A moisture-loving plant, even if native, will not thrive in an environment turned dry by rerouting of watershed flows.

Careful selection of areas for native tree preservation should be made with the advice of a landscape architect or tree arborist. Items to consider in this process include:

- Impact of removal of adjacent vegetation on survivability of trees during wind storms
- The health of tree stands including incidence of disease or infestation
- Conifers with live crown ratios of 50 percent or greater have better survivability in wind and sun exposure
- Trees and native vegetation that developed in forests are best retained in groups of sufficient size to maintain adequate growing space characteristics and maintain the integrity of the unit.
- Avoid areas around structures, roadway intersections or immediately adjacent to the roadway where trees may create a future danger, sight distance or clear zone issue and may result in future removal of trees for safety reasons.

Prioritize native vegetation and soil protection areas by location and type of area as follows:

1. Large tracts of riparian areas that connect and create contiguous riparian protection areas
2. Large tracts of critical and wildlife habitat area that connect and create contiguous protection areas
3. Tracts that create common open space areas among and/or within developed sites

4. Protection areas on individual lots that connect to areas on adjacent lots or common protection areas

5. Protection areas on individual lots.

Submittals and Approval

Clearing limits and areas for vegetation restoration shall be shown on the drainage plans for the project. Clearing limits shall be marked in the field and verified by Thurston County prior to clearing. Protective fencing shall be installed to protect native areas to be preserved; examples include orange construction fencing, temporary chain link fence, or equivalent. For revegetation areas, a plants list shall be provided indicating the type of plant, quantity, any planting requirements and location of plantings.

Areas designated to be preserved as native vegetation for stormwater dispersion shall be designated as separate tracts or shall be protected by easement. The areas shall be protected from disturbance by signage and/or fencing. A signage and fencing plan shall be prepared and included in the drainage report submittal.

Permanent signs shall explain the purpose of the area, the importance of vegetation and soils for managing stormwater and that the removal of trees or vegetation and compaction of soil is prohibited.

Design Criteria

During construction protect native tree preservation areas from disturbance. See Volume II for additional requirements related to site clearing and protecting native vegetation.

At a minimum, the applicant shall comply with provisions for native vegetation preservation and/or replacement as set forth in applicable Thurston County Code including critical areas, zoning, grading and forest practices.

Vegetation restoration and planting methods shall conform to published standards. The following guidance documents are provided as an example:

Riparian Areas

- *Restoring the Watershed A Citizen's Guide to Riparian Restoration in Western Washington*, Washington State Department of Fish and Wildlife, 1995

- *Streamside Planting Guide for Western Washington*, Cowlitz County Soil and Water Conservation District

- *Plant It Right: Restoring Our Streams,* WSU Cooperative Extension, 2002

- *Integrated Streambank Protection Guidelines*, Washington State Department of Fish and Wildlife, 2000.

Marine Bluff

- *Surface Water and Groundwater on Coastal Bluffs: A Guide for Ecology*, Washington State Department of Ecology, Shorelands and Coastal Zone Management Program Publication No. 95-107, 1995

- *Vegetation Management: A Guide for Puget Sound Bluff Property Owners*, Washington State Department of Ecology, Shorelands and Coastal Zone Management Program Publication No. 93-31, 1993.

Tree conservation areas should be designated for the site in areas not adjacent to or impacting structures (one tree height separation) or sight distance/clear area for roadways and shall be protected, or restored to follow natural successional patterns and to develop diverse multilayer canopy structure, snags, large woody debris, understory vegetation, and forest duff.

Conversion of Previously Developed Surfaces to Native Vegetation

Conversion of a previously developed surface to native vegetated landscape or restoration of disturbed areas required to be native vegetation requires the removal of impervious surface and ornamental landscaping, de-compaction of soils, and the planting of native trees, shrubs, and ground cover in compost-amended soil according to all of the following specifications:

1. Existing impervious surface and any underlying base course (e.g., crushed rock, gravel, etc.) must be completely removed from the conversion area(s).

2. Underlying soils must be broken up to a depth of 18 inches. This can be accomplished by excavation or ripping with either a backhoe equipped with a bucket with teeth, or a ripper towed behind a tractor.

3. At least 4 inches of well-decomposed compost must be tilled into the broken up soil as deeply as possible. The finished surface should be gently undulating and must be only lightly compacted.

4. The area of native vegetated landscape must be planted with native species trees, shrubs, and ground cover according to the

specifications in Table 2.1. Species must be selected as appropriate for the site shade and moisture conditions, and in accordance with the following requirements:

Table 2.1. Selected Native Vegetation, Size, and Spacing Requirements

Species	Type	Sun and Moisture Preferences	Planted Size	Spacing
Trees				
Douglas fir (*Pseudotsuga menziesii*)	Conifer	Sun, dry to moist soil	5 gallon, 6'-7' B&B	12' o.c.
Western red cedar (*Thuja plicata*)	Conifer	Sun or shade, moist to wet soil	5 gallon, 6'-7' B&B	12' o.c.
Western hemlock (*Tsuga heterophylla*)	Conifer	Sun or shade, well-drained soil	5 gallon, 6'-7' B&B	12' o..c.
Sitka spruce (*Picea sitchensis*)	Conifer	Sun or shade, moist mineral soils to wet soils	5 gallon, 6'-7' B&B	12' o.c.
Red alder (*Alnus rubra*)	Tree	Sun, a nitrogen fixer	5 gallon, 5'-6' B&B	12' o.c.
Bigleaf maple (*Acer macrophyllum*)	Tree	Sun or shade, dry to moist soil	5 gallon, 5'-6' B&B	12' o.c.
Black cottonwood (*Populus trichocarpa*)	Tree	Sun, wet soil	5 gallon, 5'-6' B&B	12' o.c.
Cascara (*Rhamnus purshiana*)	Tree/shrub	Sun to partial shade, dry to moist soil	5 gallon, 5'-6' B&B	8' o.c.
Pacific willow (*Salix lucida*)	Tree/shrub	Sun, damp soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Shrubs				
Sitka willow (*Salix sitchensis*)	Shrub	Sun or shade, dry to damp soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Vine maple (*Acer circinatum)*	Shrub	Shade, moist to damp soils	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Filbert (hazelnut) (*Corylus cornuta)*	Shrub	Sun to shade, dry soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Salmonberry (*Rubus spectabilis)*	Shrub	Sun to shade, moist to wet soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Thimbleberry (*Rubus parviflorus)*	Shrub	Sun to partial shade, dry to moist soil	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.
Ocean spray (*Holodiscus discolor)*	Shrub	Sun to partial shade, dry	1 gallon 2 gallon 5 gallon	4' o.c. 6' o.c. 8' o.c.

Table 2.1 (continued). Selected Native Vegetation, Size, and Spacing Requirements

Species	Type	Sun and Moisture Preferences	Planted Size	Spacing
Shrubs (continued)				
Tall Oregon graps (*Berberis aquifolium)*	Shrub	Sun to shade, dry to moist soil	1 gallon	4' o.c.
Snowberry (*Symphoricarpos albus)*	Shrub	Sun to shade, dry to wet soil	1 gallon, 30-36"	4' o.c.
Service berry (*Amelanchier alnifolia)*	Shrub	Sun to shade, dry to wet soil	1 gallon	6' o.c.
Indian plum (*Oemleria cerasiformis)*	Shrub	Sun to shade, moist soil	1 gallon	4' o.c.
Twinberry (*Lonicera involucrate)*	Shrub	Sun to partial shade, moist soil	1 gallon	4' o.c.
Ground Cover				
Evergreen huckleberry (*Vaccinium ovatum)*	Groundcover	Sun to partial shade, moist soil	1 gallon	2' o.c.
Kinnikinick (*Arctostaphyllos uva-ursa)*	Groundcover	Sun to partial shade, dry soil	1 gallon	2' o.c.
Salal (*Gaultheria shallon)*	Groundcover	Sun to shade, dry to moist soil	1 gallon	18" o.c.
Low Oregon graps (*Mahonia repens)*	Groundcover	Sun to partial shade, dry to moist soil	9-12"	18" o.c.
Sword fern (*Polystichum munitum)*	Groundcover	Sun to deep shade, dry to moist soil	2 gallon	3' o.c.

Source: King County Surface Water Design Manual (King County DNRP 2009).

Note:

B&B: Balled and Burlapped

a. Trees: a minimum of two species of trees must be planted, one of which is a conifer. Conifer and other tree species must cover the entire landscape area at the spacing given in Table 2.1.

b. Shrubs: a minimum of two species of shrubs shall be planted. Space plants to cover the entire landscape area, excluding points where trees are planted.

c. Groundcover: a minimum of two species of ground cover shall be planted. Space plants so as to cover the entire landscape area, excluding points where trees or shrubs are planted.

Note: *For landscape areas larger than 10,000 square feet, planting a greater variety of species than the minimum suggested above is strongly encouraged. For example, an acre could easily accommodate three tree species, three species of shrubs, and two or three species of groundcover.*

5. At least 4 inches of hog fuel or other suitable mulch must be placed between plants as mulch for weed control. It is also possible to mulch the entire area before planting; however, an 18-inch diameter circle must be cleared for each plant when it is planted in the underlying amended soil.

   Note: *Plants and their root systems that come in contact with hog fuel or raw bark have a poor chance of survival.*

6. Plantings must be watered consistently once per week during the dry season for the first 3 years.

7. The plantings must be well established on at least 80 percent of the converted area after 2 years in order to be considered a native vegetated surface.

Materials

Developments shall use native trees for replacement in areas separate from residential lots, or storm drainage areas adjacent to roadway or parking lots. Species selection shall be based on the underlying soils and the historic, native indigenous plant community type for the site, if existing conditions can support the plant community.

Trees selected for replacement purposes must be free from injury, pests, diseases, and nutritional disorders. Trees must be fully branched and have a healthy root system. Coniferous and broad leaf evergreen trees shall be no less than 3 feet in height at time of planting. Deciduous trees shall be a minimum of 5 feet in height or have a minimum caliper size of 1 inch at time of planting.

Note: Avoid the use of a single species of tree for replacement purposes. No individual species of replacement tree should exceed 50 percent of the total, and no individual species should be less than 10 percent of the total.

Construction and Maintenance

Maintenance of native vegetation restoration areas shall include monitoring the survival of planted species, weed control and soil amendment as necessary to ensure the establishment of the native vegetation. A minimum 80 percent survival of all planted vegetation at the end of 2 years is required. Ongoing maintenance shall include weeding and watering for a minimum of 3 years from installation.

If during the 2-year period survival of planted vegetation falls below 80 percent, additional vegetation shall be installed as necessary to achieve the required survival percentage. The likely cause of the high rate of plant mortality shall also be determined and corrective actions taken to ensure plant survival. If it is determined that the original plant choices are not well suited to site conditions, these plants shall be replaced with plant species that are better suited to the site.

Native vegetation and soil protection areas serve as stormwater management facilities and should be managed as are other stormwater facilities. The Maintenance Plan for the stormwater facilities shall include a written vegetation management plan and protection mechanisms as necessary to maintain the benefit of these areas over time.

2.1.2 LID.02 Post-Construction Soil Quality and Depth

Naturally occurring, undisturbed soil and vegetation provides important stormwater functions, including:

- Water infiltration
- Nutrient, sediment, and pollutant adsorption
- Sediment and pollutant biofiltration
- Water interflow storage and transmission
- Pollutant decomposition.

These functions are largely lost when development removes native soil and vegetation and replaces it with minimal topsoil and sod. ~~And~~ not only are these stormwater functions lost, but such landscapes then become pollution-generating pervious surfaces, due to increased use of pesticides, fertilizers and other landscaping ~~and~~ chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter.

Reestablishing a minimum soil quality and depth after development regains some of these stormwater functions, providing increased treatment of pollutants and sediments from development and habitation and minimizing the need for some landscaping chemicals, thus reducing pollution.

Applicability

This BMP is required in projects subject to Minimum Requirement #5, Onsite Stormwater Management. The following surfaces of a project site shall be required to implement this BMP:

- Areas that are to be incorporated into the stormwater drainage system such as surface BMPs. Note that BMP LID.08 – Bioretention has alternate soil requirements.
- All new lawn and landscape areas. Except that the areas of the project implementing BMP LID.11, "Full Dispersion" are not required to implement this BMP, however, it is still recommended.
- Disturbed areas that are to be restored to native vegetation (see BMP LID.01).
- Existing lawn and landscape areas of a redevelopment project where the project is required to retrofit the entire site to current stormwater standards (see Chapter 2 of Volume I).

Establishing minimum soil quality and depth is not the same as preservation of naturally occurring soil and vegetation. However, establishing a minimum soil quality and depth will provide improved onsite management of stormwater flow and water quality.

If soils must be amended to increase the organic content, several sources of organic matter (e.g., compost, composted woody material, biosolids, and forest product residuals) can be used. It is important that the materials used to meet the soil quality and depth requirements be appropriate and beneficial to the plant cover being established. It is also important that imported topsoils improve soil conditions and do not have an excessive percent of clay fines.

Limitations

Native soils with robust native landscapes must be protected from disturbance whenever possible, especially where no post-construction soil rehabilitation is planned.

In designated Well Head Protection Areas (WHPA) for public water systems with over 1,000 connections, compost used within the site shall be comprised entirely of vegetative materials only. Biosolids and animal manure components can result in large concentrations of nitrates leaching into groundwater aquifers and are consequently prohibited within the WHPA.

Poorly Draining Sites

If the site being considered for turf establishment does not drain well, consider an alternative to planting a lawn. If the site is not freely draining, and turf replacement is still being attempted, compost amendment will still provide stormwater benefits but should be incorporated into the soil at a reduced ratio of no more than 30 percent by volume. This upper limit is suggested in the Pacific Northwest because the region's extended saturated winter conditions may create water logging of the lawn. The landscape professional should also provide a drainage route or subsurface collection system as part of their design.

Existing Steep Slope Areas

Increasing soil moisture content may increase soil instability in areas with steep slopes. However, the Washington State Department of Transportation (WSDOT) has incorporated compost-amendment in almost all of its vegetated sites since 1992 without problems, even on the steepest sites (33 percent slope), as a result of the increased moisture holding capacity within the soils. (See design criteria below for requirements of steep slope soil amendment.)

- Onsite steep slope areas with native soils and robust native landscapes should be protected from disturbance, which is preferable to re-grading and augmenting the disturbed soil with soil amendment. Also, steep slope areas may be subject to critical area protection per TCC 17.15, which outlines criteria for classification of erosion and active landslide hazard areas.

- Where native soils and vegetation is sparse, steep slopes that remain on site that are not constructed as part of the development, should be amended by planting deep rooting vegetation. Soil amendments shall be applied with a pit application at least twice as wide as the root ball of the vegetation being planted, using a mix of 50 percent compost and 50 percent soil mixture.

Submittals and Approvals

A site specific Soil Management Plan (SMP) shall be submitted and must be approved as part of the permitting process for the project. The SMP shall be prepared per the Soils for Salmon guidance document (see Design Guidelines below) and includes:

- A scale-drawing (11" x 17" or larger) identifying area where native soil and vegetation will be retained undisturbed, and which soil treatments will be applied in landscape areas.

- A completed SMP form identifying treatments and products to be used to meet the soil depth and organic content requirements for each area.

- Computations of compost or topsoil volumes to be imported (and/or site soil to be stockpiled) to meet "pre-approved" amendment rates; or calculations by a qualified professional to meet organic content requirements if using custom calculated rates. Qualified professionals include certified Agronomists, Soil Scientists or Crop Advisors; and licensed Landscape Architects, Civil Engineers or Geologists.

- Copies of laboratory analyses for compost and topsoil products to be used, documenting organic matter contents and carbon to nitrogen ratios.

The steps involved in preparing the SMP include the following:

- Step 1: Review site Landscape Plans and Grading Plans
  - Assess how grading and construction will impact soil conditions

- Identify which areas are to receive which type of soil treatment options (1 through 4).

- Step 2: Visit Site to Determine Soil Conditions
  - Identify compaction of subgrade by digging down to a level 12 inches below finished grade and use a shovel or penetrometer to determine compaction.
  - Assess condition of native areas that are to remain undisturbed.
  - Assess soil conditions in each area to be cut, filled, or otherwise disturbed and establish scarification and amendment recommendations for each area.

- Step 3: Select Amendment Options
  - Identify areas where each amendment option will be applied and outline these areas on the SMP site plan and on the SMP form.
  - Assign each area an identifying number or letter on the SMP site plan and on the SMP form.

- Step 4: Identify Compost, Topsoils, and Other Organic Materials for Amendment and Mulch.
  - Products for soil amendment must be identified on the SMP form and recent product test results provided showing they meet the requirements of the Soil for Salmon guidance document (see Design Guidelines below).
  - Compost shall meet requirements of WAC 173-350, Section 220 "Composted Materials".

- Step 5: Calculate Amendment, Topsoil and Mulch Volumes on SMP Form
  - Calculate required cubic yards of amendment for the pre-approved amendment areas.
  - Compute custom calculated amendment rates to achieve the target Soil Organic Matter content (10 percent for landscape beds, 5 percent for turf areas).

Hydrologic and Hydraulic Design Considerations

Flow Credit for Dispersion

While hydrologic modeling credits cannot be applied for application of this BMP, credits can be taken in runoff modeling when the BMP is applied as part of a dispersion design under the conditions described in:

- BMP LID.05 Downspout Dispersion
- BMP LID.06 Sheet Flow Dispersion
- BMP LID.07 Concentrated Flow Dispersion
- BMP LID.11 Full Dispersion
- BMP LIS.12 Rural Roads Natural Dispersion
- BMP LID.13 Rural Roads Engineered Dispersion.

Design Guidelines

Guidance on implementing this BMP is still evolving as continued research is conducted and experience is gained in its use. An applicant can demonstrate compliance with this BMP by following the guidance provided in the most current edition of "*Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington*". This document is available at no charge from the following web sites: <www.SoilsforSalmon.org> and <www.BuildingSoil.org>.

Soil Retention

The duff layer and native topsoil should be retained in an undisturbed state to the maximum extent practicable. In any areas requiring grading remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas, to be reapplied to other portions of the site where feasible.

Soil Quality

All areas subject to clearing and grading that have not been covered by impervious surface, incorporated into a drainage facility or engineered as structural fill or slope shall, at project completion, demonstrate the following:

- A topsoil layer with a minimum organic matter content of 10 percent dry weight in planting beds, and 5 percent organic matter content in turf areas, and a pH from 6.0 to 8.0 or matching the pH of the original undisturbed soil. The topsoil layer shall have a minimum depth of 8 inches except where tree roots limit the depth of incorporation of amendments needed to meet the criteria. Subsoils below the topsoil layer shall be scarified at least 4 inches with some incorporation of the upper material to avoid stratified layers, where feasible.

- Planting beds must be mulched with 2 inches of organic material

The resulting soil should be conducive to the type of vegetation to be established.

Materials

Quality requirements for compost and other materials include the following:

- The organic content for "pre-approved" amendment rates can be met only using compost that meets the definition of "composted materials" in WAC 173-350-220. This code is available online at: <http://www.ecy.wa.gov/programs/swfa/facilities/350.html>.

- The compost must also have an organic matter content of 35 percent to 65 percent, and a carbon to nitrogen ratio below 25:1.

- The carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

- Calculated amendment rates may be met through use of composted materials as defined above; or other organic materials amended to meet the carbon to nitrogen ratio requirements, and meeting the contaminant standards of Grade A Compost.

Implementation Options

The soil quality design guidelines listed above can be met by using one of the methods listed below which are described in detail in the Soils for Salmon guidance document (see Design Guidelines above):

- **Option 1**. Leave undisturbed native vegetation and soil, and protect from compaction during construction. Identify areas of the site that will not be stripped, logged, graded or driven on, and fence these areas to prevent impacts during construction (see BMPs C101, C252, and C103 in Volume II). If neither soils nor vegetation are disturbed, these areas do not require amendment.

- **Option 2**. Amend existing site topsoil or subsoil in place at default "pre-approved" rates, or at custom calculated rates based on tests of the soil and amendment. Scarify or till the subgrade to a depth of 8 inches (or depth needed to achieve a total depth of 12 inches of uncompacted soil after calculated amount of amendments are added). Amend soil to meet required organic content dependent on the use (Planting area or Turf) and whether the pre-approved or calculated rate method is used.

- **Option 3**. Stockpile existing topsoil during grading, and replace it prior to planting. Stockpiled topsoil must also be amended if needed to meet the organic matter or depth requirements, either at a default "pre-approved" rate or at a custom calculated rate. If placed topsoil plus compost or other organic material will amount to less than 12 inches, then the subgrade will be scarified or tilled to achieve 12 inches of loosened soil after amendment. Replace stockpiled topsoil prior to planting. Amend stockpiled topsoil if needed to meet required organic content dependent on the use (Planting area or Turf) and whether the pre-approved or calculated rate method is used.

- **Option 4**. Import topsoil mix of sufficient organic content and depth to meet the requirements. Scarify or till subgrade in two directions to 6 inches depth. Use topsoil mix suitable for proposed use (planting bed or turf area). Place topsoil in layers per recommendations of Soils for Salmon guidance documents (see Design Guidelines above).

More than one method may be used on different portions of the same site. Soil that already meets the depth and organic matter quality standards, and is not compacted, does not need to be amended. See the Soils for Salmon (2009) website for further discussion of implementation and for pre-approved rates of soil amendment.

Construction and Maintenance

See the Soils for Salmon website and the guidance provided in the most current edition of "*Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington*" for details on implementing the Post-Construction Soil Quality and Depth BMP.

Maintenance

- Soil quality and depth should be established near the end of construction and, once established, protected from compaction (e.g., by large machinery use) and from erosion.

- Soil should be planted and mulched after installation.
- Plant debris or its equivalent should be left on the soil surface to replenish organic matter.
- Reduce irrigation and the application of fertilizers, herbicides and pesticides.

Table 2.2. Soil Management Plan for BMP LID.02

PROJECT INFORMATION **Page # ____ of ____ pages**

Complete all information on page 1; only site address and permit number on additional pages.

Site Address / Lot No.:____	
Permit Type:	**Permit Number:**
Permit Holder:	**Phone:**
Mailing Address:____	
Contact Person:	**Phone:**
Plan Prepared By:	

ATTACHMENTS REQUIRED (*Check off required items that are attached to this plan*)

___ **Site Plan showing, to scale:**	___ Areas of undisturbed native vegetation (no amendment required) ___ New planting beds and turf areas (amendment required) ___ Type of soil improvement proposed for each area
___ **Soil test results (required if proposing custom amendment rates)**	
___ **Product test results for proposed amendments**	

AREA #________ (*should match Area # on Site Plan*)

PLANTING TYPE ___ Turf ___ Undisturbed native vegetation ___ Planting Beds ___ Other: ______________________________		
SQUARE FOOTAGE OF THIS AREA: _______ square feet		
SCARIFICATION ___ Subsoil will be scarified	___ inches (depth) of scarification needed to achieve finished total 12" loosened depth.	
PRE-APPROVED AMENDMENT METHOD: ___ Topsoil import ___ Amend with compost ___ Stockpile and amend (_____ cu. yds. stockpiled)	____inches of compost or imported topsoil applied X 3.1 (*conversion factor, inches to cubic yards*) _____= cu. yards per 1,000 sq. ft. X ___ ,000s sq.ft. in this area ____ = cubic yards of amendment → → → → → (*needed to cover this area to designated depth*)	PRODUCT:_____________________ _____________________________ QUANTITY:_______CU. YDS.
CUSTOM AMENDMENT ___ Topsoil import ___ Topsoil & compost lift ___ Amend ___ Stockpile and amend (____ cu. yds. stockpiled)	**Attach test results and calculations.** ____ inches organic matter or topsoil import X 3.1 _____= cu. yards / 1,000 sq. ft. X ___ ,000s sq.ft. in this area ____ = cubic yards of amendment → → → → →	PRODUCT:_____________________ _____________________________ QUANTITY:_______CU. YDS.
MULCH	___ ,000 sq.ft. X 6.2 (*conversion, to give 2 inch mulch depth*) ____ = cubic yards of mulch → → → → → →	PRODUCT:_____________________ QUANTITY:_______CU. YDS.

TOTAL AMENDMENT/TOPSOIL/MULCH FOR ALL AREAS (*complete on page 1 only, totaling all areas/pages in this Plan*)

❑ **Product #1:**____________________________ ❑ **Quantity: _________cu. yds.** ❑ **Test Results: ___ % organic matter ____C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)
❑ **Product #2:**____________________________ ❑ **Quantity: _________cu. yds.** ❑ **Test Results: ___ % organic matter ____C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)
❑ **Product #3:**____________________________ ❑ **Quantity: _________cu. yds.** ❑ **Test Results: ___ % organic matter ____C:N ratio <25:1** (except mulch, or <35:1 for native plants) ____ **"stable"** (yes/no)

Date:	**Inspector:**	**Approved:**	**Revisions Required:**
Date:	**Inspector:**	**Approved:**	**Revisions Required:**

COMMENTS:

2.1.3 LID.03 Reduce Effective Impervious Area of Roads, Shared Accesses, Alleys, Sidewalks, Driveways, and Parking Areas

Roads, shared accesses, alleys, sidewalks, driveways, and parking areas are a substantial portion of total urban impervious area and usually have highly efficient drainage systems. Reducing the effective amount of these impervious areas and the amount of runoff they generate is a key concept of LID.

Applicability

The following sections describe strategies for reducing the impacts of impervious surfaces associated with transportation related networks, including roadways, parking lots, alleys, driveways, and sidewalks.

Limitations

Road designs must comply with the latest edition of Thurston County Road Standards for projects outside of Urban Growth Areas. Within Urban Growth Areas, for those municipalities with an agreement in place with Thurston County (currently only City of Olympia) the more stringent of the Thurston County Road Standards or the applicable municipalities road standards would apply depending on the project location., Road Standards include maximum grade, minimum roadway width, emergency access, compliance with the Americans with Disabilities Act (ADA) and safety restrictions (clear zone, stopping sight distance, etc.). If a developer or designer is interested in deviating from the road standards, they will need to request a variance. Contact Thurston County Public Works for information on variances.

Because appropriate strategies for reducing impervious areas are different in rural and urban areas, they are broken out as “urban strategies” and “rural strategies” under design criteria, below.

Submittals and Approval

As noted above, a variance is required for road design changes that deviate from the governing road standards. Several techniques are listed under “design criteria”. Those that are likely to require a variance are noted. Requests for variance from road standards shall be in a form and contain the information required by the most current version of the Thurston County Road Standards.

Design Criteria

Urban Strategies

Urban areas in Thurston County are normally under the jurisdiction of cities (Olympia, Lacey, Tumwater, Yelm) with the exception of Grand

Mound. Depending on your project location and the proposed road design strategies, a variance may be required. Contact Thurston County and the appropriate jurisdiction for additional information.

Reduce Roadway Widths

Design roads with the minimum width permissible under the applicable road design standards.

Permeable Pavement

The use of permeable paving surfaces (see BMP LID.09) is a good strategy for reducing impervious areas associated with transportation facilities. For private roads, porous paving surfaces may be used adjacent to the traveled lane (e.g., in pull-out parking, shoulders, and sidewalks) with acceptance by Thurston County and the local jurisdiction. Use of porous pavement on County-maintained roads is not allowed.

Cul-de-sacs

Where cul-de-sacs are used, techniques should be used to reduce or disconnect the impervious turnaround area. This can be accomplished by increasing the diameter of the cul-de-sac and including a pervious or bioretention landscaped area in the center where stormwater can be directed.

Sidewalks

Sidewalks on Single Side of the Road

Thurston County road standards require sidewalks on both sides of arterials, collectors, and local roads. Where pedestrian safety, ADA-compliance, and access are not compromised, developers may request a variance from this standard, proposing sidewalks on only one side of the roadway, to reduce the impervious area associated with sidewalks. To be considered for a variance, the developer must demonstrate that every lot will have pedestrian access to an abutting trail or to a sidewalk located on at least one side of the road.

Reverse Slope Sidewalks

Sidewalks and trails should be disconnected from the traveled way portion of the road, when possible. Where feasible, sidewalks should be “reverse slope”, where they slope *away* from the road and onto adjacent vegetated areas. If a sidewalk drains onto a vegetated area that is greater than or equal to 10 feet in width and the soils are either native soils or meet the criteria of BMP LID.02, “Post Construction Soil Quality and Depth” then the sidewalk area may be modeled as landscaped area over the underlying soil type.

Sidewalk Materials

Sidewalks and trails may be constructed of porous materials for private developments and roadways. Porous sidewalks within the public right-of-way would require Thurston County acceptance and a variance from the Road Standards. Porous materials for sidewalks and trails shall be ADA-compliant. See BMP LID.09, "Alternate Paving Surfaces" for guidance on these materials.

Parking

Parking Lots

Use the minimum off-street parking requirements outlined in Title 20.44.030 TCC for non-residential uses. Pervious materials should be considered for parking lots where feasible.

Shared Parking

The total amount of impervious area can be reduced by utilizing shared parking. This strategy is appropriate for land uses with non-competing hours of operation, such as a church and a school or office. See Title 23.38.180 TCC for restrictions and requirements on shared parking.

Driveways

Driveways are typically constructed with impervious surfaces and should be considered in the total stormwater runoff reduction strategy. The following are methods to reduce the amount of impervious driveway surfaces (variances may be required):

- Minimize driveway width
- Reduce driveway length where possible. This may be achieved by locating the house closer to the road or by using alley access directly into a garage.
- When possible, design clusters of homes to use shared driveways. On lots that accommodate multiple family dwellings, such as townhouses, the courtyard between garages and the stem of the driveway can be shared space.
- Consider constructing driveways using pervious materials.

Rural Strategies

Thurston County has well-draining outwash soils in many areas. The County has adopted strategies to preserve existing drainage and take advantage of the infiltration and treatment capacity of existing soils by avoiding curb and gutter where possible to promote dispersion and infiltration into roadside ditches. For rural roads, special sheet flow dispersion BMPs are provided for sites that meet specific conditions (see BMP LID.12 and BMP LID.13).

2.2 LID Stormwater Management BMPs

BMPs in this chapter include:

- LID.04 Downspout Infiltration Systems (Trenches, Drywells)
- LID.05 Downspout Dispersion Systems
- LID.06 Sheet Flow Dispersion
- LID.07 Concentrated Flow Dispersion
- LID.08 Bioretention Facilities
- LID.09 Alternative Paving Surfaces
- LID.10 Vegetated Roofs
- LID.11 Full Dispersion
- LID.12 Rural Road Natural Dispersion
- LID.13 Rural Road Engineered Dispersion

2.2.1 LID.04 Downspout Infiltration Systems

Downspout infiltration systems are used for infiltrating runoff from roof downspouts and include infiltration trenches and drywells.

Applicability

Application of rooftop downspout controls (this BMP, BMP LID.05, "Downspout Dispersion Systems") is required to meet Minimum Requirement #5. This BMP is the preferred method of rooftop downspout control, and must be considered before the other measures.

Limitations

Downspout infiltration systems may not be used to directly infiltrate runoff from pollutant-generating impervious surfaces, such as uncoated metal roofs.

Downspout infiltration systems are not allowed for properties along the Marine Bluff without special acceptance.

Submittals and Approval

UIC Registration

Infiltration drywells are considered underground injection chambers (UIC) and are therefore subject to Ecology UIC registration requirements. See Chapter 3.

Infiltration trenches are not considered UICs, unless they include perforated pipe used to disperse and inject flows (see Chapter 3).

Infiltration drywells for single family residences which only infiltrate clean roof runoff are not currently required to register as a UIC.

Soil Testing and Report

See Volume III, Chapter 3 for general soil testing requirements for infiltration.

Pretreatment

No pretreatment is required.

Hydraulic, Hydrologic and Soil Design Considerations

Flow Credit for Roof Downspout Infiltration

If roof runoff is infiltrated according to the requirements of this section, the roof area may be discounted from the project area used for sizing stormwater facilities and determining the effective impervious area thresholds of Minimum Requirements #7 (Flow Control).

Hydraulic Design Elements

A structure with a sump (see Figure 2.2) shall be located upstream of the trench, which provides a minimum of 12 inches of depth below the outlet riser. The outlet riser pipe bottom shall be designed so as to be submerged at all times, and a screening material shall be installed on the pipe outlet.

Design Criteria for Downspout Infiltration Systems

Downspout Infiltration Trench

Figures 2.1 and 2.2 present alternative design options for the downspout infiltration trench systems. These systems are designed as specified below.

Geometry

- Length of trench must not exceed 100 feet from the inlet sump
- Minimum spacing between distribution pipe centerlines must be 6 feet.

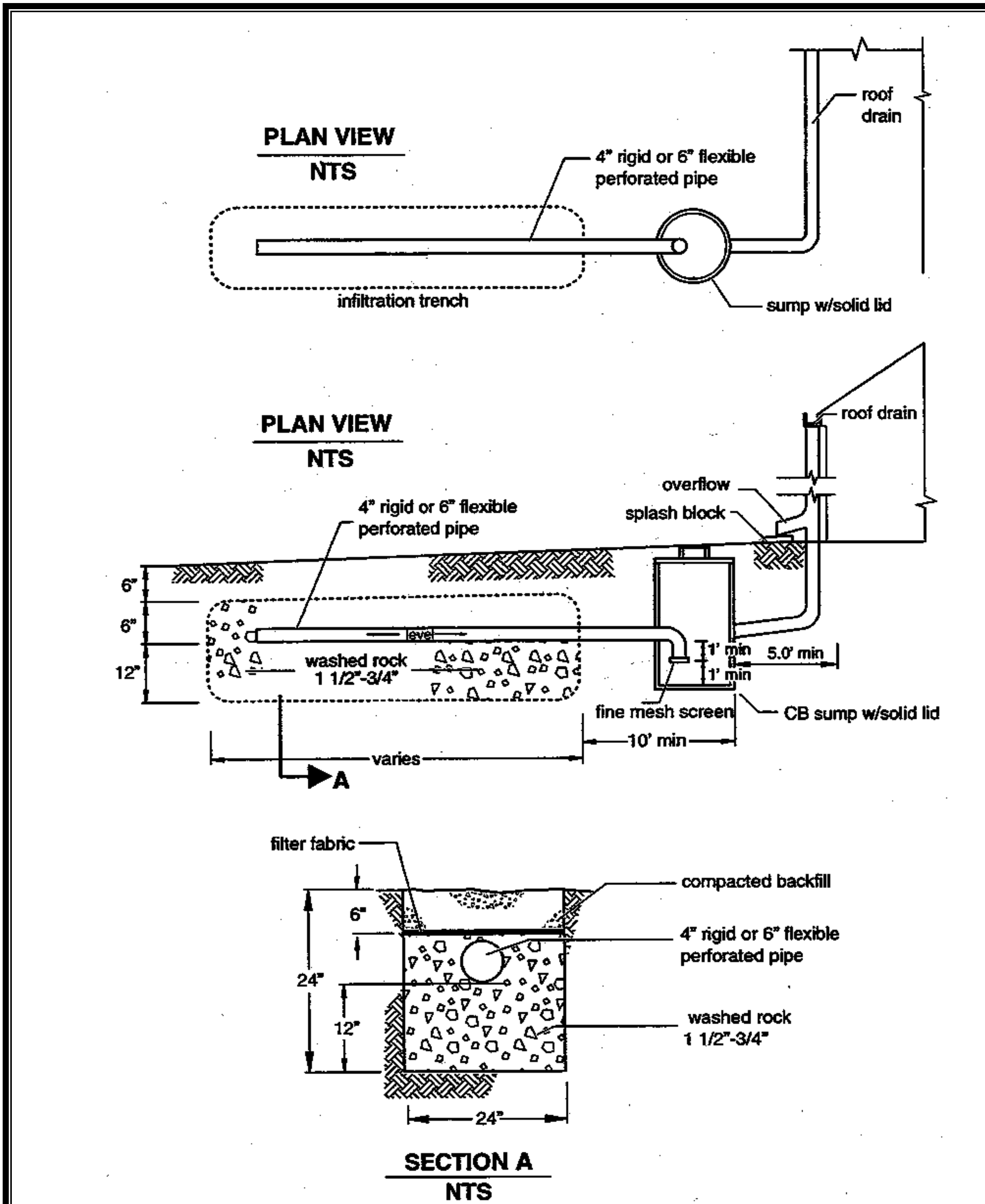
Materials

- The aggregate material for the infiltration trench shall consist of 1.5- to three-fourth-inch washed round rock.
- Geotextile filter fabric shall be wrapped entirely around trench drain rock prior to backfilling EXCEPT that a 6-inch layer of sand below the trench bottom may be used in-lieu of a filter fabric liner on the bottom.
- Infiltration trenches may be placed in fill material if the fill is placed and compacted under the direct supervision of a geotechnical engineer or professional civil engineer with geotechnical expertise, and if the measured infiltration rate is at least 8 inches per hour. Infiltration rates can be tested using the methods described in Volume III.

Other Design Criteria

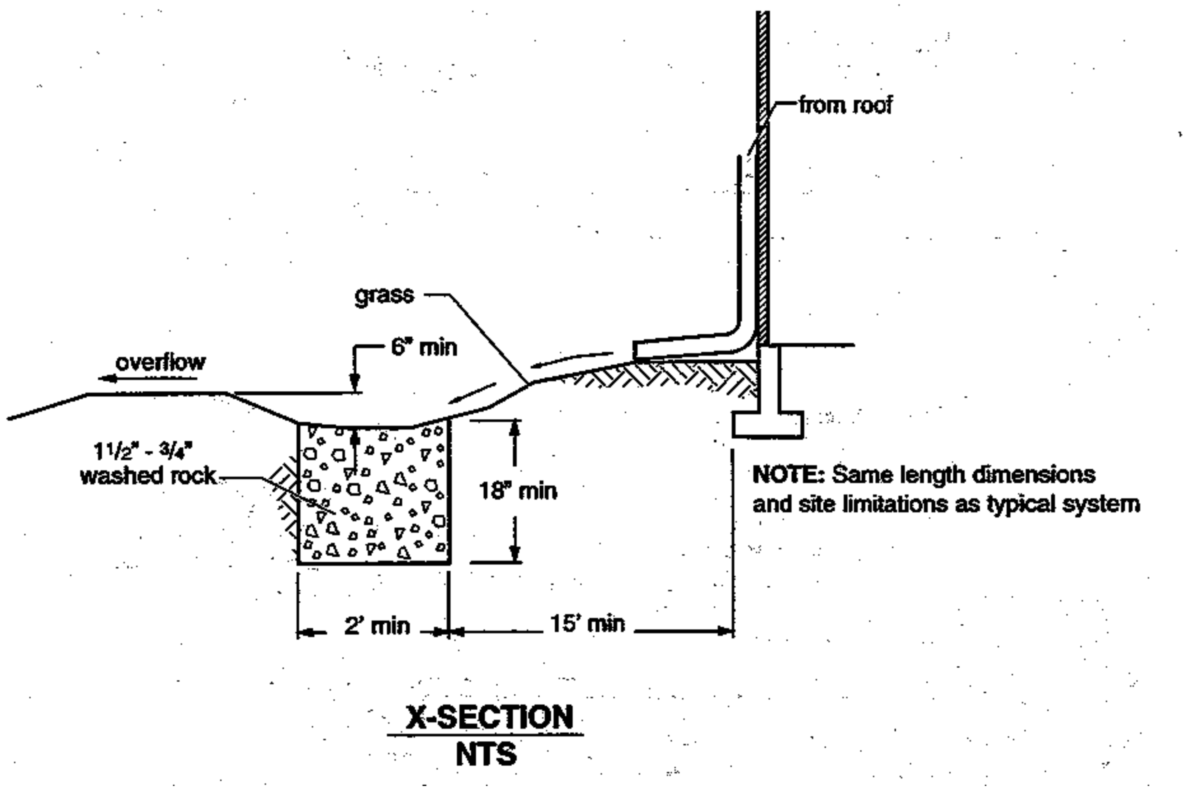
- Trenches shall be covered the same day they are opened.
- Trenches shall be no wider than can be excavated by a backhoe straddling the trench.
- Parallel trenches shall be spaced no closer than 10 feet except that trenches whose target for discharge is the interflow zone. If

hardpan is less than 6 feet below finished grade, or the trench is excavated to closer than 3 feet of hardpan (whatever the depth), then the target for infiltration is the interflow zone and:



Source: King County

Figure 2.1. Typical Downspout Infiltration Trench.



Source: King County

Figure 2.2. Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel.

- Trenches must, as nearly as practical, follow a contour line.
- Parallel trenches shall be spaced no closer than 25 feet apart.

Design Criteria for Infiltration Drywell Systems

Figure 2.3 presents the design of a typical downspout infiltration drywell system. The drywell shall include a catch basin (as shown in Figure 2.3), or its equivalent upstream of the drywell for particulate removal. These systems are designed as specified below:

Simplified Sizing for Drywells

The following table (Table 2.3) may be used for drywell sizing for projects that are not subject to Minimum Requirement #7 (Flow Control – see Volume I, Chapter 2).

Table 2.3. Roof Drywell Sizes by Soil Hydrologic Group

Soil Hydrologic Group	Total Volume Required Per 1,000 Square Feet of Roof [1]
A or B (Sand, loamy sand, sandy loam, loam)	125 cubic feet
C (Silt loam, sandy clay loam, "till" soils with Group A or B surface horizons)	250 cubic feet
D (Silts, clays, rock outcroppings, "till" soils with Group C or D surface horizons) [2]	750 cubic feet

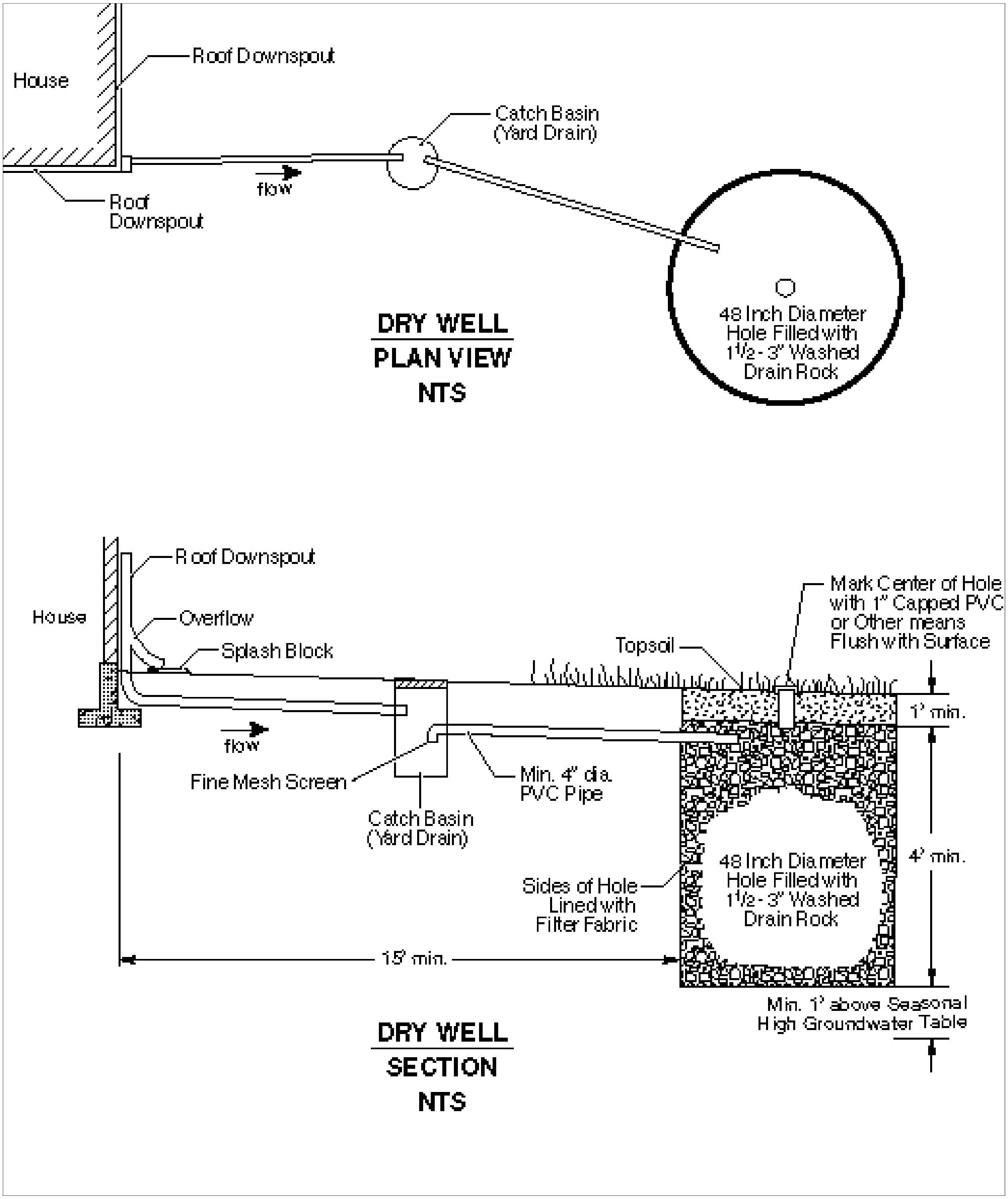
Source: Thurston County 1994.
[1] Volume includes rock backfill. Trench size may be reduced if pipe or other open structure replaces a portion of the rock backfill; contact Thurston County for guidance.
[2] Drywells are not recommended for Hydrologic Group D soils due to extremely slow percolation rates. Drywells should be used only if other reasonable alternatives are infeasible.

Geometry

- Drywell bottoms must be a minimum of 1 foot above seasonal high groundwater level or impermeable soil layers.
- Drywells shall be 48 inches in diameter (minimum) and have a depth of 5 feet (4 feet of gravel and 1 foot of suitable cover material).
- Spacing between drywells shall be a minimum of 4 feet.

Materials

Filter fabric (geotextile) must be placed on top of the drain rock and on trench or drywell sides prior to backfilling. See Appendix V-B (Facility Liners).



Source: King County

Figure 2.3. Typical Downspout Infiltration Drywell.

Structural Design Considerations

Trenches may be located under pavement, if designed by a professional engineer. Trenches must include an overflow at least 1 foot below the pavement, and be in a location that can accommodate overflow without creating a significant adverse impact to downhill properties or drainage systems. This is intended to prevent saturation of the pavement in the event of system failure. The trench depth must be measured from the overflow elevation, not the ground surface elevation.

Site Design Elements

See Appendix V-E (Site Design Elements) for setbacks for infiltration facilities.

Downspout infiltration drywells must not be built on slopes greater than 25 percent (4H:1V). Drywells may not be placed on or above an active landslide hazard area or slopes greater than 15 percent without evaluation by a professional engineer with geotechnical expertise, or a licensed geologist, hydrogeologist, or engineering geologist, and with Thurston County acceptance.

Where individual lot drywells are to be installed in a residential subdivision, the project engineer shall determine the required size of each drywell for each lot or group of lots with similar soils. The project engineer shall then record these sizes as necessary to ensure that they become restrictions for future building applications (e.g., record written conditions for lots and/or dictate drywell size on the face of the final plat mylar, etc.).

2.2.2 LID.05 Downspout Dispersion Systems

Downspout dispersion systems are gravel-filled trenches or splash blocks that spread roof runoff over vegetated, pervious areas. Dispersion attenuates peak flows by slowing entry of runoff into the conveyance system, allowing some infiltration and providing some water quality benefits, such as filtration and vegetative uptake.

Applicability

Rooftop downspout controls (this BMP, BMP LID.04, "Downspout Infiltration Systems", or BMP LID.08, "Bioretention Facilities") are required to meet Minimum Requirement #5. Downspout Infiltration (BMP LID.04) is the preferred rooftop downspout control. If infiltration is not feasible, bioretention facilities (BMP LID.08) are preferred over downspout dispersion.

Limitations

No erosion or flooding of downstream properties may result.

See Appendix V-E (Site Design Elements) for setbacks. For dispersion systems located within 50 feet of the top of a slope of 15 percent or greater with a height of 10 feet, a geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope. The Administrator or designee may require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or prohibition of infiltration facilities may result from this report.

Hydrologic and Hydraulic Design Considerations

Dispersion Trenches

If roof runoff is dispersed over a vegetative flow path 25 feet or longer through undisturbed native landscape or an area that meets the soils criteria outlined in BMP LID.02, the roof area may be modeled as landscape surface for determining thresholds for Minimum Requirement #7, Flow Control, and sizing stormwater facilities.

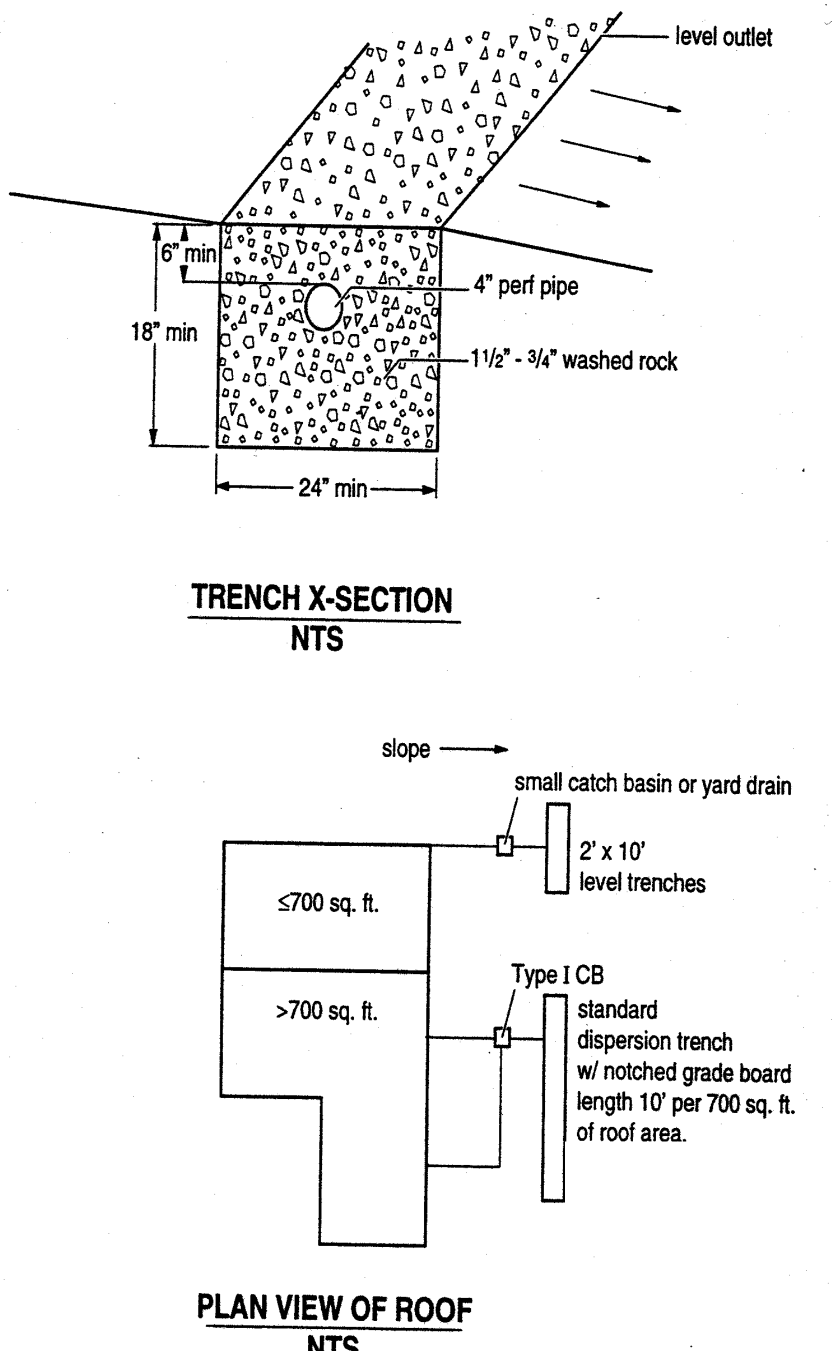
Splashblocks

If roof runoff is dispersed over a vegetative flow path 50 feet or longer through undisturbed native landscape or an area that meets the soils criteria outlined in BMP LID.02, the roof area may be modeled as landscaped surface for determining thresholds for Minimum Requirement #7, Flow Control, and sizing stormwater facilities.

Design Criteria

Dispersion Trenches

Dispersion trenches shall be designed as shown in Figure 2.4.



Source: King County

Figure 2.4. Typical Downspout Dispersion Trench.

A vegetated flow path at least 25 feet in length must be maintained between the outlet of a trench and any property line; structure; critical area (i.e., stream, wetland), or impervious surface. Critical area buffers may count towards flow path lengths. However, the area must be permanently protected from modification through a covenant or easement, or a tract dedicated by the proposed project. This does not include steep slopes. See steep slope setbacks below.

Trenches serving up to 700 square feet of roof area must be 10 foot long by 2-foot wide gravel filled trenches as shown in Figure 2.4. For roof areas larger than 700 square feet, a dispersion trench with notched grade board shall be used. The total length of this design must not exceed 50 feet, and must provide at least 10 feet of trench per 700 square feet of roof area. In both designs, it is important to include a cleanout structure prior to discharge into the dispersal area. Although the figures refer at times to a Type 1 catch basin, it is also acceptable to use an equivalent type structure which includes a lid, 1-foot minimum sump, and T-type outlet with screen.

Splashblocks

Splash blocks shall be designed as shown in Figure 2.5.

Splash blocks may be used for downspouts discharging to a vegetated flow path at least 10 feet in width and 50 feet in length as measured from the downspout to the downstream property line, structure, critical areas (i.e., stream, wetland), or other impervious surface. Flow path measurement may traverse a property line into an adjacent critical area buffer, provided that the area is permanently protected through a covenant, easement, or a tract dedicated as part of the proposed project. This does *not* include steep slopes. See *limitations*.

A maximum of 700 square feet of roof area may drain to each splash block. When flow paths of multiple splash blocks are combined, the vegetated flow path width shall increase by 50 percent with each additional splashblock.

Site Design Elements

Vegetated Flow path

For both dispersion trenches and splashblocks, the vegetated flow path must be covered with well-established vegetation to prevent erosion and promote partial infiltration. Vegetated flow paths shall consist of undisturbed native landscape area, or an area that meets the requirements of BMP LID.02, Soil Amendments, Quality and Depth.

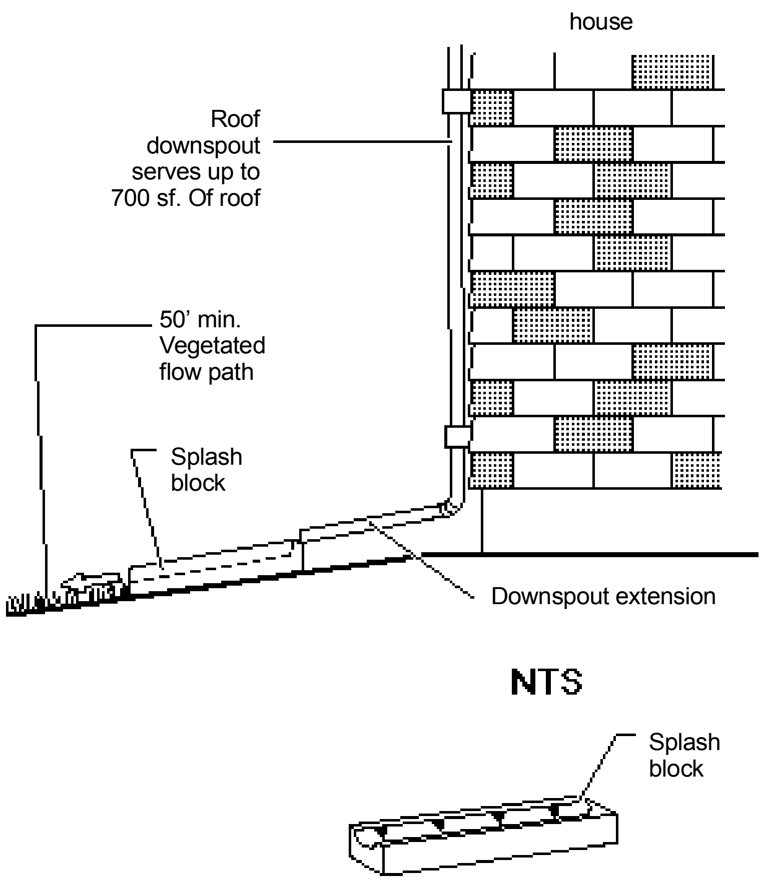


Figure 2.5. Typical Downspout Splashblock Dispersion.

Setbacks

Dispersion systems shall be set back at least 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope. The Administrator or designee may require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or prohibition of infiltration facilities may result from this report.

For sites with septic systems, the discharge point must be downslope of the primary and reserve drainfield areas. This requirement may be waived if site topography clearly prohibits flows from intersecting the drainfield.

2.2.3 LID.06 Sheet Flow Dispersion

Sheet flow dispersion is the simplest method of runoff control, and can be used with any graded impervious or pervious surface to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.

Applicability

Flat or moderately sloping (less than 15 percent) impervious surfaces such as driveways, private roadways, sport courts, patios, roofs without gutters, sloping cleared areas that are comprised of bare soil, non-native landscaping, lawn, or pasture, or any situation where concentration of flows can be avoided.

This BMP can be used to disperse unconcentrated site runoff when the project site cannot meet the requirements for full dispersion (see BMP LID.11) in terms of maximum impervious surface and native vegetation retention. If the minimum requirements of BMP LID.11 can be met for a project, then the less restrictive sheet flow dispersion criteria of that BMP can be used.

If the project is a roadway or other linear project and is in the rural area of Thurston County (outside an UGA or the NPDES Phase II permit boundary), then BMP LID.12 (Rural Roads Natural Dispersion) or BMP LID.13 (Rural Roads Engineered Dispersion) for rural roadways may be used for flow dispersion.

Limitations

No erosion or flooding of downstream properties may result.

Hydrologic and Hydraulic Design Considerations

Flow Credit for Sheet Flow Dispersion

Where sheet flow dispersion is used to disperse runoff into an undisturbed native landscape area, or an area that meets the requirements of BMP LID.02, “Soil Amendments, Quality and Depth”, the impervious area may be modeled as landscaped area for determining thresholds for Minimum Requirements #6 (Runoff Treatment) and #7 (Flow Control) and for designing stormwater facilities.

Design Criteria

See Figure 2.6 for details for driveways.

A transition zone (1-foot minimum) to discourage channeling shall be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of subgrade and shall be lower than the adjacent impervious surface by approximately 1-inch.

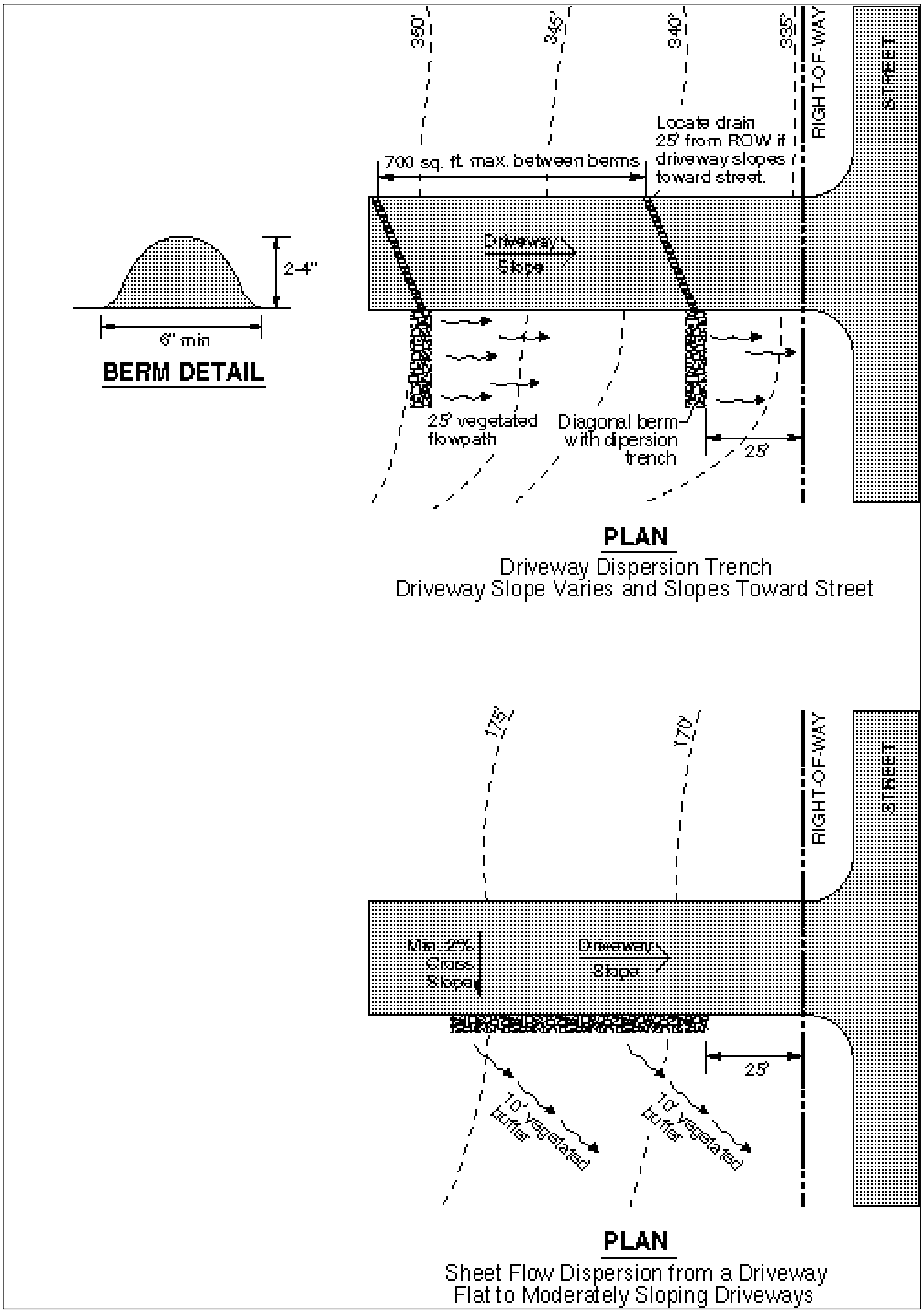


Figure 2.6. Sheet Flow Dispersion for Driveways.

material (crushed rock), modular pavement, drain rock, or other material approved by Thurston County.

A vegetated buffer width of 10 feet must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each additional 20 feet of width (or fraction thereof).

A vegetated buffer width of 25 feet of vegetation must be provided for up to 150 feet of contributing cleared area (i.e., bare soil, non-native landscaping, lawn, or pasture). Slopes within the 25-foot minimum flow path through vegetation must be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 25-foot flow path length must be increased 1.5 feet for each percent increase in slope above 8 percent, although the allowable slope shall not exceed 16 percent.

Site Design Elements

Sheet flow dispersion may not be appropriate where the drainage discharges toward slopes steeper than 15 percent or geologic hazard areas as defined by TCC 17.15. The Administrator or designee may require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or prohibition of dispersion toward the slope may result from this report. The geotechnical analysis and report shall address the potential impact of dispersion on the slope.

2.2.4 LID.07 Concentrated Flow Dispersion

Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing entry of runoff into the conveyance system, providing some infiltration and water quality benefits (i.e., sedimentation, filtration and vegetative uptake). See Figure 2.7.

Applicability

This BMP can be used to disperse concentrated site runoff when the project site cannot meet the requirements for full dispersion (see BMP LID.11) in terms of maximum impervious surface and native vegetation retention. If the minimum requirements of BMP LID.11 can be met for a project, then the less restrictive concentrated flow dispersion criteria of that BMP can be used.

If the project is a roadway or other linear project and is in the rural area of Thurston County (outside an UGA or the NPDES Phase II permit boundary), then BMP LID.12 (Rural Roads Natural Dispersion) or BMP LID.13 (Rural Roads Engineered Dispersion) may be used for flow dispersion.

Concentrated flow dispersion is appropriate for any situation where concentrated flow can be dispersed through vegetation.

Figure 2.7 shows two possible ways of spreading flows from steep driveways.

Limitations

Dispersion for driveways is usually effective only for single-family residences on large lots and in rural short plats. Lots proposed by short plats in urban areas are usually too small to provide effective dispersion of driveway runoff.

No erosion or flooding of downstream properties may result.

Submittals and Approval

Runoff discharged towards geologic or landslide hazard areas as defined by TCC 17.15 must be evaluated by a geotechnical engineer or qualified geologist. The discharge point shall not be placed on or above natural slopes greater than 15 percent and 10 feet in height, or above erosion or landslide hazard areas without evaluation by a geotechnical engineer or qualified geologist and acceptance by Thurston County.

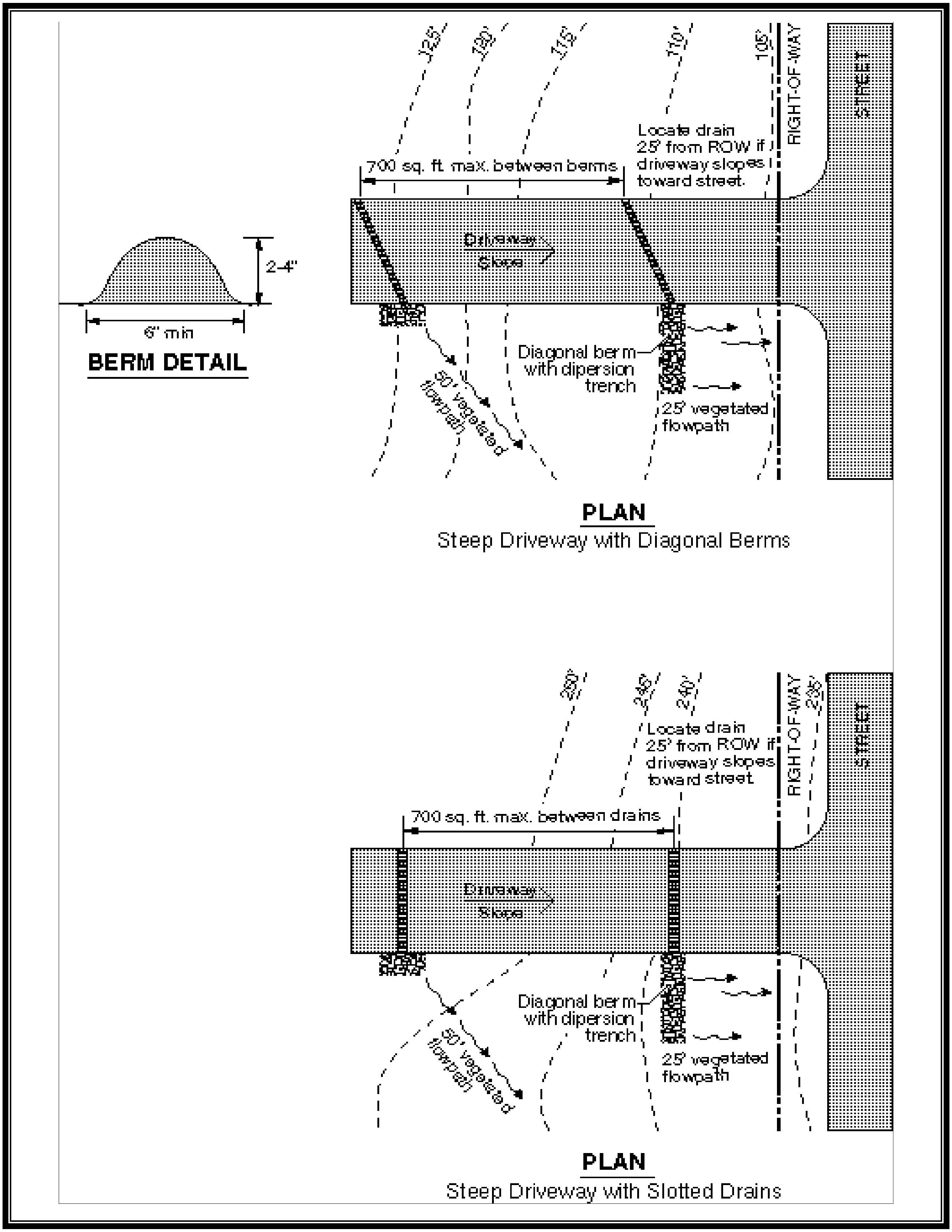


Figure 2.7. Typical Concentrated Flow Dispersion for Steep Driveways.

Native vegetation areas or landscape areas designed to meet BMP LID.02 (Post-Construction Soil Quality and Depth) which are used for dispersion of concentrated flows shall be identified on plans and plat maps and easements, tracts, or other means established to ensure their perpetual protection and maintenance of the dispersion area. Signage shall be provided to identify the extent of the area and the purpose of the area as a stormwater facility.

Hydrologic and Hydraulic Design Considerations

Flow Credit for Concentrated Flow Dispersion

Where concentrated flow dispersion is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP LID.02 – Soil Amendments, Quality and Depth, and the vegetated flow path is at least 50 feet, the impervious area may be modeled as landscaped area for establishing thresholds for Minimum Requirements #6 (Runoff Treatment and #7 (Flow Control) and for stormwater facility design.

Design Criteria

A vegetated flow path of at least 50 feet must be maintained between the discharge point and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface.

A maximum of 700 square feet of impervious area may drain to each concentrated flow dispersion BMP.

A pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each discharge point.

Site Design Elements

For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by Thurston County if site topography clearly prohibits flows from intersecting the drainfield.

2.2.5 LID.08 Bioretention Facilities

Bioretention facilities are shallow stormwater retention systems designed to mimic forested systems by managing stormwater through detention, infiltration, and evapotranspiration. Bioretention areas also provide water quality treatment through sedimentation, filtration, adsorption, and phytoremediation. Compared to traditional stormwater pond designs, these facilities are typically smaller in scale and integrated into the landscape to better mimic natural hydrologic systems.

Figure 2.8 provides an example illustration of a bioretention system.

Types of Bioretention Areas

Bioretention facilities can be configured in many ways, including the following:

- Rain gardens: Shallow depressions with a designed planting soil mix and variety of plant material, including trees, shrubs, grasses, and/or other herbaceous plants. Bioretention cells may or may not have an under-drain and are not designed as a conveyance system. Bioretention cells can be configured as depressed landscape islands, larger basins, planters, or vegetated curb extensions. They are most appropriate for small (10,000 sf or less) contributing areas.

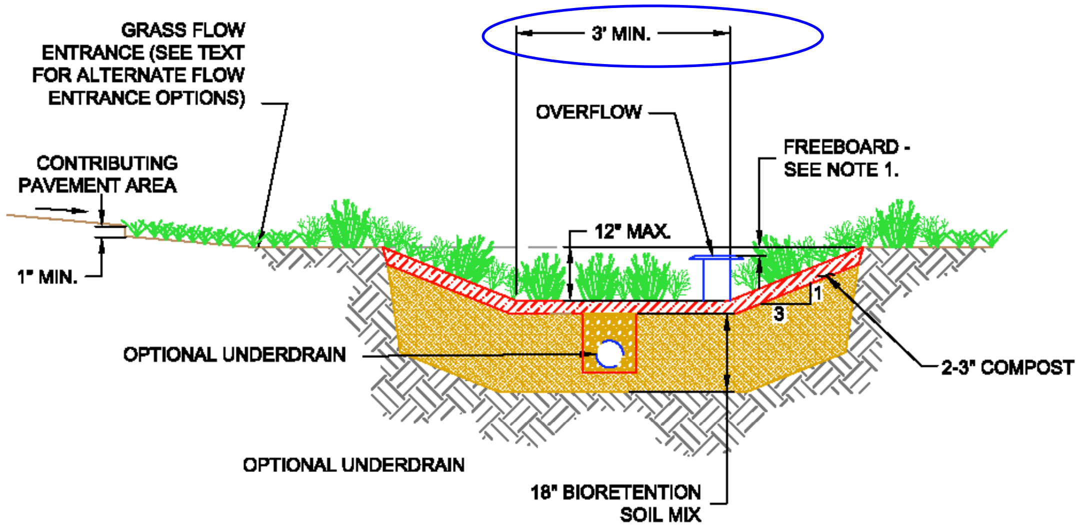
- Vegetated curb extensions: Bulb out areas along a road right-of-way containing a bioretention cell to accept roadway runoff.

- Bioretention swales/in-line bioretention: Long, linear facilities that incorporate the same design features as bioretention cells. Bioretention swales have relatively gentle side slopes and shallow flow depths.

Many other configurations of bioretention facilities are possible, but require different design methods than those described here. The following bioretention configurations require County acceptance, are discussed in the *Low Impact Development: Technical Guidance Manual for Puget Sound* (PSAT 2005).

- Biodetention: A design that uses vegetative barriers arranged in hedgerows across a slope to disperse, infiltrate, and treat stormwater.

- Sloped biodetention: use vegetative barriers are designed for a specific hydraulic capacity and placed along slope contours.



SECTION

BIORETENTION FACILITY NOTES:

1. FREEBOARD DEPTH SHALL BE 2" MIN. FOR CONTRIBUTING AREAS < 1,000 SF; FREEBOARD DEPTH SHALL BE 6" MIN. FOR CONTRIBUTING AREAS ≥ 1,000 SF.

THURSTON COUNTY BMP LID.08
DETAIL: BIORETENTION FACILITY
SCALE: NTS

1
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Figure 2.8. Bioretention Area.

- Off-line bioretention: The bioretention facility is placed next to a swale with a common flow entrance and flow exit.

- Sloped or weep garden bioretention areas: Used for steeper gradients where a retaining wall is used for structural support and for allowing storm flows, directed to the facility, to seep out.

- Tree box filters: Street tree plantings with an enlarged planting pit for additional storage, a storm flow inlet from the street or sidewalk, and an underdrain system.

Applicability

- Bioretention facilities can be designed to meet Minimum Requirement #6 (Runoff Treatment) and Minimum Requirement #7 (Flow Control). Bioretention facilities meet the requirements for basic and enhanced treatment.

Potential applications for bioretention facilities are described as follows:

- Bioretention facilities are applicable in parking lots as concaved landscaped areas (i.e., lower than the parking lot surface height, so that stormwater runoff is directed as sheet flow into the bioretention area). This application, used with porous surfaces in the parking lot, can greatly attenuate stormwater runoff.

- Areas within loop roads or cul-de-sacs are another feasible location for a bioretention facility to collect runoff from adjacent areas and portions of the roadway.

- Within right-of-ways along roads (linear bioretention swales and cells, vegetated curb extensions and planters)

- Common landscape areas within apartment complexes or other multifamily housing designs.

- Shared facilities located in common areas for individual lots within a subdivision.

- On individual lots bioretention facilities should be used to receive rooftop runoff in areas where downspout infiltration systems (BMP LID.04) are not feasible and in preference to downspout dispersion systems (BMP LID.05), and may be integrated into the landscaped areas of the lot.

- On individual lots bioretention facilities can also be used to receive driveway and other on-lot impervious and pervious surfaces.

Limitations

A minimum clearance of 3 feet is necessary between the lowest elevation of the bioretention soil, or any underlying gravel layer, and the seasonal high groundwater elevation or other impermeable layer if the area tributary to the facility meets or exceeds any of the following limitations:

- 5,000 square feet of pollution-generating impervious surface (PGIS)
- 10,000 square feet of impervious area
- Three-fourths of an acre (32,670 square feet) of lawn and landscape.

For bioretention systems and rain gardens with a contributing area less than the above thresholds, or for a bioretention swale on a linear project (roadway) with continuous sheet flow in-flow of runoff from the roadway surface a minimum of 1 foot of vertical clearance above the seasonal high groundwater level or other impermeable layer is acceptable.

Submittals and Approval

The applicant should consult with Thurston County at the pre-submittal meeting and the scoping report/meeting for the project to discuss the suitability of and requirements for a bioretention facility if one is proposed for the project.

Project submittal shall include the following in addition to the requirements of other sections:

- Source of bioretention soil mix and testing results of treatment soil
- Description of method used and results of infiltration testing of base soils and bioretention soil mix
- Hydrologic modeling results for the bio-retention facility demonstrating that the water quality treatment design storm is handled by the facility and how volumes greater than the water quality design flow are managed
- Project drawings shall include a typical cross-section of the facility and specifications for installation of treatment soils, seeding, sodding and other construction requirements
- Maintenance Plan shall include a discussion of maintenance requirements for the bio-retention facility

- The bioretention soils mix shall be tested for infiltration capacity using the following test method:
  - ASTM 2434 Standard Test Method for Permeability of Granular Soils (Constant Head) with a compaction rate of 80 percent using ASTM 1557 (Modified Proctor).
- Include in the Soils Management Plan prepared per BMP LID.02 the bioretention soils mix for any proposed bioretention facilities included in the project.

Pretreatment

If the catchment area contains unvegetated exposed soils or steep slopes, a presettling facility (e.g., filter strip, presettling basin, or vault) is required.

Hydrologic and Hydraulic Design Considerations

Infiltration Rate Determination

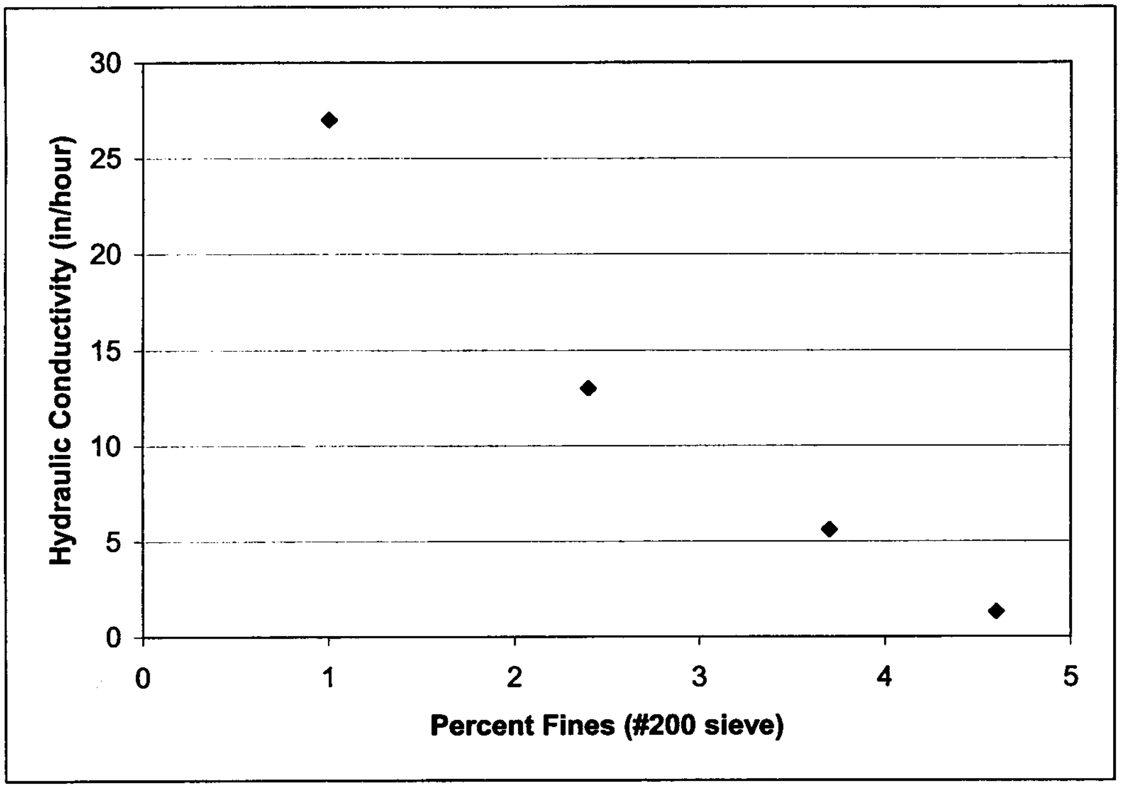
The design infiltration rate for the bioretention facility must be the lower of:

- Estimated long-term rate of the imported soil, or
- Initial infiltration rate of the underlying soil profile.

Imported Soil

The infiltration rate of imported soils can be determined using ASTM D2434 Standard Test Method for Permeability of Granular Soils (Constant Head) with a compaction rate of 80 percent using ASTM D1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. Alternately, the infiltration rate can be estimated from the proportion of fines (percent passing #200 sieve) in the aggregate portion of the imported soil. See Figure 2.9 for a relationship between measured hydraulic conductivity and percent fines (WSU 2009). If the design infiltration rate for the bioretention facility is determined by the imported soil, the quantitative method of determining the soil infiltration rate must be used.

The design infiltration rate for imported bioretention soil mix is estimated by applying a reduction factor to the measured value as discussed above. A reduction factor of 2 (multiply measured infiltration rate by 0.5) is applied where contributing areas are <5,000 sq. ft. of pollution generating surface, <10,000 sq. ft. of impervious area, and <3/4 acre of landscape area. Above these thresholds an infiltration reduction factor of 4 is applied.



Source: WSU (2009).

Figure 2.9. Percent Fines of the Four Aggregate Samples vs. Hydraulic Conductivity.

Underlying Soil

See Volume III for determination of the design infiltration rate of the underlying soil.

Modeling and Sizing

To be considered an enhanced treatment BMP, the bioretention facility must infiltrate at least 91 percent of the total volume of runoff in the inflow runoff file (based on a continuous simulation model). Otherwise, it provides basic treatment only.

If a bioretention facility is designed with an underdrain, its ability to meet the flow control criteria of Minimum Requirement #7 is limited to that area beneath the underdrain that has stormwater holding capacity.

Bioretention Facility Sizing

Bioretention facilities shall be sized by using an approved continuous simulation model and treating the facility as an infiltration facility with appropriate stage-storage and overflow/outflow rates.

When using continuous modeling to size bioretention facilities, the assumptions listed in Table 2.4 shall be applied. The tributary areas, cell bottom area, and ponding depth should be iteratively sized until the duration curves and/or peak values meet the applicable flow control requirements (see Volume I). Alternatively, bioretention systems that are not designed to fully meet applicable flow control requirements can discharge to a secondary flow control facility; as long as the net flow control requirement for the site is met through the combined performance of all facilities.

Table 2.4. Continuous Modeling Assumptions for Bioretention Cells

Variable	Assumption
Computational Time Step	5-minutes
Inflows to Facility	Surface flow and interflow from drainage area routed to facility
Precipitation and Evaporation Applied to Facility	Yes. If model does not apply precipitation and evaporation to facility, include the facility area in the basin area (note that this will significantly underestimate the evaporation of ponded water).
Bioretention Soil Infiltration Rate	See Infiltration Rate Determination, above
Bioretention Soil Porosity	40 percent
Bioretention Soil Depth	Minimum of 12 inches for flow control. Minimum of 18 inches for water quality treatment
Native Soil Design Infiltration Rate	Measured infiltration rate with correction factor applied, if applicable. If imported bioretention soil is used, a correction factor for plugging is not required.
Infiltration Across Wetted Surface Area	Yes if side slopes are 3H:1V or flatter. For steeper side slopes, only infiltration across the bottom area is modeled.
Underdrain (optional)	If underdrain is placed at bottom extent of the bioretention soil layer, all water which enters the facility must be routed through the underdrain. If there is no liner or impermeable layer and the underdrain is elevated within the bioretention soil, water stored in the bioretention soil below the underdrain may be allowed to infiltrate.
Outlet Structure	Overflow elevation set at maximum ponding elevation (excluding freeboard). May be modeled as weir flow over riser edge or notch. Note that total facility depth (including freeboard) must be sufficient to allow water surface elevation to rise above the overflow elevation to provide head for discharge.

The professional version of WWHM includes a bioretention module that can be used to size the cell with or without an underdrain. It is anticipated that other modeling programs will develop similar modules to represent bioretention cells in the future.

Entrance Velocity

The velocity of flows entering a facility shall be less than 1 foot per second to minimize erosion potential. Engineered flow dissipation (e.g.

rock pad) shall be incorporated into curb-cut or piped (concentrated) flow entrances.

Ponding Depth

The ponding depth shall be a maximum of 12 inches (unless optional detention storage is incorporated – see below).

Drawdown Time

The surface pool drawdown time shall be a maximum of 24 hours. This can be estimated by dividing the maximum ponded depth by the design (long-term) infiltration rate.

Overflow

Unless designed for full infiltration of the entire continuous model runoff file, bioretention and rain garden facilities must include an overflow. Facility overflow can be provided by a drain pipe installed at the designed maximum ponding elevation (6 inches) and connected to a downstream BMP or an approved discharge point.

Overflow drainage facilities shall be designed to convey the 100-year recurrence interval flow. This assumes the facility will be full due to runoff rates far in excess of soil infiltration capacity. The design must provide controlled discharge directly into the downstream conveyance system or another acceptable discharge point.

Optional Detention Storage

It is possible to design additional detention storage above the 12-inch design water surface (to a maximum of 30 inches total) by including an orifice control system within the overflow structure to help attenuate the flows. For example, a Type 1 Catch Basin with removable down-turned elbow (using properly designed orifices) could be used. This would allow the bioretention facility to meet the dewatering requirement of 24 hours, maximum.

If using this design, the plant selection must clearly reflect the additional proposed storage depth. This potential modified design is allowed only for large bioretention systems, not for facilities on individual lots. Care must be taken to still blend these larger and deeper facilities in with the surrounding landscape.

Underdrain

In the event that the downstream pathway of infiltration and interflow cannot be maintained, or the infiltration capacity is insufficient to handle the contributing area flows (e.g., a facility enclosed in a loop roadway system or a landscape island within a parking lot), an underdrain system can be incorporated into the facility. The underdrain system can then be connected to a nearby vegetated channel, another stormwater facility, or dispersed into a natural protection area.

Only the area below the under-drain invert and the bottom of the bioretention facility can be used in the WWHM for flow control benefit. The area above an underdrain pipe in a bioretention or rain garden facility provides attenuation and pollutant filtering. Underdrain systems should be installed only if the bioretention or rain garden is:

- Located where infiltration is not permitted and a liner is used
- In soils with infiltration rates that are not adequate to meet maximum pool drawdown time.

The underdrain can be connected to a downstream BMP such as another bioretention/rain garden facility as part of a connected system, or to an approved discharge point.

The underdrain pipe diameter will depend on hydraulic capacity required (4 to 8 inches is common). Within the public right-of-way any underdrain shall be a minimum of 12-inches with access to both ends. A geotextile fabric (specifications in Appendix V-A) must be used between the soil layer and underdrain.

The underdrain should be sloped at 0.5 percent unless otherwise specified by the project engineer.

A minimum of 6 inches of granular filter material shall be placed over the top of the underdrain pipe. Wrapping with geotextile is not recommended.

A 6-inch rigid non-perforated observation pipe or other maintenance access shall be connected to the underdrain every 250 to 300 feet to provide a clean-out port, as well as an observation well to monitor dewatering rates.

Design Criteria

Geometry

The cell ponding area shall meet the following criteria:

- The maximum side slope shall be 3H:1V. Steeper backslopes may be allowed for bioretention swales in roadway projects with limited right-of-way width with County acceptance. This criterion does not apply to bioretention planters.
- Vertical walls are not permitted except in bioretention planters

- The bottom width shall be no less than 2 feet
- The minimum freeboard measured from the invert of the overflow pipe or earthen channel to facility overtopping elevation shall be 2 inches for drainage areas less than 1,000 square feet (and linear projects with continuous inflow to a roadside bioretention swale) and 6 inches for drainage areas 1,000 square feet or greater
- If berming is used to achieve the minimum top elevation needed to meet ponding depth and freeboard needs, maximum slope on berm shall be 2H:1V, and minimum top width of design berm shall be 1 foot.

Materials

Soils

Soils shall consist of 60 percent aggregate and 40 percent compost by volume. Minimum depth of treatment soil is 18 inches.

Aggregate

Aggregate shall be well-graded utility or screened sand, and shall meet the following criteria:

- Percent passing the #200 sieve shall be between 2 and 5 percent (between 2 and 4 percent is preferred).
- Aggregate shall meet the gradation shown in Table 2.5.

Table 2.5. Bioretention Soil Aggregate Gradation

Sieve Size	Percent Passing
3/8”	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

- Coefficient of Uniformity ($C_u = D_{60}/D_{10}$) shall be 6 or greater.
- Coefficient of Curve ($C_c = (D_{30})^2/D_{60} \times D_{10}$) shall be between 1 and 3.

Compost

Compost shall meet the following criteria:

- Material shall be in compliance with WAC chapter 173-350, section 220, and be made from Type 1, 2, or 3 feedstock.
- Compost shall meet the gradation shown in Table 2.6.

Table 2.6. Bioretention Soil Compost Gradation

Sieve Size	Percent Passing
2”	100
1”	99-100
5/8”	90-100
#4	40-90

- The pH for the compost shall be between 5.5 and 8.0 as documented by test method TMECC 04.11-A “1:5 Slurry pH” or equivalent.
- Carbon:nitrogen (C:N) ratio between 20:1 and 25:1 for most landscapes. For native woody plantings, a C:N ratio between 30:1 and 35:1 is preferred.
- Organic matter content shall be between 45 percent and 65 percent as determined by test method TMECC 05.07A “Loss-on-ignition organic matter method” or equivalent.
- Electrical conductivity shall not be greater than 6 millimhos per centimeter (mmhos/cm).
- Moisture content shall be between 35 and 50 percent.
- Compost shall have no viable weed seeds.

Underdrain Pipe

Underdrain pipe shall be per WSDOT Standard Specifications Section 9-05.2 for Perforated PVC Underdrain pipe, Perforated Corrugated Polyethylene Drainage Tubing Underdrain Pipe or Perforated Corrugated Polyethylene Underdrain Pipe.

Gravel Filter Material

Gravel blankets and filter fabrics buffer the under-drain system from sediment input and clogging. Gravel Filter Material for underdrains shall be Gravel Backfill for Drains per WSDOT Standard Specifications 9-03.12(4).

Filter Fabric

Filter fabric for lining the underdrain (separation between gravel filter and native soil) shall be a non-woven geotextile fabric meeting WSDOT Standard Specifications Section 9-33 requirements for a “Separation” geotextile. See also Appendix V-B for geotextile specifications.

Alternative combinations of gravel filter material, underdrain pipe and filter fabric may be proposed if evaluated by a geotechnical or civil engineer for compatibility and suitability for the application.

Plants

A minimum of three tree, three shrub, and three herbaceous groundcover species shall be incorporated into the bioretention facility design. This is to protect against facility failure due to disease and insect infestations of a single species or environmental conditions affecting a single species.

Plants shall conform to the standards of the current edition of *American Standard for Nursery Stock* as approved by the American Standards Institute, Inc. All plant grades shall be those established by said reference.

All plant materials should have normal, well-developed branches and vigorous root systems, and be free from physical defects, plant diseases, and insect pests.

Plant size: Bioretention areas provide excellent soil conditions and should have well-defined maintenance agreements. In this type of environment small plant material provides several advantages and is recommended. Specifically, small plant material requires less careful handling, less initial irrigation, experiences less transplant shock, is less expensive, adapts more quickly to a site, and transplants more successfully than larger material. Small trees or shrubs are generally supplied in pots of 3 gallons or less.

All plants shall be tagged for identification when delivered.

Native species of plants should be selected over non-native. Appendix V-E provides lists of plants, trees, and ground covers, including native species that are appropriate for different soil moisture and inundation frequency zones within bioretention facilities.

Mulch

When used mulch should be:

- Compost in the bottom of the facilities (compost is less likely to float and is a better source for organic materials) and shredded or chipped hardwood or softwood in surrounding areas

- Free of weed seeds, soil, roots and other material that is not bole or branch wood and bark
- A maximum of 2 to 3 inches thick (thicker applications can inhibit proper oxygen and carbon dioxide cycling between the soil and atmosphere).

Mulch should not be:

- Grass clippings
- Pure bark.

Flow Entrance

The design of flow entrance to a bioretention or rain garden facility will depend upon topography, flow velocities, flow volume, and site constraints. Vegetated buffer strips are the preferred entrance type because they slow incoming flows and provide initial settling of particulates.

Four primary types of flow entrances can be used for bioretention/rain gardens:

1. Dispersed, low velocity flow across a grass or landscape area: this is the preferred method of delivering flows to the facility and can provide initial settling of particulates
2. Dispersed flow across pavement or gravel and past wheel stops for parking areas
3. Drainage curb cuts for roadway, driveway or parking lot areas: curb cuts shall include a concrete chute below the gutter grade to prevent sod from building up and backing flows into the roadway. Rock or other erosion protection material shall be installed at the outlet of the concrete gutter chute to dissipate energy
4. Pipe flow entrance: piped entrances shall include rock or other erosion protection material in the facility entrance to dissipate energy and/or provide flow dispersion.

Woody plants should not be placed directly in the entrance flow path as they can restrict or concentrate flows and can be damaged by erosion around the root ball.

Minimum requirements associated with the flow entrance/presettling design include the following:

- If concentrated flows are entering the facility, engineered flow dissipation (e.g., rock pad or flow dispersion weir) must be incorporated.
- A minimum 1-inch grade change between the edge of a contributing impervious surface and the vegetated flow entrance is required.
- Until the upstream catchment area is thoroughly stabilized, flow diversion and erosion control measures must be installed to protect the bioretention area from sedimentation.
- Dispersed flow should not be concentrated for presettling purposes.

Cell Ponding Area

The ponding area provides surface storage for storm flows, particulate settling, and the first stages of pollutant treatment within the facility. Ponding depth and draw-down rate requirements are to provide surface storage, adequate infiltration capability, and soil moisture conditions that allow for a range of appropriate plant species.

Soils must be allowed to dry out periodically in order to:

1. Restore hydraulic capacity of system,
2. Maintain infiltration rates,
3. Maintain adequate soil oxygen levels for healthy soil biota and vegetation,
4. Provide proper soil conditions for biodegradation and retention of pollutants, and
5. Prevent conditions supportive of mosquito breeding.

Construction and Maintenance

Bioretention facilities and rain gardens rely on water movement through the surface soils as infiltration and interflow to underlying soils. Therefore, it is important to always consider the pathway of interflow and ensure that the pathway is maintained in an unobstructed and uncompacted state both during and after construction.

Bioretention facilities, as with all types of infiltration facilities, should generally not be used as temporary sediment traps during construction. If a bioretention facility is to be used as a sediment trap, do not excavate to final grade until after the upgradient drainage area has been stabilized. Remove any accumulation of silt before putting the facility into service.

Minimizing compaction of the base and sidewalls of the bioretention or rain garden area is critical. Excavation, soil placement, or soil amendment shall not be allowed during wet or saturated conditions. Excavation should be performed by machinery operating adjacent to the facility and no heavy equipment with narrow tracks, narrow tires, or large lugged, high pressure tires should be allowed on the bottom of the facility. If machinery must operate in the facility for excavation, light weight, low ground-contact pressure equipment should be used and the base shall be scarified at completion to refracture soil to a minimum of 12 inches.

On-site soil mixing or placement should not be performed if soil is saturated. The bioretention soil mixture should be placed and graded by excavators and/or backhoes operating adjacent to the facility. The soil mixture should be placed in horizontal layers not to exceed 12 inches per lift for the entire area of the bioretention facility.

The soil mixture will settle and proper compaction can be achieved by allowing time for natural compaction and settlement. To speed settling, each lift can be watered until saturated. Water for saturation should be applied by spraying or sprinkling.

Maintenance

Bioretention areas require annual plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities. In general, bioretention maintenance requirements are typical landscape care procedures. See Appendix V-C for maintenance checklists.

Site Design Elements

Setbacks

Bioretention facilities shall meet the setback requirements for infiltration facilities of Appendix V-E.

Landscaping (Planting Considerations)

Plant roots aid in the physical and chemical bonding of soil particles that is necessary to form stable aggregates, improve soil structure and increase infiltration capacity.

The primary and significant benefits of small trees, shrubs, and ground cover in bioretention areas during the wet season are the presence of root activity and contribution of organic matter that aids in the development of soil structure and infiltration capacity.

Planting of bioretention areas should be designed by a landscape architect or landscaper. Appendix V-E includes a detailed bioretention plant list adapted from *Low Impact Development: Technical Guidance Manual for Puget Sound* (PSAT 2005).

Primary design considerations in plant selection include:

- *Soil moisture conditions*: Plants should be tolerant of summer drought, ponding fluctuations, and saturated soil conditions for the lengths of time anticipated by facility design.

- *Expected pollutant loadings*: Plants should tolerate pollutants and loadings from the surrounding land uses.

- *Above and below ground infrastructure in and near the facility:* Plant size and wind firmness should be considered within the context of the surrounding infrastructure. Rooting depths should be selected to not damage underground utilities if present. Perforated pipe should be more than 5 feet from tree locations.

- *Adjacent plant communities and potential invasive species control.*

- *Site distances and setbacks for roadway applications.*

- *Visual buffering:* Plants can be used to buffer structures from roads, enhance privacy among residences, and provide an aesthetic amenity for the site.

- *Aesthetics:* Visually pleasing plant design adds value to the property and encourages community and homeowner acceptance. Homeowner education and participation in plant selection and design for residential projects should be encouraged to promote greater involvement in long-term care.

Signage and Fencing

Bioretention facilities (Rain Gardens) are stormwater management facilities and shall be identified as such with signage and fencing. Signs shall be installed identifying the facility and its purpose and not to disturb. Fencing should be considered to reduce public access through the facility, especially if located within a parking area or other area easily accessible to the public.

2.2.6 LID.09 Alternative Paving Surfaces

Alternative paving surfaces are designed to accommodate pedestrian, bicycle, and auto traffic while allowing infiltration and storage of stormwater. Alternative paving surfaces include:

- Porous asphalt pavement
- Porous concrete
- Grid or lattice rigid plastic or paving blocks where the holes are filled with soil, sand, or gravel
- Cast-in-place paver systems.

Alternative paving systems may be designed with an underdrain to collect stormwater or without an underdrain as an infiltration facility.

Applicability

Appropriate applications for alternative paving surfaces include parking overflow areas, parking stalls, low volume residential roads, alleys, driveways, sidewalks/pathways, patios, emergency access, and facility maintenance roads.

Permeable paving surfaces can provide some attenuation and uptake of stormwater runoff even on cemented till soils while still providing the structural integrity required for a roadway surface to support heavy truck loads.

Permeable paving surfaces can be designed with aggregate storage to function as an infiltration facility with relatively low subgrade infiltration rates. Since the contributing flow is only the incident rainfall the hydraulic loading rate of the infiltration area is low.

Limitations

Thurston County will not currently approve porous pavement surfaces on County-maintained roads.

Porous pavement is not intended to receive “run-on” stormwater from other areas.

Porous paving surfaces are not appropriate for roads subject to high sediment loadings (such as roads that are sanded for deicing purposes in the winter). Application of sand and other gritty substances can clog the pavement, impeding the infiltration of stormwater and resulting in hazardous ponded water conditions.

Because of water quality concerns related to stormwater with high concentrations of oils or other contaminants infiltrating through the surface and contaminating groundwater, porous pavement surfaces shall not be allowed with land uses that generate heavy loadings of these pollutants. These include, but are not limited to, gas stations, commercial fueling stations, autobody shops, automobile repair services, and automobile wash services.

Sidewalk designs incorporate scoring, or truncated domes, near the curb ramp to indicate an approaching traffic area for the blind. The rougher surface of permeable paving may obscure this transition. Therefore standard concrete with scoring or truncated domes with pavers should be used for curb ramps.

The aggregate within the cells of permeable pavers can settle or be displaced from vehicle use. As a result, paver installations for disabled parking spaces and walkways should use solid pavers or standard concrete or asphalt.

Alternative pavement surfaces are suitable for use in Type A through C soils and are not recommended for Type D soils. However, with adequate accommodation of potential runoff from the porous paving surface over Type D soils, the application can be beneficial for encouraging infiltration.

Hydrologic and Hydraulic Design Considerations

Porous paving surfaces differ greatly in infiltration capacity. Base materials of porous pavement systems can be designed to infiltrate vertically into outwash soils.

Where cemented till layers of soil exist under a parking lot, a porous pavement system can still be effective to attenuate peak flows. In small area applications, the subgrade of the parking lot can be built up with porous base material and graded to direct runoff through this material to a controlled outfall, such as bioretention areas.

Flow Credit/Modeling of Alternative Paving Surfaces

Porous pavement surfaces designed in accordance with this section for infiltration should be modeled as indicated in Table 2.4. Note that alternative paving surfaces should not be receiving “run on” from other surfaces. Alternative paving surfaces are highly effective at infiltrating runoff, even with relatively low infiltration rates because the BMP surface area is the same as the contributing surface area. Installing an underdrain is typically unnecessary and greatly reduces the flow control benefit of this BMP.

Table 2.4. Continuous Modeling Assumptions for Alternative Paving Surfaces

Variable	Assumption
Computational Time Step	5-minutes
Inflows to Facility	Model pavement area as impervious basin routed to a gravel-filled trench with infiltration to underlying soil. Additional areas draining to the pavement (surface flow and interflow), if any, are also routed to the gravel trench.
Precipitation Applied to Facility	No (applied to basin before routing to trench)
Evaporation Applied to Facility	Yes. While evaporation is applied to the impervious basin before routing to the trench, additional evaporation occurs when water is stored in the storage reservoir
Storage Reservoir Depth	Average maximum subsurface water ponding depth in the storage reservoir (average across the facility) before berm overtopping or overflow. Note: The maximum ponding depth in the storage reservoir shall be a minimum of 6 inches below the surface of pavement.
Storage Reservoir Porosity	Assume maximum 20 percent unless test is provided showing higher porosity for aggregate compacted and in place
Native Soil Design Infiltration Rate	Measured infiltration rate with correction factor applied (see Volume III)
Infiltration Across Wetted Surface Area	No (bottom area only)
Underdrain (optional)	If underdrain is placed at bottom extent of the storage reservoir, all water which enters the facility must be routed through the underdrain. If there is no liner or impermeable layer and the underdrain is elevated within the storage reservoir, water stored in the reservoir below the underdrain may be allowed to infiltrate.
Outlet Structure	Overflow elevation set at average maximum subsurface ponding depth. May be modeled as weir flow over riser edge or notch. Note that freeboard must be sufficient to allow water surface elevation to rise above the overflow elevation to provide head for discharge.

Design Criteria

Manufacturer’s recommendations on design, installation, and maintenance shall be followed for each application.

Drainage Conveyance

Design roads with adequate drainage conveyance facilities as if the road surface was impermeable.

Design drainage flow paths to safely move water away from the road prism and into the roadside drainage facility for roads with base courses that extend below the surrounding grade.

Runoff Treatment

The subgrade must have an infiltration rate of less than 2.4 inches per hour and a cation exchange capacity of 5 milliequivalents CEC/100 grams dry soil or greater to provide water quality treatment that satisfies Minimum Requirement #6 requirements. Runoff treatment does not apply to alternative paving surface facilities with an underdrain.

Geometry

Positive surface drainage shall be provided to eliminate risk of ponding on pavement surface (minimum surface slope of 1 percent).

- Unless approved in writing by the Administrator or designee maximum slopes for alternative paving surfaces are 5 percent (porous asphalt), 6 percent (porous concrete), 10 percent (interlocking pavers), and 5 to 6 percent (grid and lattice systems).

Materials

Figures 2.10 and 2.11 show examples of typical cross-sections of porous paving sections. They typically consist of a top layer (porous wearing course), an aggregate subbase, an optional leveling course and geo-textile fabric.

Porous Wearing Course

The wearing course or surface layer of the alternative paving surface may consist of permeable asphalt, permeable concrete, interlocking concrete pavers, or open-celled paving grid with vegetation or gravel. The wearing course must provide adequate porosity for stormwater infiltration.

Requirements for the wearing layer include the following:

- A minimum infiltration rate of 10 inches/hour is required though higher infiltration rates are desirable.

- For porous asphalt, products must have adequate voice space, commonly 12 to 20 percent.

- For porous concrete, products must have adequate void space, commonly 15 to 21 percent.

- For grid/lattice systems filled with gravel, sand or a soil of finer particles with or without grass, fill must be at least 2 inches. Fill shall be underlain with 6 inches or more of sand or gravel to provide an adequate base. Locate fill at or slightly below the top elevation of the grid/lattice structure. Modular grid openings must be at least 40 percent of the total surface area.

- For paving blocks, fill spaces between blocks with 6 inches of free draining sand or aggregate material. Provide a minimum of 12 inches of free draining surface area.

- For a vegetated open-celled paving grid, topsoil shall have a minimum 4 percent organic matter by dry weight.

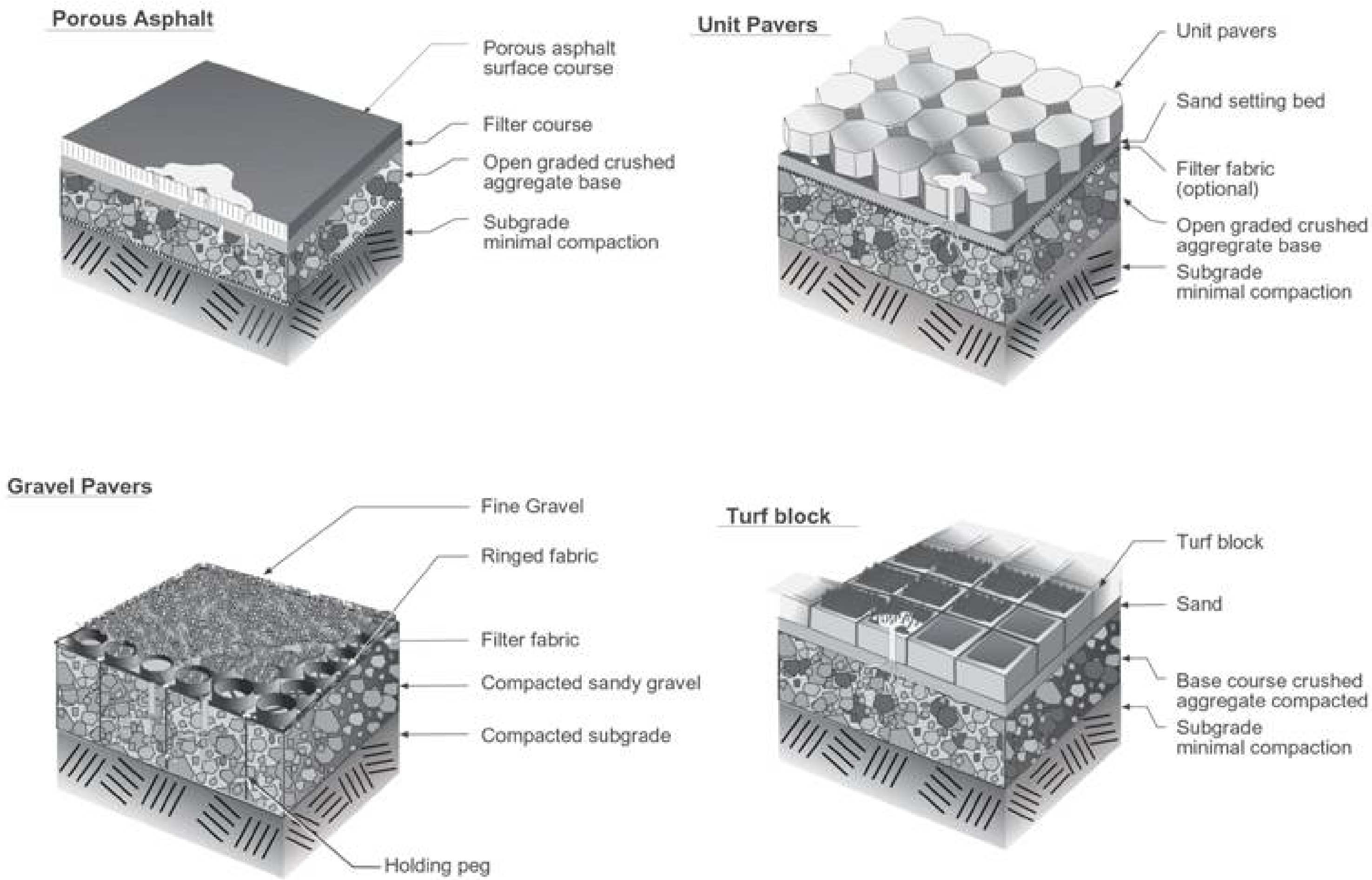


Figure 2.10. Alternative Paving Surfaces.

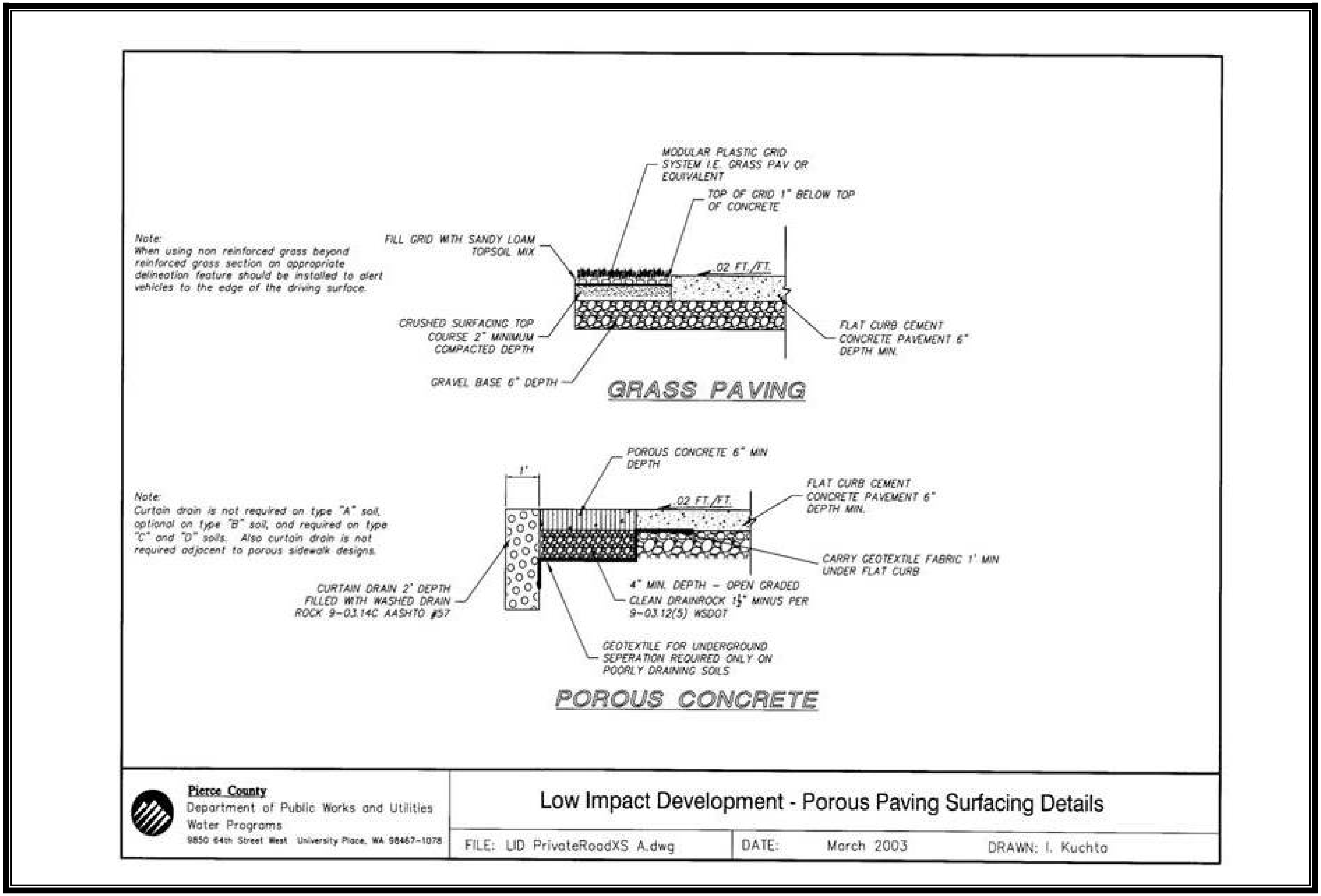


Figure 2.11. Porous Paving Surfacing Details.

Leveling Course

Depending upon the type of permeable pavement installation, a leveling course (also called a bedding or choker course) may be required (per manufacturer recommendations). A leveling course is often required for open-celled paving grids and interlocking concrete pavers. This course is a layer of aggregate that provides a more uniform surface for laying pavement or pavers and consists of crushed aggregate smaller in size than the underlying aggregate subbase. Course thickness will vary with permeable pavement type.

Aggregate Subbase

The aggregate subbase in an alternative paving surface serves as the support base and must be designed to support the expected loads and be free draining. The subbase shall meet the following criteria:

- Material must be free draining.
- A 4 to 6-inch depth of aggregate subbase is recommended under the porous wearing course and leveling course (if any)
- Aggregate subbase shall consist of larger rock at the bottom and smaller rock directly under the top surface (e.g., a gradient from 2 to 5/8 inch)
- Below are examples of possible base material specifications. See Chapter 6 of the “Low Impact Development: Technical Guidance Manual for Puget Sound” for more detailed information.
    - Driveway base material:
        - >4-inch layer of free-draining crushed rock, screened gravel, or washed sand.
        - <5 percent fines (material passing the #200 sieve) based on fraction passing the #4 sieve.
    - Roads and Parking Lots
        - Follow the standard material and quantities used for asphalt roads.

Geotextile Fabric

As part of the pavement section design, the designer should review the existing native soil or subbase characteristics and determine if a nonwoven geotextile is needed for separation of subbase from underlying soils.

Where necessary, the bottom and sides of the aggregate subbase should be contained by a nonwoven geotextile. The fabric should allow water to infiltrate but restrict movement of other particles into the gravel. See Appendix V-B for geotextile specifications.

Separation or Bottom Filter Layer (optional but recommended)

A layer of sand or crushed stone graded flat is recommended to promote infiltration across the surface, stabilize the base layer, protect the underlying soil from compaction, and serve as a transition between the base coarse and the underlying geotextile.

Subgrade

Compact the subgrade to the minimum necessary for structural stability. Use small static dual wheel mechanical rollers or plate vibration machines for compaction. Do not allow heavy compaction due to heavy equipment operation. The subgrade should not be subject to truck traffic.

Structural Design Considerations

Structural designs for porous surfaces shall be per the manufacturer's specifications. If any deviations are made from the manufacturer's recommendations or if the manufacturer's recommendations require engineering judgments, the design shall be stamped by a geotechnical engineer.

Porous systems that utilize pavers must be confined with a rigid edge system to prevent gradual movement of the paving stones.

ADA compliance should be requested from the manufacturer and is a consideration in determining where to use alternative paving surfaces.

Construction and Maintenance

Installation Criteria

Proper installation is key to the success of porous paving surfaces. As with any pavement system, porous pavement system requires careful preparation of the subgrade and base course to ensure success in terms of strength and permeability. The compressive strength of a permeable paver system relies mainly on the strength of the underlying soils, particularly when using modular or plastic units where the pavement itself lacks rigidity. Alternative paving surfaces shall be designed and installed according to manufacturer recommendations.

Install appropriate source and erosion control BMPs to prevent sediment transport from construction activities onto the base material or top course when the porous surface is applied prior to the completion of construction and stabilization of the entire site.

If possible, temporary roads should be used during construction and final construction of the base material, and porous surfacing completed after building construction is complete.

Acceptance Test

Test all permeable surfaces by throwing a bucket of water on the surface. If anything runs off the surface or puddles, additional testing is necessary prior to accepting the construction.

As directed by the Administrator or designee, test with a 6–inch ring Infiltrometer or sprinkle Infiltrometer. Wet the road surface continuously for 10 minutes. Test to determine compliance with the 10 inches per hour minimum infiltration rate.

For facilities designed to infiltrate, the bucket test shall be completed annually.

Test documentation shall be retained with maintenance records and submitted with the engineer's inspection report at project completion.

Maintenance Criteria

Appendix V-C has maintenance guidelines for alternative paving surfaces. Some general considerations are as follows:

- Clogging is the primary mechanism that degrades infiltration rates. However, as discussed above, the surface design can have a significant influence on clogging of void space.

- Studies have indicated that infiltration rates on moderately degraded porous asphalts and concrete can be partially restored by suctioning and sweeping of the surface. Highly degraded porous asphalts and concrete require high pressure washing with suction.

- Maintenance frequencies of suctioning and sweeping shall be specified in the Maintenance Plan.

- Porous pavement systems designed with pavers have advantages of ease of disassembly when repairs or utility work is necessary. However, it is important to note that the paver removal area should be no greater than the area that can be replaced at the end of the day. If an area of pavers is removed, leaving remaining edges unconfined, it is likely that loading in nearby areas will create movement of the remaining pavers thereby unraveling significantly more area than intended.

2.2.7 LID.10 Vegetated Roofs

Vegetated roofs are areas of living vegetation installed on top of buildings to provide flow control via detention, attenuation, and soil storage, and to control losses to interception, evaporation, and transpiration. Vegetated roofs are also known as ecoroofs, green roofs, and roof gardens. Vegetated roofs also provide habitat, enhance aesthetics, reduce temperature within urban centers, and last longer than traditional roofing materials (mainly due to lessened temperature fluctuation of roofing materials).

Vegetated roofs are categorized by their depth and the courses used in their construction. Deeper, or “intensive” roofs, have at least 8 inches of growth media and are planted with groundcovers, grasses, shrubs, and (sometimes) trees. Extensive vegetated roofs require regular landscape maintenance.

Shallower, or “extensive” roofs, have less than 8 inches of growth media and use drought-tolerant, low maintenance groundcovers.

Extensive systems are further classified as either “single-course” systems, consisting of a single media designed to be freely draining and support plant growth, and “multi-course” systems that include both a growth media layer and a separate, underlying drainage layer.

Applicability

Vegetated roofs are applicable in highly developed environments where other LID practices of forest retention or infiltration are not feasible. They are most appropriate for nearly flat roofs, those with a pitch of up to 2 percent. These are the easiest to install and generally provide the greatest stormwater storage capacity per inch of growth medium.

Limitations

Steeper slopes, such as those on single family residences, may result in reduced flow control performance and may trigger additional design requirements (e.g., underlying drainage layer and lateral support measures).

In addition, applications on slopes steeper than 15 percent (5H:1V) will not qualify for flow control credits.

Submittals and Approval

Vegetated roofs shall also require acceptance from the Thurston County Fire Marshal to demonstrate adequate ventilation or ability to ventilate in cases of a fire. Other building permit requirements should be investigated by the applicant.

Hydrologic and Hydraulic Design Considerations

Flow Credit for Vegetated Roofs

Extensive roofs with 3 to 8 inches of growing media can be represented as 50 percent till landscaped area and 50 percent impervious area in the stormwater hydrologic model.

Intensive roofs with soil/growing media depth of greater than 8 inches can be modeled as 50 percent till pasture and 50 percent impervious area.

Design Criteria

A vegetated roof consists of a system in which several materials are layered to achieve the desired vegetative cover and drainage characteristics (see Figure 2.12).

Materials

Design components vary depending on the vegetated roof type and site constraints, but typically include a waterproof membrane, a drain system, a drainage layer, a separation fabric, a growth medium (soil), and vegetation.

Waterproof Membrane

Waterproof membranes are made of various materials, including reinforced polyvinyl chloride (PVC), synthetic rubber (EPDM), thermoplastic polyolefins, high-density polyethylene (HDPE), modified asphalts (bitumens), and hypalon (CPSE). Some waterproofing materials come in sheets or rolls and some are available in liquid form. Each material has different strengths and functional characteristics.

Root Barrier

To discourage root damage to the waterproofing membrane, a physical root barrier may be required. The need for a root barrier depends primarily on the particular waterproof membrane selected. Some waterproofing membranes have root barrier capabilities intrinsic to the material. Modified asphalts usually require a root barrier, while EPDM and reinforced PVC typically do not. The manufacturer must be consulted to determine whether a root barrier is recommended for a particular product.

During installation, treatment to prevent root penetration should not be restricted to parts of the roof that will be covered with vegetation, as the roots will extend beyond the areas in which vegetation shows at the surface. Care should be taken to fully treat the areas at joints, borders, and seams.

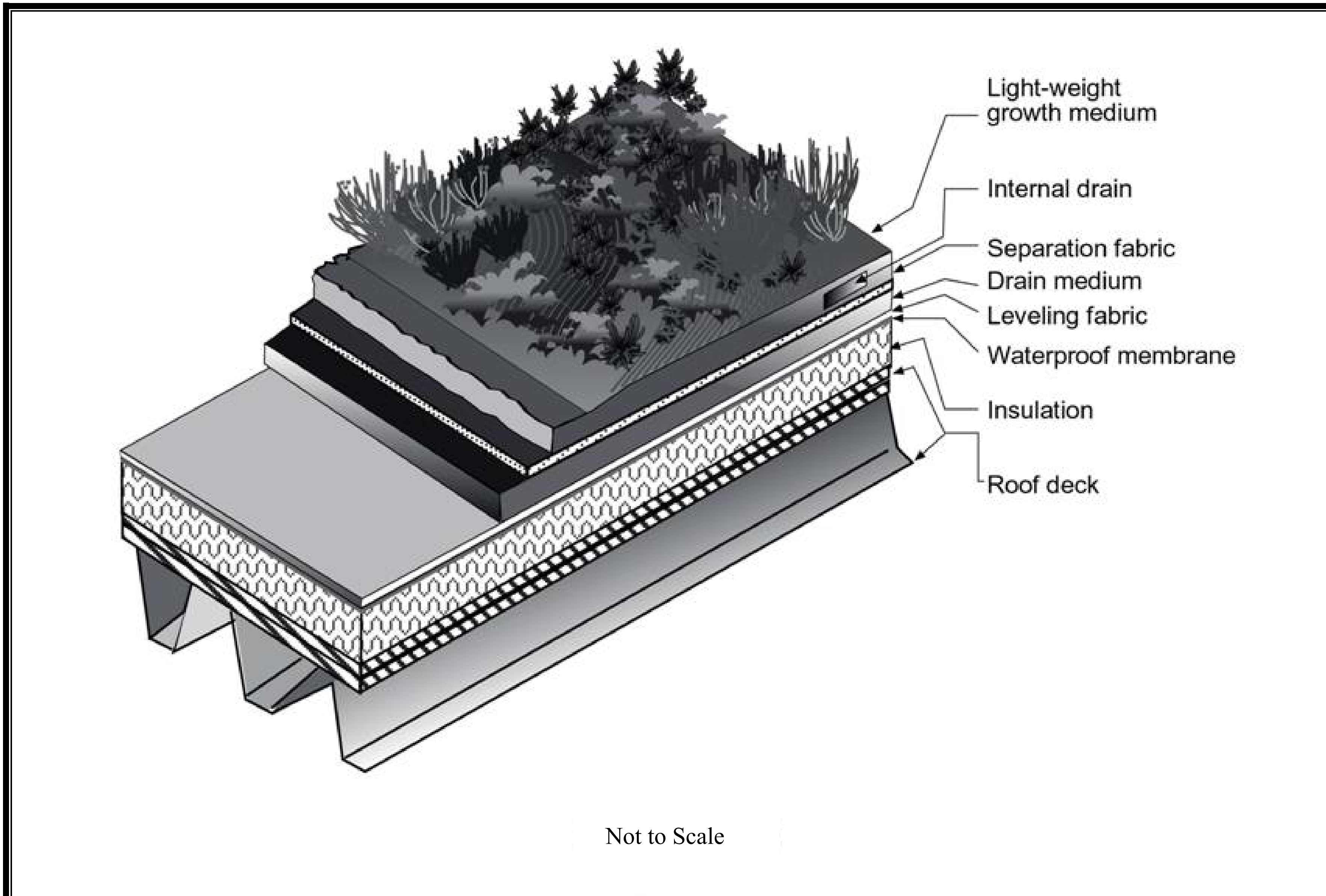


Figure 2.12. Vegetated Roof.

The root barrier shall not contain leachable water quality contaminants (e.g., herbicides, copper, and zinc), which have sometimes been used in the past to inhibit root growth. To demonstrate this, a material safety data sheet (MSDS) must be submitted.

Drainage Layer

For intensive and extensive multi-course vegetated roof systems, a drainage layer must underlie the growth medium. The drainage layer is a multipurpose layer designed to both provide void spaces to hold a portion of the water that passes through the growth medium, and to channel the water to the roof drain system.

The drainage layer can consist of a layer of aggregate or a manufactured mat or board that provides an open free-draining area. Many manufactured products include “egg carton”-shaped depressions that retain a portion of the water for eventual evapotranspiration. Some studies have shown that aggregate drainage layers may provide the better flow control.

For extensive single-course vegetated roofs larger than 1,000 square feet, hydraulic calculations shall be submitted showing that the transmissivity and permeability of the media are sufficient to convey the 25-year recurrence interval peak flow.

For aggregate drainage layers, the drainage media shall meet the following requirements:

- Minimum total pore volume of 25 percent by volume (per American Society for Testing and Materials [ASTM] E2399)
- Minimum saturated hydraulic conductivity of 0.3 centimeters per second, cm/s (per ASTM E2396-05)
- Maximum total organic matter of 1 percent by mass (per loss on ignition testing).

For optimal flow control, an aggregate drainage layer with a saturated hydraulic conductivity of less than 3.2 cm/s is recommended.

Separation Fabric

A nonwoven geotextile must be installed between the growth medium (soil) and the drainage layer to prevent fine soil and substrate components from being washed out of the growth medium into the drainage layer (note that this does not apply to single-course extensive vegetated roofs). The fabric must be pervious to allow water to percolate into the drainage layer.

If a manufactured drainage layer is used, the separation fabric is typically included.

The separation fabric shall be installed between the growth medium and the drainage layer and between the growth medium and all surrounding areas, roof edges, penetrations, and structures. The fabric also shall have average opening size sufficient to retain media.

Growth Medium

Vegetated roofs use a light-weight growth medium with adequate fertility and drainage capacity to support plants and allow infiltration and storage of water. Growth medium composition (fines content and water holding capacity) is the key to flow control performance.

The growth medium typically has a high ratio of mineral to organic material content and can be a mixture of various components including gravel, sand, compost, soil, or light weight aggregate material. Because of their excessive weight, particularly when wet, native soils are not acceptable substrates for vegetated roofs.

The growth medium must be a minimum of 4 inches deep, and shall have the following characteristics:

- Minimum total pore volume shall be 45 percent by volume for multi-course systems and 30 percent by volume for single-course systems (per ASTM E2399)
- Water capacity shall be no less than 25 percent for single-course systems, 35 percent for extensive (shallow) multi-course systems, and 45 percent for intensive (deep) multi-course systems (per ASTM E2399)
- Saturated hydraulic conductivity (permeability) should be between 0.01 and 0.85 cm/s for single-course systems and 0.002 and 0.02 cm/s for multi-course systems (per ASTM E2396-05)
- Minimum air content at maximum water capacity should be 5 percent by volume (per ASTM E2396-05), or 10 percent by volume (per FLL method)
- Maximum total maximum organic matter shall be 4 percent by mass for single-course systems, 6 percent by mass for extensive (shallow) multi-course systems, and 8 percent by mass for intensive (deep) multi-course systems (per loss on ignition testing).

Growth medium depth and characteristics must support growth for selected plant species.

Mulch, mat, or other measures to control erosion of growth media shall be maintained until 90 percent vegetation coverage is achieved.

Vegetation

Vegetation used on extensive vegetated roofs should be drought tolerant, self-sustaining, low maintenance, and perennial or self-sowing. Appropriate plants should also be able to withstand heat, cold, periodic inundation and high winds. Vegetation with these attributes typically includes succulents, grasses, herbs, and wildflowers that are adapted to harsh conditions.

Plants can be installed as vegetation mats, individual plugs, cuttings, or spread as seeds:

- *Vegetation mats* – vegetation mats are sod-like, pre-germinated mats that achieve immediate full plant coverage. They provide immediate erosion control, do not need mulch, provide the most rapid establishment for sedums, and minimize weed intrusion. They also need minimal maintenance during the establishment period and little ongoing watering and weeding.

- *Plugs or potted plants* – plugs or potted plants may provide more design flexibility than mats. However, they take longer to achieve full coverage, are more prone to erosion, need more watering during establishment, require mulching, and require more weeding. Birds sometimes pull out plugs, in which case netting may be needed until they are fully rooted.

- *Cuttings* – while cuttings may be used, they become established more slowly than mats and plugs and have a higher mortality rate.

- *Seeds* – seeds can be either hand broadcast or applied by hydroseeding. Seed plantings require more weeding, erosion control, and watering than mats and plugs.

In the long term, the generation of warm and cold air currents by rooftop heating and air-conditioning vents can cause frost and drought damage to plants. Exhaust gases such as sulfur dioxide or grease from chimneys and exhausts can result in direct damage to vegetation, depending on the species. Therefore, areas that are affected by warm air, variable air currents, and exhaust gasses need to be checked carefully to determine whether they are suitable areas for planting and to identify the type of vegetation that is best suited to the particular conditions. In addition, vegetation must be suitable for harsh (e.g., hot, cold, wet and windy) rooftop conditions.

An additional consideration is the effect of providing a vegetated roof habitat. Habitat may be enhanced by using diverse planting and including some larger plants. Some projects sites may not want to encourage wildlife (e.g., birds near air fields).

Plant spacing and plant size shall be designed by a certified landscape architect. Turf grasses are not recommended for vegetated roof application because of the dangers of longer grasses growth dying, drying out, and becoming a fire danger. Plants must not require fertilizer, pesticides, or herbicides after 2-year establishment period. Plans shall specify that vegetation coverage of selected plants shall achieve 90 percent coverage within 2 years or additional plantings shall be provided until this coverage requirement is met.

Drain System

Vegetated roof drainage facilities must be capable of collecting subsurface and surface drainage and conveying it safely to an approved discharge point. To facilitate subsurface drainage, interceptor drains are often installed at a 15 to 25 foot spacing to prevent excessive moisture build up in the media and convey water to the roof drain.

The roof outlets at vegetated roof sites must be protected from the invasion of plant growth and the entry of loose gravel, and they must be constructed and located so that they are permanently accessible.

Overflow grates tied into the roof downspouts shall be provided set at the height of the soil.

Structural Design Considerations

Extensive vegetated roofs have the lowest weight and are the most suitable for placement on existing structures.

Vegetated roofs must not be subject to any use that will significantly compact the growth medium. Unless designed for foot traffic, vegetated roof areas that are accessible to the public shall be protected (e.g., signs, railing, and fencing).

Construction and Maintenance

Irrigation Plan

Provisions must be made for supplemental irrigation during the first two dry seasons after installation to improve plant survival. Subsurface irrigation methods are preferred. If surface irrigation is the only method available, drip irrigation should be used to deliver water to the base of the plant. At a minimum, a water tap should be available on the roof for manual watering.

A permanent irrigation system using potable water may be used, but an alternative means of irrigation, such as air conditioning condensate or another readily available non-potable source should be considered to maximize efficient use of resources. Any non-potable sources must be analyzed to ensure that they do not contain chemicals that might harm or kill the vegetation. Any permanent irrigation system that relies on potable water shall be designed to apply no more than 0.2 inches of water every 14 days from June through September, after the 2-year establishment period. It is recommended that permanent irrigation systems have automatic controls, including a rain shutoff sensor.

Sufficient irrigation shall be provided to achieve and maintain 90 percent plant coverage after 2 years following installation.

Maintenance Criteria

Vegetated roofs are designed to need very little maintenance. They should also have a longer lifespan than traditional roofs because of the protective nature of the soil structure. Inspections still should be performed regularly to identify any leakage of the membrane system or blockages of the overflow system. A maintenance checklist is included in Appendix V-C and shall be included in the Maintenance Plan for the project.

2.2.8 LID.11 Full Dispersion

Purpose and Definition

This BMP allows for “fully dispersing” runoff from impervious surfaces and cleared areas of development sites that preserve the equivalent of at least 65 percent of the site (or a threshold discharge area on the site) in a forest or native condition.

Fully dispersed runoff from impervious surfaces means that the area is “ineffective.” Ineffective impervious areas are included in the Total Impervious Area thresholds when determining applicable Minimum Requirements, but are not included in the thresholds specific to the applicability of Minimum Requirement #6 (Runoff Treatment), and Minimum Requirement #7 (Flow Control).

Applicability

Full dispersion differs from other LID BMPs described previously in that if minimum native area preservation is adhered to, the limitations on how impervious surfaces are modeled and how concentrated flow can be dispersed are less restrictive. Additionally, if the minimum native area preservation requirements are met, on-site landscape area soils are not required to meet the minimum requirements of BMP LID.02 (Post-Construction Soil Quality and Depth) except as noted in the table below for landscape area equaling or exceeding 50 percent of the site on till soils.

Full dispersion would be most applicable to developments that desire to or can retain large portions of the site in native conditions such as for critical area buffers, or that concentrate development in a smaller area of a larger site to obtain some benefit from zoning codes (PRRD, Cluster Development, PRD, etc.).

Full dispersion can be used as long as the developed areas draining to the native vegetation do not have effective impervious surfaces that exceed 10 percent of the entire site.

Rural single family residential developments should use this BMP wherever possible to minimize effective impervious surface to less than 10 percent of the development site.

Other types of development that retain 65 percent of the site (or a threshold discharge area on the site) in a forested or native condition may also use this BMP to avoid triggering the flow control facility requirement.

Full Dispersion for All or Part of the Development Site

Developments that cannot preserve 65 percent or more of the site in a forested or native condition may disperse runoff into a forested or native area in accordance with the elements of this BMP if:

- The effective impervious surface of the area draining into the native vegetation area is <10 percent; and
- The development maintains ratios proportional to the 65 percent forested or native condition and 10 percent effective impervious surface area. Examples of such ratios are:

% Native Vegetation Preserved (min. allowed)	% Effective Impervious (max allowed)	% Lawn/Landscape (max allowed)
65	10	35
60	9	40
55	8.5	45
50	8	50*
45	7	55*
40	6	60*
35	5.5	65*

* Where lawn/landscape areas are established on till soils, and exceed 50 percent of the total site, they shall be developed using BMP LID.02 (Post-Construction Soil Quality and Depth).

Within the context of full dispersion for all or part of the development site the only impervious surfaces that are ineffective are those that are routed into an appropriately sized dry well or into an infiltration basin that meets the flow control standard and does not overflow into the forested or native vegetation area.

Limitations

Runoff must be dispersed into native areas per the guidelines and limitations indicated in this BMP.

Additional impervious areas are allowed that exceed the 10 percent threshold, but should not drain to the native vegetation area and are subject to the thresholds, and treatment and flow control requirements of the stormwater manual.

Native vegetation areas must be protected from future development. Protection must be provided through legal documents on record with the local government. Examples of adequate documentation include a conservation easement, conservation parcel, and deed restriction.

All trees within the preserved area at the time of permit application shall be retained, aside from approved timber harvest activities and the removal of dangerous or diseased trees. Removal of dangerous or diseased trees will require acceptance of Thurston County and may require an arborist to make a written assessment of the trees condition.

The preserved area may be used for passive recreation and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar activities that do not require permanent structures, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the preserved area.

Design Guidelines

Roof Downspouts

- Roof surfaces that comply with the downspout infiltration requirements of BMP LID.04 are considered to be "fully dispersed" (i.e., 0 percent effective imperviousness).
- All other roof surfaces are considered to be "fully dispersed" only if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent effective impervious surface, and if they comply with the downspout dispersion requirements of BMP LID.05, and have vegetated flow paths through native vegetation exceeding 100 feet.

Driveway Dispersion

- Driveway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent effective impervious surface, and if they comply with the dispersion BMPs – BMP LID.06 and BMP LID.07 — and have flow paths through native vegetation exceeding 100 feet.
- This also holds true for any driveway surfaces that comply with the roadway dispersion BMPs described below.

Roadway Dispersion BMPs

Roadway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65 percent forested (or native vegetative cover) and less than 10 percent effective impervious surface, and if they comply with the following dispersion requirements:

- Roadway runoff dispersion is allowed only on rural neighborhood collectors and local access streets. To the extent feasible, disperse driveways to the same standards as roadways to ensure adequate water quality protection of downstream resources.

- Design the road section to minimize collection and concentration of roadway runoff. Use sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) wherever possible to avoid concentration.

- When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge point from a ditch for the 100-year runoff event (using approved continuous simulation model).

- Where flows at a particular ditch discharge point were already concentrated under existing site conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.

- Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use rock pads or dispersion trenches to disperse flows. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only dispersion trenches to disperse flows.

- Dispersion trenches shall be designed to accept storm flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flow path, and shall be minimum 2’ x 2’ in section, 50 feet in length, filled with 3/4-inch to 1-1/2-inch washed rock, and provided with a level notched anchor plate flow spreader (see Figure A-12 in Appendix V-A). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to four trenches. Dispersion trenches shall have a minimum spacing of 50 feet.

- After being dispersed with rock pads or trenches, flows from ditch discharge points must traverse a minimum of 100 feet of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment.

- Flow paths from adjacent discharge points must not intersect within the 100-foot flow path lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flow path shall not exceed 15 percent slope, and shall be located within designated open space.

- Ditch discharge points shall be located a minimum of 100 feet upgradient of slopes steeper than 40 percent, wetlands, and streams.

- Where the County determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

Cleared Area Dispersion BMPs

The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is considered to be "fully dispersed" if it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:

- The contributing flow path of cleared area being dispersed must be no more than 150 feet.

- Slopes within the 25-foot minimum flow path through native vegetation shall be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 25-foot flow path length must be increased 1.5 feet for each percent increase in slope above 8 percent.

2.2.9 LID.12 Rural Road Natural Dispersion

Natural dispersion is related to sheet flow dispersion (BMP LID.06) and channelized dispersion (BMP LID.07), but only applies to linear projects such as roads, bicycle paths, etc. in rural areas that meet certain criteria. This BMP is derived from the WSDOT's *Highway Runoff Manual* and is principally for use outside of the NPDES Phase II permit boundary and Urban Growth Areas of Thurston County.

Rural road natural dispersion meets Minimum Requirement #5 (On-site Stormwater Management), basic and enhanced treatment targets of Minimum Requirement #6 (Runoff Treatment), and Minimum Requirement #7 (Flow Control).

Introduction

Natural dispersion uses existing vegetation, soils, and topography to effectively provide flow control and runoff treatment. In this way it differs from BMP LID.06 and LID.07 which allow dispersion to native vegetation areas for treatment, but may still require flow control facilities further downstream.

Natural dispersion generally requires little or no construction activity. Site selection is important to the success of this BMP. The pollutant-removal processes include infiltration into the existing soils and through vegetation root zones; evaporation; and uptake and transpiration by the vegetation.

The key to natural dispersion is that flows from the impervious area enter the natural dispersion area as sheet flow. Because stormwater enters the dispersion area as sheet flow, it only needs to traverse a narrow band of contiguous vegetation for effective attenuation and treatment. The goal is to have the flows dispersed into the surrounding landscape such that there is a low probability any surface runoff will reach a flowing body of water.

There are two types of natural dispersion: sheet flow dispersion and channelized dispersion. Sheet flow natural dispersion takes advantage of unconcentrated roadside discharge, while channelized natural dispersion requires dispersal BMPs to create sheet flow conditions.

Using natural dispersion on projects will result in benefits when determining applicable minimum requirements and thresholds. New impervious surfaces that drain to dispersion areas should be accounted for when determining the project's total new impervious surface area, but the area should be counted as noneffective impervious surface (and noneffective PGIS). When modeling the hydrology of the project site and threshold discharge area, the project engineer should treat natural dispersion areas and their tributary drainage areas as disconnected from the project site because they do not contribute flow to other flow control or runoff treatment BMPs.

Applicability

- Only allowed for roadway and linear projects such as bicycle paths, trails, utility projects in the rural areas of Thurston County (outside UGA's and NPDES Phase II permit boundary). Examples include large lot or short plat access roads through large lot subdivisions and short plats, County or private road widening projects and new construction.

- Existing topography, soils and vegetation must be conducive to dispersion (see Design Criteria below).

- Natural dispersion helps maintain the temperature norms of stormwater because it promotes infiltration, evaporation, and transpiration and should not have a surface discharge to a lake or stream.

Limitations

- The effectiveness of natural dispersion relies on maintaining sheet flow to the dispersion area, which maximizes soil and vegetation contact and prevents short-circuiting due to channelized flow. If sheet flow cannot be maintained, natural dispersion will not be effective.

- Natural dispersion areas must be protected from future development. For public projects, purchase of additional right-of-way or easements may be required to satisfy the criteria for natural dispersion areas. For private projects, dedicated tracts or easements are required to protect natural dispersion areas.

- Natural dispersion areas initially may cost as much as other constructed BMPs because rights-of-way or easements often need to be purchased, but long-term maintenance costs are lower. These natural areas will also contribute to the preservation of native habitat and provide visual buffering of the roadway.

- Floodplains are not suitable areas for natural dispersion.

The following area additional limitations for site where runoff is channelized upstream of the dispersion area:

- The channelized flow must be redispersed before entering the natural dispersion area. Flow dispersal trenches (see Section 3.2 of Volume III) must be used to create sheet flow conditions.

- Energy dissipaters in conjunction with flow dispersal trench may be needed to prevent high velocities through the natural dispersion areas.
- Channelized flows are limited to on-site flows. Parallel conveyance systems may be needed to separate off-site flows.

Submittals and Approvals

Include in the submittals required in Volume I the following:

- Calculations demonstrating the flows for the 100-year storm meet the criteria of this BMP
- Documentation of easements, tracts or other protective mechanisms for the dispersion area
- Identify the location of signage and fencing required to protect the dispersion area from future disturbance/development
- Details of dispersion pads, energy dissipators, level spreaders, etc. necessary to construction the project
- Identify on a site plan the contributing areas, point of dispersion and dispersion areas
- Geotechnical information documenting the underlying soils type and infiltration rate for the dispersion area
- Show the location of wells, drainfields, steep slopes and how the design meets the setback criteria for this BMP
- Include in the Soils Management Plan prepared per BMP LID.02 the location of the dispersion area and any planting or soils enhancement required.

Hydrologic and Hydraulic Design Considerations

Those pollution and non-pollution generating impervious surfaces that are dispersed according to this BMP are considered non-effective impervious surface. They are counted in the total impervious area when applying minimum requirements (Volume I, Section 2.3), but not towards the individual thresholds of Minimum Requirement #6 (Runoff Treatment) or Minimum Requirement #7 (Flow Control).

The size of the natural dispersion area depends on the flow contributing area and the predicted rates of water loss through the dispersion system.

The designer should ensure the dispersion area is sufficient to dispose the runoff through infiltration, evaporation, transpiration, and soil absorption.

Design Criteria

Sheet Flow

Sheet flow dispersion criteria for natural dispersion areas are as follows:

- The sheet flow path leading to the natural dispersion area shall not be longer than 150 feet. The sheet flow path is measured in the direction of flow and generally represents the width of the pavement area.
- Pervious shoulders and side slopes are not counted in determining the sheet flow path.
- The longitudinal length of the dispersion area should be equivalent to the longitudinal length of roadway that is contributing sheet flow.
- The longitudinal pavement slope (i.e., centerline grade) contributing flow to a dispersion area shall be less than 5 percent. The lateral pavement slope (i.e., crown or superelevation) shall be less than 8 percent.
- Roadway side slopes leading to natural dispersion areas should be 25 percent (4H:1V) or flatter. Slopes steeper than 25 percent are allowed if the existing side slopes are well vegetated and show no signs of erosion problems.
- For any existing slope that will lead to a natural dispersion area, if evidence of channelized flow (rills or gullies) is present, a flow spreading device should be used before those flows are allowed to enter the dispersion area.

Sheet flow dispersion areas are sized based on soil characteristics of the dispersion area as follows:

For sheet flow dispersion on all Type A and some Type B soils (depending on saturated hydraulic conductivity rates):

- For short-term infiltration rates (as determined in Volume III) of 4 inches per hour or greater and for the first 20 feet (along the sheet flow path) of impervious surface that drains to the dispersion area, there must be 10 lateral feet of dispersion area width. For each additional foot of impervious surface (along the sheet flow path) that drains to the dispersion area, 0.25 lateral feet of dispersion area shall be provided.

- For dispersion areas that receive sheet flow from only disturbed pervious areas (bare soil and non-native landscaping), for every 6 feet (along the sheet flow path) of disturbed pervious area, 1 lateral foot width of dispersion area is required.

The following criteria are specific to sheet flow dispersion on all Type C and D soils and some Type B soils with short-term infiltration rates of 4 inches per hour or less:

- For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.

- The dispersion area shall have a minimum width of native vegetation of 100 feet (measured in the direction of the flow path).

Figure 2.13 illustrates the configuration of a typical natural dispersion area relative to the roadway.

Channelized Flow

Channelized flow dispersion criteria for Type A, B, C, and D soils are as follows:

- Concentrated runoff from the roadway and adjacent upstream areas (such as in a ditch or cut slope) must be incrementally discharged from the conveyance system (such as a ditch, gutter, or storm sewer) via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows must not exceed 0.5 cubic feet per second (cfs) at any single discharge point from the conveyance system for the 100-year runoff event (determined by an approved continuous flow model). Where flows at a particular discharge point are already concentrated under existing site conditions (for example, in a natural channel that cross the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.

- Discharge points with up to 0.2 cfs discharge for the peak 100-year flow may use rock pads or dispersion trenches to disperse flows. Discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow must use only dispersion trenches to disperse flows.

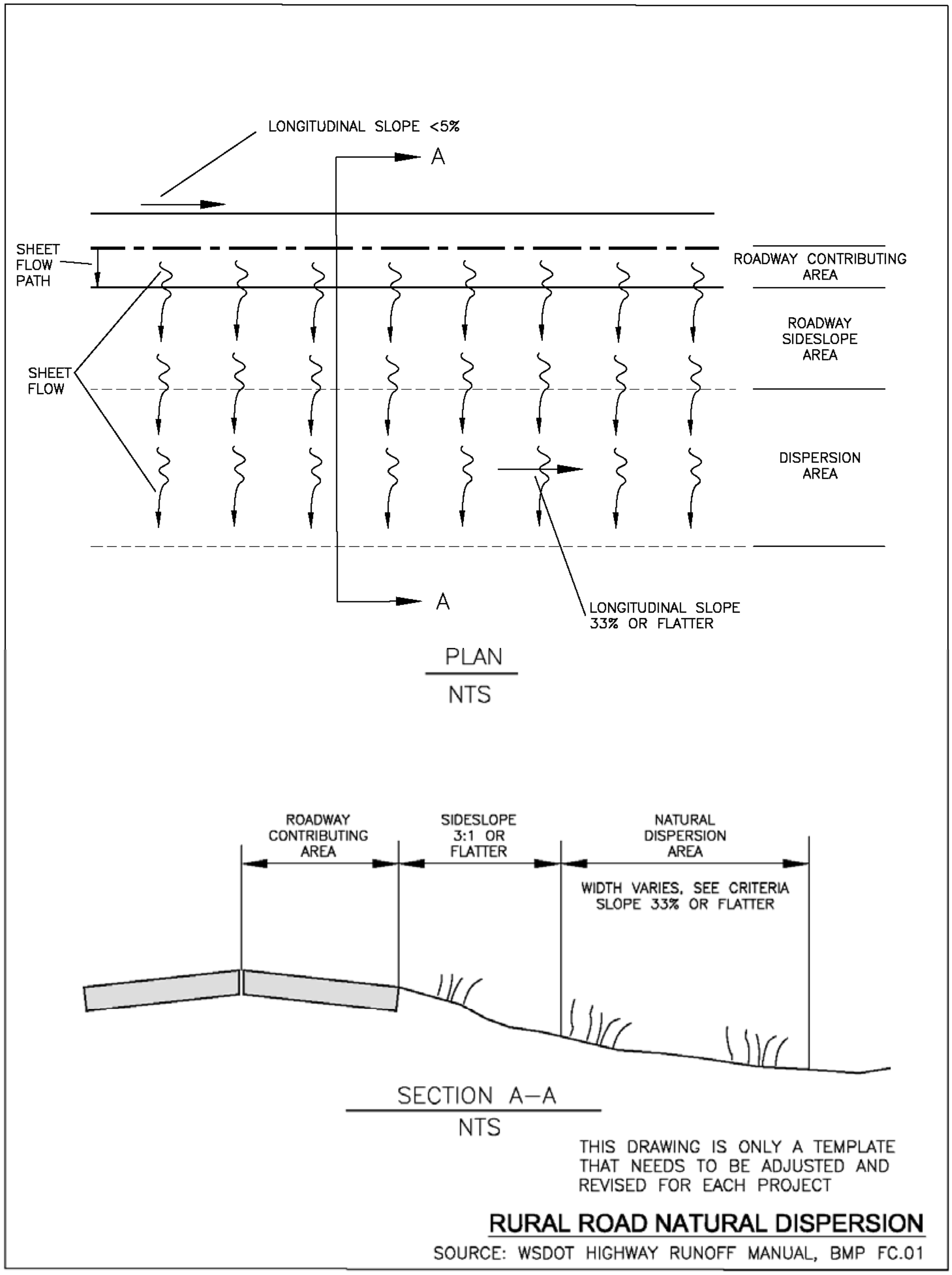


Figure 2.13. Natural Dispersion.

- Dispersion trenches must be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end; aligned perpendicular to the flow path; a minimum of 2' x 2' in section; 50 feet in length; filled with 3/4 to 1-1/2 inch washed rock; and provided with a level notched grade board (see Figure 3.4, Flow Dispersal Trench, in Volume III). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between four trenches (maximum). Dispersion trenches must have a minimum spacing of 50 feet.

- After being dispersed with rock pads or trenches, flows from discharge points must traverse the required flow path length of the dispersion area before entering an existing on-site channel carrying existing concentrated flows away from the roadway alignment.

  Note: to provide the required flow path length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed.

- Flow paths from adjacent discharge points must not intersection within the required flow path lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point.

- Ditch discharge points must be located a minimum of 100 feet upgradient of slopes steeper than 40 percent within a vertical change of at least 10 feet, wetlands, and streams.

- Where the County determines that there is a potential for significant adverse impacts downstream (such as erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

The following criterion is specific to channelized flow dispersion on all Type A and some Type B soils, depending on infiltration rates.

- For short-term infiltration rates (as determined in Volume III) of 4 inches per hour or greater, the dispersion area should be at least 50 percent of the tributary drainage area.

The following criteria are specific to channelized dispersion on all Type C and D soils and on Type B soils with short-term infiltration rates less than 4 inches per hour:

- For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.

- The dispersion area shall have a minimum width of native vegetation of 100 feet, measured in the direction of the flow path.

Pipe or Ditch Conveyance System

Flows collected in a pipe or ditch conveyance system require energy dissipation and dispersal at the end of the conveyance system before entering the dispersion area. For flow dispersal and energy dissipation BMPs and techniques, see Section 3.8 of Volume III.

Site Design Elements

The key to natural dispersion is having vegetative land cover with a good established root zone where the roots, organic matter, and soil macroorganisms provide macropores to reduce surface compaction and prevent soil pore sealing. The vegetative cover also provides filtration and maintains sheet flow, reducing the chance for erosion. The following areas are considered appropriate candidates for natural dispersion because they are likely to retain these vegetative conditions over the long term:

- County right-of-way (for County projects only)
- Protected natural areas (critical area buffers, green belts, etc.)
- Dedicated tracts in plats for native vegetation protection
- Agricultural areas
- Parks and nature areas
- Commercial or government-owned forest lands
- Rural areas with zoned densities of less than one dwelling unit per 5 acres.

While these are generally appropriate areas for natural dispersion, the dispersion area shall still be protected from future development by an easement or dedicated tract. **Note:** Though natural dispersion areas should be adjacent to the project site, they do not have to be immediately adjacent to the length of the roadway.

Natural dispersion area shall have the following attributes:

- Be well vegetated with established root zones
- Have an average longitudinal slopes of 6H:1V or flatter

- Have an average lateral slope of 6H:1V or flatter for both the roadway side slopes and natural area to be part of the natural dispersion area

- Have infiltrative soil properties that are verified by a soils professional per Volume III methods.

Natural dispersion areas that have impervious areas (for example, abandoned roads with compacted subgrades) within them shall have those areas tilled and restored using the soil amendments and plantings per BMP LID.01 (Restoring Natural Vegetation).

Natural dispersion areas that are within a landslide hazard area must be evaluated by a geotechnical engineer or qualified geologist.

Natural dispersion areas shall have a separation of at least2 feet between the existing ground elevation and the average annual maximum groundwater elevation. This separation depth requirement applies to the entire limits of the dispersion area. There should be no discernible continuous surface flow paths through the dispersion area.

Intent: Natural dispersion areas are not likely to have a uniform slope across their entire area. As a result, there are ponding areas and uneven terrain. Minor channelization of flow within the dispersion area is expected. However, a continuous flow path through the entire dispersion area disqualifies its use as a BMP because channelized flow promotes erosion of the channel that carries the flow and greatly reduces the potential for effective pollutant removal and peak flow attenuation.

When selecting natural dispersion areas, determine whether there are groundwater management plans for the area and contact the local water purveyors to determine whether the project lies within a designated wellhead protection area or groundwater protection zone, septic drain fields, or aquifer recharge area. There may be additional restrictions within these areas.

Setback Requirements

- Natural dispersion areas can extend beyond the right-of-way provided that documentation ensures (via easements or dedicated tracts) the dispersion area is not developed in the future. Occasionally for public roadway projects, limited right-of-way prevents the securing of the required easements on adjacent properties and limits the ability to construct flow control facilities. In this particular case, the dispersion area can be considered protected if the adjacent land is zoned agricultural, forestry, or rural residential (5-acre parcels or greater). An attempt to obtain a drainage easement for this circumstance should still be made.

- Natural dispersion areas shall be setback at least 100 feet from drinking water wells and springs used for public drinking water supplies. Natural dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones for a public water system must comply with the Washington State Department of Health (DOH) requirements.

- Natural dispersion areas shall be setback at least 100 feet from septic drainfields. The 100-foot setback is in addition to the required dispersion area. For example if there is a 100-foot width dispersion area, there would be an additional 100-foot setback making a total of 200 feet from the point of discharge of water to the dispersion area to the drainfield area. If the applicant can demonstrate that the dispersion flow path will not intercept the drainfield, this setback requirement may be relaxed.

- If the project significantly increases flows to off-site properties, a drainage easement may be required or additional right-of-way purchased.

Signage

- The limits of natural dispersion area shall be marked as a stormwater management facility and also shall be physically marked in the field during and after construction. Signage ensures the natural dispersion area is protected from construction activity disturbance and is adequately protected by measures shown in the temporary erosion and sedimentation control (TESC) plan.

- Signage helps ensure the natural dispersion area is not cleared or disturbed after the construction project.

- Signage shall be posted at a minimum on all four sides of the dispersion area and at intervals not exceeding 75 feet.

- See Appendix V-E for sign specifications.

Construction Considerations

- For installation of dispersal BMPs and conveyance systems near dispersion areas, the area that needs to be cleared or grubbed should be minimized. Maintaining plant root systems is important for dispersion areas.

- The area around dispersion areas should not be compacted.

- To the maximum extent practicable, low-ground-pressure vehicles and equipment should be used during construction.

Maintenance

- Maintenance of natural dispersion areas includes maintaining natural vegetation or restoring natural vegetation disturbed after construction.
- Signage and fencing shall be inspected and restored /replaced as required.
- Ensure that sheet flow paths are maintained to the dispersion areas, perform hand maintenance to ensure sheet flow.
- Maintain energy dissipators and level spreaders. Cleanout any structures associated with these devices and inspect spreaders to ensure they are functioning correctly. Remove buildup of soil/debris over the surface of level spreader as required to maintain its function.

2.2.10 LID.13 Rural Road Engineered Dispersion

Engineered dispersion is related to Sheet Flow Dispersion (BMP LID.06) and Concentrated Flow Dispersion (BMP LID.07) but only applies to linear projects such as roads, bicycle paths, etc. in rural areas that meet certain criteria. This BMP is derived from the WSDOT's Highway Runoff Manual and is principally for use outside of the NPDES Phase II Permit boundary and Urban Growth Areas of Thurston County.

Engineered dispersion is similar to natural dispersion (BMP LID.13). The distinction between these BMPs is that natural dispersion can take advantage of an existing vegetated area for dispersion, while this dispersion area must be at least partially constructed. This BMP can be used for impervious surfaces that are graded to drain via sheet flow or are graded to collect and convey stormwater to engineered dispersion areas after going through a flow spreading or energy dissipater device. Engineered dispersion uses the existing vegetation or landscaped areas, existing soils or engineered compost-amended soils, and topography to effectively provide flow control and runoff treatment. This type of dispersion may require major or minor construction activity depending on the existing site conditions. Site selection is very important to the success of this BMP. The pollutant-removal processes include infiltration to the existing or engineered soils and through vegetation root zones; evaporation; and uptake and transpiration by the existing vegetation or landscaped areas.

The key to effective engineered dispersion is that flows from the impervious area enter the dispersion area as sheet flow. Because stormwater enters as sheet flows to the dispersion area, it need only traverse a band of contiguous vegetation and compost-amended soils for effective attenuation and treatment. Absorption capacity can be gained by using compost-amended soils to disperse and absorb contributing flows to the dispersion area. The goal is to have the flows dispersed into the surrounding landscape such that there is a low probability that surface runoff will reach a flowing body of water.

Rural road engineered dispersion meets Minimum Requirement #5 (On-site Stormwater Management), basic and enhanced treatment targets of Minimum Requirement #6 (Runoff Treatment), and Minimum Requirement #7 (Flow Control).

Applicability

- Engineered dispersion is ideal for roadway and other linear projects that collect and convey stormwater to discrete discharge points along the project.

- Engineered dispersion maintains temperature norms of stormwater because it promotes infiltration, evaporation, and transpiration and should not have a surface discharge to a lake or stream.

Limitations

- The effectiveness of engineered dispersion relies on maintaining sheet flow to the dispersion area, which maximizes soil and vegetation contact and prevents short-circuiting due to channelized flow. If sheet flow cannot be maintained, engineered dispersion will not be effective.

- Dispersion areas must be protected from future development. For Public projects, purchase of additional right-of-way or easements may be required. For private projects, dedicated tracts or easements are required to protect engineered dispersion areas.

- Engineered dispersion areas may cost as much as other BMPs because right of way or easements often need to be purchased and compost-amended soils may need to be added. But long-term maintenance costs are lower.

- Floodplains are not suitable areas for engineered dispersion.

Submittals and Approvals

Include in the submittals required in Volume I the following:

- Calculations demonstrating the flows for the 100-year storm meet the criteria of this BMP

- Documentation of easements, tracts or other protective mechanisms for the dispersion area.

- Identify the location of signage and fencing required to protect the dispersion area from future disturbance/development

- Details of dispersion pads, energy dissipators, level spreaders, etc. necessary to construction the project

- Identify on a site plan the contributing areas, point of dispersion and dispersion areas

- Geotechnical information documenting the underlying soils type and infiltration rate for the dispersion area

- Show the location of wells, drainfields, steep slopes and how the design meets the setback criteria for this BMP

- Show areas of engineered dispersion on the Soil Management Plan required as part of BMP LID.02. Include specifications for the soil mix and a planting plan.

Hydrologic and Hydraulic Design Considerations

The required size of the engineered dispersion area depends on the area contributing flow and the predicted rates of water loss through the dispersion system. The designer should ensure the dispersion area is able to dispose of (through infiltration, evaporation, transpiration, and soil absorption) stormwater flows predicted by an approved continuous runoff model.

Because a water balance model has not be developed for designing engineered dispersion areas, a set of conservative guidelines similar to those given for natural dispersion have been agreed upon with Ecology (WSDOT 2008). Updates to the engineered dispersion criteria may occur and the project engineer should check with the Administrator to determine if additional criteria have been implemented.

Design Criteria

Geometry

- The average longitudinal slope of the dispersion area shall not exceed 6H:1V.
- The average lateral slope of the dispersion area shall not exceed 6H:1V.
- There should be no discernible flow paths through the dispersion area. A channel or flow path may short circuit the flows and reduce treatment and infiltration ability.
- There should be no surface water discharge from the dispersion area to a conveyance system or Category I or II wetlands (as defined by Ecology's Wetland Rating Systems for western Washington).

Sizing Criteria

Figure 2.14 illustrates a typical engineered dispersion area relative to the adjacent roadway.

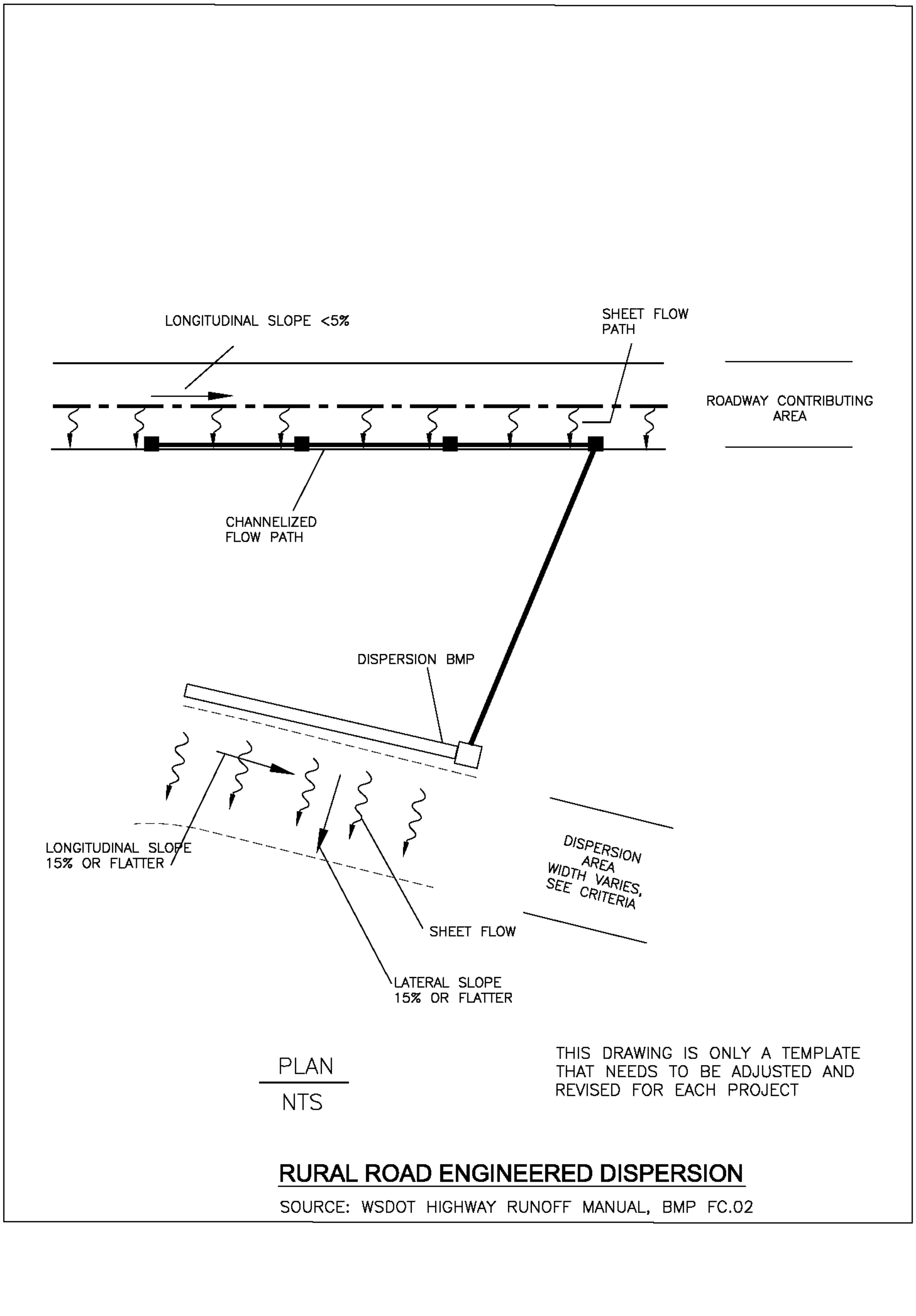


Figure 2.14. Engineered Dispersion.

Sheet Flow Dispersion

Sheet flow dispersion criteria for Type A, B, C, and D soils are as follows:

- The sheet flow path leading to the engineered dispersion area shall not be longer than 150 feet. The sheet flow path is measured in the direction of flow and generally represents the width of the pavement area.
- Pervious shoulders and side slopes are not counted in determining the sheet flow path.
- The longitudinal length of the dispersion area shall be equivalent to the longitudinal length of the roadway that is contributing sheet flow.
- Roadway side slopes leading to engineered dispersion areas should be 25 percent (4H:1V) or flatter. Roadway side slopes that are 25 percent to 15 percent (7H:1V) should not be considered part of the dispersion area. Slopes steeper than 25 percent are allowed if the existing side slopes are well vegetated and show no signs of erosion problems. For any existing slope that will lead to an engineered dispersion area, if evidence of channelized flow (rills or gullies) is present, a flow-spreading device should be used before those flows are allowed to enter the dispersion area.
- Roadway side slopes that are 15 percent or flatter are considered part of the dispersion area if engineered dispersion practices are applied to the slope (6.5 feet of compost amended side slope width mitigates for 1 foot of impervious surface). The use of natural or engineered dispersion concepts within one threshold discharge area is acceptable.

The following criteria are specific to sheet flow dispersion on all Type A and some Type B soils, depending on infiltration rates:

- For short-term infiltration rates of 4 inches per hour or greater, and for the first 20 feet (along the sheet flow path) of impervious surface that drains to the dispersion area, there must be 10 lateral feet of dispersion area width. For each additional foot of impervious surface (along the sheet flow path) that drains to the dispersion area, 0.25 lateral feet of dispersion area shall be provided.
- For dispersion areas that receive sheet flow only from disturbed pervious areas (bare soil and non-native landscaping), for every

6 feet (along the sheet flow path) of disturbed pervious area, 1 lateral food width of dispersion area is required.

The following criteria are specific to sheet flow dispersion on all Type C and D soils and Type B soils with a short-term infiltration rate less than 4 inches per hour:

- For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.
- The dispersion area shall have a minimum width of 100 feet, measured in the direction of the flow path.

Channelized Flow Dispersion

Channelized flow dispersion criteria for Type A, B, C, and D soils are as follows:

- Concentrated runoff from the roadway and adjacent upstream areas (such as in a ditch or cut slope) must be incrementally discharged from the conveyance system (such as a ditch, gutter, or storm sewer) via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows must not exceed 0.5 cubic feet per second (cfs) at any single discharge point from the conveyance system for the 100-year runoff event (determined by an approved continuous flow model). Where flows at a particular discharge point are already concentrated under existing site conditions (for example, in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.
- Discharge points with up to 0.2 cfs discharge for the peak 100-year flow may use rock pads or dispersion trenches to disperse flows. Discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow must use only dispersion trenches to disperse flows.
- Dispersion trenches must be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end; aligned perpendicular to the flow path; a minimum of 2’ x 2’ in section; 50 feet in length; filled with 3/4 to 1-1/2 inch washed rock; and provided with a level notched grade board (see Figure 3.4, Flow Dispersal Trench, in Volume III). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between four trenches (maximum). Dispersion trenches must have a minimum spacing of 50 feet.

- After being dispersed with rock pads or trenches, flows from discharge points must traverse the required flow path length of the dispersion area before entering an existing on-site channel carrying existing concentrated flows away from the roadway alignment.

  Note: To provide the required flow path length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed.

- Flow paths from adjacent discharge points must not intersection within the required flow path lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point.

- Discharge points must be located a minimum of 100 feet upgradient of slopes steeper than 40 percent within a vertical change of at least 10 feet, wetlands, and streams.

- Where the County determines that there is a potential for significant adverse impacts downstream (such as erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

The following criterion is specific to channelized flow dispersion on all Type A and some Type B soils, depending on infiltration rates.

- For short-term infiltration rates (as determined in Volume III) of 4 inches per hour or greater, and for the first 20 feet (along the sheet flow path) of impervious surface that drains to the dispersion area, there must be 10 lateral feet of dispersion area width. For each additional foot of impervious surface (along the sheet flow path) that drains to the dispersion area, 0.25 lateral feet of dispersion area shall be provided.

The following criteria are specific to channelized flow dispersion on all Type C and D soils and Type B soils with a short-term infiltration rate less than 4 inches per hour:

- For every 1 foot of contributing pavement width, a dispersion area width of 6.5 feet is needed.

- The dispersion area shall have a minimum width of native vegetation of 100 feet, measured in the direction of the flow path.

Pipe or Ditch Conveyance System

Flows collected in a pipe or ditch conveyance system require energy dissipation and dispersal at the end of the conveyance system before entering the dispersion area. For flow dispersal BMPs, see Section 3.8 of Volume III.

Materials

Soils in engineered dispersion areas must meet the requirements of BMP LID.02 (Post-Construction Soil Quality and Depth).

Site Design Elements

The following areas are appropriate engineered dispersion areas because they are likely to remain in their existing condition over the long term:

- County right-of-way (for County projects only).
- Protected beautification areas and landscape areas.
- Agricultural areas.
- Parks and nature areas.
- Commercial or government-owned forest lands.
- Rural areas with zoned densities of less than one dwelling unit per 5 acres.

Engineered dispersion areas shall have infiltrative soil properties that are verified by the geotechnical professional using the methods described in Volume III.

Engineered dispersion areas that have impervious areas (for example, abandoned roads with compacted subgrades) within them shall have those areas tilled and reverted using the soil amendments per BMP LID.02 (Post-Construction Soil Quality and Depth).

Engineered dispersion areas that are within a landslide hazard area must be evaluated by a geotechnical engineer or qualified geologist. Engineered dispersion areas should not be sited above slopes greater than 20 percent or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and acceptance by Thurston County.

Engineered dispersion areas shall have a separation of at least 2 feet between the existing ground elevation and the average annual maximum groundwater elevation. This separation depth requirement applies to the entire limits of the dispersion area.

When selecting engineered dispersion areas, determine whether there are groundwater management plans for the area and contact the local water purveyors to determine whether the project lies within a wellhead or groundwater protection zone, septic drain fields, or aquifer recharge area. There may be additional restrictions within these areas.

Setback Requirements

- Engineered dispersion areas can extend beyond the right-of-way provided that documentation ensures (via easements or dedicated tracts) the dispersion area is not developed in the future.

- Engineered dispersion areas shall be setback at least 100 feet from drinking water wells and springs used for public drinking water supplies. Engineered dispersion areas upgradient of drinking water supplies and within the 1-, 5-, and 10-year time of travel zones must comply with the Washington State Department of Health (DOH) requirements.

- Engineered dispersion areas shall be setback at least 100 feet from septic drainfields. The 100-foot setback is in addition to the required dispersion area. For example if there is a 100-foot width dispersion area, there would be an additional 100-foot setback making a total of 200 feet from the point of discharge of water to the dispersion area to the drainfield area. If the applicant can demonstrate that the dispersion flow path will not intercept the drainfield, this setback requirement may be relaxed.

- If the project significantly increases flows to off-site properties, a drainage easement may be required or additional right-of-way purchased.

Signage

- The limits of engineered dispersion area shall be marked as a stormwater management facility and also shall be physically marked in the field during and after construction. Signage ensures the dispersion area is protected from construction activity disturbance and is adequately protected by measures shown in the temporary erosion and sedimentation control (TESC) plan.

- Signage helps ensure the engineered dispersion area is not cleared or disturbed after the construction project.

- Signage shall be posted at a minimum on all four sides of the dispersion area and at intervals not exceeding 75 feet.

- See Appendix V-E for sign specifications.

Construction Considerations

- For installation of dispersal BMPs and conveyance systems near dispersion areas, the area that needs to be cleared or grubbed should be minimized. Maintaining plant root systems is important for dispersion areas.

- The area around dispersion areas should not be compacted.

- To the maximum extent practicable, low-ground-pressure vehicles and equipment should be used during construction.

Maintenance

- Use the maintenance checklist for vegetated filter strips and energy dissipators for maintenance requirements (Appendix V-C).

- Signage and fencing shall be inspected and restored /replaced as required.

- Ensure that sheet flow paths are maintained to the dispersion areas, perform hand maintenance to ensure sheet flow.

- Maintain energy dissipators and level spreaders. Cleanout any structures associated with these devices and inspect spreaders to ensure they are functioning correctly. Remove buildup of soil/debris over the surface of level spreader as required to maintain its function.

Chapter 3 - Infiltration BMPs

Infiltration BMPs discharge stormwater into the ground, rather than through a surface or piped outflow. Infiltration can aid in pollutant removal, peak flow control, groundwater recharge, and flood control.

However, to avoid contaminating drinking water sources, infiltration facilities must be sited properly (see site suitability criteria in Volume III) and stormwater runoff must often be pretreated before infiltration. See the individual BMP design guidelines in this chapter for pretreatment requirements.

3.1 General Considerations

3.1.1 Runoff Treatment and Flow Control

Infiltration can be used for both runoff treatment and flow control.

To adequately address groundwater protection when evaluating infiltration, it is important to understand the difference between soils suitable for runoff treatment and soils suitable only for flow control.

Infiltration for runoff treatment treats stormwater by using the filtration, adsorption, and biological decomposition properties of soils. To be used for runoff treatment, soils must include sufficient organic content and sorption capacity to remove pollutants. Examples are silty and sandy loams.

Coarser soils, such as gravelly sands, can provide flow control through rapid infiltration to groundwater, but are not suitable for treating runoff. The use of coarser soils to provide flow control for runoff from pollution generating surfaces must be preceded by treatment in some cases to protect groundwater quality. Thus, there will be instances when soils are suitable for treatment but not flow control, and vice versa.

The hydraulic design goal should be to mimic the natural hydrologic balance between surface and ground water, as needed to protect water uses. Frequently infiltration will be used in combination with detention and release to meet Minimum Requirement #7 (Flow Control). Detention may be provided after infiltration or in combination with infiltration by installing a control structure for controlled release of stormwater for events that exceed the infiltration capacity of the facility.

3.1.2 Site Suitability

Because infiltration facilities release stormwater to groundwater, they must be located and designed to ensure that stormwater discharge will not contaminate drinking water sources or downstream surface waters. Site characterization and suitability criteria are described in Volume III and includes characterization of the soils; locational restrictions and siting criteria; calculating a design infiltration rate; characterization of the infiltration receptor (vadose zone), and underlying aquifer; and mounding analysis requirements.

3.1.3 Underground Injection Control

Infiltration is regulated by the Washington State Department of Ecology (Ecology) and the Underground Injection Control (UIC) Program (Washington Administrative Code [WAC] 173-218).

The following information on Underground Injection Control (UIC) is excerpted from the 2006 Department of Ecology document *Guidance for UIC Wells that Manage Stormwater*. This document is available online at: <http://www.ecy.wa.gov/biblio/0510067.html>.

The UIC program in the state of Washington is administered by the Department of Ecology. In 1984, the Department of Ecology adopted Chapter 173-218 WAC – Underground Injection Control to implement the program. A UIC well is a manmade subsurface fluid distribution system designed to discharge fluids into the ground and consists of an assemblage of perforated pipes, drain tiles, or other similar mechanisms, or a dug hole that is deeper than the largest surface dimension (WAC 173-218-030).

UIC systems include drywells, pipe or French drains, drain fields, and other similar devices that are used to discharge stormwater directly into the ground. Infiltration trenches with perforated pipe used to disperse and inject flows (as opposed to collect and route to surface drainage, as in an underdrain) are considered to be UIC wells. All stormwater UICs must be registered with Ecology, except residential UICs used for roof runoff control.

The following are not UIC wells; therefore, this guidance does not apply in these situations:

- Buried pipe and/or tile networks that serve to collect water and discharge that water to a conveyance system or to surface water.
- Surface infiltration basins and flow dispersion stormwater infiltration facilities, unless they contain additional infiltration structures at the bottom of the basin/system such as perforated pipe, or additional bored, drilled, or dug shafts meant to inject water further into the subsurface greater than 20 feet deeper than

the bottom of the pond (or deeper than the largest surface dimension per above).

- Infiltration trenches designed without perforated pipe or a similar mechanism
- A system receiving roof runoff from a single family home.

The two basic requirements of the UIC Program are:

- Register UIC wells with the Washington State Department of Ecology unless the wells are located on tribal land. (Those wells should be registered with the Environmental Protection Agency.)
- Make sure that current and future underground sources of ground water are not endangered by pollutants in the discharge (non-endangerment standard).

UIC wells must either be rule-authorized or covered by a state waste discharge permit to operate. If a UIC well is rule-authorized, a permit is not required. Rule-authorization can be rescinded if a UIC well no longer meets the non-endangerment standard. Ecology can also require corrective action or closure of a UIC well that is not in compliance. Additional information on UIC systems can be found online at: <http://www.ecy.wa.gov/biblio/0510067.html>.

In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or low permeability layer when designing a stormwater facility. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical reports, runoff treatment BMPs, and monitoring may be required including but not limited to groundwater monitoring through a wet season (December 1st through April 30th).

3.1.4 Groundwater Protection Areas

The applicant must check the Critical Aquifer Recharge (CARA) map, sole source aquifer designations, and wellhead protection areas mapped by the Washington State Department of Health and Thurston County to determine if the project lies within a groundwater protection area. A site is not suitable if the infiltration facility will cause a violation of Washington State Ground Water Quality Standards. At a minimum, projects located within groundwater protection areas may be required to meet one of the soil requirements for infiltration for water quality treatment outlined in Volume 3, Section 2.3.1. If an infiltration facility is proposed within a designated well head protection area for a public water system serving over 1,000 connections the enhanced treatment is required prior to infiltration.

3.1.5 Verification of Performance

Verification testing of the completed full-scale infiltration facility (BMPs IN.01, IN.02, or IN.03) is required during the first 1 to 2 years of operation and prior to release of any financial assurance instruments (bonds, letters of credit, assignment of funds). Verification testing is required to ensure that the completed full-scale infiltration facility operates as designed including confirmation of estimated design infiltration rates.

The applicant shall submit a facility monitoring and evaluation report to document the results of the verification testing. A licensed civil engineer shall prepare and seal the report. The report shall document work and assess stormwater infiltration facility performance versus design.

All field work shall be done under the engineer's direction and supervision. Testing shall consist of automated continuous water level monitoring over a sufficient number of storms to provide an accurate "long-term" infiltration rate. Testing shall either have a minimum of 30 days' test results with two or more events exceeding 30 percent of facility volume, or one full wet season's data (November 1 to March 30). An alternative, with Administrator or designee acceptance, is to simulate storm events using hydrant or trucked water. The report shall specify any actions needed to restore performance, such as sediment removal or facility expansion.

A program for monitoring of groundwater quality may be required and if so it shall be prepared by the site professional. Instances in which groundwater monitoring may be required include shallow groundwater, infiltration facilities at commercial or industrial sites, and infiltration facilities located within critical, sensitive or sole-source aquifer areas as designated by Thurston County. For those facilities required to conduct groundwater monitoring, the ground water monitoring wells installed during site characterization may be used for this purpose. At a minimum at least one up-gradient and one down-gradient groundwater sample will be collected per year and analyzed for pollutants such as metals, nitrogen, phosphorous and dissolved solids.

Long-term (more than 2 years) in-situ drawdown and confirmatory monitoring of the infiltration facility is also strongly recommended, along with a maintenance program that results in achieving expected performance levels. Long term monitoring and groundwater monitoring shall be included in the Maintenance plan for the facility including methods of testing, frequency and reporting requirements.

3.1.6 Contingency Planning

The methods used to estimate infiltration rates described in Volume III are expected to yield relatively accurate estimates of ultimate infiltration rates. However, soils, shallow geology, and groundwater conditions can be extremely complex and highly variable, which may cause inaccuracies. Therefore, it is necessary to have a plan for fixing under performance discovered after facilities are installed (see Section 3.1.2, Verification of Performance).

All projects using infiltration facilities shall provide a contingency plan for under performance. The plan shall include a reasonable "worst-case" project of long-term infiltration performance and describe methods and costs for improving/restoring performance and/or expanding facility size. These costs shall provide one basis for required performance/operation and maintenance bonding (see Volume I).

3.2 Infiltration BMPs

This section includes the following BMPs:

- IN.01 Infiltration Basin
- IN.02 Infiltration Trench
- IN.03 Infiltration Vault
- IN.04 Bio-Infiltration Swale.

3.2.1 IN.01 Infiltration Basins

Infiltration basins are earthen impoundments used for the collection, temporary storage and infiltration of incoming stormwater runoff.

This section describes design and maintenance criteria for infiltration basins (see schematic in Figure 3.1).

Applicability

Infiltration basins for flow control are used to convey stormwater runoff from new development or redevelopment to the ground and ground water after appropriate treatment. Infiltration basins designed to meet runoff treatment criteria of Minimum Requirement #6 rely on the soil profile or an engineered soil layer to provide pollutant removal. Runoff in excess of the infiltration capacity of the basin must be managed to comply with the flow control requirements in Volume I, Minimum Requirement #7, if applicable.

Infiltration basins are a good option (and may be required) for flow control where soils have adequate infiltration rates and the site meets the site suitability criteria for infiltration facilities described in Volume III.

Infiltration basins for water quality treatment are capable of achieving performance objectives for water quality treatment. In general, this treatment method can capture and remove or reduce target pollutants to levels that:

- Will not adversely affect public health or beneficial uses of surface and ground water resources, and
- Will not cause a violation of ground water quality standards

Infiltration treatment systems are typically installed:

- As off-line systems, or on-line for small drainages
- As a polishing treatment for street/highway runoff after pretreatment for solids and oil.
- As part of a treatment train
- As retrofits at sites with limited land areas, such as residential lots, commercial areas, parking lots, and open space areas
- With appropriate pretreatment for oil and silt control to prevent clogging. Appropriate pretreatment devices include a pre-settling basin or a basic treatment BMP such as wet pond/vault, biofilter, constructed wetland, media filter, and oil/water separator.

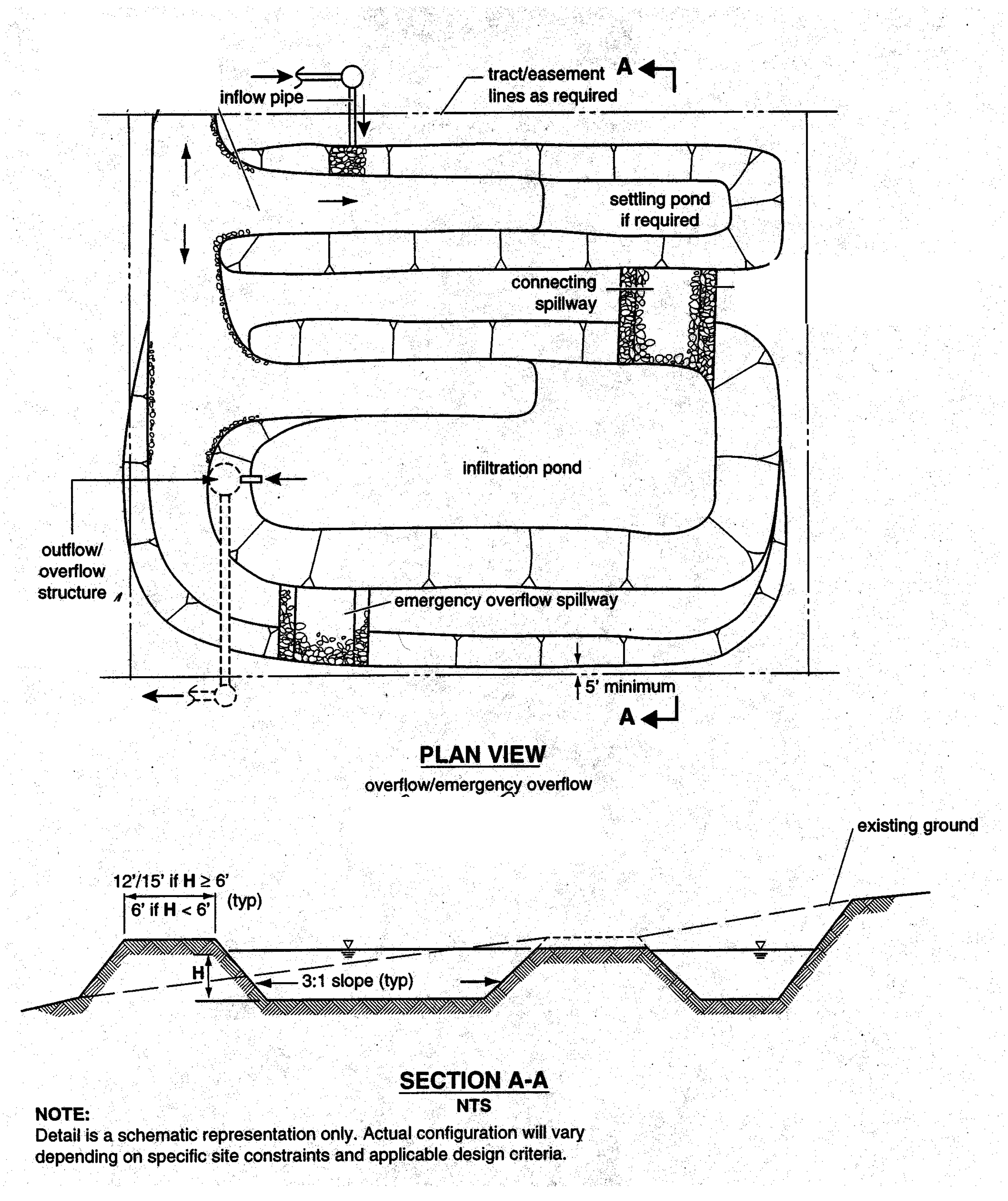


Figure 3.1. Typical Infiltration Pond/Basin.

Infiltration basins are preferred over infiltration trenches (BMP IN.02), infiltration vaults (BMP IN.03), and bio-infiltration swales (BMP IN.04). This is primarily because basins are easier and less expensive to construct and maintain.

Limitations

See Volume III for soil testing and site suitability criteria.

Submittals and Approval

Prepare submittals required by Volume I and include the following information in the submittal:

- Hydrologic modeling results showing the how the facility meets the flow control minimum requirements
- Show details of all structures and material and construction specifications
- Planting plan showing plant species, quantity, location and any special planting requirements
- Provide at least one cross section of the pond through the control structure
- Provide design calculations for the overflow structures
- Show how the facility location meets setback requirements
- Required contingency planning and performance verification testing information
- Geotechnical report and infiltration rate calculations required by Volume III.

Pretreatment

With the exception of clean runoff water from roofs or other non-pollution generating pervious or impervious surfaces, all stormwater shall pass through a designed biofiltration system (BMPs BF.01, BF.03, BF.04, or BF.05) or presettling basin (BMP WP.05) for water quality treatment prior to discharge to an infiltration facility. The pretreatment facility must safely convey or bypass the developed 100-year peak flow per conveyance design standards of Volume III.

Hydrologic and Hydraulic Design Considerations

See Volume III for detailed guidance on modeling infiltration basins.

100-Year Overflow Conveyance

An overflow route must be identified for stormwater flows that overtop the facility when infiltration capacity is exceeded or when the facility becomes plugged and fails. The overflow route must be able to convey the 100-year developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage. The emergency overflow spillway shall be designed in accordance with the requirements for detention pond overflow spillway design criteria (BMP D.01).

Spill Control Device

All infiltration facilities must have a spill control device upstream of the facility to capture oil or other floatable contaminants before they enter the infiltration facility. If a "tee" section is used for spill control, the top of the spill control riser must be set above the infiltration facility's 100-year overflow elevation to prevent oils from entering the infiltration facility.

Soil Physical and Chemical Suitability for Treatment

(Applies to infiltration facilities used as treatment facilities not to facilities used for flow control only).

The soil texture and design infiltration rates should be considered along with the physical and chemical characteristics specified below to determine if the soil is adequate for removing the target pollutants. Section 2.3.1 of Volume III discusses the soil properties needed to meet runoff treatment requirements.

Engineered soils may be used to meet infiltration BMP design criteria in Volume V and the performance goals in Minimum Requirement #6 (Runoff Treatment; Volume I). BMP LID.08 Bioretention provides an acceptable engineered soil specification for runoff treatment. Use of alternate engineered soils must be approved by the County, and requires field performance evaluation(s), using acceptable protocols, to determine effectiveness, feasibility, and acceptability.

Design Criteria

Geometry

- The slope of the basin bottom shall not exceed 3 percent in any direction.
- A minimum of 1 foot of freeboard is required when establishing the design ponded water depth. Freeboard is measured either from the rim of the infiltration facility to the maximum ponding level, or

from the rim down to the overflow point if overflow or a spillway is included.

Materials

- **Lining material**: Basins can be open or covered with a 6- to 12-inch layer of filter material such as coarse sand, or a suitable filter fabric, to help prevent the buildup of impervious deposits on the soil surface. A nonwoven geotextile shall be selected that will function sufficiently without plugging (see geotextile specifications in Appendix V-A). The filter layer can be replaced or cleaned when/if it becomes clogged.

- **Vegetation**: The embankment, emergency spillways, spoil and borrow areas, and other disturbed areas shall be stabilized and planted—preferably with grass—in accordance with the *Drainage Design and Erosion Control Plan* (see Minimum Requirement #1 of Volume I).

- Treatment infiltration basins must have sufficient vegetation established on the basin floor and side slopes to prevent erosion and sloughing and to provide additional pollutant removal. Erosion protection of inflow points to the basin must also be provided (e.g., riprap, flow spreaders, energy dissipators. Select suitable vegetative materials for the basin floor and side slopes to be stabilized.

- Seed mixtures shall be the same as those recommended in Table E-2 in Appendix V-E. The use of slow-growing, stoloniferous grasses will permit long intervals between mowing (twice a year is usually satisfactory). Fertilizers shall be applied only as necessary and in limited amounts, to avoid contributing to ground water pollution. Consult the local extension agency for appropriate fertilizer types and application rates.

Site Design Elements

Access must be provided for vehicles to easily maintain the forebay (presettling basin) area, while not disturbing vegetation or resuspending sediment any more than absolutely necessary.

Access Road

An access road to the control structure and at least one access point per cell are needed, and may be designed and constructed as specified in Appendix V-D.

Construction Criteria

- Initial basin excavation must be conducted to within 2 feet of the final elevation of the basin floor. Excavate infiltration trenches and basins to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. The final phase of excavation must remove all silt accumulated in the infiltration facility before putting it into service. After construction is completed, prevent sediment from entering the infiltration facility by first conveying runoff water through an appropriate pretreatment system such as a presettling basin, wet pond, or sand filter.

- Infiltration basins should not be used as temporary sediment traps during construction. If an infiltration facility is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient drainage area has been stabilized. Any silt accumulation in the basin must be removed before putting it into service.

- Light-tracked equipment is recommended to avoid compaction of the basin floor. The use of draglines and trackhoes should be considered for constructing infiltration basins. The infiltration area must be flagged or marked to keep heavy equipment away.

- The infiltration basin area shall be clearly identified and protected prior to construction to prevent compaction of underlying soils by vehicle traffic.

- Infiltration basins shall not begin operation until all erosion-causing project improvements are completed, and all exposed ground surfaces are stabilized by revegetation or landscaping.

Maintenance Criteria

Provision shall be made for regular and perpetual maintenance and access (tract, easement, etc., see Volume III) to the infiltration basin/trench. Adequate access, including measures to prevent encroachment into tracts/easements for purposes of inspection, operation and maintenance must be part of infiltration basin and trench design. Provisions must be made for regular and perpetual maintenance of the infiltration basin or trench, including replacement or reconstruction of any media used for treatment purposes. The ~~Operation and~~ Maintenance Plan shall be submitted to and approved by the County to ensure maintenance of the desired infiltration rate.

Debris/sediment accumulation – Removal of accumulated debris/sediment in the basin/trench should be conducted every 6 months or as needed to prevent clogging, or when the measured infiltration rate is significantly less than the design rate.

Vegetation growth should not be allowed to exceed 18 inches in height. Mow the slopes periodically and check for clogging, and erosion.

See Appendix V-C for additional information on maintenance requirements.

3.2.2 IN.02 Infiltration Trenches

This section describes design, construction, and maintenance criteria for infiltration trenches. For trenches associated with roof downspout infiltration, see BMP LID.04.

Figures 3.2 through 3.7 provide different configurations for infiltration trenches. Infiltration trenches are rectangular trenches generally at least 24 inches wide backfilled with a coarse stone aggregate that temporarily stores stormwater runoff in the voids of the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil.

Applicability

Infiltration trenches are more appropriate for small contributing areas or the risk of clogging and flooding increases. They are also suited to retrofit situations where limited area is available for infiltration basins.

Limitations

See Volume III for soil testing and site suitability criteria.

Submittals and Approval

In addition to submittal requirements of Volume I, complete geotechnical investigations and prepare a site suitability analysis per Volume III. If an infiltration trench includes a perforated distribution pipe, the BMP is subject to the requirements of the Underground Injection Control (UIC) regulations (see Section 3.1.3).

Pretreatment

With the exception of clean runoff water from roofs or other non-pollution generating pervious or impervious surfaces, all stormwater shall pass through a designed biofiltration swale system, basic filter strip or presettling basin for water quality treatment (see BMP BF.01, BMP BF.04 and BMP WP.05) prior to discharge to an infiltration trench. The pretreatment facility must safely convey or bypass the developed 100-year peak flow per conveyance design standards of Volume III.

Hydrologic and Hydraulic Design Considerations

See Volume III for guidance on determining a design infiltration rate and hydrologic modeling requirements.

- **Overflow Channel**: Because an infiltration trench is normally used for small drainage areas, an emergency spillway is not necessary. However, a non-erosive overflow channel leading to a stabilized watercourse shall be provided.

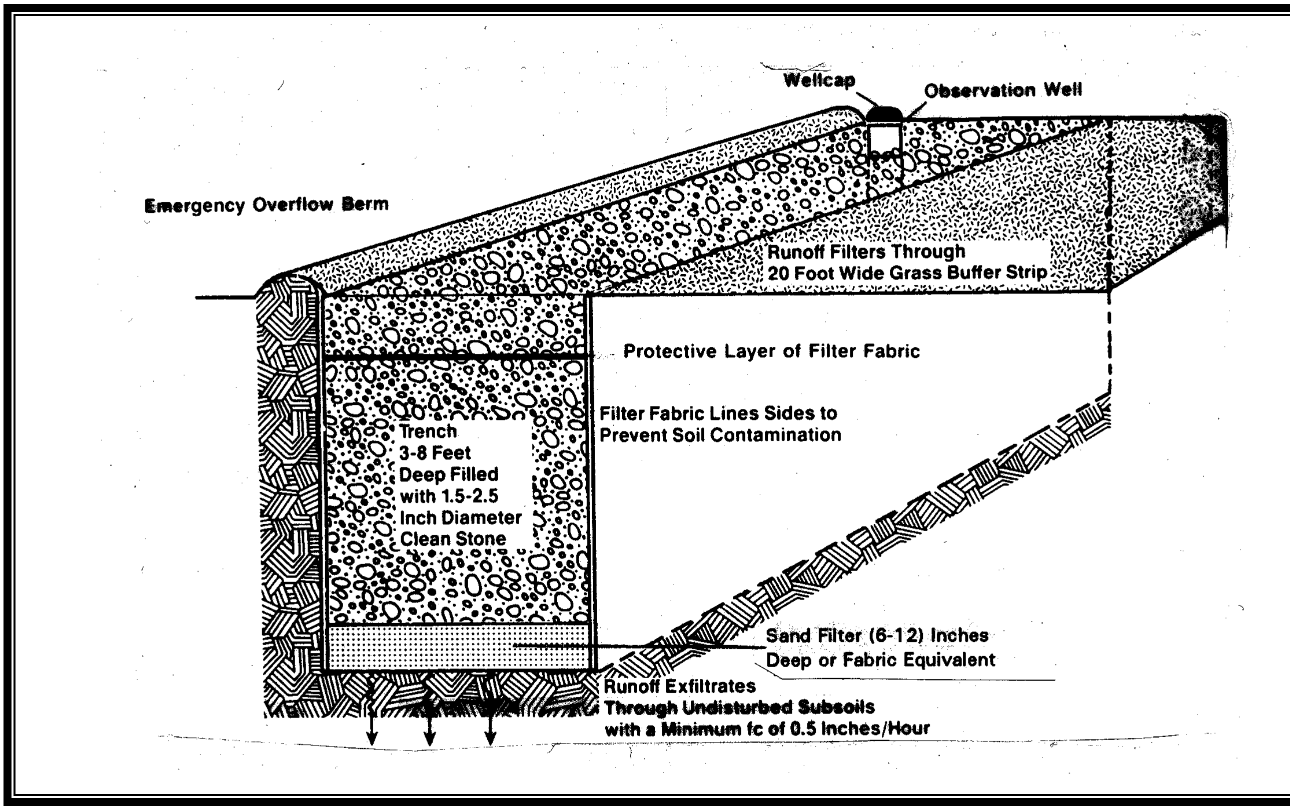


Figure 3.2. Schematic of an Infiltration Trench.

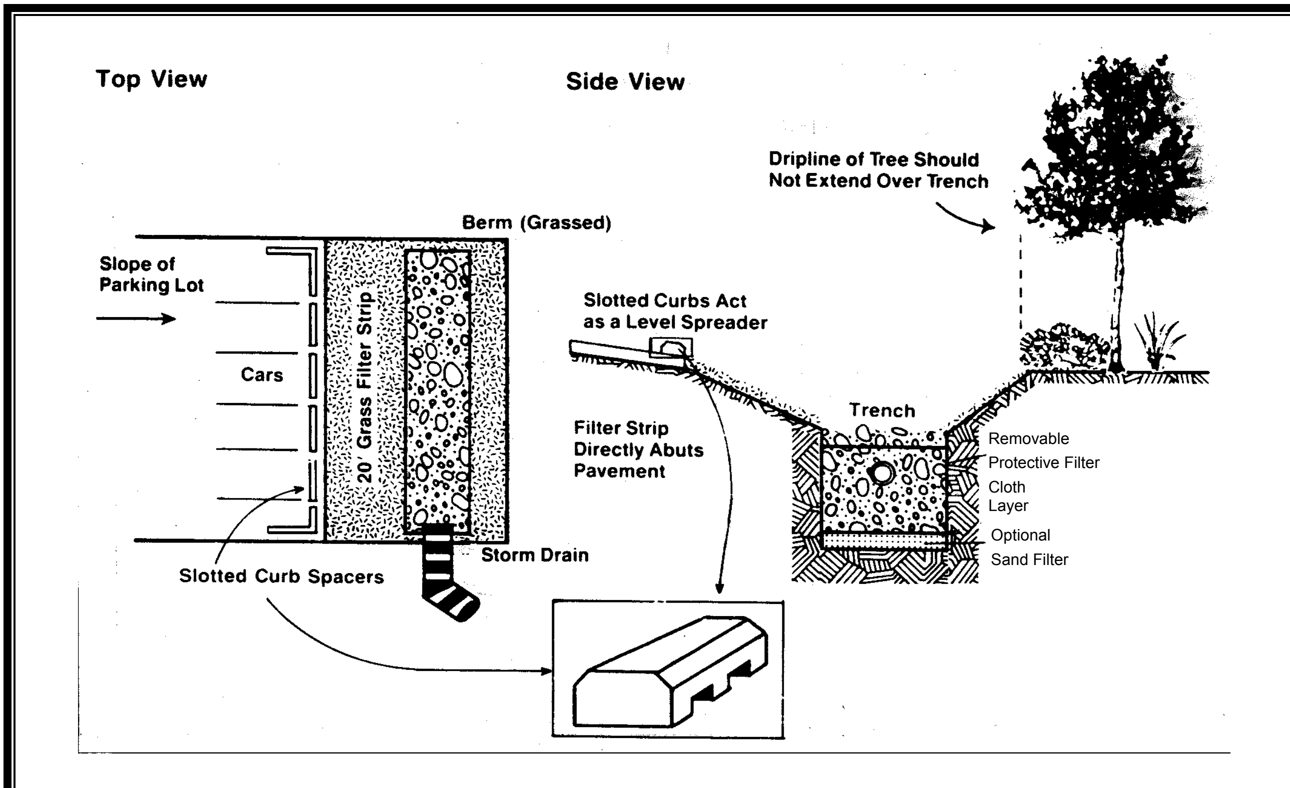
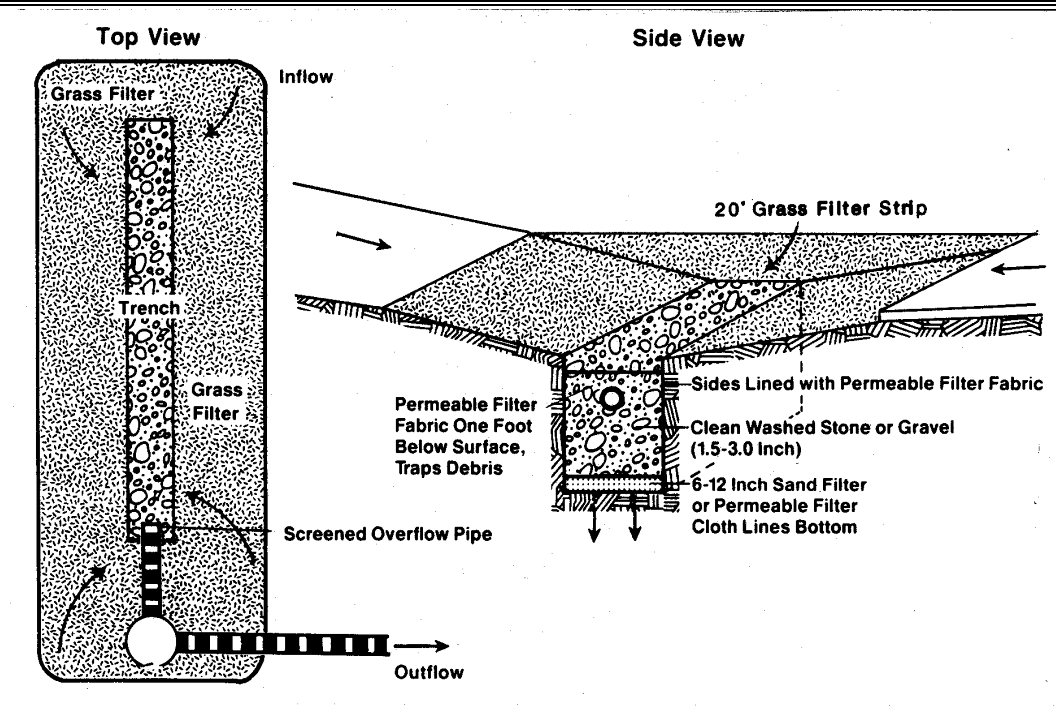
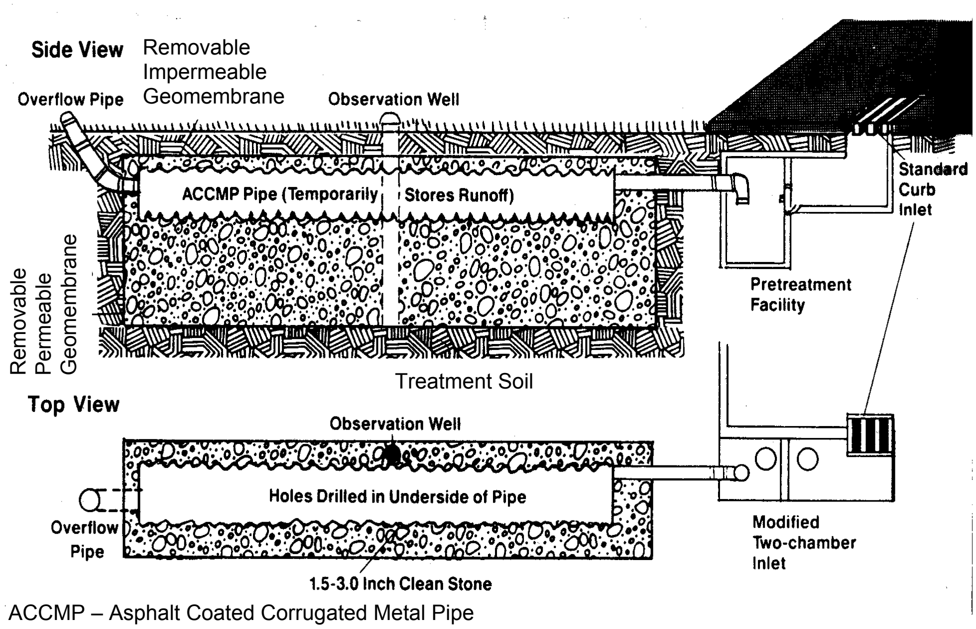


Figure 3.3. Parking Lot Perimeter Trench Design.



Source: Schueler (reproduced with permission)

Figure 3.4. Median Strip Trench Design.



Source: Schueler (reproduced with permission)

Figure 3.5. Oversized Pipe Trench Design.

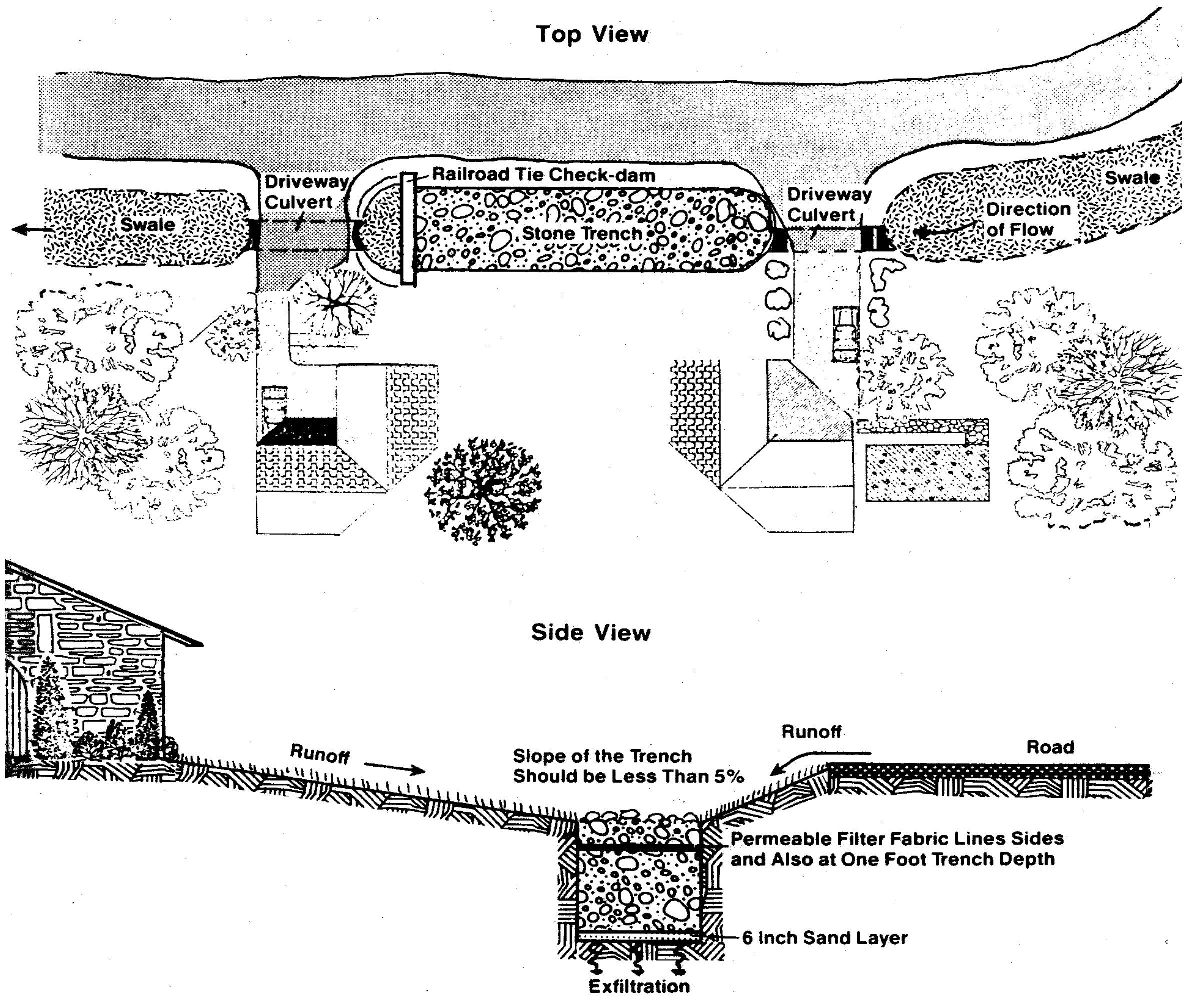


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Figure 3.6. Swale/Trench Design.

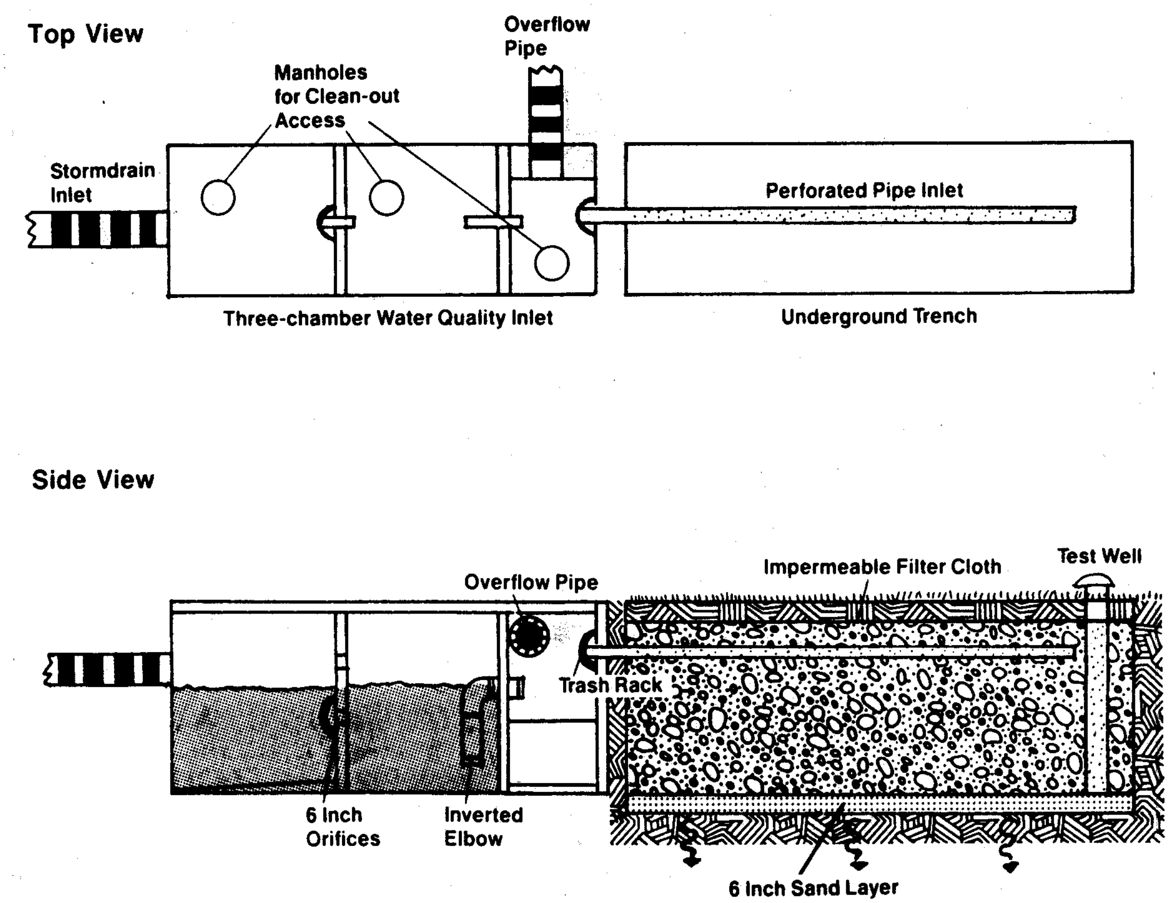

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Figure 3.7. Underground Trench with Oil/Grit Chamber.

- **Surface Cover**: A stone-filled trench can be placed under a porous or impervious surface cover to conserve space. If located under an off-street parking lot the following are required:
  - Observation wells must be placed no further than 100 feet apart.
  - The Maintenance Plan must clearly state that the pavement may have to be removed for maintenance.
  - No infiltration facilities shall be allowed under streets or roads, public or private (if more than one parcel is served).
- **Observation Well**: An observation well shall be installed at the lower end of the infiltration trench to check water levels, drawdown time, and sediment accumulation, and to conduct water quality monitoring. Figure 3.2 illustrates observation well details. The well should consist of a perforated PVC pipe 4 to 6 inches in diameter, and be constructed flush with the ground elevation. For larger trenches, a 12- to 36-inch-diameter well can be installed to facilitate maintenance operations (e.g., pumping out sediment). The top of the well shall be capped to discourage vandalism and tampering.

Design Criteria

Trench Cover

The surface of the trench can be covered with grating, or consist of stone, gabion, sand, or a grassed covered area with a surface inlet.

Distribution Pipe

Perforated rigid pipe at least 8 inches in diameter can also be used to distribute stormwater in the infiltration trench. However, an infiltration trench with distribution pipe is subject to the requirements of the Underground Injection Control (UIC) program (see Section 3.1.3).

Geometry

Infiltration trenches are generally at least 24 inches wide. However, narrower or wider trenches are allowed if they meet the requirements of this section.

Parallel trenches shall be spaced no closer than 10 feet or based on recommendations of the geotechnical engineer.

Trenches should generally follow a contour line.

Materials

- **Backfill Material**: The aggregate material for the infiltration trench must consist of a clean washed aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. Void space for these aggregates must be in the range of 30 to 40 percent.

- **Geotextile fabric liner**: The aggregate fill material shall be completely encased in an engineering geotextile material. Geotextile must surround all of the aggregate fill material except for the top 1 foot, which is placed over the geotextile. Geotextile fabric with acceptable properties must be carefully selected to avoid plugging (see Appendix V-A of Volume V).

- The sand filter shown at the base of the infiltration trenches in the attached figures is optional.

Spill Control

All infiltration trenches must have a spill control device upstream of the facility to capture oil or other floatable contaminants before they enter the infiltration facility. If a “tee” section is used for spill control, the top of the spill control riser must be set above the infiltration facility’s 100-year overflow elevation to prevent oils from entering the infiltration facility.

Construction and Maintenance

- Initial trench excavation shall be conducted to within no less than 2 feet of the final elevation of the basin floor. Excavate infiltration trenches to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. The final phase of excavation must remove all silt accumulation in the infiltration trench before putting it into service. After construction is completed, prevent sediment from entering the infiltration facility by first conveying the runoff water through an appropriate pretreatment system such as a presettling basin, biofiltration swale or filter strip, wet pond, or sand filter.

- Infiltration facilities should not be used as temporary sediment traps during construction. If an infiltration facility is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient drainage area has been stabilized. Any asilt accumulation in the basin must be removed before putting it into service.

- The infiltration facility area shall be clearly identified and protected prior to construction to prevent compaction of underlying soils by vehicle traffic.

- Infiltration facilities shall not begin operation until all erosion-causing project improvements are completed and all exposed ground surfaces are stabilized by revegetation or landscaping.

- **Trench Preparation**: Excavated materials must be placed away from the trench sides to enhance trench wall stability. Care must also be taken to keep this material away from slopes, neighboring property, sidewalks and streets. It is recommended that this material be covered with plastic (see erosion and sediment control criteria in Volume II).

- **Stone Aggregate Placement and Compaction**: The stone aggregate should be placed in lifts and compacted using plate compactors. As a rule of thumb, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing potential piping and geotextile clogging, and settlement problems.

- **Potential Contamination**: Prevent natural or fill soils from intermixing with the stone aggregate. All contaminated stone aggregate must be removed and replaced with uncontaminated stone aggregate.

- **Overlapping and Covering**: Following the stone aggregate placement, the geotextile must be folded over the stone aggregate to form a 12 inch minimum longitudinal overlap. When overlaps are required between rolls, the upstream roll must overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect.

- **Voids behind Geotextile**: Voids between the geotextile and excavation sides must be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Natural soils should be placed in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. Soil piping, geotextile clogging, and possible surface subsidence will be avoided by this remedial process.

- **Unstable Excavation Sites**: Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trapezoidal, rather than rectangular, cross-sections may be needed.

See Appendix V-C for information on maintenance requirements.

3.2.3 IN.03 Infiltration Vault

This section describes design, construction, and maintenance criteria for infiltration vaults.

Infiltration vaults are typically bottomless underground structures used for temporary storage and infiltration of stormwater runoff to groundwater. Infiltration tanks are large-diameter cylindrical structures with perforations in the base. These types of underground infiltration facilities can be a useful alternative for sites with constraints that make siting an infiltration pond difficult.

Applicability

Infiltration of runoff is the preferred method of flow control following appropriate runoff treatment. Runoff in excess of the infiltration capacity must be detained and released in compliance with the flow control requirement described in Minimum Requirement 6.

Limitations

Because infiltration vaults are difficult to maintain, County acceptance must be gained prior to implementation of this BMP.

Infiltration vaults shall not be located under the travel way in public rights-of-way. For all residential subdivisions and mixed use developments the infiltration vault shall be located in a separate tract with access from a public right-of-way. See Section 3.6 of Volume III for additional requirements.

Submittals and Approval

In addition to submittal requirements of Volume I, complete geotechnical investigations and prepare a site suitability analysis per Volume III.

Pretreatment

With the exception of clean runoff water from roofs or other non-pollution generating pervious or impervious surfaces, all stormwater shall pass through a designed biofiltration swale system, basic filter strip or presettling basin for water quality treatment (see BMP BF.01, BMP BF.04 and BMP WP.05) prior to discharge to an infiltration trench. The pretreatment facility must safely convey or bypass the developed 100-year peak flow per conveyance design standards of Volume III.

Hydrologic and Hydraulic Design Considerations

See Volume III for guidance on determining a design infiltration rate and hydrologic modeling requirements.

- **Overflow**: A primary overflow must be provided to bypass flows over the 100-year postdeveloped peak flow to the infiltration vault.

Design Criteria

Geometry

- The maximum depth from finished grade to the vault invert shall be 20 feet
- The minimum internal height shall be 7 feet, measured from the highest point of the vault floor (not sump), and the minimum width shall be 4 feet. However, concrete vaults may be a minimum 3 feet in height and width if used as tanks with access manholes at each end, and if the width is no larger than the height. The minimum internal height requirement may not be needed for any areas covered by removable panels.

Spill Control

All infiltration vaults must have a spill control device upstream of the facility to capture oil or other floatable contaminants before they enter the infiltration facility. If a "tee" section is used for spill control, the top of the spill control riser must be set above the infiltration facility's 100-year overflow elevation to prevent oils from entering the infiltration facility.

Structural Design Considerations

Materials

Minimum 3,000 psi structural reinforced concrete shall be used for infiltration vaults. All construction joints must be provided with water stops. Pre-cast vaults or vaults made of materials other than concrete may be allowed subject to meeting the requirements of this section and with prior acceptance of the Administrator or designee.

Infiltration vaults may be constructed using material other than reinforced concrete, such as large, perforated, corrugated metal pipe (see Figure 3.8), provided that the following additional criteria are met:

- Bedding and backfill material for the structure must be washed drain rock extending at least 1 foot below the bottom of the structure, at least 2 feet beyond the sides, and up to the top of the structure.
- Drain rock must be completely covered with construction geotextile for separation (per the *Standard Specifications*) prior to backfilling. If the drain rock becomes mixed with soil, the affected rock material must be removed and replaced with washed drain rock to provide maximum infiltration effectiveness.

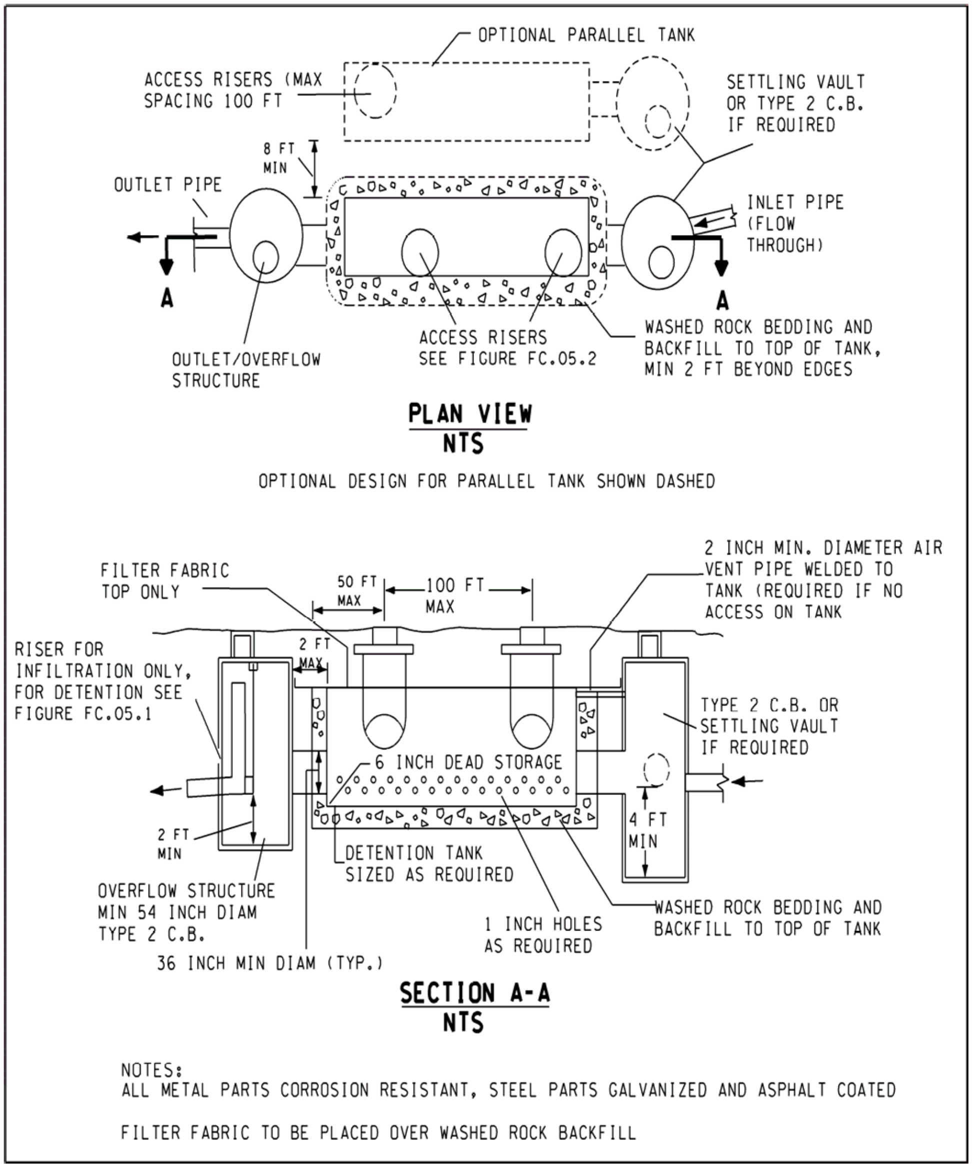


Figure 3.8. Infiltration Vault.

- The perforations (holes) in the bottom half of the pipe must be 1 inch in diameter and start at an elevation of 6 inches above the invert. The nonperforated portion of the pipe in the lower 6 inches is intended for sediment storage to protect clogging of the native soil beneath the structure.

- The number and spacing of the perforations should be sufficient to allow complete infiltration of the soils with a safety factor of 2.0 without jeopardizing the structural integrity of the pipe.

Structural Stability

All vaults must meet structural requirements for overburden support and H-20 vehicle loading. Vaults located under roadways must meet the live load requirements of the Standard Specifications. Cast-in-place wall sections must be designed as retaining walls. Structural designs for cast-in-place vaults must be stamped by a licensed structural civil engineer. Bottomless vaults must be provided with footings placed on stable, well consolidated native material and sized considering overburden support, traffic loading (assume maintenance traffic, if vault is placed outside right of way), and lateral soil pressures when the vault is dry. Infiltration vaults are not allowed in fill slopes unless a geotechnical analysis approves fill stability. The infiltration medium at the bottom of the vault must be native soil.

Access

Access must be provided over the inlet pipe and outlet structure. The following guidelines for access shall be used:

- Access openings must be positioned a maximum of 50 feet from any location within the tank. Additional access points may be needed on large vaults. If more than one “v” is provided in the vault floor, access to each “v” must be provided.

- For vaults with greater than 1,250 square feet of floor area, a 5' by 10' removable panel shall be provided over the inlet pipe (instead of a standard frame, grate and solid cover). Alternatively, a separate access vault may be provided as shown in Figure 3.8.

- Ladders and hand-holds 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 below.

- All access openings, except those covered by removable panels, shall have round, solid locking lids, or 3-foot square, locking diamond plate covers.

- Vaults with widths 10 feet or less shall have removable lids.

- Any vault requiring internal structural walls shall provide wall openings sufficient for maintenance access between cells. The openings shall be sized and situated to allow access to the maintenance “v” in the vault floor.

- Vaults must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

- Ventilation pipes (minimum 12-inch diameter or equivalent) shall be provided in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Alternatively removable panels over the entire vault may be provided.

Construction and Maintenance

Initial excavation should be conducted to within 1 foot of the final elevation of the infiltration vault base. Final excavation to the finished grade should be deferred until all disturbed areas in the upgradient drainage area have been stabilized or protected. The final phase of excavation should remove all accumulated sediment.

Infiltration vaults, as with all types of infiltration facilities, should generally not be used as temporary sediment traps during construction. If an infiltration vault is to be used as a sediment trap, it must not be excavated to final grade until after the upgradient drainage area has been stabilized. Any accumulation of silt in the vault must be removed before the vault is put into service.

Relatively light-tracked equipment is recommended for excavation to avoid compacting the soil beneath the base of the infiltration vault. The use of draglines and trackhoes should be considered. The infiltration area should be flagged or marked to keep equipment away.

See Appendix V-C for information on maintenance requirements.

3.2.4 IN.04 Bio-Infiltration Swales

Bio-infiltration swales, also known as Grass Percolation Areas, combine grassy vegetation and soils to remove stormwater pollutants by percolation into the ground. Their pollutant removal mechanisms include filtration soil sorption, and uptake by vegetative root zones.

Applicability

In general, bio-infiltration swales are used for treating stormwater runoff from roofs, roads and parking lots. Runoff volumes greater than water quality design volume are typically overflowed to the subsurface through an appropriate conveyance facility such as a dry well, or an overflow channel to surface water. Overflows that are directed to a surface water must meet Minimum Requirement #7 or #8 (as applicable) unless the discharge is to a marine water, or qualifies for a flow control exemption in accordance with the criteria in Minimum Requirement #7.

Limitations

See Volume III for soil testing and site suitability criteria.

Submittals and Approval

The applicant should consult with Thurston County at the pre-submittal meeting and stormwater scoping report/meeting for the project to discuss the suitability of and requirements for a bio-infiltration swale if one is proposed for the project.

Project submittal shall include the following in addition to the requirements of other sections:

- Source of treatment soil and testing results of treatment soil
- Description of method used and results of infiltration testing of base soils
- Description of method used and results of infiltration testing for treatment soil
- Hydrologic modeling results for the bio-infiltration swale demonstrating that the water quality treatment design storm is handled by the facility and how volumes greater than the water quality design flow are managed
- Project drawings shall include a typical cross-section of the swale and specifications for installation of treatment soils, seeding, sodding and other construction requirements

- Maintenance Plan shall include a discussion of maintenance requirements for the bio-infiltration swale.

Pretreatment

Pretreatment should be provided for removal of debris, gross TSS, and oil & grease to prevent the clogging of the treatment soil and/or growth of the vegetation, where necessary. Use of a pre-settling basin or other approved pre-treatment structure may be required depending on the specific location, contributing stormwater flows and other site specific factors.

Hydrologic and Hydraulic Design Considerations

The space available for ponding water within a bio-infiltration swale can be sized by either:

- Completely retaining the water quality design volume, i.e., the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model (or, the runoff volume from a 6-month, 24-hour storm). No reduction in volume is taken for any infiltration. Under this option, the overflow to a dry well or to a surface water must be above the elevation corresponding to the water quality design volume.

- Using the same design sizing procedures for infiltration facilities designed as treatment facilities.

Drawdown time for the water quality design volume: 48 hours max.

The treatment soil infiltration rate should not exceed 1-inch per hour for a treatment zone depth of 6 inches relying on the root zone to enhance pollutant removal. The Site Suitability Criteria in Volume III must also be applied; if a design soil depth of 18 inches is used, then a maximum infiltration rate of 2.4 inches per hour is applicable.

The maximum ponded level is 6 inches.

Design Criteria

Swale Bottom

The swale bottom should be flat with a longitudinal slope less than 1 percent.

Treatment Soil

Treatment soil shall be at least 18 inches thick with a CEC of at least 5 meq/100 gm dry soil, organic content of 8 to 10 percent, and sufficient target pollutant loading capacity. The design soil thickness may be reduced to as low as 6 inches if appropriate performance data demonstrates that the vegetated root zone and the natural soil can be expected to provide adequate removal and loading capacities for the target pollutants. The design professional should calculate the pollutant loading capacity of the treatment soil to estimate if there is sufficient treatment soil volume for an acceptable design period.

Other combinations of treatment soil thickness, CEC, and organic content design factors can be considered if it is demonstrated that the soil and vegetation will provide a target pollutant loading capacity and performance level acceptable to the local jurisdiction.

The treatment zone depth of 6 inches or more should contain sufficient organics and texture to ensure good growth of the vegetation.

Use native or adapted grass for vegetating the swale. The swale bottom shall be sodded to a height of at least 6 inches above the swale bottom the remaining sidewalls can be seeded.

Identify pollutants, particularly in industrial and commercial area runoff that could cause a violation of Ecology's ground water quality Standards (Chapter 173-200 WAC). Include appropriate mitigation measures (pretreatment, source control, etc.) for those pollutants.

Construction and Maintenance

See construction and maintenance requirements for biofiltration swale (BMP BF.01) and Appendix V-C.

Chapter 4 - Detention BMPs

4.1 Detention Facility BMPs

Detention facilities temporarily store increased surface runoff from development, meeting performance standards described in Minimum Requirement #7 for flow control (Volume I). The following types of detention facilities are described in this chapter:

- D.01 Detention Ponds
- D.02 Detention Tanks
- D.03 Detention Vaults
- D.04 Use of Parking Lots for Detention.

4.1.1 D.01 Detention Ponds

Drainage facilities, including detention ponds, should be made attractive features of the urban environment. Pond designers are encouraged to be creative in shaping and landscaping detention ponds and to consider aesthetics as an important design criterion.

Applicability

Detention ponds are appropriate for sites large enough for them. Detention ponds are not designed for habitat, in part because they usually drain completely between storms. If a detention facility is needed that provides habitat, flow control and runoff treatment, consider constructed wetlands designed with detention storage (BMP WP.04). Combined constructed wetland and detention ponds occupy a comparable amount of surface area as detention ponds while providing habitat, runoff treatment and a more aesthetically pleasing facility.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the detention pond shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the detention pond shall be lined. Pond liners may not be used to place detention facilities below the seasonally high groundwater elevation.

Limitations

Detention ponds occupy a large amount of surface area, and so are typically not used for sites with a high land cost or dense development.

Submittals and Approval

The following information shall be included in required submittals (see Volume I, Chapter 3):

- Hydrologic modeling results showing the how the facility meets the flow control standards (Minimum Requirement #7 – see Volume I, Chapter 2).
- Details of all structures and material and construction specifications.
- Planting plan showing plant species, quantity, location and any special planting requirements.
- Cross section of the pond through the control structure (additional sections and details may be needed depending on the complexity of the grading).

- Design calculations for the overflow structures.
- Demonstration of how the facility location meets setback requirements.

Pretreatment

Pretreatment is not required.

Hydrologic and Hydraulic Design Considerations

General Hydraulic Design Considerations

Detention ponds must be designed as flow-through systems, and a design that maximizes the flow path between inlet and outlet is recommended to promote sedimentation.

Flows must enter the detention pond through a conveyance system separate from the control structure and outflow conveyance system.

Detention Volume and Outflow

The volume and outflow design for detention ponds must comply with both Minimum Requirement #7 in Volume I, and hydrologic analysis and design methods described in Volume III. See Appendix V-A for design guidelines for restrictor orifice structures.

Infiltration Considerations

Detention ponds may be sited on soils that are sufficiently permeable for a properly functioning infiltration system (see Section 3.2). These detention ponds have a surface discharge, and may also use infiltration as a second pond outflow. Detention ponds sized with infiltration as a second outflow must meet all the requirements in Section 3.2 for infiltration ponds and Volume III for a soils report, testing, groundwater protection, presettling, and construction techniques.

Primary Overflow

The detention pond must have a primary overflow (usually a riser pipe within the control structure – see Appendix V-A) to bypass the 100-year developed peak flow over or around the restrictor system. This assumes the facility will be full due to plugged orifices or high inflows. The primary overflow is intended to protect against breaching of a pond embankment. The design must provide controlled discharge directly into the downstream conveyance system or other acceptable discharge point.

Secondary Inlet to Control Structure

A secondary inlet to the control structure must be provided in ponds as additional protection against overtopping if the control structure inlet becomes plugged. A grated opening in the control structure manhole functions as a weir when used as a secondary inlet (see Appendix V-A).

Note: The maximum circumference of this opening must not exceed one-half the control structure circumference. The "birdcage" overflow structure shown in Appendix V-A may also be used as a secondary inlet.

Emergency Overflow Spillway

Ponds must have an emergency overflow spillway (except as noted in the next paragraph). For impoundments of 10 acre-feet or greater, the emergency overflow spillway must meet the state's dam safety requirements. For impoundments under 10 acre-feet, ponds must have an emergency overflow spillway sized to pass the 100-year developed peak flow in the event of total control structure failure (e.g., blockage of the control structure outlet pipe) or extreme inflows. Emergency overflow spillways are intended to control the location of pond overtopping and direct overflows back into the downstream conveyance system or other acceptable discharge point.

As an alternative to an emergency overflow spillway for ponds with constructed berms over 2 feet in height, or for ponds located on grades in excess of 5 percent, emergency overflow may be provided by an emergency overflow structure, such as a Type II manhole fitted with a birdcage as shown in Appendix V-A. The emergency overflow structure must be designed to pass the 100-year developed peak flow, with a minimum 6 inches of freeboard, directly to the downstream conveyance system or another acceptable discharge point.

Where an emergency overflow spillway would discharge toward a steep slope, consideration shall be given to providing an emergency overflow structure in addition to the spillway.

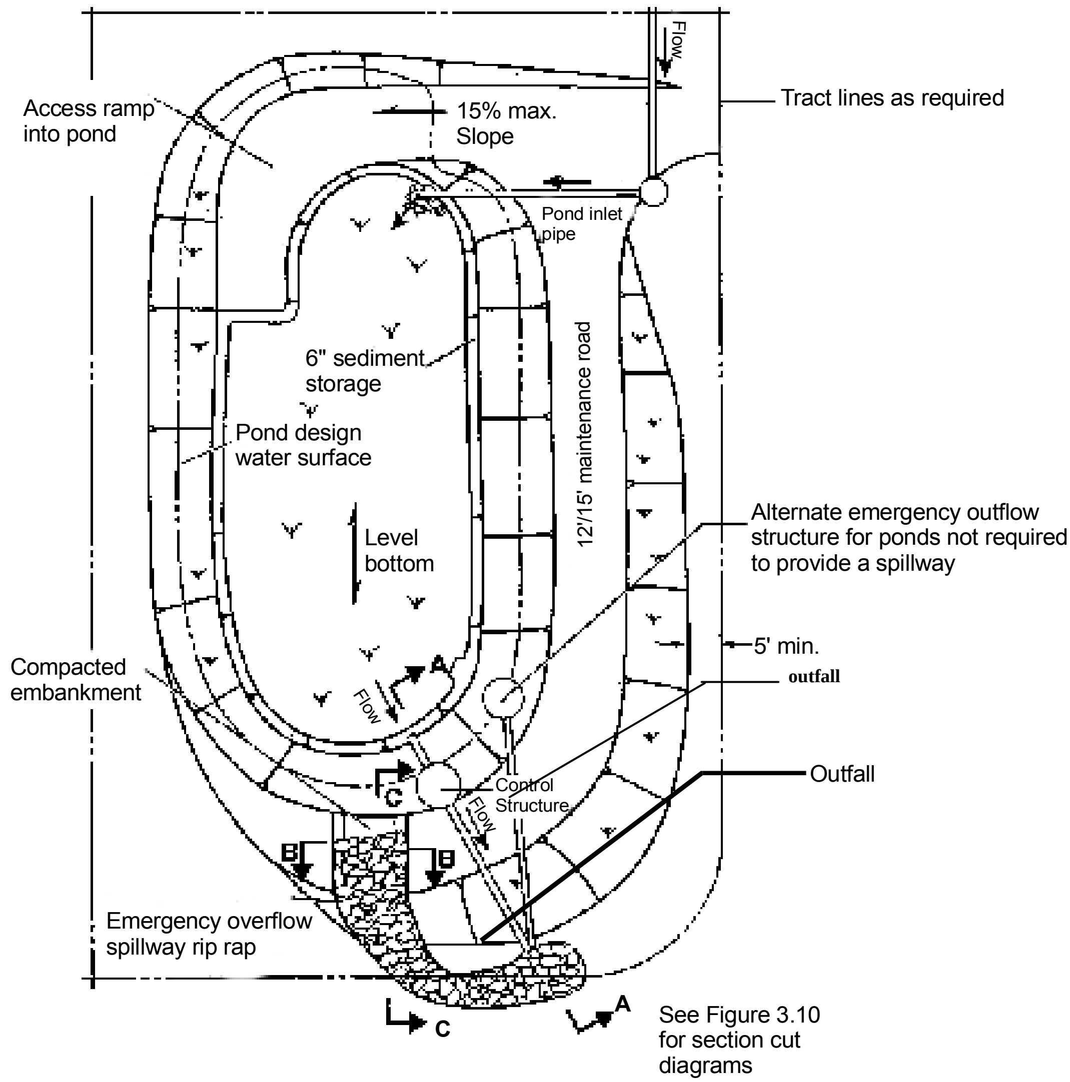
The emergency overflow spillway must be armored with riprap in conformance with the Outlet Protection BMP in Volume II. The spillway must be armored full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows reenter the conveyance system (see Figure 4.2).

Emergency Overflow Spillway Capacity

For impoundments under 10 acre-feet, the emergency overflow spillway weir section must be designed to pass the 100-year runoff event for developed conditions assuming a broad-crested weir (see Appendix V-A).

Design Criteria

See Figures 4.1 and 4.2 for typical detention pond layout.



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

Figure 4.1. Typical Detention Pond.

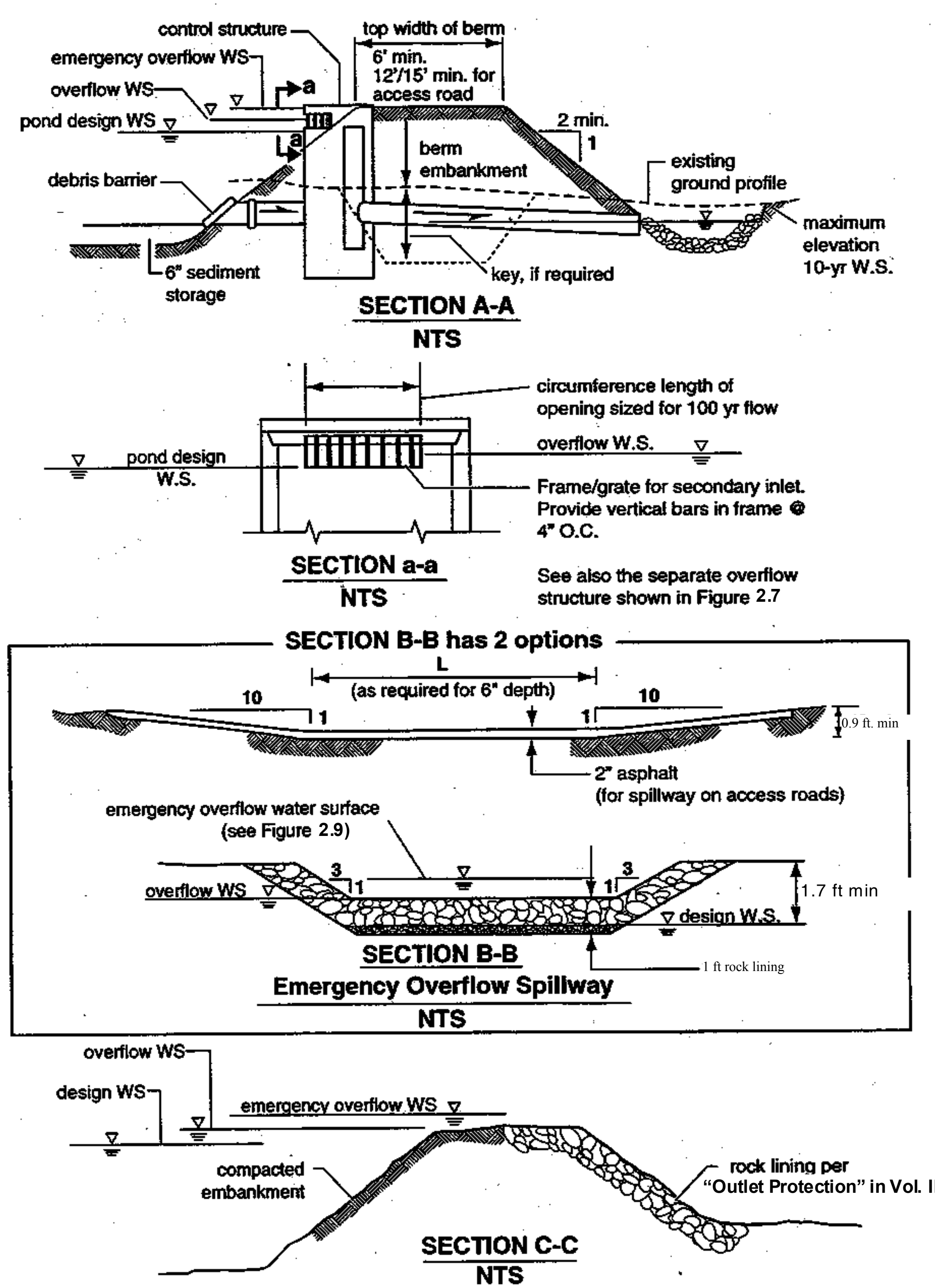


Figure 4.2. Typical Detention Pond Sections.

Geometry

- Pond bottoms must be level and be located a minimum of 0.5 foot (preferably 1 foot) below the inlet and outlet to provide sediment storage.
- Interior side slopes up to the emergency overflow water surface shall not be steeper than 3H:1V unless a fence is provided (see Appendix V-E, Fencing).
- Exterior side slopes must not be steeper than 2H:1V unless analyzed for stability by a geotechnical engineer.

Structural Design Considerations

Ponds Located near Steep Slopes or Landslide Hazard Areas

A geotechnical analysis and report must be prepared for work located within 300 feet of the top of a slope designated a landslide hazard area (as defined in Thurston County Code Title 17.15.600, typically 50 percent, or lesser slopes if seeps are present). The scope of the geotechnical report shall include the assessment of impoundment seepage on the stability of natural slopes where the facility will be located within the setback limits of steep slopes (greater than 15 percent and 10 foot height).

The Administrator or designee may require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or other prohibitions may result from this report. The geotechnical analysis and report shall address the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

Vertical Side Slopes

Vertical retaining walls including rockeries, concrete, masonry unit walls, and keystone type walls may be used to contain the pond, provided:

- They are designed by a licensed geotechnical engineer or civil engineer with structural experience and account for the saturated conditions of the base and retained soils. Structural calculations are stamped by the professional engineer.
- A fence is provided along the top of the wall (see Appendix V-E)
- The entire pond perimeter may be retaining walls, however, it is recommended that at least 25 percent of the pond perimeter be a vegetated soil slope not steeper than 3H:1V
- An access ramp to the bottom of the pond is provided.

Embankments

Pond berm embankments must meet the following requirements:

- Constructed on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical report), which is free of loose surface soil materials, roots and other organic debris

- Constructed by excavating a "key" equal to 50 percent of the berm embankment cross-sectional height and width (except on till soils where the "key" minimum depth can be reduced to 1 foot of excavation into the till)

- Constructed of compacted soil (a minimum of 95 percent of the maximum dry density, standard proctor method per ASTM D1557) placed in 6 inch lifts, with the following soil characteristics per the United States Department of Agriculture's Textural Triangle: a minimum of 30 percent clay, a maximum of 60 percent sand, a maximum of 60 percent silt, with nominal gravel and cobble content or as recommended by a geotechnical engineer. (Note: glacial till is normally well-suited for berm embankment material) The core shall be adequate to make the embankment impervious.

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

- Exposed earth on the pond side slopes shall be sodded or seeded with appropriate seed mixture (see Volume II, Erosion and Sedimentation Control BMPs). Establishment of protective vegetative cover shall be ensured with appropriate surface protection BMPs and reseeded as necessary.

- Where maintenance access is provided along the top of the berm, the minimum width of the top of the berm shall be 15 feet.

- Pond berm embankments greater than 6 feet in height shall require a design by a qualified Professional Engineer licensed in the State of Washington. Berm embankment width shall otherwise vary as recommended by the Professional Engineer.

- Embankments less than 6 feet in height shall have a minimum 6 foot top width and slopes not to exceed 2H:1V. However, maintenance access for mowing and pond access must still be provided.

- Embankments adjacent to a stream or other body of water shall be sufficiently protected with riprap or bio-engineering methods to prevent erosion of the pond embankment. Other control measures may be necessary to protect the embankment.

- Exterior and interior side slopes of retention and detention ponds that are steeper than 2H:1V, must be analyzed for stability by a qualified civil or geotechnical engineer.

- Anti-seepage filter-drain diaphragms must be placed on outflow pipes in berm embankments impounding water with depths greater than 8 feet at the design water surface. See Part IV, Section 3.3.B (pages 3-27 to 3-30) of the Dam Safety Guidelines (Ecology 2004). An electronic version of the Dam Safety Guidelines is available in PDF format at <http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html>.

Dam Safety for Detention BMPs

Stormwater facilities that can impound 10 acre-feet (435,600 cubic feet; 3.26 million gallons) or more with the water level *at the embankment crest* are subject to the state's dam safety requirements, even if water storage is intermittent and infrequent (WAC 173-175-020(1)). The principal safety concern is for the downstream population at risk if the dam should breach and allow an uncontrolled release of the pond contents. Peak flows from dam failures are typically much larger than the 100-year flows which these ponds are typically designed to accommodate.

Electronic versions of dam safety guidance documents in PDF format are available on the Department of Ecology Web site at: <http://www.ecy.wa.gov/programs/wr/dams/dss.html>.

Site Design Elements

For planting recommendations, setbacks, signage and fencing, see Appendix V-E.

Construction and Maintenance

For access road design information, see Appendix V-D.

Maintenance

Maintenance can help ensure that detention ponds continue to function as originally designed. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. Thurston County, a designated group (such as a homeowner's association) or some individual must accept responsibility for maintaining the structures and the impoundment area. It is Thurston County policy not to accept maintenance responsibility for facilities constructed by a private applicant even if they serve runoff from the public right-of-way.

A maintenance plan must be formulated that outlines the schedule and scope of maintenance operations. See Appendix V-C for information on maintenance requirements for detention ponds.

Any standing water removed during the maintenance operation must be disposed of at an approved discharge location. Any discharge to a sanitary sewer system requires approval of the sewer service provider and is generally not allowed. Pretreatment may be necessary if standing water is not free of pollutants. Residuals must be disposed in accordance with state and local solid waste regulations (see Minimum Functional Standards for Solid Waste Handling, Chapter 173-304 WAC).

4.1.2 D.02 Detention Tanks

Detention tanks are underground storage facilities typically constructed with large diameter corrugated metal pipe. Standard detention tank details are shown in Figure 4.3 and Figure 4.4.

Applicability

Detention tanks are appropriate for highly developed sites with limited land available for surface facilities.

Limitations

Detention tanks are typically laid flat or at a very low slope, so they are not likely appropriate for steep sections of roadway, due to the large amount of excavation required.

Tanks shall not be located under the travel way in public rights-of-way.

Hydrologic and Hydraulic Design Considerations

General Hydraulic Design Considerations

Tanks may either be designed as flow-through or back-up systems (see Figure 4.3).

Detention Volume

The volume and outflow design for detention tanks must comply with both Minimum Requirement #7-Flow Control in Volume I and hydrologic analysis and design methods described in Volume III.

Control Structures

Details of outflow control structures are given in Appendix V-A.

Tanks may be designed as flow-through systems or may be designed as backup systems if preceded by water quality facilities, since little sediment should reach the inlet/control structure and low head losses can be expected because of the proximity of the inlet/control structure to the tank.

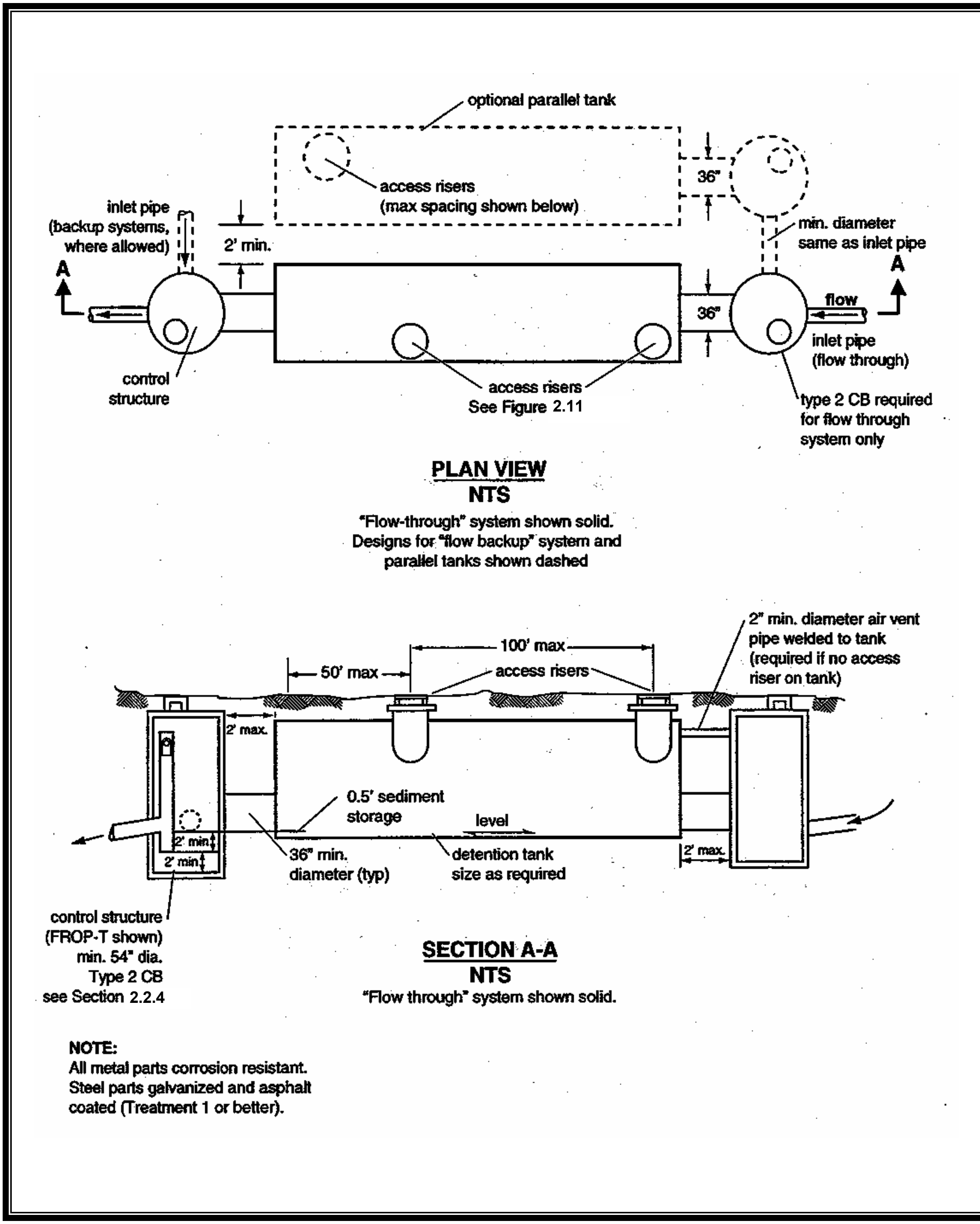
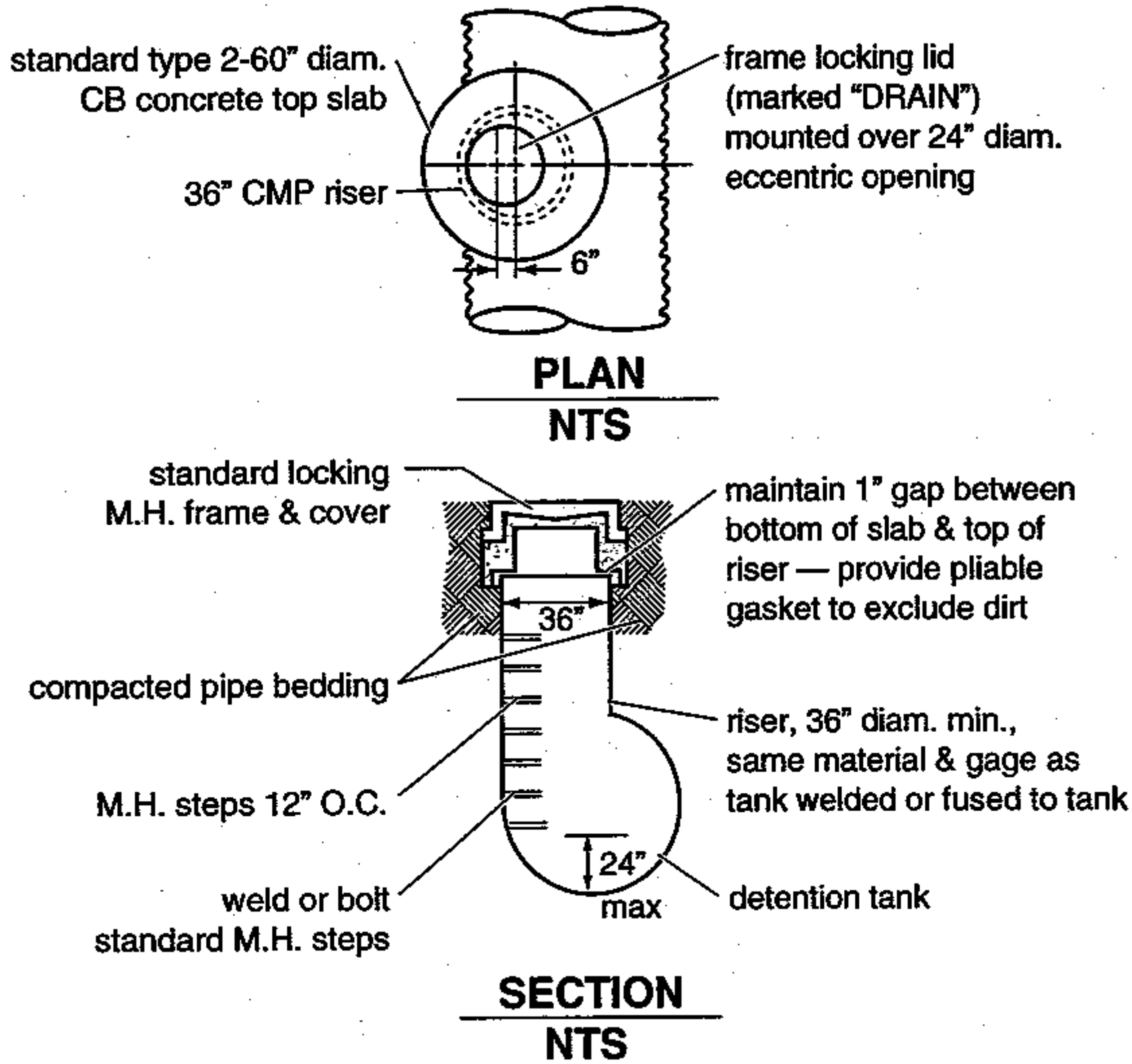


Figure 4.3. Typical Detention Tank.



Notes:

1. Use adjusting blocks as required to bring frame to grade.
2. All materials to be aluminum or galvanized and asphalt coated (Treatment 1 or better).
3. Must be located for access by maintenance vehicles.
4. May substitute WSDOT special Type IV manhole (RCP only).

Figure 4.4 Detention Tank Access Detail.

Design Criteria

Geometry

- The detention tank bottom shall be located 0.5 feet below the inlet and outlet to provide dead storage for sediment.

- The minimum pipe diameter for a detention tank is 36 inches.

- Tanks larger than 36 inches shall be connected to each adjoining structure with a short section (2-foot maximum length) of 36-inch minimum diameter pipe. These sections will not be considered as access when determining required access points.

- The maximum depth to a detention tank invert shall be 20 feet.

Materials

Materials for underground detention tanks shall conform to requirements for conveyance systems described in Volume III. Materials for pipe shall be limited to:

- Aluminum spiral rib pipe (12-gauge minimum)

- Corrugated aluminum pipe and pipe arch (12-gauge minimum)

- Reinforced concrete pipe

- Corrugated high density polyethylene pipe (CPEP) – Smooth interior

No corrugated iron or steel pipe (galvanized or aluminized) will be allowed. Galvanized metals leach zinc into the environment, especially in standing water situations. This can result in zinc concentrations that are toxic to aquatic life. Therefore, use of galvanized materials in stormwater facilities and conveyance systems is prohibited.

Pipe material, joints, and protective treatment for tanks shall be in accordance with Section 9.05 of the *WSDOT Standard Specifications for Road, Bridge, and Municipal Construction*.

Detention tanks are not to be perforated so as to provide infiltration of stormwater.

Structural Design Considerations

Structural Stability

Tanks must meet structural requirements for overburden support and traffic loading (if appropriate). H-20 live loads shall be accommodated for tanks lying under parking areas and access roads. Metal tank end plates shall be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gauge material than the pipe, and may require reinforcing ribs. Tanks shall be placed on stable, well-consolidated native material with a suitable bedding. Tanks shall not be placed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Buoyancy

Buoyancy calculations shall be required where groundwater may induce flotation. Buoyancy must be balanced by ballasting with backfill or concrete backfill, providing concrete anchors, increasing total weight, or providing subsurface drains to permanently lower the groundwater table. Calculations that demonstrate stability must be documented by the project engineer.

Access

Access requirements for detention tanks are as follows:

- Access must be provided to the upstream terminus of the tank if the tank is designed with a common inlet/outlet (e.g., a backup system rather than a flow through system).
- All tank openings must be easily accessible by maintenance vehicles.
- The maximum depth from finished grade to tank invert shall be 20 feet.
- Access points must support expected wheel loads.
- Access openings shall be positioned a maximum of 50 feet from any location within the tank.
- All tank access openings shall have round, solid locking lids (usually 1/2- to 5/8-inch diameter Allen-head cap screws).
- Thirty six-inch minimum diameter CMP riser-type manholes (Figure 4.4) of the same gage as the tank material may be used for access along the length of the tank and at the upstream terminus of the tank in a backup system. The top slab is separated (1-inch

minimum gap) from the top of the riser to allow for deflections from vehicle loadings without damaging the riser tank.

- Tanks must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

Site Design Elements

Detention tanks shall not be located under the travel way in public rights-of-way. For all residential subdivisions and mixed use developments the detention tank shall be located in a separate tract with access from a public right-of-way. See Section 3.6 of Volume III for additional requirements.

Setbacks

All stormwater vaults and tanks shall be setback from any structure or property line at least a distance equal to the depth of the ground disturbed in setting the structure. Additional setbacks are listed under BMP D.01 – Detention Pond and Appendix V-E. Vaults and tanks shall also be within tracts or easements with widths equivalent to those listed for conveyance systems in Section 3.6 of Volume III.

All facilities must be a minimum of 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

Construction and Maintenance

Maintenance

Provisions to facilitate maintenance operations must be built into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Appendix V-C for specific maintenance requirements.

Access Roads

Access roads are needed to all detention tank control structures and risers. The access roads shall be designed and constructed as specified in Appendix V-D. Access shall be provided through a tract or easement connecting to a public right-of-way. See additional access requirements in Volume III.

4.1.3 D.03 Detention Vaults

Applicability

Detention vaults are box-shaped underground storage facilities typically constructed with reinforced concrete. Detention vaults are appropriate for highly developed sites with limited land available for surface facilities.

Hydrologic and Hydraulic Design Considerations

Detention Volume and Outflow

Volume and outflow design for detention vaults must comply with both Minimum Requirement #7 in Volume I, and the hydrologic analysis and design methods described in Volume III.

Restrictor and orifice design are given in Appendix V-A.

Details of outflow control structures are given in Appendix V-A.

Design Criteria

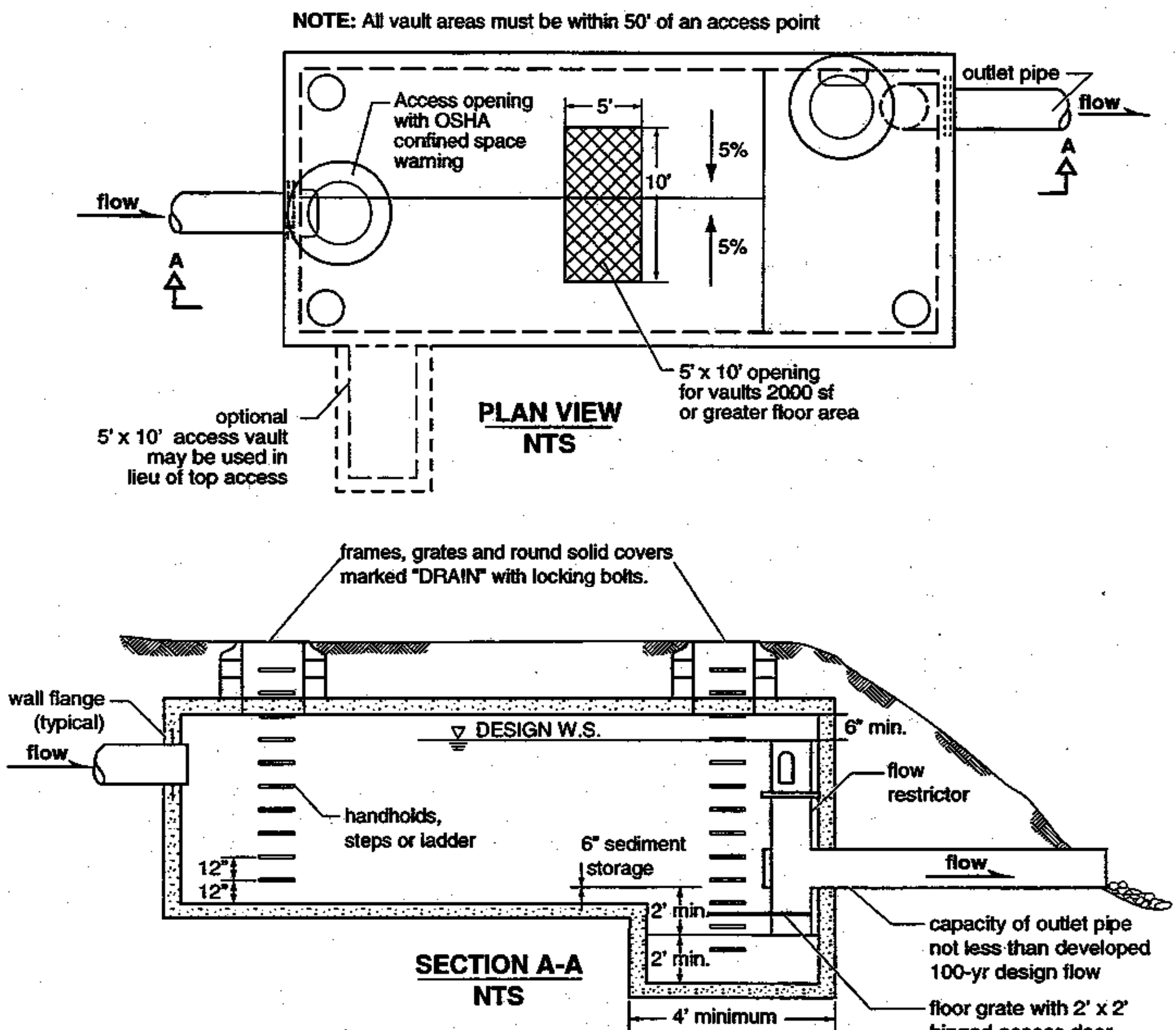
A standard detention vault detail is shown in Figure 4.5. Control structure details are shown in Appendix V-A.

Typical design guidelines are as follows:

- Detention vaults may be designed either as flow through systems with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. Distance between the inlet and outlet should be maximized where feasible.

- The detention vault bottom may slope at least 5 percent from each side towards the center, forming a broad "v" to facilitate sediment removal. More than one "v" may be used to minimize vault depth. Alternatively, the vault bottom may be flat with 0.5 to 1 foot of sediment storage if removable panels are provided over the entire vault. It is recommended that the removable panels be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.

- The invert elevation of the outlet shall be elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom. The outlet shall also be elevated a minimum of 2 feet above the orifice to retain oil within the vault.



NOTES:

1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment I or better).
2. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.
3. Vaults ≤ 10' wide must use removable lids.
4. Prefabricated vault sections may require structural modifications to support 5' x 10' opening over main vault. Alternatively, access can be provided via a side vestibule as shown.

Figure 4.5. Typical Detention Vault.

Geometry

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

- The minimum internal height shall be 7 feet, measured from the highest point of the vault floor (not sump), and the minimum width shall be 4 feet. However, concrete vaults may be a minimum 3 feet in height and width if used as tanks with access manholes at each end, and if the width is no larger than the height. The minimum internal height requirement may not be needed for any areas covered by removable panels.

Structural Design Considerations

Materials

Minimum 3,000 psi structural reinforced concrete shall be used for detention vaults. All construction joints must be provided with water stops. Pre-cast vaults or vaults made of materials other than concrete may be allowed subject to meeting the requirements of this section and with prior acceptance of the Administrator or designee.

Structural Stability

All vaults shall meet structural requirements for overburden support and H-20 traffic loading (See Standard Specifications for Highway Bridges, 1998 Interim Revisions, American Association of State Highway and Transportation Officials). Cast-in-place wall sections shall be designed as retaining walls. Structural designs for cast-in-place vaults shall be stamped by a licensed civil engineer with structural expertise. Vaults shall be placed on stable, well-consolidated native material with suitable bedding. Vaults shall not be placed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Access

Access must be provided over the inlet pipe and outlet structure. The following guidelines for access shall be used:

- Access openings must be positioned a maximum of 50 feet from any location within the tank. Additional access points may be needed on large vaults. If more than one “v” is provided in the vault floor, access to each “v” must be provided.

- For vaults with greater than 1,250 square feet of floor area, a 5' by 10' removable panel shall be provided over the inlet pipe (instead of a standard frame, grate and solid cover). Alternatively, a separate access vault may be provided as shown in Figure 3.16.

- Ladders and hand-holds 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 below.

- All access openings, except those covered by removable panels, shall have round, solid locking lids, or 3-foot square, locking diamond plate covers.

- Vaults with widths 10 feet or less shall have removable lids.

- Any vault requiring internal structural walls shall provided wall openings sufficient for maintenance access between cells. The openings shall be sized and situated to allow access to the maintenance “v” in the vault floor.

- Vaults must comply with the OSHA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

- Ventilation pipes (minimum 12-inch diameter or equivalent) shall be provided in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Alternatively removable panels over the entire vault may be provided.

Site Design Elements

Detention vaults shall not be located under the travel way in public rights-of-way. For all residential subdivisions and mixed use developments the detention vault shall be located in a separate tract with access from a public right-of-way. See Section 3.6 of Volume III for additional requirements.

Setbacks

All stormwater vaults shall be setback from any structure or property line at least a distance equal to the depth of the ground disturbed in setting the structure. Additional setbacks are listed under BMP D.01 – Detention Pond and in Appendix V-E. Vaults shall also be within tracts or easements with widths equivalent to those listed for conveyance systems in Section 3.6 of Volume III.

All facilities must be a minimum of 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

Construction and Maintenance

Maintenance

Maintenance must be a basic consideration in design and in determination of first cost. Provisions to facilitate maintenance operations must be built into the vault, including panels, access openings, and openings between structural interior walls as applicable, as specified under *structural design considerations*, above.

See Appendix V-C for additional information on maintenance requirements.

Access

An access road must be provided to the control structure, panels, and other maintenance openings. See Appendix V-D for design and construction requirements.

4.1.4 D.04 Use of Parking Lots for Additional Detention

Private parking lots may be used to provide additional detention volume for runoff events greater than the 2-year runoff event if the following requirements are met:

- The depth of water detained does not exceed 1 foot at any location in the parking lot for runoff events up to and including the 100-year event.
- The gradient of the parking lot area subject to ponding is 1 percent or greater.
- The emergency overflow path is identified and noted on the engineering plan. The overflow must not create a significant adverse impact to downhill properties or drainage system.
- Fire lanes used for emergency equipment are free of ponding water for all runoff events up to and including the 100-year event.
- No overflow to a public right-of-way occurs.

Chapter 5 - Biofiltration BMPs

5.1 Biofiltration BMPs

Biofiltration provides runoff treatment by combining vegetation with slow and shallow-depth flow. As runoff passes through the vegetation, pollutants are removed by filtration, infiltration, and settling. These effects are aided by the reduction in velocity of stormwater as it passes through the biofilter. Biofiltration facilities include *swales*, designed to convey and treat concentrated runoff at shallow depths and slow velocities, and *filter strips*, broad areas of vegetation for treating sheet flow runoff.

A biofilter can be used as a basic treatment BMP for stormwater runoff from roadways, driveways, parking lots, and other pollution generating pervious and impervious surfaces. It can also be used as the first stage of a treatment train, multiple BMPs in a series for treating contaminated stormwater runoff. Placement of the biofilter "off-line" is preferred to on-line applications to avoid flattening of the vegetation and the erosive effects of high flows.

Generally biofiltration BMPs are suitable for sites that have the following characteristics:

- Accessibility for operation and maintenance
- Suitable growth environment (soil, exposure to sunlight, etc.) for the vegetation
- Adequate change in grade to allow inflow to the biofilter and conveyance to additional treatment/detention facilities located downstream.

The following biofiltration BMPs are described in this section:

- BF.01 Basic Biofiltration Swale
- BF.02 Wet Biofiltration Swale
- BF.03 Continuous Inflow Biofiltration Swale
- BF.04 Basic Filter Strip
- BF.05 Narrow Area Filter Strip
- BF.06 Compost Amended Vegetated Filter Strip.

5.1.1 BF.01 Basic Biofiltration Swale

Biofiltration swale with check dams at Ecology headquarters

Applicability

Biofiltration swales are a low-cost, easy to construct and maintain BMP that provides basic treatment or provides pretreatment for an infiltration facility or for another enhanced BMP.

Limitations

Basic biofiltration swales require a substantial amount of open space and flat, longitudinal slopes, and so will not work on every site. A site suitable for biofiltration swales should have the following:

- Adequate space to accommodate the swale (a minimum of 100 feet long with a bottom width of 2 feet; may be larger depending on flows)
- A longitudinal slope between 1.5 percent and 2.5 percent. Shallower slopes would require an underdrain and steeper slopes would require check dams at vertical drops of 12 to15 inches.
- Maintenance access.

Submittals and Approval

Biofiltration swale calculations as outlined in this section shall be provided for each biofiltration swale included in the project. Include calculations in the submittal completed in accordance with the requirements of Volume I, Chapter 3.

Project drawings shall show the location, slope, and bottom width of each biofiltration swale. Detail sheets shall include a biofiltration swale cross-section and specifications for seeding, amending soils, sodding and other design criteria as described in this section.

Pretreatment

Pretreatment is not required.

Hydrologic and Hydraulic Design Considerations

Table 5.1. Sizing Criteria Biofiltration Swale

Design Parameter	Requirement
Longitudinal Slope	0.015 – 0.025 (unless underdrain or check dams are included in the design - see note 1.)
Maximum Velocity	1 ft/sec
Maximum velocity for channel stability[2]	3 ft/sec
Maximum water depth	2” – if mowed frequently; 4” if mowed infrequently
Manning coefficient	0.2-0.3 (0.24 if mowed infrequently
Bed width (bottom)	2-10 ft (unless dividing berm and flow spreader are incorporated into the design – see note 3.)
Freeboard height	0.5 ft
Minimum hydraulic residence time at K multiplied by WQ Design Flow Rate	9 minutes (18 minutes for continuous inflow)
Minimum length	100 ft
Maximum sideslope	3H:1V 4H:1V preferred (backslope of 2H:1V allowed for limited right-of-way areas)

Notes:

1. For swales, if the slope is less than 1.5% install an underdrain using a perforated pipe, or equivalent. Amend the soil if necessary to allow effective percolation of water to the underdrain. Install the low-flow drain 6 inches deep in the soil. Slopes greater than 2.5% need check dams (riprap) at vertical drops of 12-15 inches. Underdrains can be made of 5 inch Schedule 40 PVC perforated pipe or equivalent with 6 inches of drain gravel on the pipe. The gravel and pipe must be enclosed by geotextile fabric.
2. Maximum flowrate for channel stability shall be the 100-year, 24-hour discharge calculated with WWHM using a 15-minute time step, or alternatively the 100-year, 24-hour event using a single event hydrologic model (SBUH or SCS).
3. For swale widths up to 16 feet the cross-section can be divided with a berm (concrete, plastic, compacted earthfill) using a flow spreader at the inlet.

Design Process Overview

To design a biofiltration swale for a project, perform the following per the detailed design guidance included in this section:

- Identify the location on the site, available slope constraints, and contributing area to the swale. Determine if swale will be upstream or downstream of detention and whether on-line or off-line. Note: if swale is downstream of detention a "wet biofiltration swale" swale design is required, see BMP BF.02.
- If slope is less than 1.5 percent, an underdrain will be required. If slope greater than 2.5 percent check dams will be required.
- Perform hydrologic modeling to establish design flows using either a single-event model (SBUH or SCS) or continuous simulation model.
- Size the swale to treat the water quality design event. Minimum length is 100 feet.
- Check the hydraulic capacity/stability of the swale under the 100-year flow condition (for on-line swale only).
- Select vegetation cover suitable for the swale.
- Determine need for level spreader and establish spacing/design.

Design Flow

Biofiltration swales shall be designed to treat the water quality design storm, as calculated using the Santa Barbara Urban Hydrograph (SBUH) method for a 6-month, 24-hour storm with a Type 1A rainfall distribution (Volume III). If hydrologic calculations are being performed using a continuous hydrologic model, the water quality design flow rate predicted by an approved continuous runoff model may be multiplied by the ratio from Figure 5.1a or 5.1b (for online or off-line swales, respectively) to obtain the design flow rate. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures. Recent biofiltration sizing recommendations (9 minutes detention at the peak design flow rate estimated by SBUH for a 6-month, 24-hour storm with a Type 1A rainfall distribution) will be maintained until more definitive information on bioswale performance is collected.

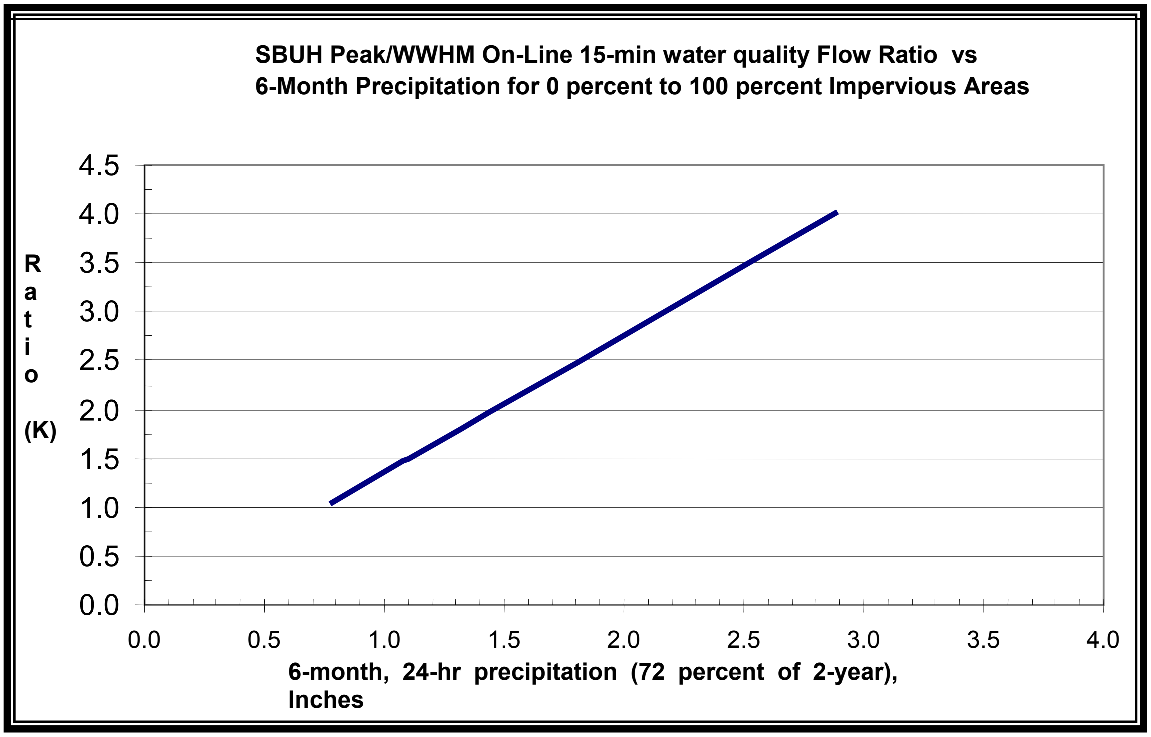


Figure 5.1.a. Ratio of SBUH Peak/Water Quality Flow.

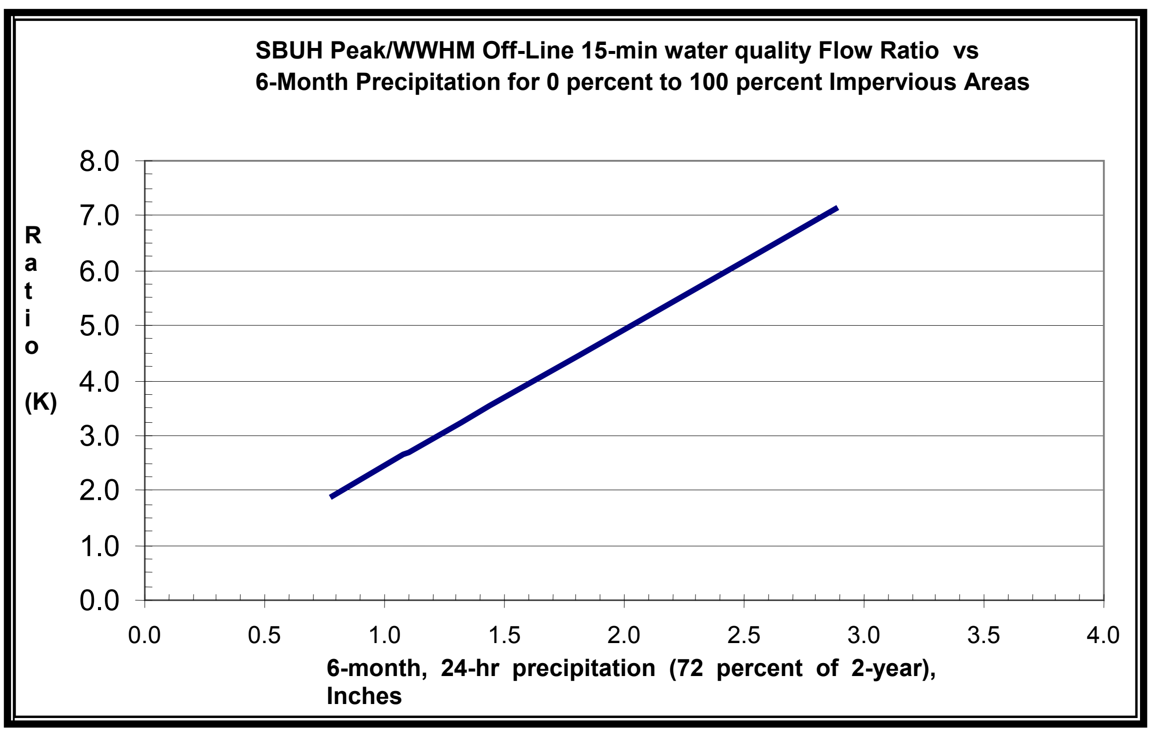


Figure 5.1.b. Ratio of SBUH Peak/Water Quality Flow.

Guidance for Bypassing Off-line Facilities

Biofiltration swales should be designed as off-line facilities, which receive only the water quality design flow rate, where feasible. For online systems, designers must evaluate the hydraulic capacity/stability for inflows greater than design flows. When designing a swale to be off-line, the stability check described under *Sizing Procedure for Biofiltration Swales* is not required.

Swales designed in an off-line mode shall not engage a bypass until the flow rate exceeds the water quality design flow rate.

Hydraulic Residence Time

The swale length must be a minimum of 100 feet. Swale length is determined by selecting swale slope and sectional properties that keep velocity below 1.0 feet per second for the water quality design flow rate and provide a minimum 9-minute hydraulic residence time (see Step D-7).

Velocity

The maximum velocity under the design flow rate is 1.0 feet per second. A velocity greater than 1.0 feet/sec has been found to flatten grasses, thus reducing filtration.

Sizing Procedure for Biofiltration Swales

This guide provides biofilter swale design procedures in full detail, along with examples.

Preliminary Steps (P)

P-1 Determine the Water Quality design flow rate (Q) in 15-minute time-steps using an approved continuous runoff model. Use the correct flow rate, off-line or online, for your design situation. Alternatively, use SBUH (Volume III) to calculate water quality design flow rate (6-month, 24-hour storm), in which case the correction factor, K, will not be required.

P-2 Establish preliminary geometry for your swale depending on your site. For initial calculations, assume the following (note that some of these design criteria may be modified if needed by adding underdrains or check dams but these are good initial assumptions):

- Longitudinal slope of 1.5 to 2.5 percent
- Minimum length 100 feet
- Width of 2 to 10 feet
- Side slopes of 3H:1V or flatter. (2H:1V Allows for backslope only in limited right-of-way applications).

Design Calculations for Biofiltration Swale

D-1. Select the design depth of flow:

- 2” if mowed frequently; 4” if mowed infrequently

D-2. Select a value of Manning's n.

- The manning coefficient will depend on the vegetation selected and the frequency of mowing. It should be in the range of 0.2 – 0.3. A manning coefficient of no less than 0.24 should be used if the swale will be mowed infrequently.

D-3. Select swale shape-typically trapezoidal.

D-4. Set up a table or spreadsheet relating flow depth to hydraulic radius, flow area, and wetted perimeter. For a trapezoidal channel, the relations will be as follows:

$A = by + (Z_1y^2 + Z_2y^2)/2$

Wetted perimeter, $P = b + d(\sqrt{1+Z_1^{\ 2}} + \sqrt{1+Z_2^2})$

Hydraulic Radius, R = A/P

Where:

A = cross-sectional area of flow (square feet)

b = bottom width of trapezoid (feet)

y = flow depth (feet)

Z_1 = side slope on one side of trapezoid ([ft of horizontal distance]/[ft of vertical distance])*;

Z_2 = side slope on other side of trapezoid ([ft of horizontal distance]/[ft of vertical distance])*

*For example, if a swale has side slopes of 3 (horizontal): 1 (vertical), $Z_1 = Z_2 = 3$.

D-5. Use Chezy-Manning equation (which yields velocity), multiplied by the area to calculate conveyance capacity and determine whether swale has adequate capacity to convey water quality design flow within maximum flow depth and velocity constraints.

$$v = \frac{1.49}{n} R^{2/3} \sqrt{s}\text{, and}$$

$$Q = vA$$

- $Y \leq 0.17$ feet if mowed frequently; $y \leq 0.33$ feet if mowed infrequently.

- $V \leq 1$ foot per second.

If the velocity exceeds 1.0 feet/sec, adjust the swale geometry (wider swale bottom, flatter side slopes, and/or flatter longitudinal slope) and repeat steps D-4 and D-5 until the condition is met.

D-7. Compute the swale length (L, feet)

$L = Vt$

Where: t = hydraulic residence time (seconds), or 540 seconds (9 minutes).

If a biofilter length is greater than the space permits, investigate how Q can be reduced (e.g., use of LID BMPs). Alternatively, reduce velocity by adjusting the swale geometry (wider swale bottom, flatter side slopes, and/or flatter longitudinal slope) and repeat the analysis.

D-8. If there is still not sufficient space for the biofilter, consider the following solutions:

- Divide the site drainage to flow to multiple biofilters

- Use infiltration to provide lower discharge rates to the biofilter (only if the infiltration requirements in Volume III are met)

- Reduce the developed surface area to gain space for biofiltration

- Nest the biofilter within or around another BMP.

Check for Stability (Minimizing Erosion)

The stability check must be performed for the combination of highest expected flow and least vegetation coverage and height. A check is not required for biofiltration swales that are located "off-line" from the primary conveyance/detention system. Maintain the same units as in the biofiltration capacity analysis.

The maximum permissible velocity for erosion prevention (Vmax) is 3 feet per second.

SC-1. Calculate 100-year recurrence interval flow using 15-minute time steps using an approved continuous runoff model or the 100-year recurrence interval, 24-hour flow from a single event model (SBUH, SCS). If 15-minute time steps are not available in the continuous simulation runoff model, the designer can use the100-year hourly peak flows times an adjustment factor of 1.6 to approximate peak flows in 15-minute time steps.

SC-2. Estimate the vegetation coverage ("good" or "fair") and height when the biofilter will receive flow, or whenever the coverage and height will be least. Avoid flow introduction during the vegetation establishment period by timing planting or bypassing.

SC-3. Estimate the degree of retardance from Table 5.2. When uncertain, be conservative by selecting a relatively low degree.

Table 5.2. Guide for Selecting Degree of Retardance [(a)]

Coverage	Average Grass Height (inches)	Degree of Retardance
Good	<2	E. Very Low
	2-6	D. Low
	6-10	C. Moderate
	11-24	B. High
	>30	A. Very High
Fair	<2	E. Very Low
	2-6	D. Low
	6-10	D. Low
	11-24	C. Moderate
	>30	B. High

[a] See Chow (1959). In addition, Chow recommended selection of retardance C for a grass-legume mixture 6-8 inches high and D for a mixture 4-5 inches high. No retardance recommendations have appeared for emergent wetland species. Therefore, judgment must be used. Since these species generally grow less densely than grasses, using a "fair" coverage would be a reasonable approach.

SC-4. Select a trial Manning's *n* for the high flow condition. The minimum value for poor vegetation cover and low height (possibly, knocked from the vertical by high flow) is 0.033. A good initial choice under these conditions is 0.04.

SC-5. See Figure 5.2 to obtain a first approximation for VR, VR_{approx}.

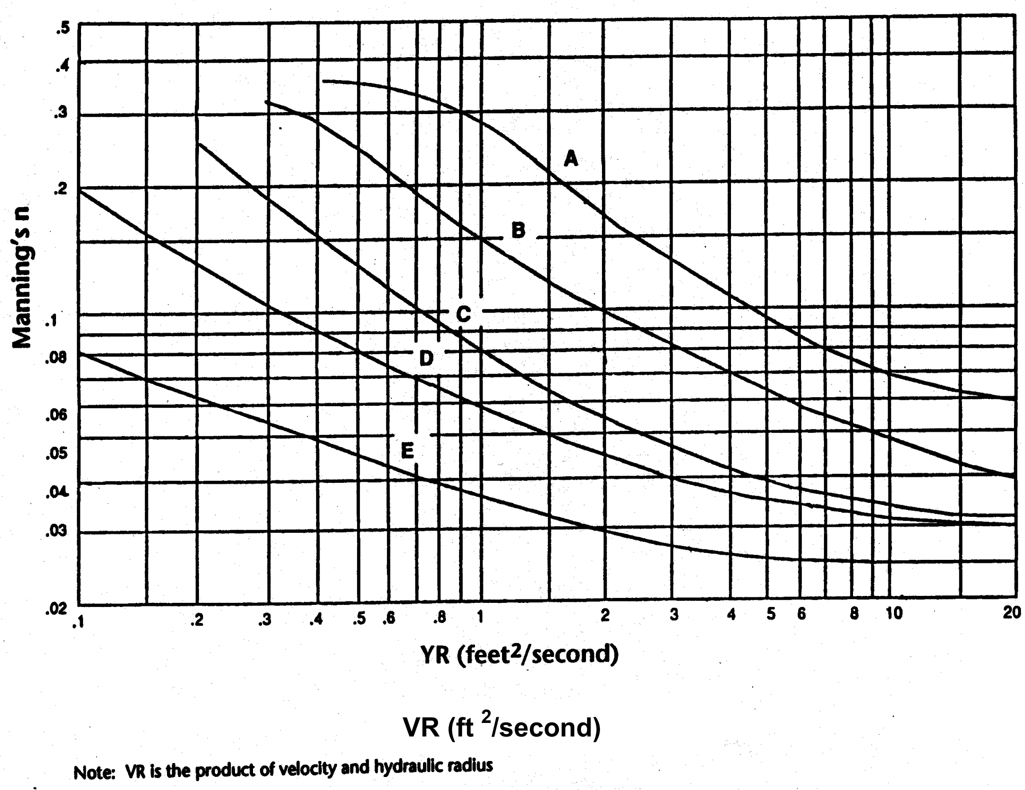
SC-6. Compute hydraulic radius, R_{100}, from VR in Figure 5.2 and a Vmax of 3 ft/second,

$R_{100} = VR_{approx} / V_{max,}$ where VR_{approx} is from Figure 5.2 (step SC-5).

SC-7. Use Chezy-Manning equation multiplied by R to solve for the actual VR:

$$vR = \frac{1.49}{n_{100}} R_{100}^{\;5/3} \sqrt{s}\,,$$

Where n_{100} is as selected in step SC-4; and R_{100} is the hydraulic radius calculated in step SC-6.



Source: Livingston, et al., 1984

Figure 5.2. The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E).

SC-8. Compare the actual VR from Step SC-7 and first approximation from Step SC-5. If they do not agree within 5 percent, repeat Steps SC-4 to SC-8 until acceptable agreement is reached. If $n<0.033$ is needed to get agreement, set $n = 0.033$, repeat Step SC-7, and then proceed to Step SC-9.

SC-9. Compute the actual V for the final design conditions:

Check to be sure $V < V_{max}$ of 3 ft/second.

SC-10. Compute the required swale cross-sectional area, A, for stability:

SC-11. Compare the A, computed in Step SC-10 of the stability analysis, with the A from the biofiltration capacity analysis (Step D-5).

If less area is required for stability than is provided for capacity, the capacity design is acceptable. If not, use A from Step SC-10 of the stability analysis and recalculate channel dimensions.

SC-12. Calculate the depth of flow at the stability check design flow rate condition for the final dimensions and use A from Step SC-10.

SC-13. Compare the depth from Step SC-12 to the depth used in the biofiltration capacity design (Step D-1). Use the larger of the two and add 0.5 feet of freeboard to obtain the total depth (y_t) of the swale. Calculate the top width for the full depth using the appropriate equation.

SC-14. Recalculate the hydraulic radius: (use b from Step D-4 calculated previously for biofiltration capacity, or Step SC-11, as appropriate, and y_t = total depth from Step SC-13).

SC-15. Make a final check for capacity based on the stability check design storm (this check will ensure that capacity is adequate if the largest expected event coincides with the greatest retardance). Use Equation 1, a Manning's n selected in Step D-2, and the calculated channel dimensions, including freeboard, to compute the flow capacity of the channel under these conditions. Use R from Step SC-14, above, and $A = b(y_t) + Z(y_t)^2$ using b from Step D-4, D-15, or SC-11 as appropriate.

If the flow capacity is less than the stability check design storm flow rate, increase the channel cross-sectional area as needed for this conveyance. Specify the new channel dimensions.

Completion Step (CO)

CO. Review all of the criteria and guidelines for biofilter planning, design, installation, and operation above and specify all of the appropriate features for the application.

Design Criteria

Figures 5.3 through 5.6 provide details of biofiltration swales.

Geometry

Length

Biofiltration swales shall have a minimum length of 100 feet but 200 feet is preferable, where feasible.

Use a wide radius curved path to gain length where land is not adequate for a linear swale (avoid sharp bends to reduce erosion or provide for erosion protection).

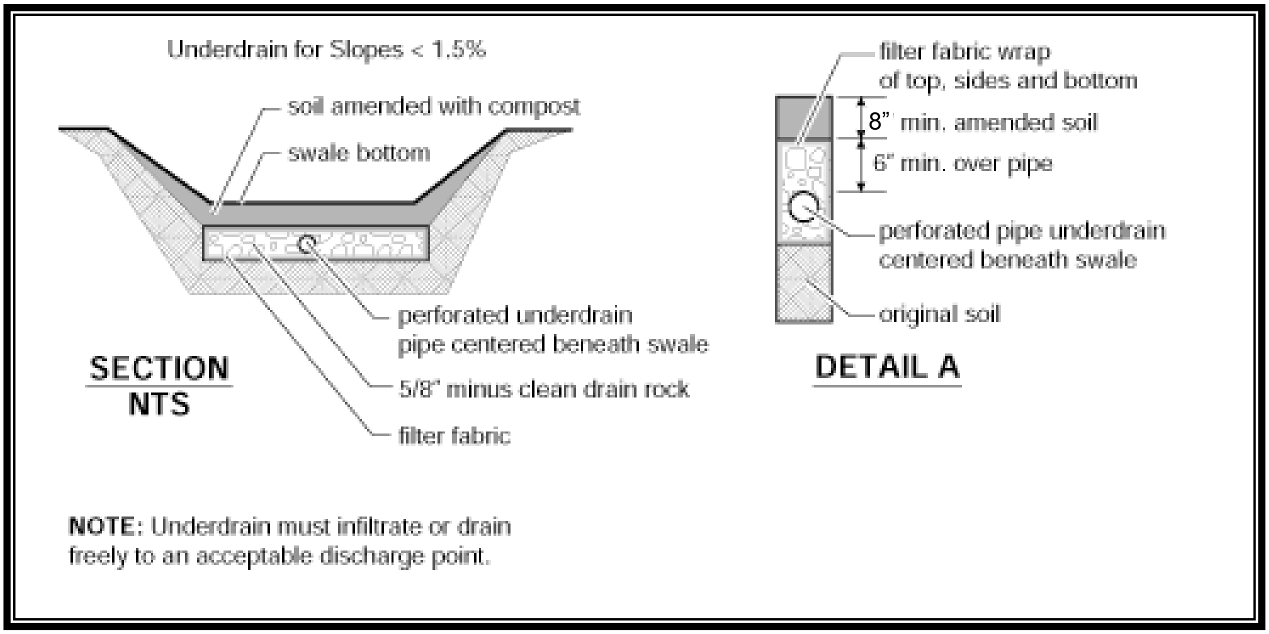


Figure 5.3. Biofiltration Swale Underdrain Detail.

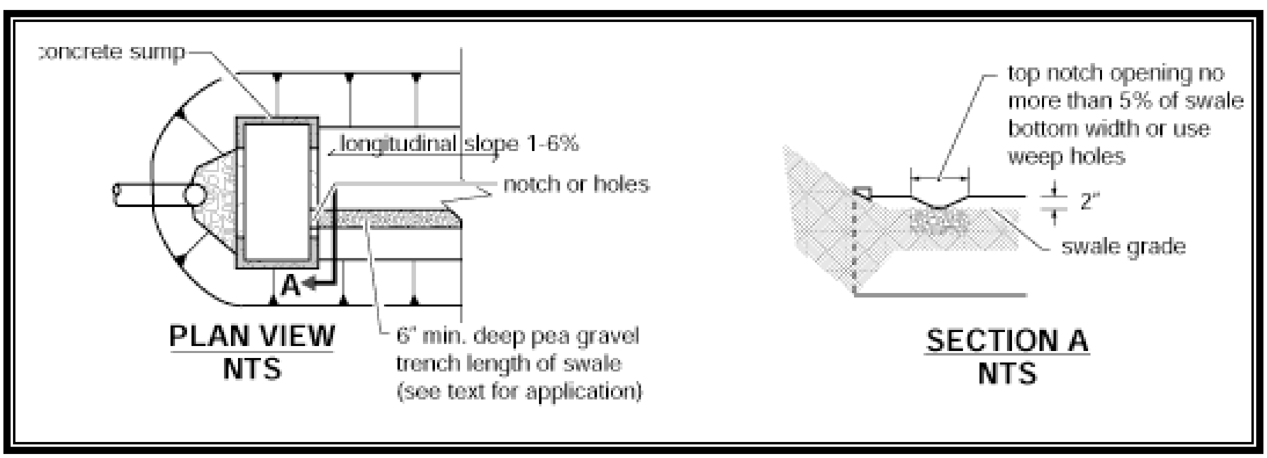
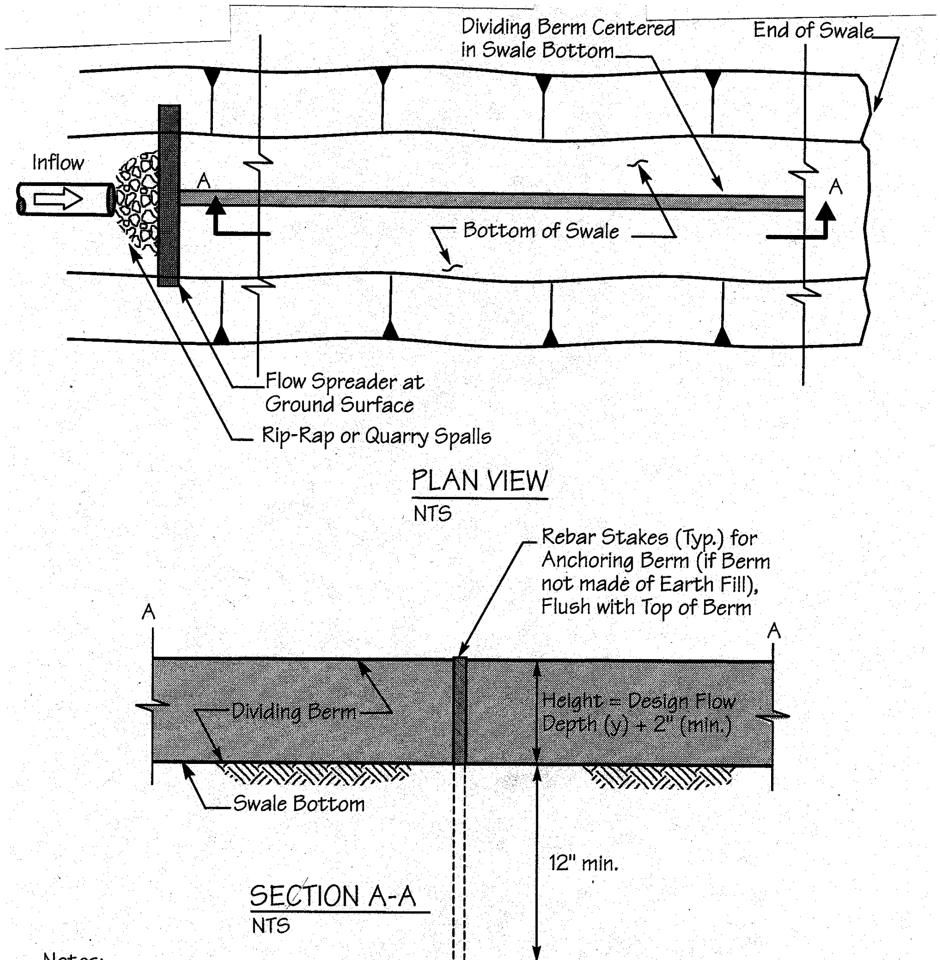


Figure 5.4. Biofiltration Swale Low-Flow Drain Detail.



Notes:

1. Berm may be Made of Compacted Earthfill (seeded with grass), Timber, Concrete Plastic, or Similar Weather - Resistant Non - Erodible Material.
2. Rebar Stakes or Similar Berm Anchoring Materials Needed if Berm Made of Timber, Plastic, or Concrete Curbing - Stake Placement Required at Both Ends of Each Individual Member (at a minimum).

Figure 5.5. Swale Dividing Berm.

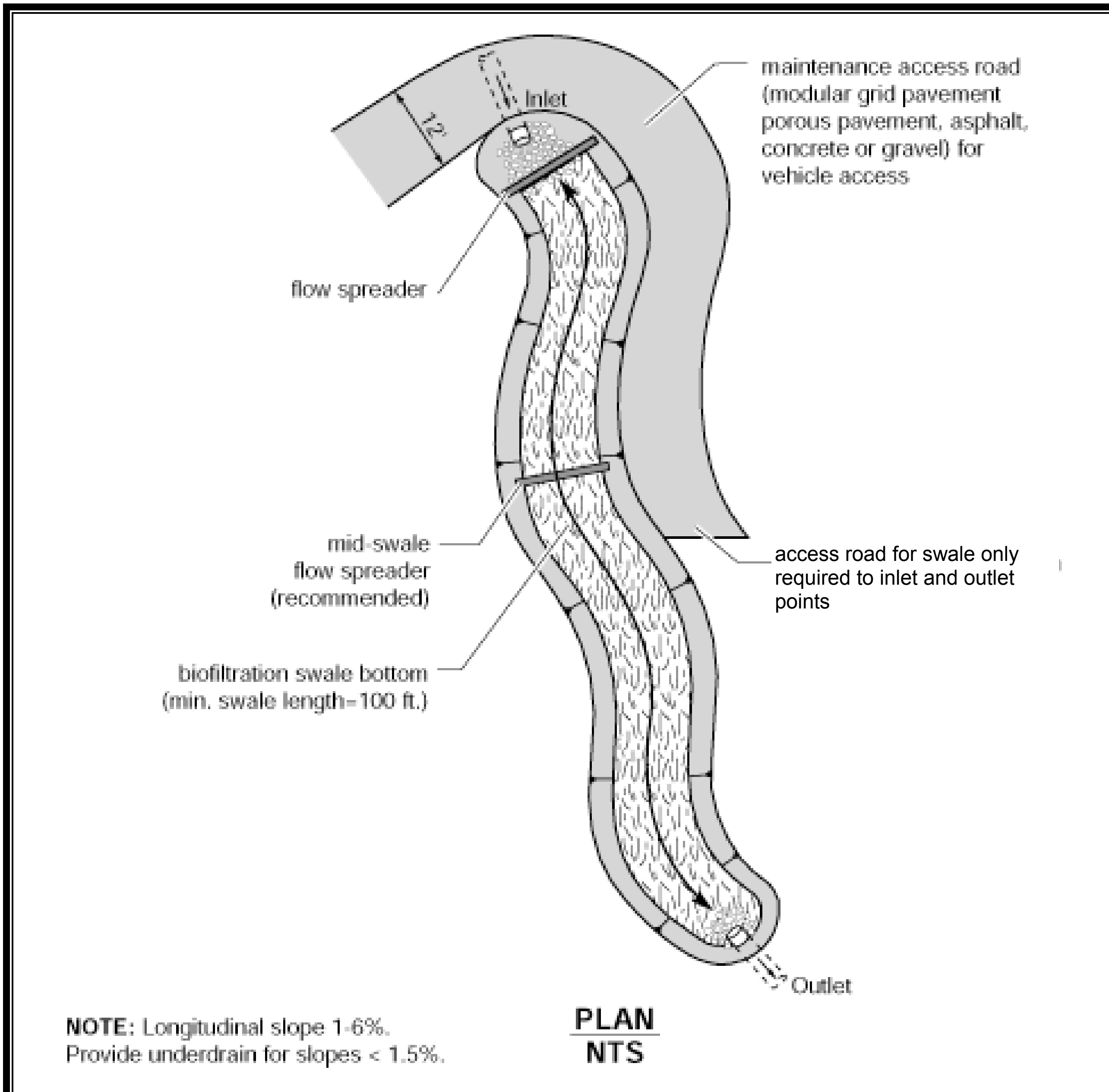


Figure 5.6. Biofiltration Swale Access Features.

Longitudinal Slope

The longitudinal slopes should be between 1.5 percent and 2.5 percent, where feasible. If a flatter or steeper slope is required, the following requirements apply:

- If the slope is less than 1.5 percent, install an underdrain using a perforated pipe or equivalent.
- Amend the soil if necessary to allow effective percolation of water to the underdrain.

- Install the low-flow drain 6 inches deep in the soil.
- Underdrains can be made of 6-inch Schedule 40 PVC perforated pipe with 6 inches of drain gravel on the pipe. The gravel and pipe must be enclosed by geotextile fabric (see Figure 5.3).
- Slopes greater than 2.5 percent need check dams (riprap) at vertical drops of 12 to 15 inches.

Effective treatment depends on flows being dispersed throughout the width of the swale. To avoid channelization, the following design elements are recommended:

- Install level spreaders (minimum 1 inch gravel) at the head and every 50 feet in swales of 4 feet width (or greater). Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofilter as needed.

Width and Cross Section

Biofiltration swales are typically trapezoidal in shape.

The swale bottom should be between 2 and 10 feet wide, unless a dividing berm is provided. For swale widths up to 16 feet the cross-section can be divided with a berm (concrete, plastic, compacted earthfill) using a flow spreader at the inlet (Figure 5.5).

Materials

Soil Criteria

The swale shall have a minimum 8 inches of topsoil that conforms to the following:

Table 5.3. Soil Recommendations for Swales

Composition	Percentage	Notes
Sandy Loam	60 to 90	A higher percentage of sand is recommended for soils with longitudinal slopes <2 percent to promote infiltration.
Clay	0 to 10	
Composted organic matter	10 to 30	Use compost amended soil where practicable. Shall not include animal waste or toxic materials.

If groundwater contamination is a concern, seal the bed with clay or a treatment liner (see Appendix V-B).

Vegetation Criteria

Tables 5.4 and 5.5 present recommended grasses and groundcovers. The following invasive species shall not be used:

- *Phalaris arundinaceae* (reed canarygrass)
- *Lythrum salicaria* (purple loosestrife)
- *Phragmites* spp. (reeds)
- *Iris pseudocorus* (yellow iris)
- *Typha* spp (Cattails).

Table 5.4. Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas

Mix 1		Mix 2	
75-80 percent	tall or meadow fescue	60-70 percent	tall fescue
10-15 percent	seaside/colonial bentgrass	10-15 percent	seaside/colonial bentgrass
5-10 percent	Redtop	10-15 percent	meadow foxtail
		6-10 percent	alsike clover
		1-5 percent	marshfield big trefoil
		1-6 percent	Redtop

Note: all percentages are by weight. * based on Briargreen, Inc.

Table 5.5. Groundcovers and Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington

Groundcovers	
kinnikinnick*	*Arctostaphylos uva-ursi*
Epimedium	*Epimedium grandiflorum*
creeping forget-me-not	*Omphalodes verna*
--	*Euonymus lanceolata*
yellow-root	*Xanthorhiza simplissima*
--	*Genista*
white lawn clover	*Trifolium repens*
white sweet clover*	*Melilotus alba*
-------	*Rubus calycinoides*
strawberry*	*Fragaria chiloensis*
broadleaf lupine*	*Lupinus latifolius*
Grasses (drought-tolerant, minimum mowing)	
dwarf tall fescues	*Festuca* spp. (e.g., Many Mustang, Silverado)
hard fescue	*Festuca ovina duriuscula* (e.g., Reliant, Aurora)
tufted fescue	*Festuca amethystine*
buffalo grass	*Buchloe dactyloides*
red fescue*	*Festuca rubra*
tall fescue grass*	*Festuca arundinacea*
blue oatgrass	*Helictotrichon sempervirens*

Select fine, turf-forming, water-resistant grasses where vegetative growth and moisture will be adequate for growth.

Use sod with low clay content in the bottom of the swale and to a depth of 1 foot to initiate adequate vegetative growth. Consider sun/shade conditions for adequate vegetative growth and avoid prolonged shading of any portion not planted with shade tolerant vegetation.

Construction and Maintenance

The biofiltration swale should not be put into operation until areas of exposed soil in the contributing drainage catchment have been sufficiently stabilized.

Effective erosion and sediment control (ESC) measures should remain in place until the swale vegetation is established (see Volume II for ESC BMPs).

Avoid compaction during construction. Grade biofilters to attain uniform longitudinal and lateral slopes.

Eight inches of top soil meeting soil criteria above shall be tilled into the top 8 inches of native soil. Sod of a type meeting the requirements of Table 5.3 shall be installed in the bottom and to a minimum of 1-foot vertical depth above the swale bottom. (Establishing a stand of grass from seed able to hold up to the flows in the swale usually takes too long to establish.) Top soil shall be placed to provide a smooth transition from the sod area to the upper swale area to be seeded.

The swale may need to be irrigated if moisture is insufficient during dry weather season.

Fertilizing a biofilter should be avoided if at all possible. Test the soil for nitrogen, phosphorous, and potassium and consult with a landscape professional about the need for fertilizer in relation to soil nutrition and vegetation requirements. If use of a fertilizer cannot be avoided, use a slow-release fertilizer formulation in the least amount needed.

Maintain access to biofilter inlet, outlet, and for mowing (Figure 5.6).

- If a swale is equipped with underdrains, vehicular traffic on the swale bottom (other than grass mowing equipment) should be avoided to prevent damage to the drainpipes.
- Biofiltration swales located within a residential subdivision shall include signage of a type approved by Thurston County indicating that the biofiltration swale is a water quality treatment facility, that no filling, grading, fertilizing or other disturbance of the swale is

allowed without prior acceptance of Thurston County. One sign shall be located at a minimum along the frontage of each lot and not greater than 200 feet for lot frontages greater than 200 feet. The signs shall be embedded in concrete or otherwise secured to prevent removal.

See Appendix V-C for additional information on maintenance requirements.

5.1.2 BF.02 Wet Biofiltration Swale

A wet biofiltration swale is a variation of a basic biofiltration swale for use where the longitudinal slope is slight, water tables are high, or continuous low base flow is likely to result in saturated soil conditions. When saturation exceeds about 2 weeks, typical grasses will die. Vegetation for wet biofiltration swales, however, is specifically adapted to withstand saturated soil conditions.

Wet swale example

Applicability

Wet biofiltration swales are applied where a basic biofiltration swale is desired but not allowed or advisable due to any of the following conditions:

- The swale is on till soils and is downstream of a detention pond providing flow control
- Saturated soil conditions are likely because of seeps or base flows on the site
- Longitudinal slopes are slight (generally less than 2 percent).

Limitations

The plants selected for wet biofiltration swales are appropriate for saturated soil conditions. Therefore, this BMP is not appropriate where stormwater is likely to infiltrate rapidly, drain quickly, or when saturated soil conditions are otherwise not expected.

Submittals and Approval

As part of submittals made as required in Volume I, include information described under BF.01 for a basic biofiltration swale.

Pretreatment

Pretreatment is not required.

Hydrologic and Hydraulic Design Considerations

Use the same design approach as for basic biofiltration swales except for the following:

- **Adjust for Extended Wet Season Flow:** If the swale will be downstream of a detention pond providing flow control, multiply the treatment area (bottom width times length) of the swale by 2, and readjust the swale length, if desired. Maintain a 5:1 length to width ratio.
- **Intent:** An increase in the treatment area of swales following detention ponds is required because of the differences in vegetation established in a constant flow environment. Flows following detention are much more prolonged. These prolonged flows result in more stream-like conditions than are typical for other wet biofilter situations. Since vegetation growing in streams is often less dense, this increase in treatment area is needed to ensure that equivalent pollutant removal is achieved in extended flow situations.
- **High-Flow Bypass:** A high-flow bypass (i.e., an off-line design) is required for flows greater than the off-line water quality design flow that has been increased by the ratio indicated in Figure 5.1b. The bypass is necessary to protect wetland vegetation from damage. Unlike grass, wetland vegetation will not quickly regain an upright attitude after being laid down by high flows. New growth, usually from the base of the plant, often taking several weeks, is required to regain its upright form. The bypass may be an open channel parallel to the wet biofiltration swale.
- **Water Depth and Base Flow:** Same as for basic biofiltration swales except the design water depth shall be 4 inches for all wetland vegetation selections, and **no underdrains or low-flow drains are required**.
- **Flow Velocity, Energy Dissipation, and Flow Spreading:** Same as for basic biofiltration swales except no flow spreader is needed.

Design Criteria

Geometry

Swale Geometry: Same as specified for basic biofiltration swales except for the following modifications:

- ***Criterion 1:*** The bottom width may be increased to 25 feet maximum, but a length-to-width ratio of 5:1 must be provided. No longitudinal dividing berm is needed. *Note: The minimum swale length is still 100 feet.*

- ***Criterion 2:*** If longitudinal slopes are greater than 2 percent, the wet swale must be stepped so that the slope within the stepped sections averages 2 percent. Steps may be made of retaining walls, log check dams, or short riprap sections. **No underdrain or low-flow drain is required**.

Materials

Soil Criteria

Same as for basic biofiltration swales (see Table 5.3).

Vegetation Criteria

A list of acceptable plants and recommended spacing is shown in Table 5.6. In general, it is best to plant several species to increase the likelihood that at least some of the selected species will find growing conditions favorable.

Table 5.6. Recommended Plants for Wet Biofiltration Swale

Common Name	Scientific Name	Spacing (on center)
Shortawn foxtail	*Alopecurus aequalis*	seed
Water foxtail	*Alopecurus geniculatus*	seed
Spike rush	*Eleocharis spp.*	4 inches
Slough sedge*	*Carex obnupta*	6 inches or seed
Sawbeak sedge	*Carex stipata*	6 inches
Sedge	*Carex* spp.	6 inches
Western mannagrass	*Glyceria occidentalis*	seed
Velvetgrass	*Holcus mollis*	seed
Slender rush	*Juncus tenuis*	6 inches
Watercress*	*Rorippa nasturtium-aquaticum*	12 inches
Water parsley*	*Oenanthe sarmentosa*	6 inches
Hardstem bulrush	*Scirpus acutus*	6 inches
Small-fruited bulrush	*Scirpus microcarpus*	12 inches

* Good choices for swales with significant periods of flow, such as those downstream of a detention facility.

Note: Cattail (*Typha latifolia*) is not appropriate for most wet swales because of its very dense and clumping growth habit which prevents water from filtering through the clump.

A wetland seed mix may be applied by hydroseeding, but if coverage is poor, planting of rootstock or nursery stock is required. Poor coverage is considered to be more than 30 percent bare area through the upper two-thirds of the swale after 4 weeks.

Site Design Elements

Access is only required to the inflow and the outflow of the swale; access along the length of the swale is not required. Also, wheel strips may not be used for access in the swale.

Intent: An access road is not required along the length of a wet swale because of infrequent access needs. Frequent mowing or harvesting is not desirable. In addition, wetland plants are fairly resilient to sediment-induced changes in water depth, so the need for access should be infrequent.

Construction and Maintenance

Construction considerations are the same as for basic biofiltration swales.

Mowing is not required. However, harvesting of very dense vegetation may be desirable in the fall after plant die-back to prevent the sloughing of excess organic material into receiving waters.

5.1.3 BF.03 Continuous Inflow Biofiltration Swale

A continuous inflow biofiltration swale is a basic swale modified by increasing its length to achieve an average residence time equivalent to a regular swale. The continuous design is needed where water enters a biofiltration swale continuously along the side slope rather than discretely at the head.

Applicability

The continuous inflow biofiltration swale is appropriate where inflows are not concentrated, such as locations along the shoulder of a road without curbs. This design may also be used where frequent, small point flows enter a swale, such as through curb inlet ports spaced at intervals along a road, or from a parking lot with frequent curb cuts.

Limitations

No inlet port should carry more than about 10 percent of the flow

A continuous inflow swale is not appropriate where significant lateral flows enter a swale at some point downstream from the head of the swale. In this situation, the swale width and length must be recalculated from the point of confluence to the discharge point, in order to provide adequate treatment for the increased flows.

Submittals and Approval

As part of submittals made as required in Volume I, include information described under BF.01 for a basic biofiltration swale.

Pretreatment

Pretreatment is not required.

Hydrologic and Hydraulic Design Considerations

The design flow for continuous inflow swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be online facilities.

If only a single design flow is used, the flow rate at the outlet shall be used. The goal is to achieve an average residence time through the swale of 9 minutes as calculated using the online water quality design flow rate multiplied by the ratio, K, in Figure 5.1a. Assuming an even distribution of inflow along the side of the swale, double the hydraulic residence time to a minimum of 18 minutes.

Design Criteria

Geometry

Same as basic biofiltration swale.

Materials

Same as specified for **basic biofiltration swale**, except for the following:

For continuous inflow biofiltration swales, interior side slopes above the water quality design treatment elevation shall be planted in grass. A typical lawn seed mix or biofiltration seed mixes are acceptable. Landscape plants or groundcovers other than grass may not be used anywhere between the runoff inflow elevation and the bottom of the swale. The use of grass on interior side slopes reduces the chance of soil erosion and transfer of pollutants from landscape areas to the biofiltration treatment area.

5.1.4 BF.04 Basic Filter Strip

A basic filter strip is flat with no side slopes (Figure 5.7). Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.

Vegetated Filter Strip in Median Along I-5 in Snohomish County

Applicability

A basic filter strip is typically used online, adjacent, and parallel to paved areas like parking lots, driveways, and roadways. The filter strip soil and vegetation criteria can also be modified to provide enhanced treatment – see *Materials under the Design Criteria* section.

Limitations

Filter strips shall only receive sheet flow. The maximum permissible tributary flow path is 150 feet.

Submittals and Approval

No additional submittals (except those described in Volume I as applicable to your project) are required.

Pretreatment

Pretreatment is not required.

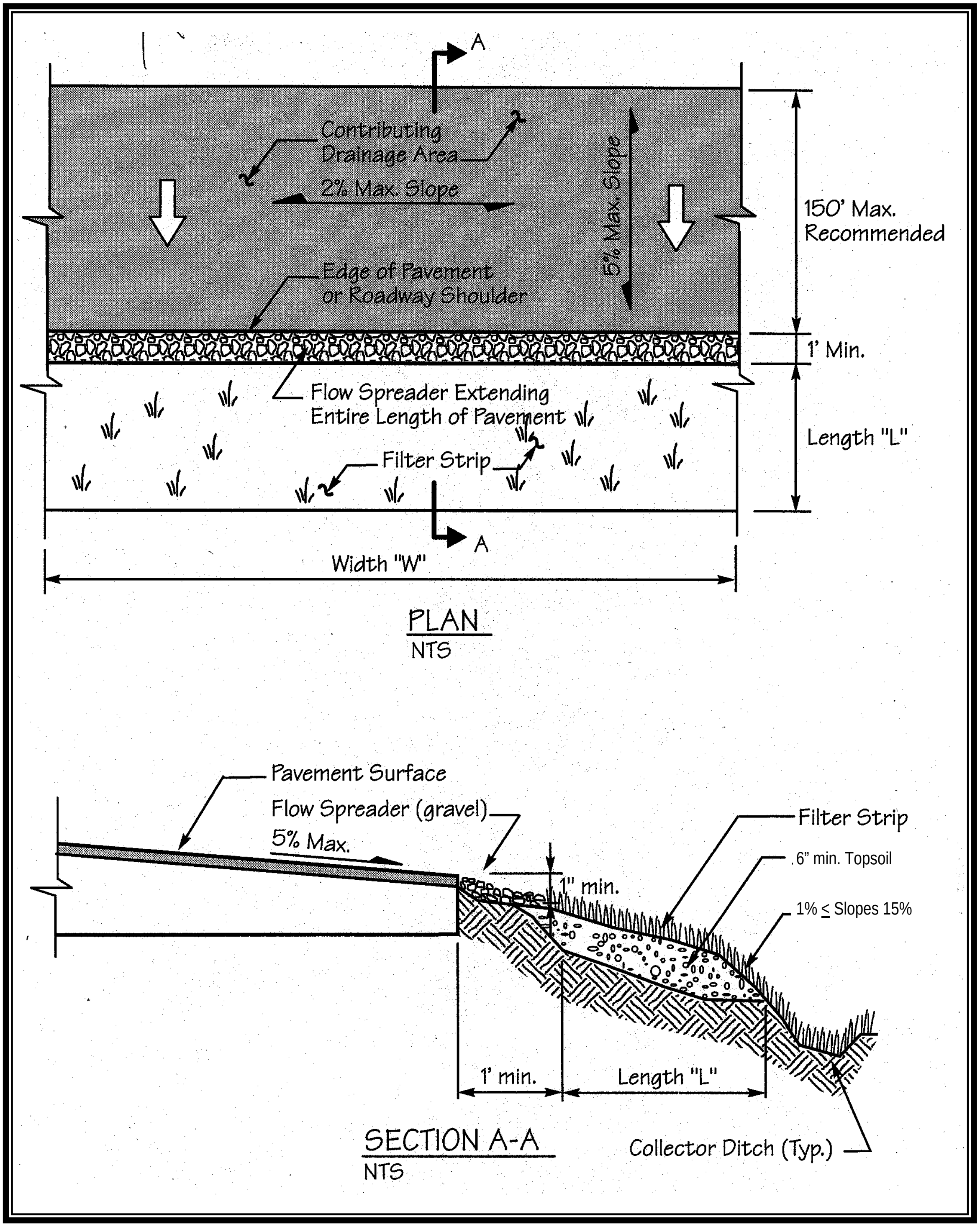


Figure 5.7. Typical Filter Strip.

Hydrologic and Hydraulic Design Considerations

Water Quality Design Flow Rate

Filter strips shall be designed to treat the water quality design storm, as calculated using the Santa Barbara Urban Hydrograph (SBUH) method for a 6-month, 24-hour storm with a Type 1A rainfall distribution (Volume III). If hydrologic calculations are being performed using a continuous hydrologic model, the water quality design flow rate predicted by an approved continuous runoff model may be multiplied by the ratio from Figure 5.1a or 5.1b to obtain the design flow rate. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures.

Maximum Water Depth

1 inch.

Maximum Velocity

0.5 feet per second.

Manning Coefficient

0.35 (0.45 if compost-amended, and mowed to maintain grass height ≤ 4 inches)

Hydraulic Residence Time

9 minutes.

Sizing Method

Calculate the design flow depth using Manning's equation as follows:

$$KQ = (1.49A\ R^{0.67}\ s^{0.5})/n$$

Substituting for AR:

$$KQ = (1.49Ty^{1.67}\ s^{0.5})/n$$

Where:

$Ty = A_{rectangle,\ ft}{}^{2}$

$y \approx R_{rectangle}$, design depth of flow, ft. (1 inch maximum)

Q = peak Water Quality design flow rate based on an approved continuous runoff model, ft^3/sec

K = The ratio determined by using Figure 5.1a. If SBUH model is used for water quality design flow rate calculations, K = 1.

n = Manning's roughness coefficient

s = Longitudinal slope of filter strip parallel to direction of flow

T = Width of filter strip perpendicular to the direction of flow, ft.

A = Filter strip inlet cross-sectional flow area (rectangular), ft^2

R = hydraulic radius, ft.

Rearranging for y:

$y = [KQn/1.49Ts^{0.5}]^{0.6}$
y must not exceed 1 inch

Note: As in swale design an adjustment factor of K accounts for the differential between the WWHM Water Quality design flow rate and the SBUH design flow.

Calculate the design flow velocity V, ft./sec., through the filter strip:

$$V = KQ/Ty$$

V must not exceed 0.5 ft./sec

Calculate required length, in feet, of the filter strip at the minimum hydraulic residence time, t, of 9 minutes:

$$L = tV = 540V$$

Design Criteria

Geometry

The slope of the filter strip (perpendicular to the roadway or other contributing area) shall be between 1 and 15 percent.

The maximum slope of contributing area flowing toward the filter strip is five percent unless flow spreading and energy dissipation is included in the design (see Figure 5.7). The maximum slope of the contributing area parallel to the filter strip is 2 percent.

The inlet edge shall be a minimum of 1 inch lower than contributing paved area.

For roadways with curbs, curb cuts shall be a minimum 12-inch wide and 1-inch above the filter strip inlet. Curb cuts shall be spaced at 10 feet intervals, maximum.

Materials

Compost Amended Vegetated Filter strip: The filter strip may be able to provide enhanced treatment where the following are met:

- Where a filter strip area is compost-amended to a minimum of 10 percent organic content in accordance with BMP LID.02;
- Hydroseeded grass maintained at 95 percent density and a 4-inch length by mowing and periodic re-seeding (possible landscaping with herbaceous shrubs)

If groundwater contamination is a concern, seal the bed with clay or a treatment liner.

5.1.5 BF.05 Narrow Area Filter Strip

A narrow area filter strip is used in impervious areas with flow paths of 30 feet or less and that can drain along their widest dimension to grassy areas.

The narrow area filter strip design method is included here because of technical limitations in the basic design method, which result (counterintuitively) in filter strips proportionately longer as the contributing drainage becomes narrower. Several parties are researching filter strip design parameters; this research may lead to more stringent design requirements that supersede the design criteria presented here.

Applicability

A narrow area filter strip could be used at roadways with limited right-of-way or for narrow parking strips.

Limitations

If space is available to use the basic filter strip design, that design shall be used in preference to the narrow filter strip.

Submittals and Approval

Submittals completed in accordance with the requirements in Chapter 3 of Volume I shall include the following:

- Calculations for filter strip length, including a copy of Figure 5.8
- Justification for use of a narrow area filter strip. Explain why a standard filter strip or other BMP could not be used. Use of a narrow area filter strip requires specific Administrator acceptance.

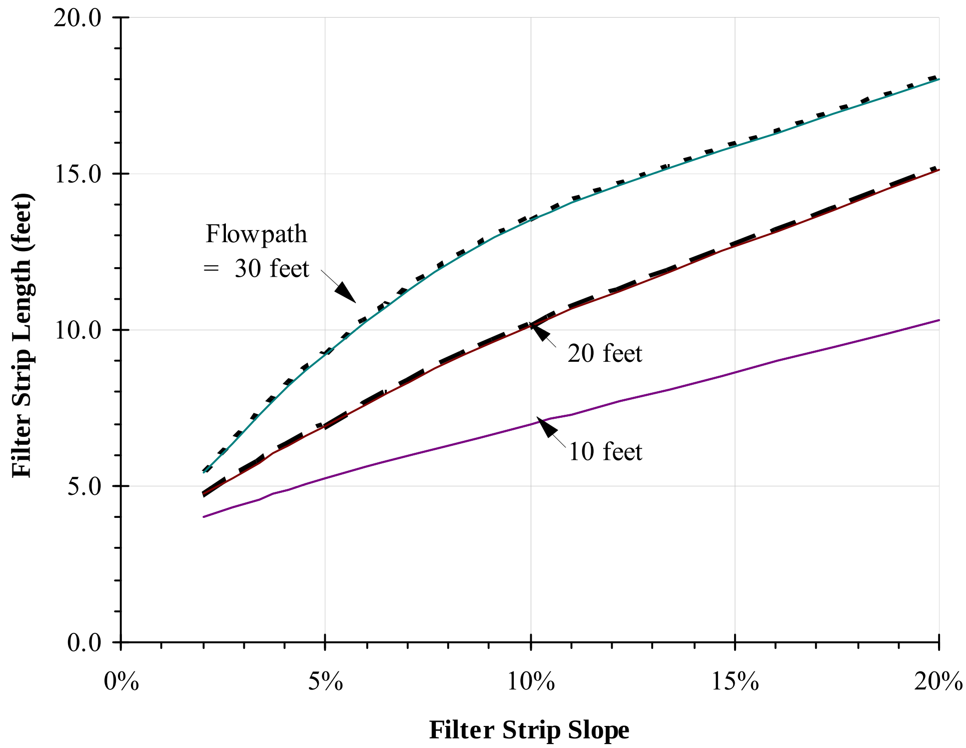
Pretreatment

Pretreatment is not required.

Hydrologic and Hydraulic Design Considerations

Design criteria for narrow area filter strips are the *same as specified for basic filter strips*. The sizing of a narrow area filter strip is based on the length of flow path draining to the filter strip and the longitudinal slope of the filter strip itself (parallel to the flow path).

Step 1: Determine the length of the flow path from the upstream to the downstream edge of the impervious area draining sheet flow to the strip. Normally this is the same as the width of the paved area, but if the site is sloped, the flow path may be longer than the width of the impervious area.



Note: minimum allowable filter strip length is 4 feet

Figure 5.8. Filter Strip Lengths for Narrow Right-of-Way.

Step 2: Calculate the longitudinal slope of the filter strip (along the direction of unconcentrated flow), averaged over the total width of the filter strip. The minimum sizing slope is 2 percent.

If the slope is less than 2 percent, use 2 percent for sizing purposes. The maximum allowable filter strip slope is 20 percent. If the slope exceeds 20 percent, the filter strip must be stepped down the slope so that the treatment areas between drop sections do not have a longitudinal slope greater than 20 percent.

Drop sections must be provided with erosion protection at the base and flow spreaders to re-spread flows. Vertical drops along the slope must not exceed 12 inches in height. If this is not possible, a different treatment facility must be selected.

Step 3: Select the appropriate filter strip length for the flow path length and filter strip longitudinal slope (Steps 1 and 2 above) from the graph in Figure 5.8. The filter strip must be designed to provide this minimum length *L* along the entire stretch of pavement draining into it.

To use the graph: Find the length of the flow path on one of the curves (interpolate between curves as necessary). Move along the curve to the point where the design longitudinal slope of the filter strip (x-axis) is directly below. Read the filter strip length on the y-axis which corresponds to the intersection point.

Chapter 6 - Wet Pool BMPs

6.1 Wet Pool BMPs

Wet pools treat stormwater runoff by allowing particulates to settle during stilling conditions ("sedimentation"), by biological uptake of dissolved pollutants, and by vegetative filtration. Wet pool facilities include wet ponds, wet vaults, and stormwater treatment wetlands. Wet pools may be single-purpose facilities, providing only runoff treatment, or may be combined with a detention pond or vault to provide flow control. If combined, the volume for detention can often be included above the wet pool with little further loss of development area.

The following wet pool BMPs are described in this chapter:

- WP.01 Stormwater Treatment Wetland
- WP.02 Wet Ponds
- WP.03 Wet vaults
- WP.04 Combined Detention/Wet Pond Facilities
- WP.05 Presettling Basins

6.1.1 WP.01 Stormwater Treatment Wetlands

Stormwater treatment wetlands are shallow, man-made ponds designed to treat stormwater using the biological processes of emergent aquatic plants (see stormwater wetland details in Figures 6.1 and 6.2).

Stormwater treatment wetlands perform well to remove sediment, metals, and pollutants that bind to humic or organic acids. Phosphorus removal in stormwater treatment wetlands is highly variable.

Note: Wetlands created to mitigate disturbance impacts (e.g., filling) may not be used as stormwater treatment facilities.

Wm Bush Park wetland in Lacey

Applicability

This design occupies about the same surface area as wet ponds, but may be better integrated aesthetically into a site because of the abundance of emergent aquatic vegetation. Stormwater treatment wetlands are a good water quality facility choice in areas with high winter groundwater levels.

A stormwater treatment wetland may provide treatment only (have a permanent pool with no live storage) or may provide both storage and treatment (have both a permanent pool and live storage). See WP.04, combined detention/wet pond facilities for more information on stormwater treatment wetlands that provide both runoff treatment and detention.

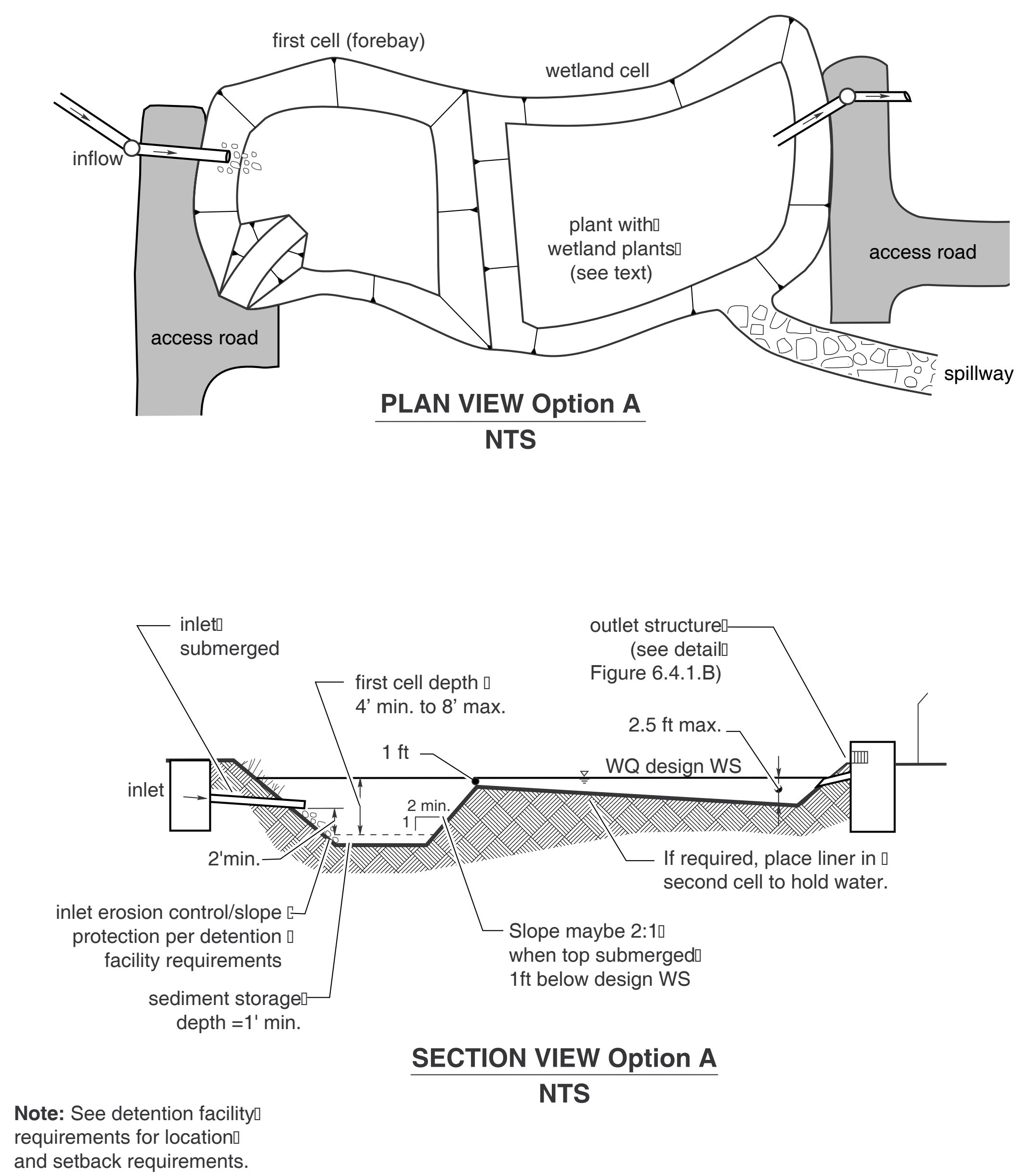


Figure 6.1. Stormwater Wetland – Option One.

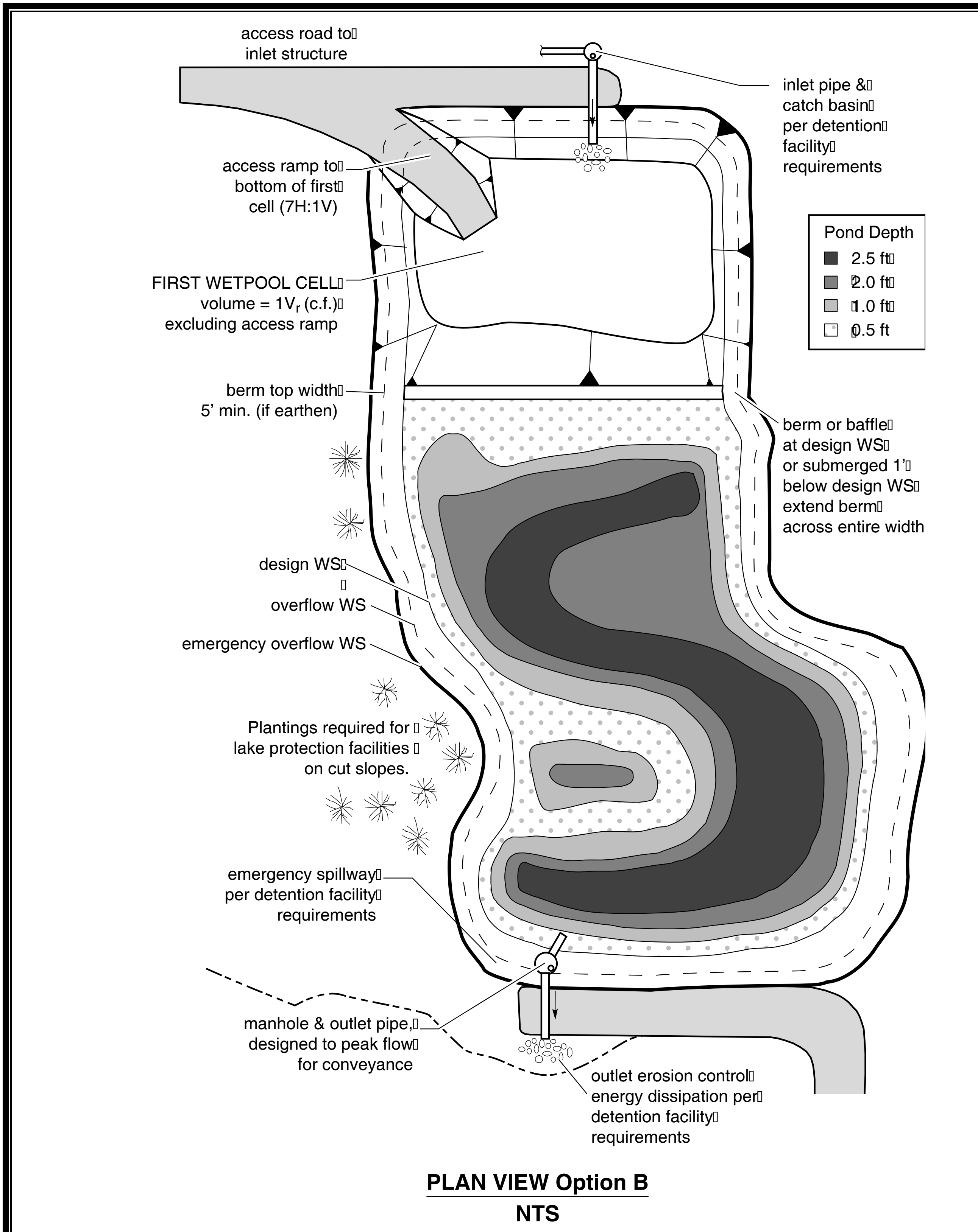


Figure 6.2. Stormwater Wetland — Option Two.

Limitations

The most critical factor for a successful design is the provision of an adequate supply of water for most of the year. Since water depths are shallower than in wet ponds, water loss by evaporation is an important concern.

A stormwater treatment wetland placed in soils with a field-saturated percolation rate of greater than 0.5 inches per hour shall be lined.

All constructed wetlands shall be designed by the project engineer in conjunction with a wetland consultant.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the stormwater wetland shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the stormwater wetland shall be lined.

Submittals and Approval

Make submittals required by Volume I and include the following information in the submittal:

- Detailed planting plan for the wetland to include species, quantity, location, and special planting considerations for all plantings to be incorporated into the wetland
- Description of liner material to be used. If lining of the stormwater wetland pond is not proposed, submit documentation from a geotechnical professional demonstrating that the soils have an infiltration rate of less than 0.5 in/hr.
- Hydrologic modeling results showing the volume required for the stormwater wetland as well as calculations showing how area and volume requirements are met for each cell
- Details of all structures and material and construction specifications
- Cross section of the stormwater wetland through the outlet structure
- Design calculations for the overflow structures
- Document that facility location meets setback requirements.

Pretreatment

Pretreatment is accomplished in the presettling cell of the wetland, so a separate pretreatment facility is not required.

Hydrologic and Hydraulic Design Considerations

When used for stormwater treatment, stormwater wetlands employ some of the same design features as wet ponds. However, instead of primarily using gravity settling for treatment, pollutant removal mediated by aquatic vegetation and the microbiological community associated with that vegetation becomes the dominant treatment process. Thus, when designing wetlands, plant vigor and biomass are primary design concerns, not water volume.

Inlets and Outlets

Inlets and outlets shall be configured using the requirements of wet ponds (see BMP WP.02).

Sizing Procedure

Step 1: The volume of a basic wet pond is used as a template for sizing the stormwater wetland. The design volume is the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model.

Step 2: Calculate the surface area of the stormwater wetland. The surface area of the wetland shall be the same as the top area of a wet pond sized for the same site conditions. Calculate the surface area of the stormwater wetland by using the volume from Step 1 and dividing by the average water depth (use 3 feet).

Step 3: Determine the surface area of the first cell of the stormwater wetland. Use the volume determined from Criterion 2 under "Wetland Geometry", and the actual depth of the first cell.

Step 4: Determine the surface area of the wetland cell. Subtract the surface area of the first cell (Step 3) from the total surface area (Step 2).

Step 5: Determine water depth distribution in the second cell. Decide if the top of the dividing berm will be at the surface or submerged (designer's choice). Adjust the distribution of water depths in the second cell according to Criterion 8 under "Wetland Geometry" below. Note: This will result in a facility that holds less volume than that determined in Step 1 above. This is acceptable.

> Intent: The surface area of the stormwater wetland is set to be roughly equivalent to that of a wet pond designed for the same site so as not to discourage use of this option.

Step 6: Choose plants. See Table 9.1 for a list of plants recommended for wet pond water depth zones, or consult a wetland scientist.

Design Criteria

Geometry

Stormwater wetlands shall consist of two cells, a presettling cell and a wetland cell.

Presettling Cell

The presettling cell shall contain approximately 33 percent of the wet pool volume calculated in Step 1 above. The depth of the presettling cell shall be between 4 feet (minimum) and 8 feet (maximum), excluding sediment storage. One foot of sediment storage shall be provided in the presettling cell.

Wetland Cell

The wetland cell shall have an average water depth of about 1.5 feet (plus or minus 3 inches).

Two examples are provided for grading the bottom of the wetland cell.

- One example is a shallow, evenly graded slope from the upstream to the downstream edge of the wetland cell (see Figure 6.1).
- The second example is a “naturalistic” alternative, with the specified range of depths intermixed throughout the second cell (see Figure 6.2). To the extent possible create a complex microtopography within the wetland, and design the flow path to maximize sinuous flow between wetland cells. A distribution of depths shall be provided in the wetland cell depending on whether the dividing berm is at the water surface or submerged (see Table 6.1 below). The maximum depth is 2.5 feet in either configuration. Other configurations within the wetland geometry constraints listed above may be approved by Thurston County.

Table 6.1. Distribution of Depths in Wetland Cell.

Dividing Berm at Water Quality Design Water Surface		Dividing Berm Submerged 1 Foot	
Depth Range (ft)	**Percent**	**Depth Range (ft)**	**Percent**
0.1 to 1	25	1 to 1.5	40
1 to 2	55	1.5 to 2	40
2 to 2.5	20	2 to 2.5	20

Berm

The "berm" separating the two cells shall be shaped such that its downstream side gradually slopes to form the second shallow wetland cell (see the section view in Figure 6.1). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see Criterion 8 below).

The top of berm shall be either at the water quality design water surface or submerged 1 foot below the water quality design water surface, as with wet ponds. Correspondingly, the side slopes of the berm must meet the following criteria:

If the top of berm is at the water quality design water surface, the berm side slopes shall be no steeper than 3H:1V.

If the top of berm is submerged 1 foot, the upstream side slope may be up to 2H:1V. If the berm is at the water surface, then for safety reasons, its slope shall be not greater than 3:1, just as the pond banks shall not be greater than 3:1 if the pond is not fenced. A steeper slope (2:1 rather than 3:1) is allowable if the berm is submerged in 1 foot of water. If submerged, the berm is not considered accessible, and the steeper slope is allowable.

Materials

Lining Requirements

Many wetland plants can adapt to periods of summer drought, however the stormwater wetland design should maximize the duration of wet conditions to the extent possible. Therefore, for all constructed wetlands placed in soils with a field-saturated percolation rate greater than 0.5 inches per hour, both cells of the stormwater wetland shall be lined with a low-permeability liner. The criteria for liners given in Appendix V-B must be observed. A minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with three parts native soil) must be placed over the liner. For geomembrane liners, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.

Vegetation

The wetland cell shall be planted with emergent wetland plants following the recommendations given in Table 6.2 or the recommendations of the wetland specialist. Note: Cattails (*Typha latifolia*) are not recommended. They tend to escape to natural wetlands and crowd out other species. In addition, the shoots die back each fall and will result in oxygen depletion in the wet pool unless they are removed.

Consultation with a wetland consultant (an individual with education and experience in freshwater or wetland biology landscape architecture, or equivalent) is required for stormwater treatment wetlands on sites with contributing areas of greater than 1 acre. The services of a wetland consultant are highly recommended, but not required, on smaller sites (contributing areas of 1 acre or less). On smaller stormwater treatment wetland projects, the project engineer may adapt the following planting approach for use without requiring a wetland consultant.

Table 6.2. Emergent Wetland Plant Species Recommended for Wet Ponds

Species	Common Name	Notes	Maximum Depth
Agrostis exarata [(1)]	Spike bent grass	Prairie to coast	to 2 ft
Carex stipata	Sawbeak sedge	Wet ground	
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	to 2 ft
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	to 2 ft
Juncus tenuis	Slender rush	Wet soils, wetland margins	
Oenanthe sarmentosa	Water parsley	Shallow water along stream and pond margins; needs saturated soils all summer	
Scirpus atrocinctus (formerly *S. cyperinus*)	Woolgrass	Tolerates shallow water; tall clumps	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sagittaria latifolia	Arrowhead		
INUNDATION 1 TO 2 FT			
Agrostis exarata [(1)]	Spike bent grass	Prairie to coast	
Alisma plantago-aquatica	Water plantain		
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	
Juncus effusus	Soft rush	Wet meadows, pastures, wetland margins	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sparganium emmersum	Bur reed	Shallow standing water, saturated soils	
INUNDATION 1 TO 3 FT			
Carex obnupta	Slough sedge	Wet ground or standing water	1.5 to 3 ft
Beckmania syzigachne [(1)]	Western sloughgrass	Wet prairie to pond margins	
Scirpus acutus [(2)]	Hardstem bulrush	Single tall stems, not clumping	to 3 ft
Scirpus validus [(2)]	Softstem bulrush		
INUNDATION GREATER THAN 3 FT			
Nuphar polysepalum	Spatterdock	Deep water	3 to 7.5 ft
Nymphaea odorata [(1)]	White waterlily	Shallow to deep ponds	to 6 ft

Notes:
(1) Non-native species. Beckmania syzigachne is native to Oregon. Native species are preferred.
(2) Scirpus tubers must be planted shallower for establishment, and protected from foraging waterfowl until established. Emerging aerial stems should project above water surface to allow oxygen transport to the roots.

Primary sources: Municipality of Metropolitan Seattle, Water Pollution Control Aspects of Aquatic Plants, 1990. Hortus Northwest, Wetland Plants for Western Oregon, Issue 2, 1991. Hitchcock and Cronquist, Flora of the Pacific Northwest, 1973.

The stormwater treatment wetland bottom and wetted side slopes shall be planted with nursery-grown plants and shrubs. Field-harvested (wild) plants may be used with approval of the wetland consultant and the Administrator or designee. The stormwater treatment wetland bottom must have suitable soil type and be tilled for planting and root establishment. Soil amendments may be necessary. All planting shall occur between the months of October and April unless otherwise approved by the Administrator or designee.

For each 1,500 square feet of stormwater treatment wetland bottom, plant at least 100 open-water or emergent plants in homogeneous groups of 10 or more, on 2-foot centers. In addition, plant at least 30 shrubs on 5-foot centers, midway between the low and high-water level. Shrubs may be from cuttings or stakes if appropriate to the type of plant and proper planting methods are used to improve survival. Plantings used must be from the recommended list in Table 6.2 unless otherwise approved by the Administrator or designee.

The wetland consultant shall monitor performance of the stormwater treatment wetland vegetation for a minimum of 2 years. Monitoring shall occur at least yearly during the summer months. Measures of success are as follows:

1. Minimum survival of shrubs shall be 80 percent. Lesser survivals may be allowed if original planting density exceeded minimums. All plants lost shall be replaced between the months of October and April by like species unless recommended otherwise by the wetland consultant and accepted by the Administrator or designee.

2. Minimum percent vegetated cover of stormwater treatment wetland bottom area, excluding exotic and invasive species, at two years shall be 50 percent. If stormwater treatment wetland cover is less than 50 percent, removal of exotic/invasive species and additional plantings may be required.

A bond or other financial guarantee to ensure the above measures of success are attained may be required.

Site Design Elements

Access and Setbacks

Location of the stormwater wetland relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as described in Appendix V-E for detention ponds.

Access and maintenance roads shall be provided and designed according to the design criteria provided in Appendix V-D. Access and maintenance roads shall extend to both the wetland inlet and outlet structures. An access ramp shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the wetland side slopes.

Construction and Maintenance

The presettling cell must include a gravity drain for maintenance.

Construction of the naturalistic alternative (Option 2) can be easily done by first excavating the entire area to the 1.5-foot average depth. Then soil subsequently excavated to form deeper areas can be deposited to raise other areas until the distribution of depths indicated in the design is achieved.

The presettling cell of a stormwater treatment wetland may be used as a sedimentation pond during construction. However, any sediment that has accumulated in the pond must be removed after construction is complete and before the stormwater treatment wetland is permanently online.

If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific site conditions. The geotechnical analysis shall address situations in which one of the two cells is empty while the other remains full of water.

The county may require a bypass/ shutoff valve to enable the stormwater treatment wetland to be taken off-line for maintenance purposes.

6.1.2 WP.02 Wet Ponds

A wet pond is a constructed stormwater pond that retains a permanent pool of water ("wet pool") during the rainy season. The larger the volume of the wet pool the more effective the pond in settling particulate pollutants. Peak flow control can be provided in the "live storage" area above the permanent pool (see BMP WP.04). Figures 6.3 and 6.4 illustrate a typical wet pond BMP.

Wetpond along Yelm Hwy in Lacey

Applicability

A wet pond requires a larger area than a biofiltration swale or a sand filter, but it can be integrated to the contours of a site fairly easily. In till soils, the wet pond holds a permanent pool of water that provides an attractive aesthetic feature.

Wet ponds may be single-purpose facilities, providing only runoff treatment, or they may be combined with a detention pond to also provide flow control. If combined, the wet pond can often be stacked under the detention pond with little further loss of development area. See BMP WP.04 for a description of combined detention and wet pool facilities.

The following design criteria cover two wet pond applications – the basic wet pond and the large wet pond.

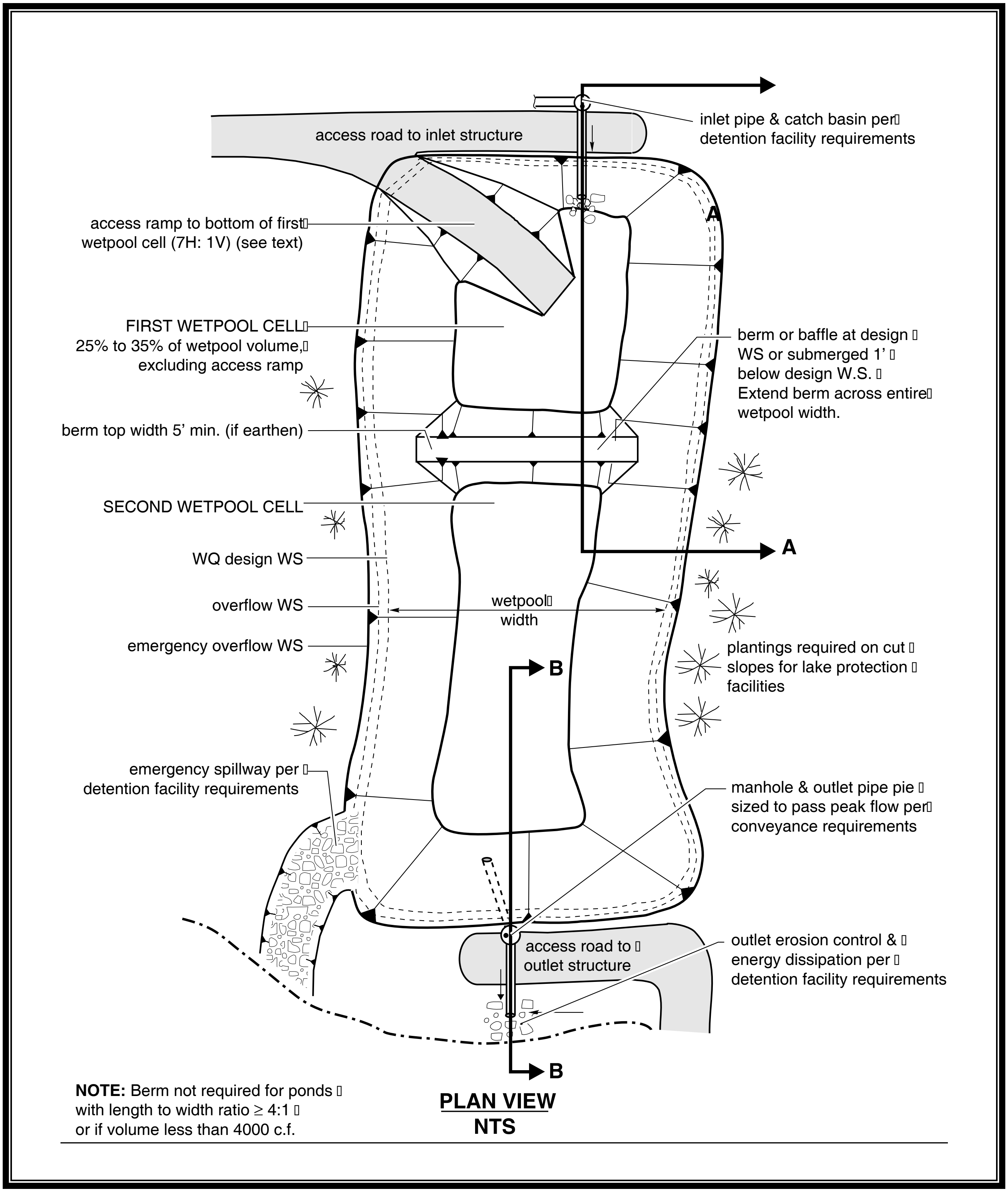


Figure 6.3. Wet Pond.

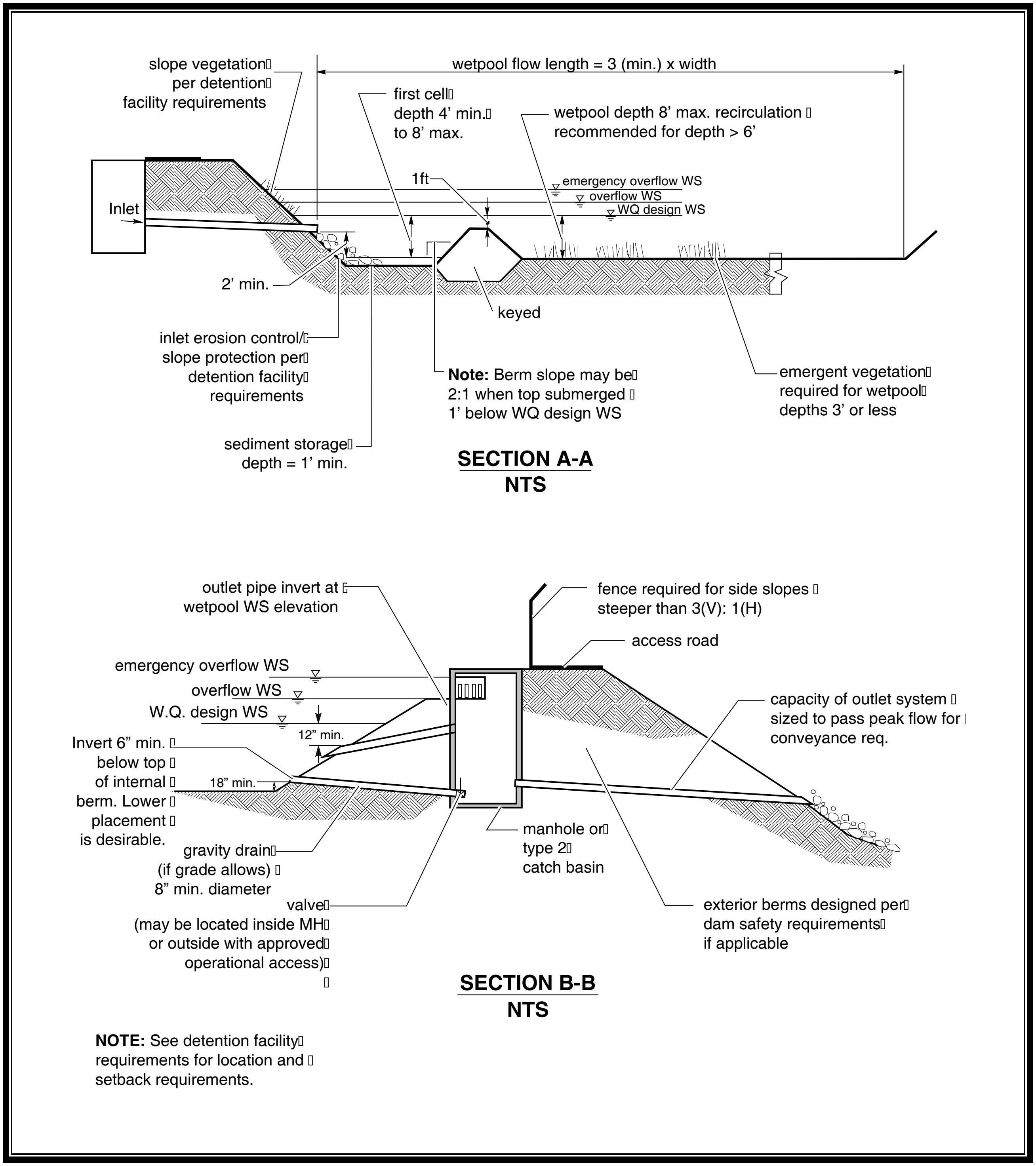


Figure 6.4. Wet Pond.

Large wet ponds are designed for higher levels of pollutant removal (phosphorus treatment).

Limitations

Wet ponds rely on a permanent pool of water for water quality treatment and aesthetics. Bioretention facilities (BMP LID.07) or infiltration basins (BMP IN.01) are better choices where there are porous soils.

If wet ponds are proposed in areas with porous soils (infiltration rate of greater than than 0.5 inches per hour), the pond will be required to be lined to maintain a permanent wet pool.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the wet pond shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the wet pond shall be lined.

Submittals and Approval

Complete applicable submittals in accordance with the requirements in Volume I. For projects proposing wet ponds for runoff treatment, provide the following information in the submittal:

- Justification for use of a wet pond. A wet pond is an allowed water quality treatment facility for projects in which a stormwater treatment wetland (BMP WP.01) is not feasible or practicable. The applicant shall explain why a stormwater treatment wetland is infeasible for the project or site, subject to acceptance of the Administrator.
- Documentation from a geotechnical professional demonstrating that the soils have an infiltration rate of less than 0.5 inches per hour if lining of the wet pond is not proposed
- Hydrologic modeling results showing the volume required for the wet pool. If the facility is a combined wet/detention pond, calculations shall also demonstrate compliance with Minimum Requirement #7 (Flow Control).
- Details of all structures and material and construction specifications
- Planting plan showing plant species, quantity, location and any special planting requirements
- Cross section of the pond through outlet structure.

- Design calculations for the overflow structures
- Documentation that facility location meets setback requirements.

Pretreatment

Pretreatment is not required for this BMP.

Hydrologic and Hydraulic Design Considerations

Wet Pool Volume

- The primary design factor that determines a wet pond's treatment efficiency is the volume of the wet pool. The larger the wet pool volume, the greater the potential for pollutant removal.

Conveyance modeling for the stormwater system leading to the wet pond must be shown to include consideration of the backwater effects of the submerged inlet.

Basic Wet Pond

For a basic wet pond, the wet pool volume provided shall be equal to or greater than volume of the 6-month, 24-hour storm or alternatively the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model.

Large Wet Pond

A large wet pond requires a wet pool volume at least 1.5 times larger than the basic wet pond.

Sizing Procedure

Procedures for determining a wet pond's dimensions and volume are outlined below.

Step 1: Identify required wet pool volume using an approved continuous runoff model – the 91st percentile, 24-hour runoff volume. A large wet pond requires a volume at least 1.5 times the 91st percentile, 24-hour runoff volume.

Step 2: Determine wet pool dimensions. Determine the wet pool dimensions satisfying the design criteria outlined below. A simple way to check the volume of each wet pool cell is to use the following equation:

$$V = \frac{h(A_1 + A_2)}{2}$$

where V = wet pool volume (cf)
h = wet pool average depth (ft)
A_1 = water quality design surface area of wet pool (sf)
A_2 = bottom area of wet pool (sf)

Step 3: Design pond outlet pipe and determine primary overflow water surface. The pond outlet pipe shall be placed on a reverse grade from the pond's wet pool to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

- Use the nomographs in Volume III, Appendix III-C to select a trial size for the pond outlet pipe sufficient to pass the online water quality design flow, Q_{wq} indicated by an approved continuous runoff model.
- Use the nomographs in Volume III, Appendix III-C to determine the critical depth d_c at the outflow end of the pipe for Q_{wq}.
- Use the nomographs in Volume III, Appendix III-C to determine the flow area A_c at critical depth.
- Calculate the flow velocity at critical depth using continuity equation ($V_c = Q_{wq} / A_c$).
- Calculate the velocity head V_H ($V_H = V_c^2 / 2g$, where g is the gravitational constant, 32.2 feet per second).
- Determine the primary overflow water surface elevation by adding the velocity head and critical depth to the invert elevation at the outflow end of the pond outlet pipe (i.e., overflow water surface elevation = outflow invert + d_c + V_H).
- Adjust outlet pipe diameter as needed and repeat steps (a) through (e).

Step 4: Determine wet pond dimensions. General wet pond design criteria and concepts are shown in Figures 6.3 and 6.4.

Velocities

The runoff shall be discharged uniformly and at a velocity below 3 feet per second in Type A and B soils, and 5 feet per second in Type C and D soils or as necessary to prevent erosion and to insure quiescent conditions within the BMP.

Outlet Structure

The inverted outlet pipe traps oils and floatables in the wet pond.

An outlet structure shall be provided. Either a Type 2 catch basin with a grated opening (jail house window) or a manhole with a cone grate (birdcage) may be used (see Appendix V-A for an example). The outlet structure receives flow from the pond outlet pipe. The grate or birdcage openings provide an overflow route should the pond outlet pipe become clogged. The overflow criteria provided below specifies the sizing and position of the grate opening.

The pond outlet pipe shall be back-sloped, or have a turn-down elbow, and extend 1 foot below the water quality design water surface. A floating outlet, set to draw water from 1 foot below the water surface, is also acceptable if vandalism concerns are adequately addressed.

The pond outlet pipe shall be sized, at a minimum, to pass the online water quality design flow. **Note**: The highest invert of the outlet pipe sets the water quality design water surface elevation.

Overflow

The overflow criteria for single-purpose (treatment only, not combined with flow control) wet ponds are as follows:

- The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a birdcage above the pond outlet structure.
- The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the water quality design flow through the pond outlet pipe. *Note: The grate invert elevation sets the overflow water surface elevation.*
- The grated opening shall be sized to pass the 100-year recurrence interval design flow. The capacity of the outlet system shall be sized to pass the peak flow for the conveyance requirements.

An emergency spillway shall be provided and designed according to the design criteria in Appendix V-A.

Base Flow

A small amount of base flow is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.

Design Criteria

Geometry

The wet pond geometry should be designed to avoid short circuiting and promote plug flow.

Plug flow describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm.

Design features that encourage plug flow and avoid dead zones are:

- A tear-drop shape, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners
- Dissipating energy at the inlet
- Providing a large length-to-width ratio
- Providing a broad surface for water exchange using a berm designed as a broad-crested weir to divide the wet pond into two cells rather than a constricted area such as a pipe
- Maximizing the flow path between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Inlets

All inlets shall enter the first cell. The inlet to the wet 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 should be submerged at least 1 foot, if possible.

> Intent: The inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

Length:width Ratio

Inlets and outlets shall be placed to maximize the flow path through the facility. The ratio of flow path length to width from the inlet to the outlet shall be at least 3:1. The flow path 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

The number of inlets to the facility should be limited; ideally there should be only one inlet. If there are multiple inlets, the length-to-width ratio shall be based on the average flow path length for all inlets.

Intent: It is anticipated that sediment removal will only be needed for the first cell in the majority of cases. The gravity drain is intended to allow water from the first cell to be drained to the second cell when the first cell is pumped dry for cleaning.

- 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.

  Intent: To prevent highly sediment-laden water from escaping the pond when drained for maintenance.

- The drain shall be at least 8 inches (minimum) 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.

  Intent: Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate shall be situated so that water pressure pushes toward the seal.

- Operational access to the valve shall be provided to the finished ground surface.

- The valve location shall be accessible and well-marked with 1 foot of paving placed around the box. It must also 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 should not be used unless unavoidable.

  Intent: Galvanized metal contributes zinc to stormwater, sometimes in very high concentrations.

Wet ponds with wet pool volumes less than or equal to 4,000 cubic feet may be single celled (i.e., no baffle or berm is required). The ratio of flow path length to width shall be at least 4:1 in single celled wet ponds, but should preferably be 5:1.

For wet ponds with wet pool volumes greater than 4,000 cubic feet, the wet pool shall be divided into two cells separated by a baffle or berm. Both cells must have level pond bottoms.

The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell). For wet pool depths in excess of 6 feet, some form of recirculation shall be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.

Pre-settling Cell

The first cell shall contain between 25 to 35 percent of the total wet pool volume. 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.

Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1 foot.

Second Cell

Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see Planting requirements).

Baffle or Berm

A berm or baffle shall extend across the full width of the wet pool, and tie into the wet pond side slopes.

The baffle or berm volume shall not count as part of the total wet pool volume. The full-length berm or baffle promotes plug flow and enhances quiescence and laminar flow through as much of the entire water volume as possible. Alternative methods to the full-length berm or baffle that provide equivalent flow characteristics may be approved on a case-by-case basis by Thurston County.

The term baffle means a vertical divider placed across the entire width of the pond, stopping short of the bottom. A berm is a vertical divider typically built up from the bottom, or if in a vault, connects all the way to the bottom.

Side Slopes

Provide side slopes that are sufficiently gentle to avoid the need for fencing (3H:1V or flatter).

Submerged Berm

The top of the berm may extend to the water quality design water surface, or be 1 foot below the water quality design water surface. If at the water quality design water surface, berm side slopes should be 3H:1V. Berm side slopes may be steeper (up to 2:1) if the berm is submerged 1 foot. Submerging the berm is intended to enhance safety by discouraging pedestrian access when side slopes are steeper than 3H:1V. An alternative to the submerged berm design is the use of barrier planting to prevent easy access to the divider berm in an unfenced wet pond.

If good vegetation cover is not established on the berm, erosion control measures should be used to prevent erosion of the berm back-slope when the pond is initially filled.

Materials

Lining

Liners, if required, shall meet the requirements of Appendix V-B.

Soils

The method of construction of soil/landscape systems can cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations. The soil formulation will impact the plant species that will flourish or suffer on the site, and the formulation should be such that it encourages desired species and discourages undesired species.

On most pond sites, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon in very poor soils.

Vegetation

Planting requirements for detention ponds also apply to wet ponds.

Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating. In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.

Large wet ponds intended for phosphorus control shall not be planted within the cells, as the plants will release phosphorus in the winter when they die off.

If the second cell of a basic wet pond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 6.2 for recommended emergent wetland plant species for wet ponds.

> Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

Cattails (*Typha latifolia*) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.

If the wet pond discharges to a phosphorus-sensitive lake or wetland (see Chapter 4 of Volume I), shrubs that form a dense cover should be planted on slopes above the water quality design water surface on at least three sides. For banks that are berms, no planting is allowed if the berm is regulated by dam safety requirements. The purpose of planting is to discourage waterfowl use of the pond and to provide shading. Some suitable trees and shrubs include:

- Vine maple (*Acer circinatum*)
- Wild cherry (*Prunus emarginata*)
- Red osier dogwood (*Cornus stolonifera*)
- California myrtle (*Myrica californica*)
- Indian plum (*Oemleria cerasiformis*)
- Pacific yew (*Taxus brevifolia*)
- Numerous ornamental species.

Structural Design Considerations

The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it should be submerged 1 foot below the design water surface to discourage access by pedestrians.

Embankments that impound water must comply with the Washington State Dam Safety Regulations (Chapter 173-175 WAC). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or

3.26 million gallons) above natural ground level, then dam safety design and review are required by Ecology.

No trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety.

Site Design Elements

The following design features should be incorporated to enhance aesthetics where possible:

- Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.
- Create flat areas overlooking or adjoining the pond for picnic tables or seating that can be used by residents. Walking or jogging trails around the pond are easily integrated into site design.
- Include fountains or integrated waterfall features for privately maintained facilities
- Provide visual enhancement with clusters of trees and shrubs
- Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.

Setbacks

Location of a wet pond relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as described in Appendix V-E for detention ponds.

Access

Access and maintenance roads shall be provided and designed according to the requirements in Appendix V-D. Access and maintenance roads shall extend to both the wet pond inlet and outlet structures. An access ramp shall be provided to the bottom of all cells, unless trackhoe (maximum reach of 20 feet) can reach all portions of the cell and can load a truck parked at the pond edge or on the internal berm of a wet pond or combined pond.

The access and maintenance road could be extended along the full length of the wet pond and could double as play courts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.

If the dividing berm is also used for access, it shall be built to sustain loads of up to 80,000 pounds.

Construction and Maintenance

As with other similar BMPs, wet ponds may be used as sedimentation ponds during construction. However, any sediment that has accumulated in the pond must be removed after construction is complete and before the pond is permanently online.

If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific site conditions. The geotechnical analysis shall address situations in which one of the two cells is empty while the other remains full of water.

The County may require a bypass/ shutoff valve to enable the pond to be taken off-line for maintenance purposes.

A gravity drain for maintenance is required where feasible. The engineer must demonstrate why a drain is not feasible and show in the Maintenance Plan how to drain the pond.

6.1.3 WP.03 Wet Vaults

A wet vault is an underground structure similar in appearance to a detention vault, except with a permanent pool of water (wet pool) that dissipates energy and improves the settling of particulate pollutants (see Figure 6.5). Being underground, the wet vault lacks biological pollutant removal mechanisms (e.g., algae uptake) present in surface wet ponds.

Wet vault construction at Bellingham

Applicability

A wet vault requires specific acceptance of the Administrator or designee. With acceptance, a wet vault may be used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other treatment BMPs. The use of wet vaults for residential development is highly discouraged.

If oil control is required for a project, a wet vault may be combined with an API oil/water separator.

Limitations

A wet vault is believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper. There is also concern that oxygen levels will decline, especially in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.

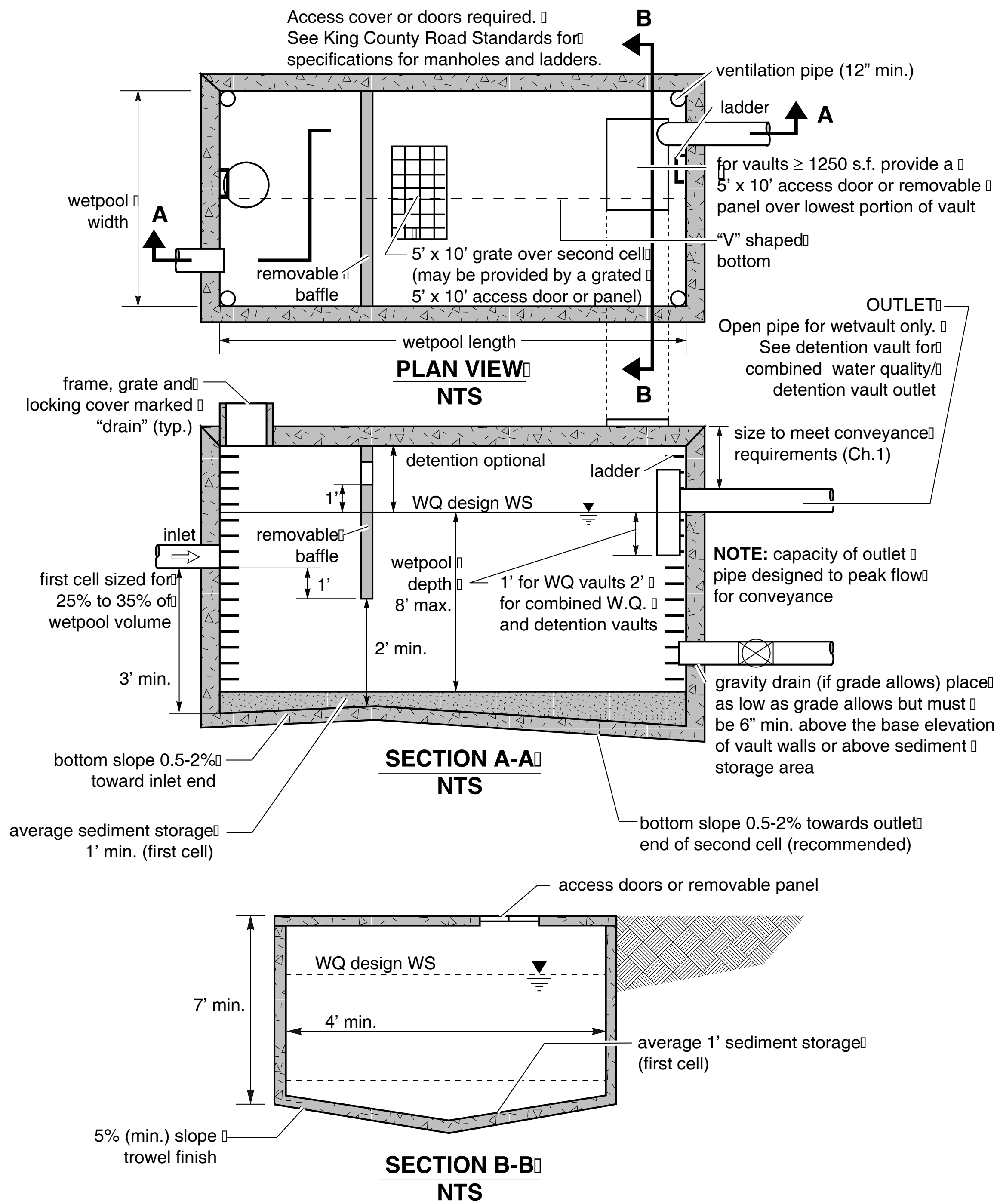


Figure 6.5. Wet Vault.

Below-ground structures like wet vaults are difficult and expensive to maintain. The need for maintenance is often not seen and as a result routine maintenance does not occur.

Submittals and Approval

The use of a wet vault for runoff treatment is restricted to those circumstances where other alternatives are not feasible of practicable due to situations such as limited space or safety concerns. Its use requires the specific acceptance of the Administrator or designee. The applicant shall submit to the Administrator or designee the justification for using a wet vault for the project and why other runoff treatment facilities are not suitable.

If use of a wet vault is approved for the project, include documentation of acceptance and calculations in the submittal prepared for the project in accordance with the requirements of Chapter 3 of Volume I.

Pretreatment

A catch basin structure shall be installed upstream from the wet vault with a minimum sediment storage depth of 2 feet to capture large sediment and debris prior to entry to the vault.

Hydrologic and Hydraulic Design Considerations

Wet Vault Sizing

As with wet ponds, the primary design factor that determines the removal efficiency of a wet vault is the volume of the wet pool. The larger the volume, the more effective the pollutant removal.

The sizing procedure for a wet vault is identical to the sizing procedure for a wet pond. The wet pool volume for the wet vault shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event using a single event hydrologic model (SBUH/SCS). Alternatively, the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model may be used.

Design Criteria

Typical design details and concepts for the wet vault are shown in Figure 6.5.

Geometry

Pollutant removal performance of wet vaults may be improved by avoiding dead zones (like corners) where little exchange occurs, using large length-to-width ratios (a flow length-to-width ratio greater than 3:1

minimum is desirable), dissipating energy at the inlet, and ensuring that flow rates are uniform to the extent possible and not increased between cells.

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

Where possible, the inlet and outlet should be at opposing corners of the vault to increase the flow path.

Inlet

The number of inlets to the wet vault should be limited, and the flow path length should be maximized from inlet to outlet for all inlets to the vault.

The inlet to the wet vault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom. The top of the inlet pipe should be submerged at least 1 foot, if possible.

> Intent: The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

Outlet

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 pipe must be a minimum of 6 inches.

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

Baffle

If a removable baffle is used, the following criteria apply:

- The baffle shall extend from a minimum of 1 foot above the WQ design water surface to a minimum of 1 foot below the invert elevation of the inlet pipe.
- The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.
- 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, the baffle or wall may be omitted and the vault may be one-celled.

- The second cell may be level (longitudinally) sloped toward the outlet, with a high point between the first and second cells. The intent of sloping the bottom is to direct the sediment accumulation to the closest access point for maintenance purposes. Sloping the second cell towards the access opening for the first cell is also acceptable.

- The vault bottom shall slope laterally a minimum of 5 percent 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: Thurston County may allow the vault bottom to 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.

- 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.

- Provision for passage of flows should the outlet plug shall be provided.

- Wet vaults may be constructed using arch culvert sections provided the top area at the WQ design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet.

  Intent: To prevent decreasing the surface area available for oxygen exchange.

- Wet vaults shall conform to the "Materials" and "Structural Stability" criteria specified for detention vaults (BMP D.03).

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

Presettling Cell

The sediment storage in the first cell shall be an average of 1 foot. Because of the v-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the schedule below:

Vault Width	Sediment Depth (from bottom of side wall)
15'	10"
20'	9"
40'	6"
60'	4"

Where feasible, the bottom of the first cell shall be sloped toward the access opening. Slope shall be between 0.5 percent (minimum) and 2 percent (maximum).

Second Cell

The second cell shall be a minimum of 3 feet deep since planting cannot be used to prevent resuspension of sediment in shallow water as it can in open ponds.

Where feasible, the floor of the second cell should slope toward the outlet for ease of cleaning.

Materials

Wet Vaults shall meet the material requirements and structural design considerations for Detention Vaults as listed in BMP D.03, Section 4.1.3 of Volume V.

Modifications for Combining with a Baffle Oil/Water Separator

If the project site is a high-use site (see Volume I) and a wet vault is proposed, the vault may be combined with a baffle oil/water separator to meet the runoff treatment requirements 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 more frequent inspection and cleaning than for a wet vault used only for TSS removal. See Appendix V-C for information on maintenance of baffle oil/water separators.

The following additional design criteria apply to wet vaults combined with baffle oil/water separators:

- The sizing procedures for the baffle oil/water separator (Chapter 8) shall be run as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a larger vault size, increase the wet vault size to match.

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

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

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

- The vault shall be watertight and shall be coated to protect from corrosion.

- 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.

- Wet vaults used as oil/water separators must be off-line and must bypass flows greater than the off-line WQ design flow multiplied by the off-line ratio indicated in Figure 5.1.b. *Intent: This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.*

Structural Design Considerations

The two cells of a wet vault shall 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 flow path. *Intent: Treatment effectiveness in wet pool 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.*

If a wall is used to separate the two cells, a 5-foot by 10-foot removable maintenance access must be provided for both cells.

Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03, of this Volume).

Construction and Maintenance

Lockable grates instead of solid manhole covers are recommended to increase air contact with the wet pool.

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 percent 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. *Intent: The grate allows air contact with the wetpool in order to minimize stagnant conditions which can result in oxygen depletion, especially in warm weather.*

Thurston County may require a bypass/shutoff valve to enable the vault to be taken off-line for maintenance.

Sediment that has accumulated in the vault must be removed after construction in the drainage area is complete. If no more than 12 inches of sediment have accumulated after the infrastructure is built, cleaning may be left until after building construction is complete. In general, sediment accumulation from stabilized drainage areas is not 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.

6.1.4 WP.04 Combined Detention and Wet Pool Facilities

Combined detention and water quality wet pool facilities look like detention facilities, but also contain a permanent pool of water. The following design procedures, requirements, and recommendations describe differences in the design of standalone water quality facilities when combined with detention storage.

Applicability

The following combination facilities are summarized in this section:

Table 6.3. Combined Detention and Wetpool Facilities

Facility	Flow Control	Level of Treatment
Basic detention/wetpond	Flow control	Basic treatment
Large detention/wetpond	Flow control	Phosphorus treatment
Detention/wetvault	Flow control	Basic Treatment
Detention/stormwater wetland	Flow Control	Basic Treatment

Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area.

Limitations

The fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone water quality facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wet pool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wet pool volume, the live storage component of the facility shall be provided above the seasonal high water table.

For projects located within a designated Well Head Protection Area (WHPA) for a public water system with over 1,000 connections the bottom of the wet pond shall be above the seasonal high groundwater elevation. Where less than 3-feet of separation exists to seasonal high groundwater, the wet pond shall be lined.

Submittals and Approval

Make submittals required by Volume I and as required for the individual detention or wet pool / wet vault BMP. Include the following information in the submittal:

- Hydrologic modeling results showing the volume required for the wet pool as well as calculations demonstrating compliance with flow control minimum requirements
- Justification for not providing a liner, if lining the facility is not proposed
- Details of all structures and material and construction specifications
- Planting plan showing plant species, quantity, location and any special planting requirements
- Cross section of the pond through the control structure
- Design calculations for the overflow structures
- Documentation of how the facility location meets setback requirements.

Pretreatment

No pretreatment is required. Except that if the combined facility is a wet vault/detention vault then a catch basin with a minimum 2-foot sediment depth shall be installed immediately upstream from the vault.

Hydrologic and Hydraulic Design Considerations

The sizing procedure for combined detention and wet ponds are identical to those outlined for wet ponds and for detention facilities. The wet pool volume for a combined facility shall be equal to or greater than the 91st percentile, 24-hour runoff volume estimated by an approved continuous runoff model. Follow the standard procedure specified in Volume III to size the detention portion of the pond.

Design Criteria

Typical design details and concepts for a combined detention and wet pond are shown in Figures 6.6 through 6.8. The detention portion of the facility shall meet the design criteria and sizing procedures set forth in BMP D.01.

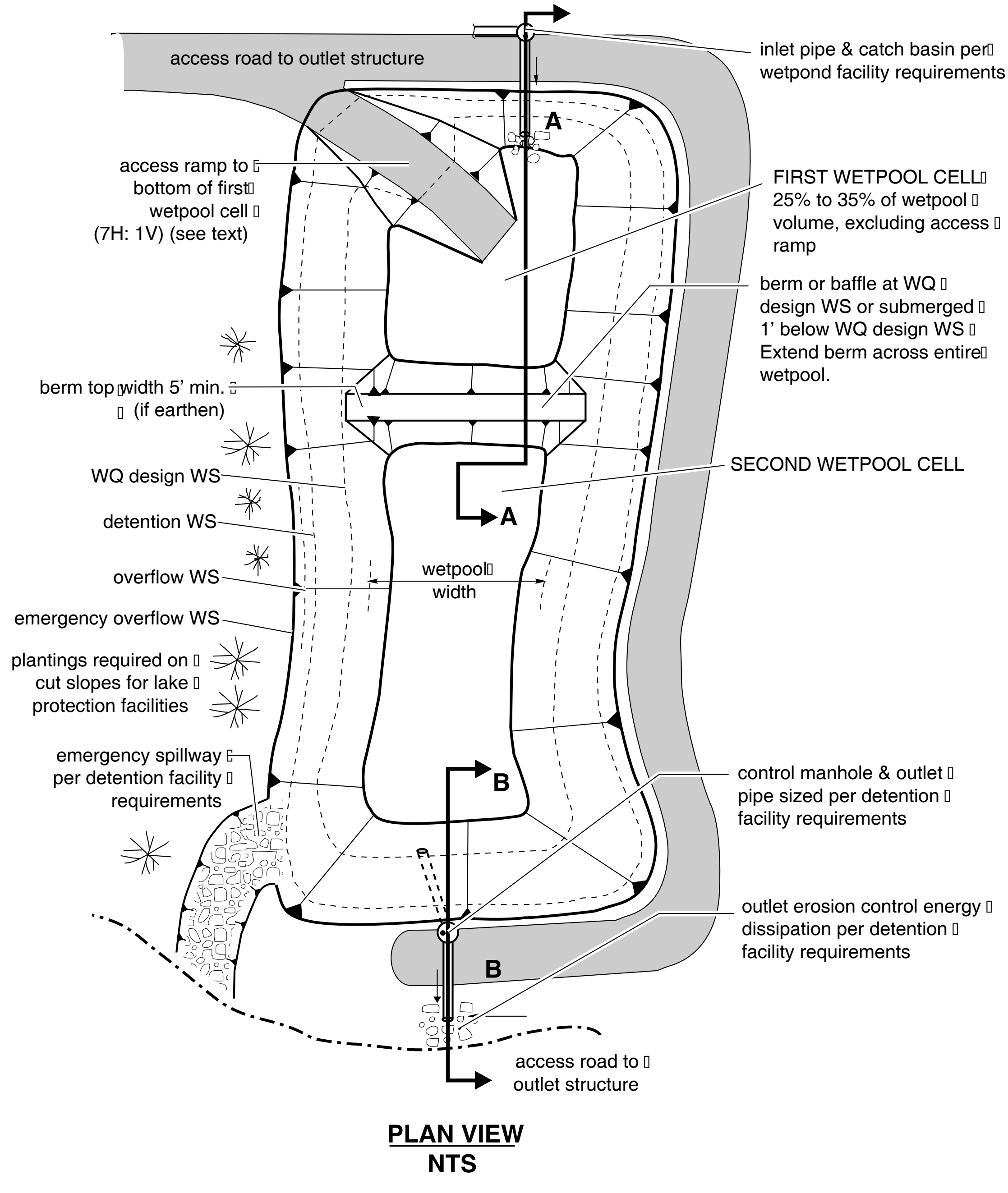


Figure 6.6. Combined Detention and Wetpond.

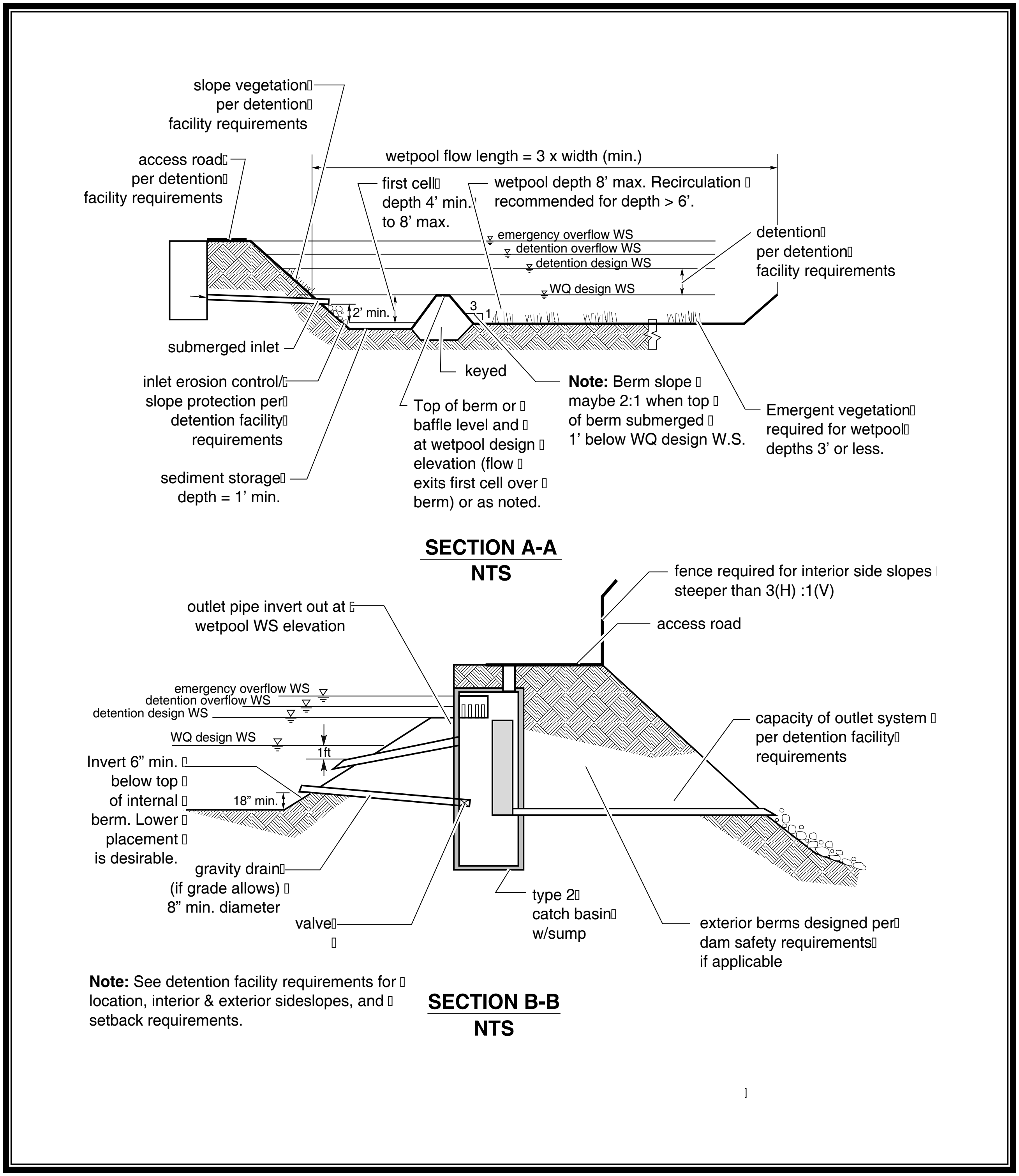
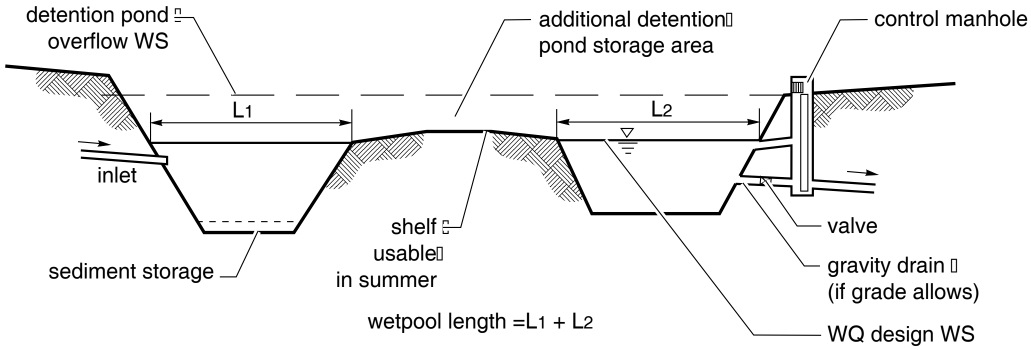
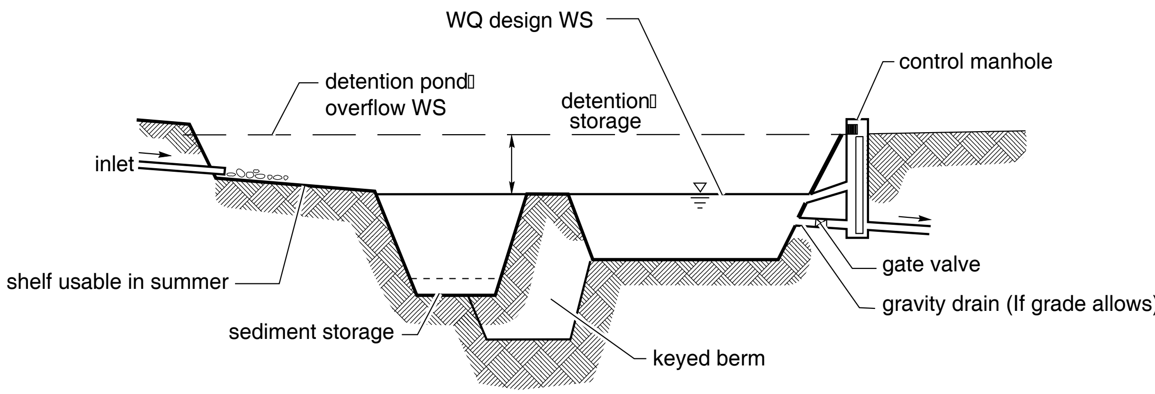


Figure 6.7. Combined Detention and Wetpond (continued).



SECTION VIEW
NTS



SECTION VIEW
NTS

Note: These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.

Figure 6.8. Alternative Configurations of Detention and Wetpool Areas.

Detention Pond and Wet Pond

Geometry

The wet pool and sediment storage volumes shall not be included in the required detention volume.

The "Wet Pool Geometry" criteria for wet ponds (see BMP WP.02) shall apply with the following modifications/clarifications:

- Criterion 1: The permanent pool may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wet pool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wet pond criteria governing water depth must, however, still be met. See Figure 6.8 for two possibilities for wet pool cell placement.

  Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months.

- Criterion 2: The minimum sediment storage depth in the first cell is 1 foot. The 6 inches of sediment storage required for detention ponds do not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

Berms, Baffles, and Slopes

Same as for wet ponds (see BMP WP.02).

Inlet and Outlet

The "Inlet and Outlet" criteria for wet ponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined ponds.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for control structures in Volume V-A.

Planting Requirements

Same as for wetponds.

Access and Setbacks

Same as for wetponds.

Combined Detention and Wetvault

Geometry

Minimum sediment storage depth in the first cell shall average 1 foot. The 6 inches of sediment storage required for detention vaults do not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.

The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator.

Inlet and Outlet

The inlet and outlet criteria for wet vaults shall apply with the following modifications:

- Provide a sump in the outlet structure of the vault
- Design the detention flow restrictor and its outlet pipe according to the requirements for detention vaults.

Combined Detention and Stormwater Wetland

Sizing Criteria

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure outlined in BMP WP.01 to determine the stormwater wetland size. Follow the standard procedure for sizing a detention pond for the detention portion of the wetland.

Water Level Fluctuations Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

Geometry

The design criteria for detention ponds and stormwater wetlands must both be met, except for the following modifications or clarifications:

- The minimum sediment storage depth in the first cell is 1 foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

Inlet and Outlet Criteria

The inlet and outlet criteria for wetponds shall apply with the following modifications:

- Provide a sump in the outlet structure of combined facilities
- Design the detention flow restrictor and its outlet pipe according to the requirements for detention ponds.

Planting Requirements

The Planting Requirements for stormwater wetlands are modified to use the following plants which are better adapted to water level fluctuations:

- *Scirpus acutus* (hardstem bulrush) 2 – 6’ depth
- *Scirpus microcarpus* (small-fruited bulrush) 1 – 2.5’ depth
- *Sparganium emersum* (burreed) 1 – 2’ depth
- *Sparganium eurycarpum* (burrreed) 1 – 2’ depth
- *Veronica* sp. (marsh speedwell) 0 – 1’ depth

In addition, the shrub *Spirea douglasii* (Douglas spirea) may be used in combined facilities.

Access and Setbacks

Same as for stormwater wetlands.

6.1.5 WP.05 Presettling Basins & Pretreatment

A presettling basin is a structure that provides pretreatment of runoff to remove coarser-grained suspended solids, which can impact other runoff treatment BMPs.

Applicability

Removal of suspended solids pretreatment helps prevent clogging or excessive sedimentation in the main water quality facility. Pretreatment is required:

- For sand filters and infiltration BMPs to protect them from excessive siltation and debris
- Where the basic treatment facility or the receiving water may be adversely affected by non-target pollutants (e.g., oil), or may be overwhelmed by a heavy load of targeted pollutants (e.g., suspended solids).

Presettling basins are a typical pretreatment BMP used to remove suspended solids. All basic, enhanced, and phosphorus treatment options may be used for pretreatment to reduce suspended solids.

A detention pond sized to meet the flow control standard in Volume I may also be used to provide pretreatment for suspended solids removal.

This remainder of this section discusses Presettling Basins as a BMP.

Limitations

Runoff treated by a presettling basin may not be discharged directly to a receiving water or to groundwater because it only removes coarse particulates—not fine-grained or dissolved materials. It must be further treated by a basic or enhanced runoff treatment BMP.

Hydrologic and Hydraulic Design Considerations

Treatment Volume

The total treatment volume of the presettling basin shall be at least 30 percent of the total water quality treatment design volume (e.g., 30 percent of the size of a wetpond designed per BMP WP.02).

Drawdown Time

Drawdown time of the presettling storage area (excluding wet pool area) must not exceed 40 hours.

Design Criteria

Geometry

A presettling basin shall be designed to include a wet pool sedimentation area at least 6 inches deep at the bottom of the facility.

If the runoff in the presettling basin will be in direct contact with the soil, it must be lined per the liner requirement in Appendix V-B.

The presettling basin shall meet the following requirements:

- The length-to-width ratio shall be at least 3:1. Berms or baffles may be used to lengthen the flow path.
- The minimum depth shall be 4 feet; the maximum depth shall be 6 feet.
- Inlets and outlets shall be designed to minimize velocity and reduce turbulence. Inlet and outlet structures should be located at opposite ends of the basin in order to maximize particle-settling opportunities.

Structural Design Considerations

Embankments that impound water must comply with the *Washington State Dam Safety Regulations* (Chapter 173-175 WAC). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or 3.26 million gallons) above natural ground level, then dam safety design and review are required by Ecology.

Site Design Elements

Setbacks

Setbacks shall be the same as for wet ponds.

Construction and Maintenance

A fixed sediment depth monitor should be installed in the first cell to gauge sediment accumulation, unless an alternative gauging method is proposed.

Applicable maintenance requirements for a wet pond also apply to a pre-settling basin and are further described in Appendix V-C.

Chapter 7 - Media Filtration BMPs

Media filtration BMPs rely on the physical, biological, and chemical properties of various media such as sand, perlite, zeolite, and activated carbon to remove pollutants. Filter systems are commonly configured as basins, trenches, vaults, or proprietary cartridge filtration systems.

NOTE: Thurston County will not accept ownership of media filtration facilities without prior acceptance. See Appendix V-C for maintenance requirements:

7.1 Media Filtration Design BMPs

The following media filtration BMPs are described in this section:

- MF.01 Sand Filter Basin
- MF.02 Sand Filter Vault
- MF.03 Linear Sand Filter.
- MF.04 Media Filter Drain.

Proprietary media filters which have been approved by Ecology with a General Use Level Designation for the required level of treatment may be proposed for some projects with there is insufficient land available for surface facilities. Acceptance by the Manual Administrator or designee is required. For information on current approved proprietary media filters and other emerging technologies, see Ecology's website: <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/>.

7.1.1 MF.01 Sand Filter Basin

The sand filter basin is a technology adopted from wastewater treatment. Stormwater passes through a sand layer, which filters out particulates—and in the case of amended sand, dissolved substances as well.

Applicability

Sand filtration can be used in most types of developments. Applications include residential subdivisions, parking lots for commercial and industrial establishments, gas stations, high-use sites, high-density multifamily housing, roadways, and bridge decks. They are not recommended in areas undergoing construction or otherwise generating high sediment loads.

Sand filter basins may be designed to provide basic or enhanced treatment, depending on the media:

Basic Sand Filter

Basic sand filters are expected to achieve the performance goals for basic treatment. Based on experience in King County, Washington and Austin, Texas, basic sand filters should be capable of achieving the following average pollutant removals:

- 80 percent total suspended solids at influent Event Mean Concentrations (EMCs) of 30 to 300 mg/L (King County, 1998) (Chang, 2000)
- Oil and grease to below 10 mg/L daily average and 15 mg/L at any time, with no ongoing or recurring visible sheen in the discharge.

Amended Sand Filter

Sand filters can also be amended to provide enhanced treatment. Use of amended sand filters for enhanced treatment requires prior County and Ecology approval.

Large Sand Filter

Large sand filters are approved for phosphorus treatment. They are expected to remove at least 50 percent of total phosphorous compounds by collecting and treating 95 percent of the runoff volume (ASCE and WEF, 1998).

Limitations

Sand filter basins require a large amount of space, and so are not appropriate for tightly constrained sites.

There must be adequate hydraulic head between the inlet and outlet (see *Hydrologic and Hydraulic Design Considerations*). They are not appropriate for areas subject to large loadings of debris, heavy sediment loads, and oils and greases that could clog or prematurely overload the sand.

Submittals and Approval

Submit design calculations, drawings and details as part of submittal requirements of Volume I.

Pretreatment

Pretreatment is necessary to reduce velocities to the sand filter and remove debris, floatables, large particulate matter, and oils. In high water table areas, adequate drainage of the sand filter may require additional engineering analysis and design considerations. An underground filter (BMP MF.02) should be considered in areas subject to freezing conditions (Urbonas, 1997).

Hydrologic and Hydraulic Design Considerations

Sand filters may be located either online or off-line, subject to the following:

- ***Online*** sand filters must NOT be placed upstream of a detention facility. This is to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.

- ***Offline*** sand filters placed ***upstream*** of a detention facility must have a flow splitter designed to send all flows at the 15-minute water quality flow rate, as predicted by an approved continuous runoff model, to the sand filter.

- ***Offline*** sand filters placed ***downstream*** of a detention facility must have a flow splitter designed to send all flows at the 2-year recurrence interval flow from the detention pond, as predicted by an approved continuous runoff model, to the treatment facility.

Sand Filter Sizing Procedure

Sand filters must capture and treat the Water Quality Design Storm volume, which is 91 percent of the total runoff volume (95 percent for large sand filter) as predicted by an approved, equivalent, continuous runoff model.

General facility sizing methods are described below, followed by design criteria to be used when designing a sand filter with an approved continuous runoff model.

General Design Method

Whether designing the sand filter manually or with an approved model, either method uses Darcy's law for modeling flow through a porous media like sand or soil:

$$Q = KiA$$

Where:

Q = water quality design flow (cfs)

K = hydraulic conductivity of the media (fps)

A = surface area perpendicular to the direction of flow (sf)

i = hydraulic gradient (ft/ft) for a constant head and constant media depth

$$i = \frac{h+L}{L}$$

and:

h = average depth of water above the filter (ft), defined as d/2

d = maximum water storage depth above the filter surface (ft)

L = thickness of sand media (ft).

Darcy's law underlies both the manual and the modeling design methods. V, or more correctly, 1/V, is the direct input in the sand filter design. The relationship between V and K is revealed by equating Darcy's law and the equation of continuity, Q = VA. (Note: When water is flowing into the ground, V is commonly called the filtration rate. It is ordinarily measured via a soil infiltration test.)

Specifically:

$$Q = KiA \quad \text{and} \quad Q = VA \text{ so,}$$
$$VA = KiA \quad \text{or} \quad V = Ki$$

Note that $V \neq K$. The filtration rate is not the same as the hydraulic conductivity, but they do have the same units (distance per time). K can be equated to V by dividing V by the hydraulic gradient i, which is defined above.

The hydraulic conductivity K does not change with head nor is it dependent on the thickness of the media, only on the characteristics of the media and the fluid. The hydraulic conductivity of 1 inch per hour

(2.315×10^{-5} fps) specified for sand filter design is based on bench-scale tests of conditioned rather than clean sand.

This design hydraulic conductivity represents the average sand bed condition as silt is captured and held in the filter bed. Unlike the hydraulic conductivity, the filtration rate V changes with head and media thickness, although the media thickness is constant in the sand filter design. Table 7.1 shows values of V for different water depths d (d=2h).

Table 7.1. Sand Filter Design Parameters

	Sand Filter Design Parameters					
Facility ponding depth d (ft)	1	2	3	4	5	6
Filtration rate V (in/hr) [a]	1.33	1.67	2.00	2.33	2.67	3.00
1/V (min/in)	45	36	30	26	22.5	20

[a] The filtration rate is not used directly, but is provided for information. V equals the hydraulic conductivity, K, times the hydraulic gradient, i. The hydraulic conductivity used is 1 inch/hr. The hydraulic gradient = (h + L)/L, where h = d/2 and L = the sand depth (1.5 ft).

Modeling Method

When using continuous modeling to size a sand filter, apply the assumptions listed in Table 7.2. Several available modeling programs include built-in modules to size sand filters.

Table 7.2. Sand Filter Design and Sizing Criteria

Variable	Assumption
Computational Time Step	15-minutes
Inflows to Facility	Model output for water quality design
Ponding Depth	Maximum water depth over the filter media
Precipitation Applied to Facility	Checked (always activated when sizing above ground sand filters)
Evaporation Applied to Facility	Checked (always activated when sizing above ground sand filters)
Media depth	18 inches or other as designed
Sand Media Hydraulic Conductivity	1 inch per hour
Use Wetted Surface Area	Only if side slopes are 3:1 or flatter

Inlet

Inlet bypass and flow spreading structures (e.g., flow spreaders, weirs or multiple orifice openings) shall be designed to capture the applicable design flow rate, minimize turbulence and to spread the flow uniformly across the surface of the sand filter. Stone riprap or other energy dissipation devices shall be installed to prevent gouging of the sand medium and to promote uniform flow. Include emergency spillway or overflow structures (see Appendix V-A).

Overflow

An overflow shall be included in the design of the basic and large sand filter basin (see Appendix V-A). The overflow height shall be at the maximum hydraulic head of the pond above the sand bed.

Underdrain

The following are design criteria for the underdrain piping: (types of underdrains include: a central collector pipe with lateral feeder pipes, or, a geotextile drain strip in an 8-inch gravel backfill or drain rock bed, or, longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.)

- Upstream of detention underdrain piping shall be sized to handle double the 2-year recurrence interval flow indicated by an approved continuous runoff model (the doubling factor is a safety factor used in the absence of a conversion factor from the 1-hour time step to a 15-minute time step). Downstream of detention the underdrain piping shall be sized for the 2-year recurrence interval flow indicated by an approved continuous runoff model. In both instances there shall be at least 1 foot of hydraulic head above the invert of the upstream end of the collector pipe (King County, 1998).

- Internal diameters of underdrain pipes shall be a minimum of 6 inches and two rows of three-eighth-inch holes spaced 6 inches apart longitudinally (maximum), with rows 120 degrees apart (laid with holes downward). Maximum perpendicular distance between two feeder pipes must be 10 feet. Drain piping could be installed in basin and trench configurations.

- Main collector underdrain pipe shall be at a slope of 1 percent minimum.

- A geotextile fabric (specifications in Appendix V-B) must be used between the sand layer and drain rock or gravel and placed so that 2 inches of drain rock/gravel is above the fabric.

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

Design Criteria

Figures 7.1, 7.2, 7.3, and 7.4 provide details of a sand filter basin.

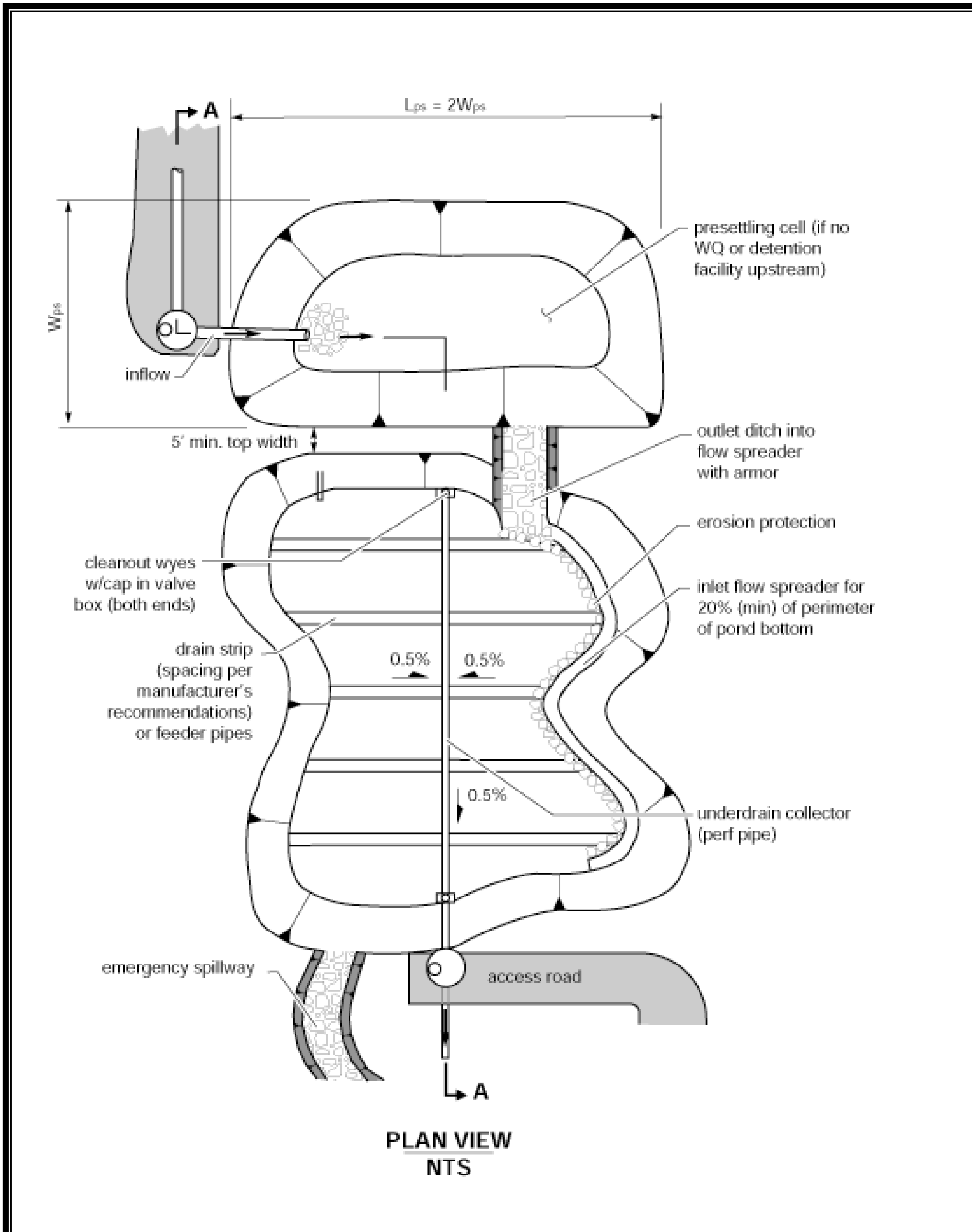


Figure 7.1. Sand Filter with Pretreatment Cell.

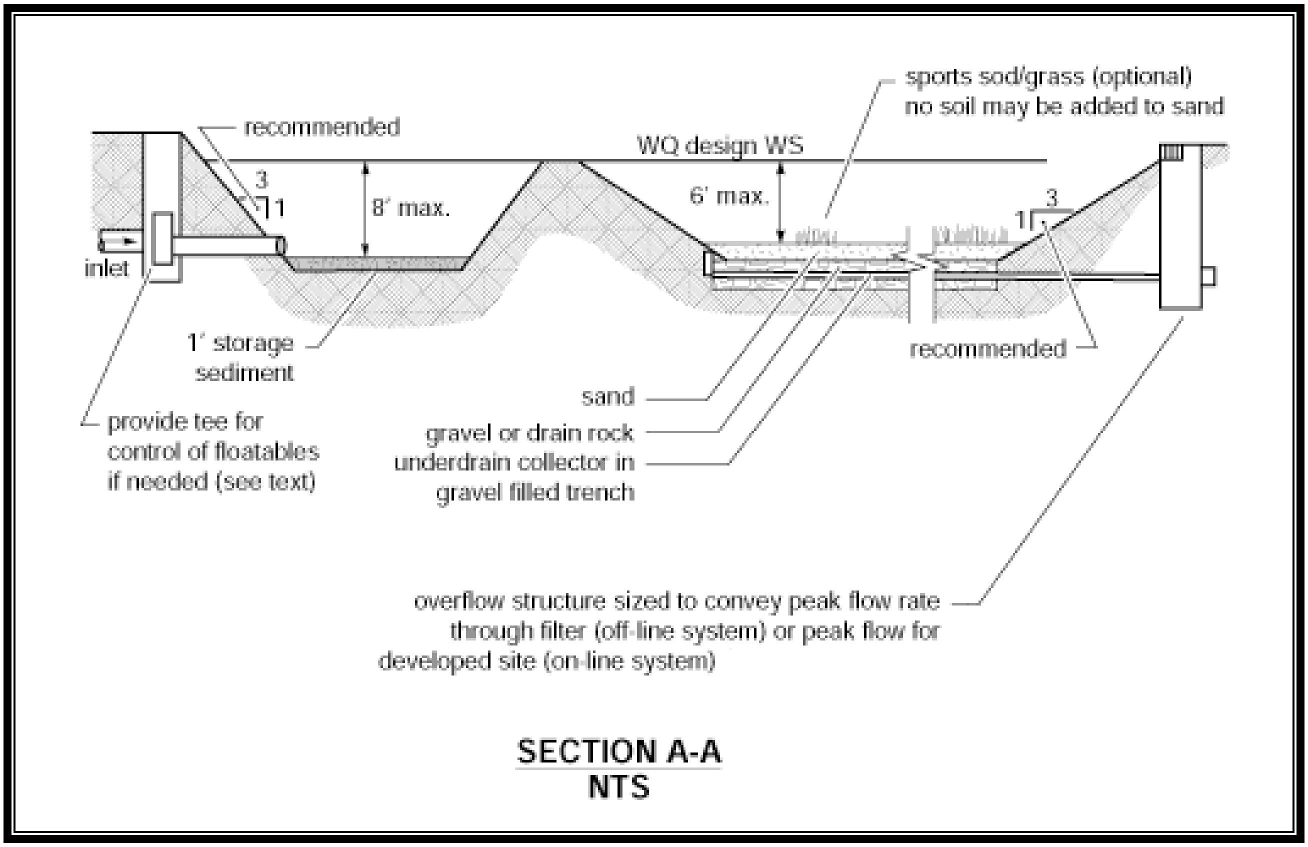


Figure 7.2. Sand Filter with Pretreatment Cell – Section.

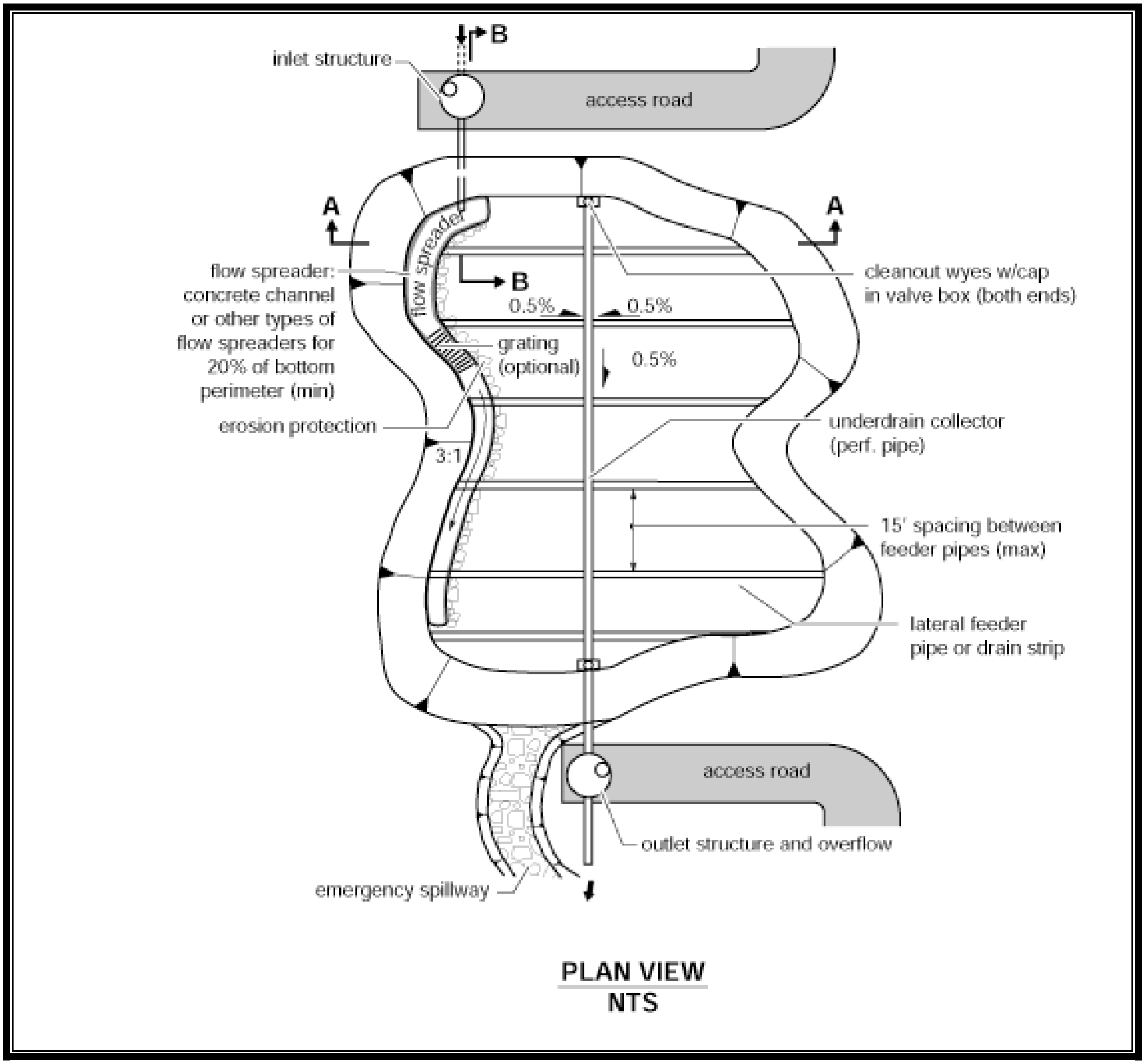


Figure 7.3. Sand Filter with Level Spreader.

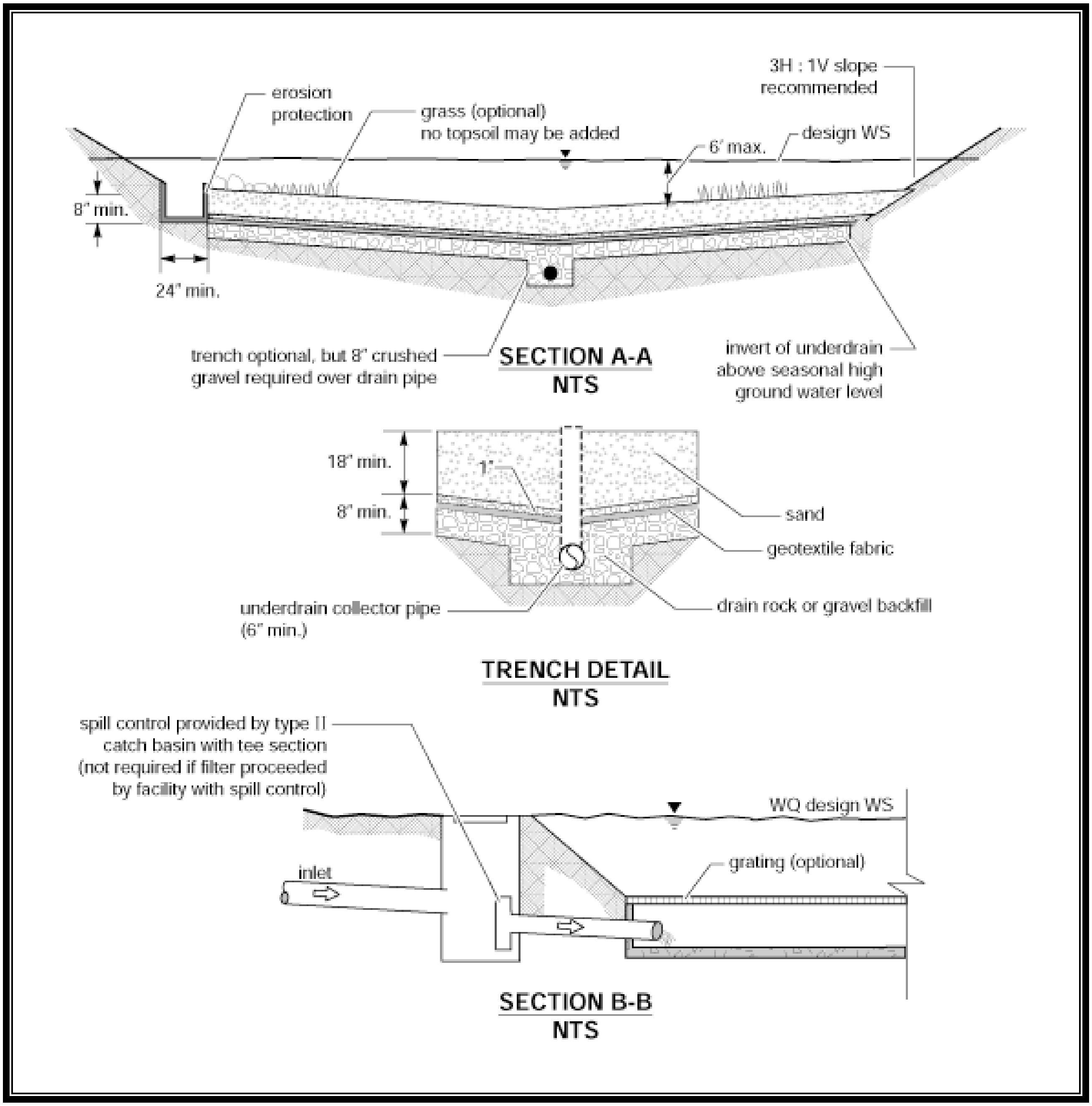


Figure 7.4. Sand Filter with Level Spreader – Sections and Details.

Geometry

Side slopes for earthen/grass embankments must not exceed 3:1 to facilitate mowing.

Materials

Drain Rock

Drain rock shall be 0.75 to 1.5 inch rock or gravel backfill, washed free of clay and organic material.

Underdrain Piping

All piping is to be schedule 80 PVC or greater wall thickness.

Sand

Sand bed depth shall be a minimum of 18 inches. The sand in a filter must consist of a medium sand meeting the size gradation (by weight) given in Table 7.3 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. (**Note**: Standard backfill for sand drains, WA. Std. Spec. 9-03.13, does not meet this specification and shall not be used for sand filters.)

Table 7.3. Sand Medium Specification

U.S. Sieve Number	Percent Passing
4	100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2

Impermeable Liners for Sand Bed Bottom

Impermeable liners are required where the underflow could cause problems with structures. If an impermeable liner is not provided, then an analysis must be provided identifying possible adverse effects of seepage zones on groundwater, and near building foundations, basements, roads, parking lots and sloping sites.

Impermeable liners may be clay, concrete, or geomembrane. Clay liners shall have a minimum thickness of 12 inches and meet the specifications given in Table 7.4. If a geomembrane liner is used it must have a minimum thickness of 30 mils and be ultraviolet resistant. The geomembrane liner must be protected from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane.

Table 7.4. Clay Liner Specifications

Property	Test Method	Unit	Specification
Permeability	ASTM D-2434	cm/sec	1 x 10^{-6} max.
Plasticity Index of Clay	ASTM D-423 and D-424	percent	Not less than 15
Liquid Limit of Clay	ASTM D-2216	percent	Not less than 30
Clay Particles Passing	ASTM D-422	percent	Not less than 30
Clay Compaction	ASTM D-2216	percent	95 percent of Standard Proctor Density

Source: City of Austin, 1988.

If an impermeable liner is not required then a geotextile fabric liner must be installed that retains the sand and meets the specifications listed in Appendix V-A, unless the basin has been excavated to bedrock.

Structural Design Considerations

Concrete liners may also be used for sedimentation chambers and for sedimentation and sand filtration basins less than 1,000 square feet in area. Concrete must be 5 inches thick Class A or better and shall be reinforced by steel wire mesh. The steel wire mesh must be 6 gauge wire or larger and 6-inch by 6-inch mesh or smaller. An “Ordinary Surface Finish” is required. When the underlying soil is clay or has an unconfined compressive strength of 0.25 ton per square foot or less, the concrete must have a minimum 6-inch compacted aggregate base. This base must consist of coarse sand and river stone, crushed stone or equivalent with diameter of 0.75 to 1 inch.

Site Design Elements

High groundwater may damage underground structures or affect the performance of filter underdrain systems. There must be sufficient clearance (at least 2 feet) between the seasonal high groundwater level and the bottom of the sand filter to obtain adequate drainage.

Sand filters without impermeable liners shall not be built on fill sites and shall be located at least 20 feet downslope and 100 feet upslope from building foundations.

Construction and Maintenance

Construction Considerations

Until all project improvements which produce surface runoff are completed, and all exposed ground surfaces are stabilized by revegetation or landscaping, sand filtration systems may not be operated, and no surface runoff may be permitted to enter the system.

Careful level placement of the sand is necessary to avoid formation of voids within the sand that could lead to short-circuiting (particularly around penetrations for underdrain cleanouts), and to prevent damage to the underlying geomembranes and underdrain system. Over-compaction should be avoided to ensure adequate filtration capacity. Sand is best placed with a low ground pressure bulldozer (4 psig or less).

After the sand layer is placed, water settling is recommended. To enable settling, flood the sand with 10 to 15 gallons of water per cubic foot of sand.

Maintenance Access

Include a maintenance access ramp with a slope not greater than 7:1 at the inlet and the outlet of a surface filter. Consider installing an access port for inspection and maintenance.

Cleanouts and Underdrain Piping

A valve box must be provided for access to the cleanouts.

Access for cleaning all underdrain piping shall be provided. This may consist of installing cleanout ports, which tee into the underdrain system and surface above the top of the sand bed.

7.1.2 MF.02 Sand Filter Vault

A sand filter vault (see Figures 7.5 and 7.6) is similar to a sand filter basin, except that the sand layer and underdrains are installed below grade. A sand filter vault consists of presettling and sand filtration cells.

Applicability

A sand filter vault is appropriate where space limitations preclude aboveground facilities or in areas subject to freezing.

Limitations

A sand filter vault is not appropriate in high water table areas. There must be adequate hydraulic head (approximately 4 feet) between the inlet and outlet. As with sand filter basins, vaults are not appropriate for areas subject to large loadings of debris, heavy sediment loads, and oils and greases that could clog or prematurely overload the sand.

Submittals and Approval

Submit design calculations, drawings and details as part of submittal requirements of Volume I.

Pretreatment

Design shall include a forebay, pre-settling basin or other treatment BMP prior to the sand filter for coarse sediment removal.

Hydrologic and Hydraulic Design Considerations

Sand filter sizing is the same as for MF.01 (sand filter basin).

Vaults may be designed as off-line systems or online for small drainages.

Off-line Systems

In an off-line system a diversion structure (see Appendix V-A) shall be installed to divert the design flow rate into the sediment chamber and bypass the remaining flow to detention/retention (if necessary to meet Minimum Requirement #7), or to surface water.

Inlet

Optimize sand inlet flow distribution with minimal sand bed disturbance. A maximum of 8-inch distance between the top of the spreader and the top of the sand bed is suggested. Flows may enter the sand bed by spilling over the top of the wall into a flow spreader pad or alternatively a pipe and manifold system may be used. Any pipe and manifold system must retain the required dead storage volume in the first cell, minimize turbulence, and be readily maintainable.

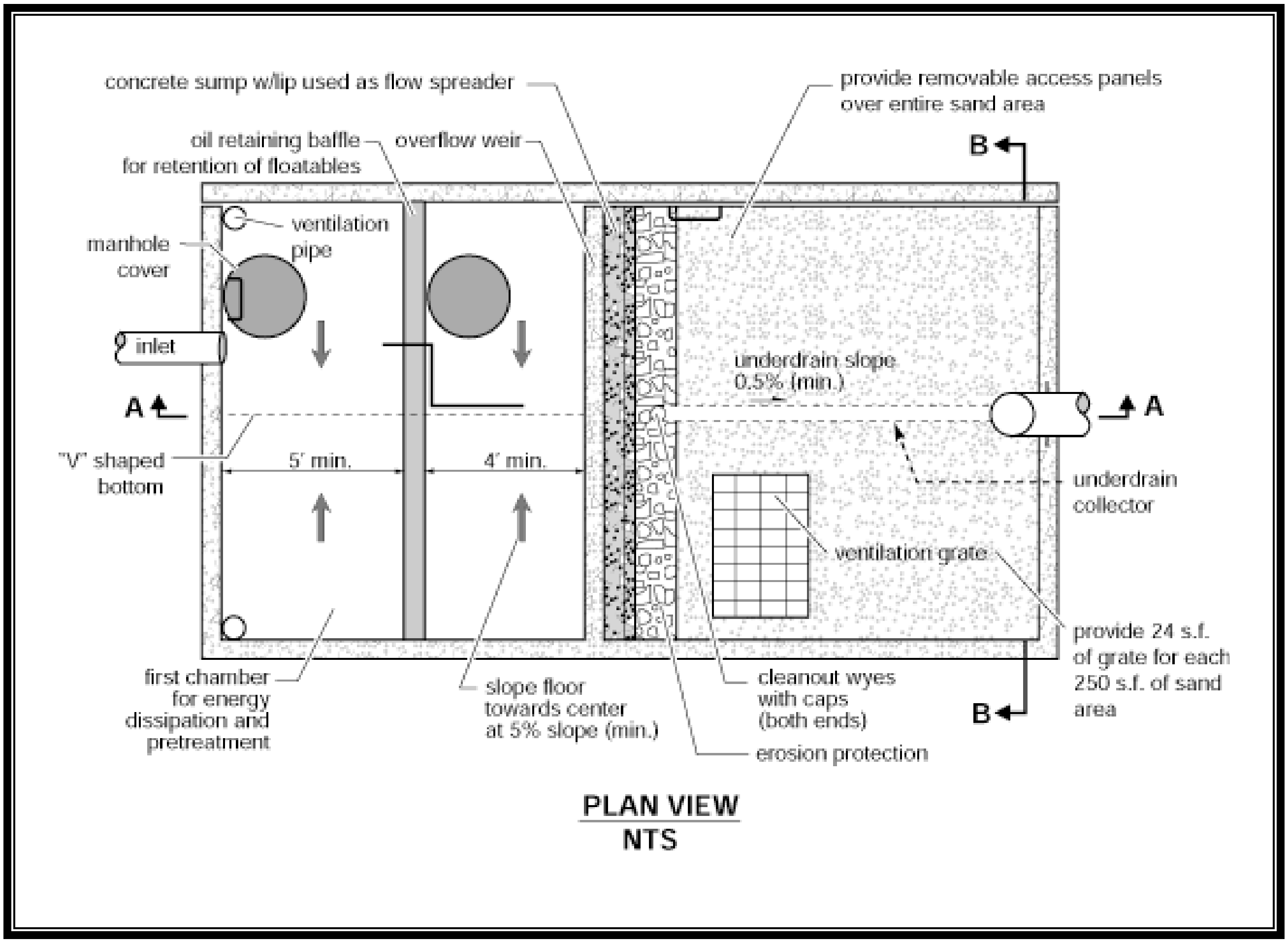


Figure 7.5. Sand Filter Vault.

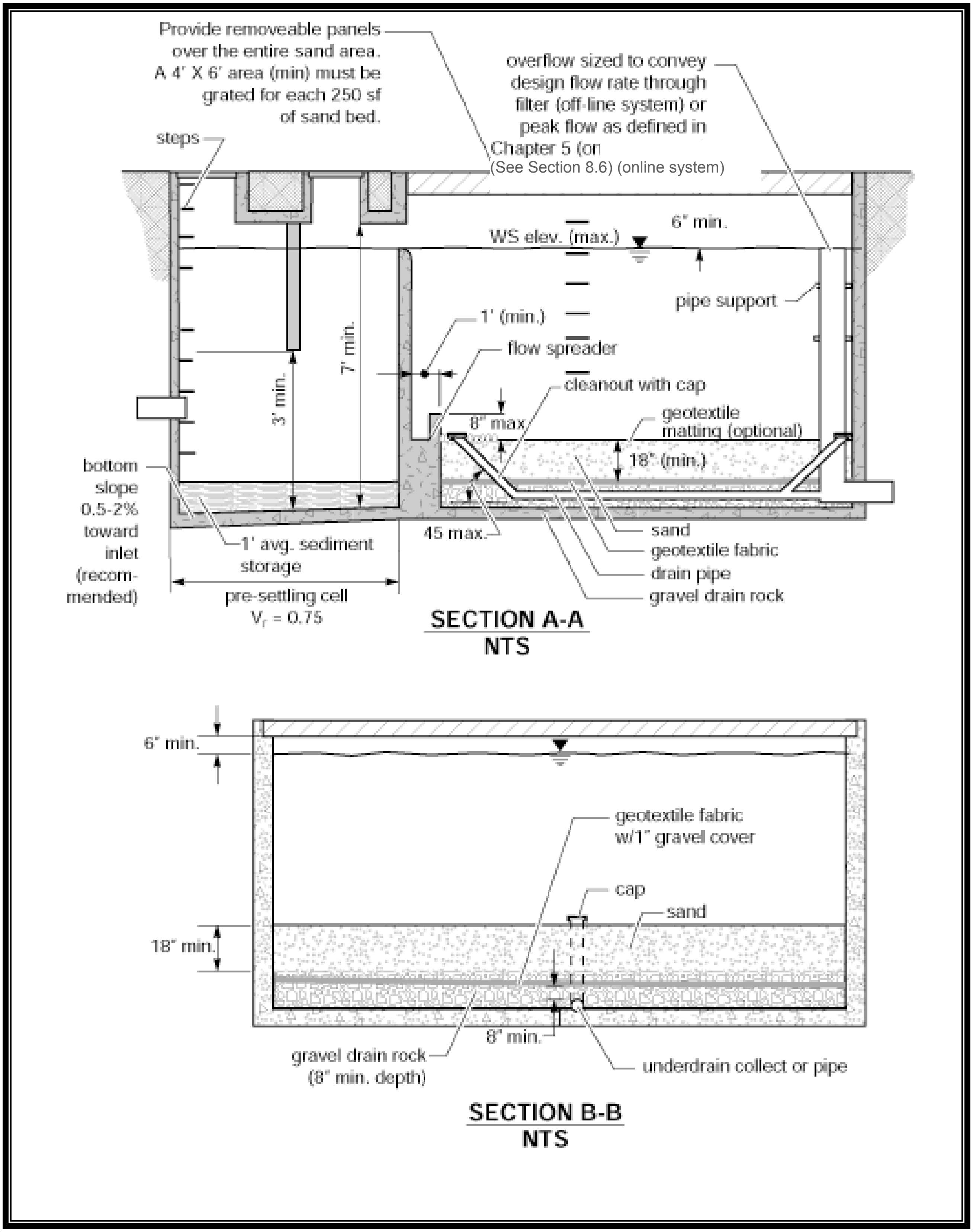


Figure 7.6. Sand Filter Vault: Sections.

If an inlet 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. Geotextile fabric secured on the surface of the sand bed, or equivalent method, may be used.

Design Criteria

The filter bed shall consist of a sand top layer, and a geotextile fabric second layer with an underdrain system.

Geometry

Presettling Cell

Design the presettling cell for sediment collection and removal. A V-shaped bottom, removable bottom panels, or equivalent sludge handling system should be used. One foot of sediment storage in the presettling cell must be provided.

The presettling chamber must be sealed to trap oil and trash. This chamber is usually connected to the sand filtration chamber through an invert elbow to protect the filter surface from oil and trash.

Baffle

If a retaining baffle is necessary for oil/floatables in the presettling cell, it must extend at least 1 foot above to 1 foot below the design flow water level. Provision for the passage of flows in the event of plugging must be provided. Access opening and ladder must be provided on both sides of the baffle.

Materials

Sand filter vaults must conform to the materials and structural suitability criteria specified for wet vaults

A geotextile fabric (see Appendix V-B) over the entire sand bed may be installed that is flexible, highly permeable, three-dimensional matrix, and adequately secured. This is useful in trapping trash and litter.

Structural Design Considerations

Sand filters vaults shall conform to the structural suitability and materials criteria specified for wetvaults.

Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03 of this Volume).

Construction and Maintenance

Provide a sand filter inlet shutoff/bypass valve for maintenance

Provision for access is the same as for wet vaults. Removable panels must be provided over the entire sand bed.

To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate shall be provided for each 250 square feet of sand bed surface area. For sufficient distribution of airflow across the sand bed, grates may be located in one area if the sand filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.

7.1.3 MF.03 Linear Sand Filter

A linear sand filter (see Figure 7.7) is typically a long, shallow, two-celled, rectangular vault. The first cell is designed for settling coarse particles, and the second cell contains the sand bed. Stormwater flows into the second cell via a weir section that also functions as a flow spreader.

Applicability

Linear sand filters are well-suited to small drainages (less than 2 acres of impervious area), and can fit well into long narrow spaces such as the perimeter of a paved surface.

A linear sand filter can be used to treat runoff from high-use sites for total suspended solids and oil/grease removal or, alternatively, as a part of a treatment train to provide enhanced or phosphorus treatment.

Limitations

Below-ground structures like wetvaults are relatively difficult and expensive to maintain. The need for maintenance is often not seen and as a result routine maintenance does not occur.

Submittals and Approval

Submit design calculations, drawings and details as part of submittal requirements of Volume I.

Pretreatment

Pretreatment is achieved in the upstream cell of the linear sand filter which provides for settling of coarse particles. Therefore, a separate pretreatment facility is not required.

Hydrologic and Hydraulic Design Considerations

Maximum sand bed ponding depth is 1 foot.

Drain pipe must be sloped a minimum of 0.5 percent.

Design Criteria

Figure 7.7 shows a plan view and sections of a linear sand filter. The linear sand filter has a sediment chamber and a sand filter chamber.

The two chambers shall be divided by a divider wall that is level and extends a minimum of 12 inches above the sand bed.

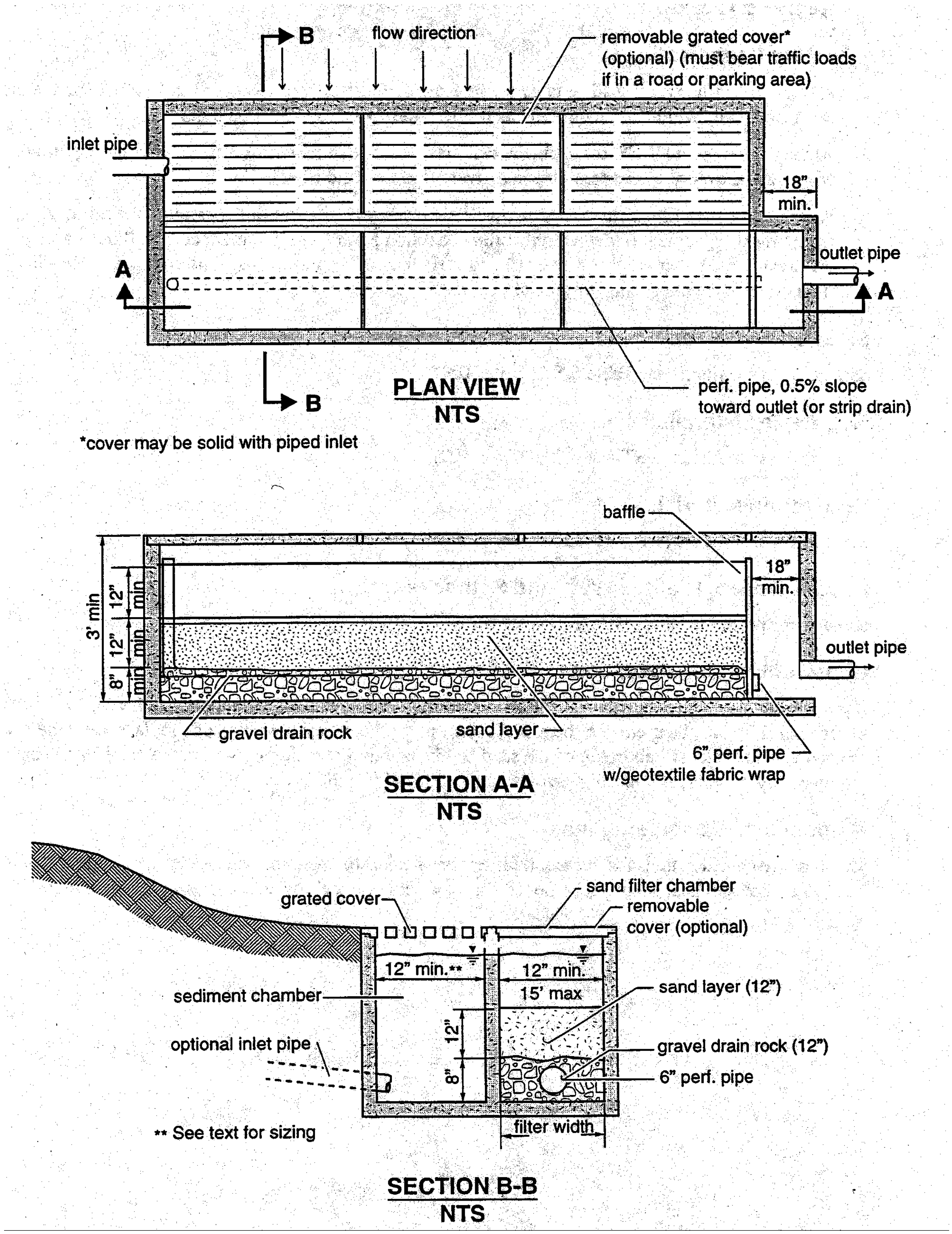


Figure 7.7. Linear Sand Filter.

Geometry

Sediment Chamber

The sediment chamber width shall be as follows:

Sand filter width, inches	12-24	24-48	48-72	72+
Sediment chamber width, inches	12	18	24	w/3

Stormwater may enter the sediment cell by sheet flow or a piped inlet.

Sand Filter Chamber

The width of the sand filter chamber must be between 1 foot and 15 feet.

The sand filter bed must be a minimum of 12 inches deep and have an 8-inch layer of drain rock with perforated drainpipe beneath the sand layer.

Materials

Linear sand filters must conform to the materials criteria specified for wet vaults.

The drainpipe must be a minimum of 6 inches in diameter and be wrapped in geotextile.

Structural Design Considerations

Linear sand filters must conform to the structural suitability materials criteria specified for wet vaults.

Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03 of this Volume).

Construction and Maintenance

Linear sand filters must be vented as for sand filter vaults.

7.1.4 MF.04 Media Filter Drain (Formerly Ecology Embankment)

The media filter drain (MFD), previously referred to as the ecology embankment, is a linear flow-through stormwater runoff treatment device The MFD can be sited adjacent to roadside embankments (conventional design) and medians (dual media filter drain), borrow ditches, or other linear depressions.

The media filter drain (MFD), previously referred to as the *ecology embankment*, is a linear flow-through stormwater runoff treatment device that was developed by the Washington State Department of Transportation (WSDOT). The MFD can be sited along roadway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions.

MFD's have four basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the MFD mix. This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surface base course (CSBC). This layer of CSBC must be porous enough to allow treated flows to freely drain away from the MFD mix.

Typical MFD configurations are shown in Figures 7.8, 7.9, and 7.10.

The MFD has a general use level designation (GULD) from the Department of Ecology for basic, phosphorus, and enhanced treatment. The MFD removes suspended solids, phosphorus, and metals from stormwater runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration.

Applicability

The MFD can be used where available right-of-way is limited, sheet flow is feasible (i.e., no curbs), lateral gradients are generally less than 25 percent (4H:1V), and longitudinal gradients are less than 5 percent.

Media Filter Drains

Since maintaining sheet flow across the media filter drain is required for its proper function, the ideal locations for media filter drains are roadside embankments or other long, linear grades.

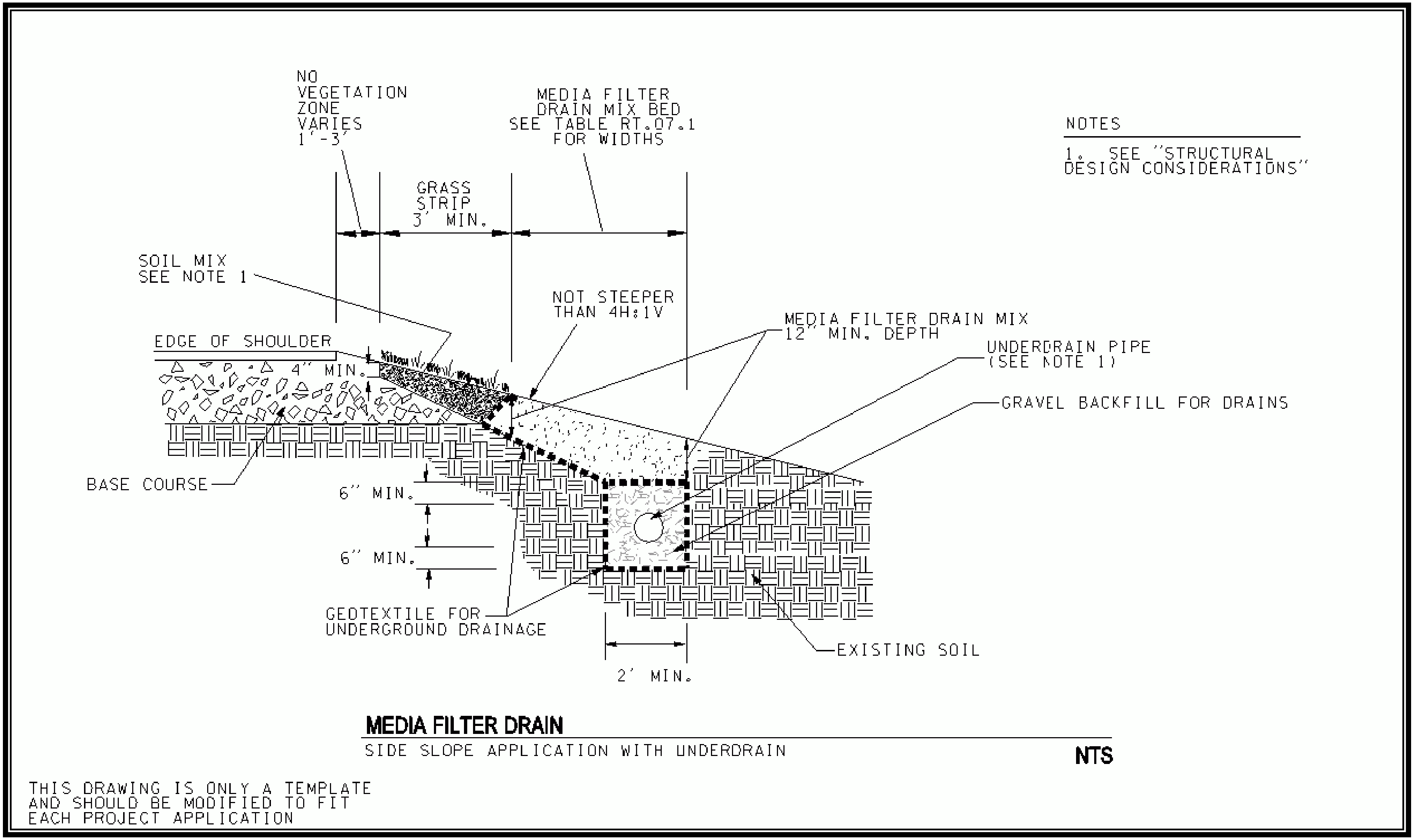


Figure 7.8. Media Filter Drain: Side Slope Application with Underdrain.

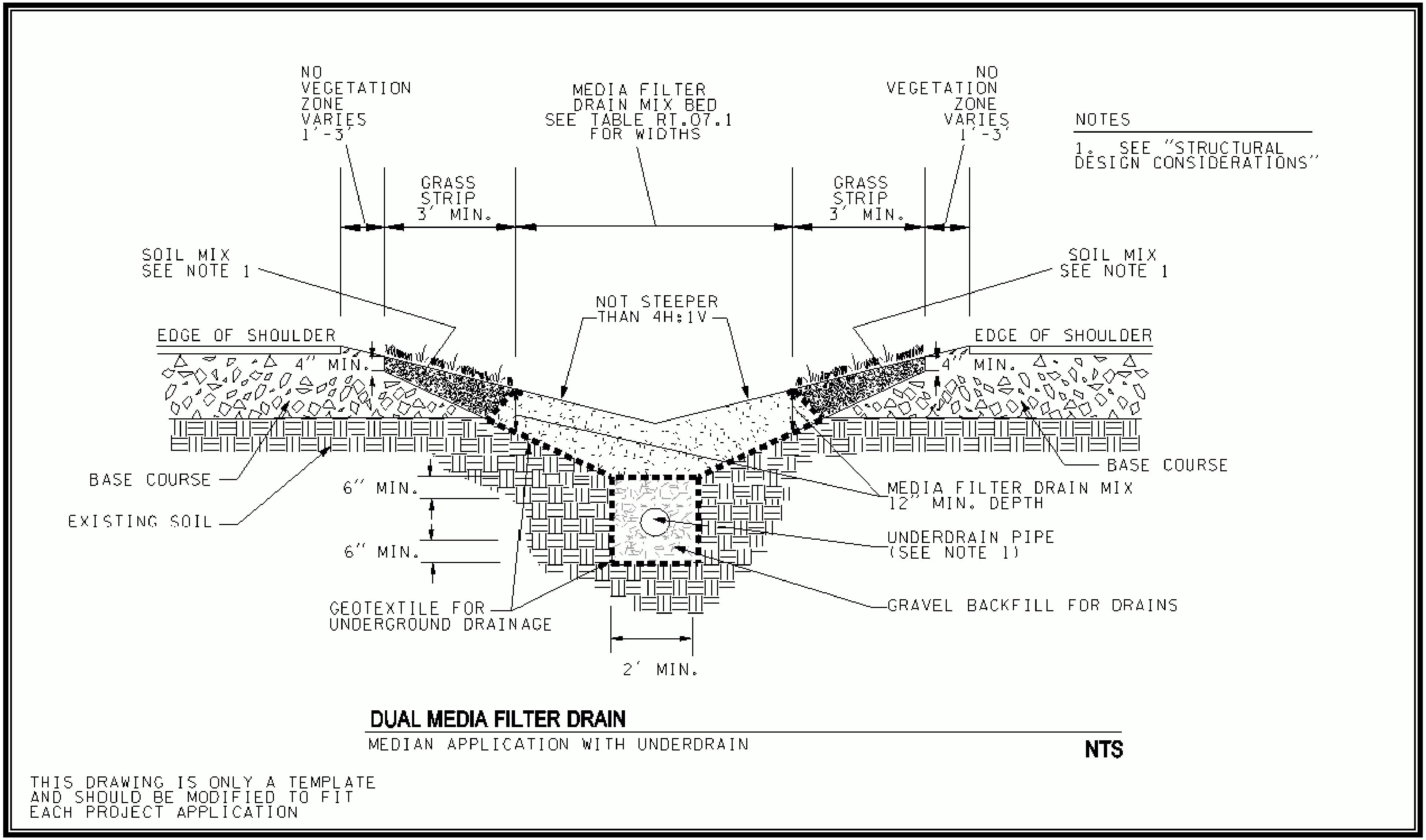


Figure 7.9. Dual Media Filter Drain: Median Application with Underdrain.

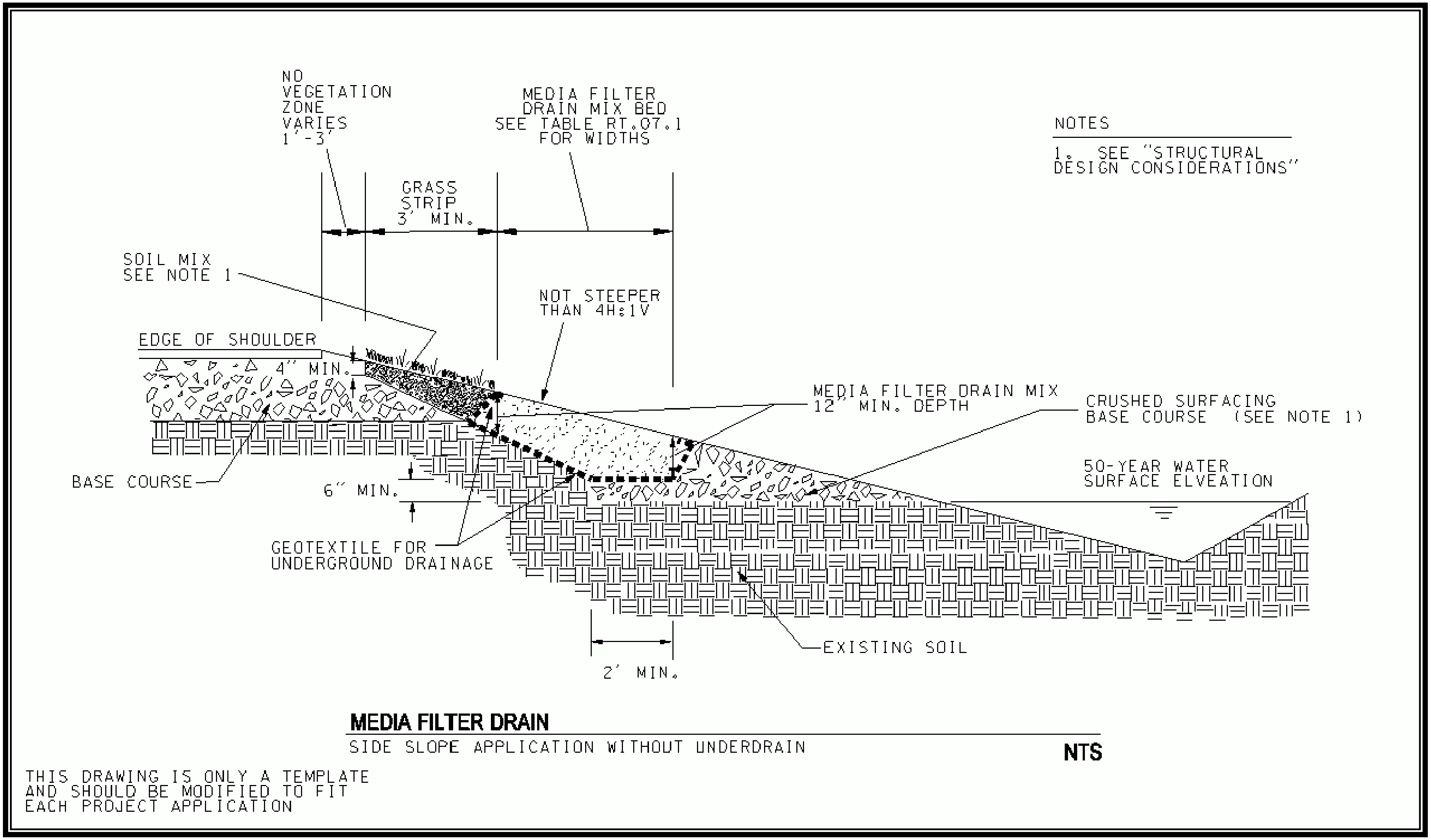


Figure 7.10. Media Filter Drain: Side Slope Application without Underdrain.

Dual Media Filter Drains

The dual media filter drain is fundamentally the same as the side-slope version. It differs in siting and is more constrained with regard to drainage options. Prime locations for dual media filter drains are medians, roadside drainage or borrow ditches, or other linear depressions. It is especially critical for water to sheet flow across the dual media filter drain.

Limitations

Flow Path

The longest flow path from the contributing area delivering sheet flow to the media filter drain shall not exceed 75 feet for impervious surfaces and 150 feet for pervious surfaces.

Channelized Flow

Media filter drains shall not be used where continuous off-site inflow may result in channelized flows or ditch flows running down the middle of the dual media filter drain.

Steep Slopes

- Avoid construction on longitudinal slopes steeper than 5 percent.
- Avoid construction on 3H:1V lateral slopes, and preferably use flatter than 4H:1V slopes. As slopes approach 3H:1V, without design modifications, sloughing may become a problem due to friction limitations between the separation geotextile and underlying soils. In areas where lateral slopes exceed 4H:1V, it may be possible to construct terraces to create 4H:1V slopes, or to otherwise stabilize up to 3H:1V slopes.
- In areas where slope stability may be problematic, consult a geotechnical engineer.

Wetlands

- Do not construct in wetlands and wetland buffers.
- In many cases, a media filter drain (due to its small lateral footprint) can fit within the fill slopes adjacent to a wetland buffer. In those situations where the fill prism is located adjacent to wetlands, an interception trench/underdrain will need to be incorporated as a design element in the media filter drain.

Shallow Groundwater

- Mean high water table levels in the project area need to be determined to ensure that the MFD mix bed and the underdrain will not become saturated by shallow groundwater.

- There must be at least 1 foot of depth between the seasonal high groundwater table and the bottom of the facility.

Submittals and Approval

As part of the submittals required by Volume I include the following:

- Design information and calculations for the MFD including sizing criteria, assumptions for hydrologic modeling of the MFD and other data necessary to evaluate the suitability of the MFD in the proposed application.

- The Maintenance Plan shall include maintenance procedures for the MFD, frequency of maintenance and other information necessary for the ongoing maintenance of the MFD.

- The Drawings and Specifications for the project shall show the location of the MFD in the site plan, cross-sections and details of the MFD with all necessary information to construct it according to the plans, and specifications for all components of the MFD including seeding mix design, MFD bed design and testing requirements, and soil/material placement and compaction requirements.

- The Soils Management Plan required by BMP LID.02 shall include the area of the MFD and proposed soil amendments.

Pretreatment

No pretreatment is required. Sheet flow runoff from the roadway surface can be routed directly to the MFD.

Hydrologic and Hydraulic Design Considerations

The basic design concept behind the media filter drain and dual media filter drain is to fully filter all runoff through the MFD mix. Therefore, the infiltration capacity of the MFD mix and of the drainage below the MFD mix bed needs to match or exceed the hydraulic loading rate.

Infiltration Rate

The MFD mix has an estimated initial filtration rate of 50 inches per hour and a long-term filtration rate of 28 inches per hour, which accounts for siltation. With an additional safety factor, the rate used to size the length of the media filter drain should be 14 inches per hour.

Design Flow Rate

For western Washington, $Q_{Roadway}$ is the flow rate at or below which 91 percent of the runoff volume will be treated, based on a 15-minute time step, and can be determined using the water quality analysis feature in WWHM.

Sizing MFD Mix Bed

For runoff treatment, sizing the MFD mix bed is based on the requirement that the runoff treatment flow rate from the contributing roadway area $Q_{Roadway}$ cannot exceed the long-term infiltration capacity of the media filter drain, $Q_{Infiltration}$:

$$Q_{Roadway} \leq Q_{Infiltration}$$

$Q_{Roadway}$ is described under *Design Flow Rate*. $Q_{infiltration}$ may be calculated as follows.

$Q_{infiltration}$, the long-term infiltration capacity of the media filter drain is based on the following equation:

$$\frac{LTIR_{EM} * L_{EE} * W_{EE}}{C * SF} = Q_{Infiltration}$$

where: $LTIR_{EM}$ = Long-term infiltration rate of the MFD mix (use 10 inches per hour for design) (in/hr)

L_{EE} = Length of media filter drain (parallel to contributing pavement) (ft)

W_{EE} = Width of the MFD mix bed (ft)

C = Conversion factor of 43,200 ((in/hr)/(ft/sec))

SF = Safety Factor (equal to 1.0, unless unusually heavy sediment loading is expected)

Assuming that the length of the media filter drain is the same as the length of the contributing pavement, solve for the width of the media filter drain:

$$W_{EE} \geq \frac{Q_{Roadway} * C * SF}{LTIR_{EM} * L_{EE}}$$

Project applications of this design procedure have shown that, in almost every case, the calculated width of the media filter drain does not exceed 1.0 foot. Therefore, Table 7.5 was developed by WSDOT to simplify the design steps and should be used to establish an appropriate width.

Table 7.5. Design Widths for Media Filter Drains

Pavement Width that Contributes Runoff to the Media Filter Drain	Minimum Media Filter Drain Width*
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet

Width does not include the required 1–3 foot gravel vegetation-free zone or the 3-foot filter strip width (see Figure 7.8).

Design Criteria

Media filter drains have four basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the MFD mix.

Inflow

Runoff is always conveyed to a media filter drain using sheet flow from the pavement area. The longitudinal pavement slope contributing flow to a media filter drain should be less than 5 percent. Although there is no lateral pavement slope restriction for flows going to a media filter drain, the designer should ensure that flows remain as sheet flow.

No-Vegetation Zone

Stormwater runoff is conveyed to the MFD via sheet flow over a vegetation-free gravel zone to ensure sheet dispersion, and to provide some pollutant trapping. The no-vegetation zone is a shallow gravel trench located directly adjacent to the impervious surface to be treated. The no-vegetation zone is a crucial element in a properly functioning media filter drain or other BMPs that use sheet flow to convey runoff from the impervious surface to the BMP. The no-vegetation zone functions as: a level spreader to promote sheet flow, a deposition area for coarse sediments, and an infiltration area to reduce runoff volumes.

Grass Strip

Adjacent to the no-vegetation zone, a grass strip, which may be amended with compost, is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system.

Media Filter Drain Mix Bed

The runoff is then filtered through a bed of porous, alkalinity-generating granular medium—the MFD mix. Geotextile lines the underside of the MFD mix bed.

Conveyance System Below Media Filter Drain Mix

Treated water drains from the MFD mix bed into the conveyance system below the MFD mix. The conveyance system must be porous enough to allow treated flows to freely drain away from the MFD mix.

This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surfacing base course (CSBC).

Underdrain Trench

The gravel underdrain trench provides hydraulic conveyance when treated runoff needs to be conveyed to a desired location such as a downstream flow control facility or stormwater outfall.

The underdrain trench shall be a minimum of 2 feet wide for either the conventional or dual media filter drain. The gravel underdrain trench may be eliminated (see Figure 7.9) if there is evidence to support that flows can be conveyed laterally to an adjacent ditch or onto a fill slope that is properly vegetated to protect against erosion. The MFD mix shall drain freely, draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

Underdrain Pipe

The trench's perforated underdrain pipe is a protective measure to ensure free flow through the MFD mix. It may be possible to omit the underdrain pipe if it can be demonstrated that the pipe is not necessary to maintain free flow through the MFD mix and underdrain trench.

In Group C and D soils, an underdrain pipe would help to ensure free flow of the treated runoff through the MFD mix bed. In some Group A and B soils, an underdrain pipe may be unnecessary if most water percolates into subsoil from the underdrain trench. The need for underdrain pipe should be evaluated in all cases.

Geometry

The no-vegetation zone should be between 1 foot and 3 feet wide. Depth will be a function of how the adjacent paved section is built from subgrade to finish grade; the resultant cross section will typically be triangular to trapezoidal.

The width of the vegetated filter strip is dependent on the availability of space within the sloped area where the media filter drain is to be constructed. The baseline design criterion for the grass strip within the media filter drain is a 3-foot-minimum-width, but wider grass strips are recommended if the additional space is available.

The MFD mix shall be a minimum of 12 inches deep, including the section on top of the underdrain trench. The MFD mix bed shall have a bottom width of at least 2 feet in contact with the conveyance system below the media filter drain mix.

In general, the length of a media filter drain or dual media filter drain is the same as that of the contributing pavement. Any length is acceptable as long as the surface area of the MFD mix bed is sufficient to fully infiltrate the runoff treatment design flow rate.

In profile, the surface of the media filter drain should preferably have a lateral slope less than 4H:1V (<25 percent). On steeper terrain, it may be possible to construct terraces to create a 4H:1V slope, or other engineering may be employed if approved by Thurston County and Ecology, to ensure slope stability up to 3H:1V. If sloughing is a concern on steeper slopes, consideration should be given to incorporating permeable soil reinforcements, such as geotextiles, open-graded/permeable pavements, or commercially available ring and grid reinforcement structures, as top layer components to the MFD mix bed. Consultation with a geotechnical engineer is required.

Materials

WSDOT Standard Specifications should be consulted for the following:

- Gravel Backfill for Drains, 9-03.12(4)
- Underdrain Pipe, 7-01.3(2)
- Construction Geotextile for Underground Drainage, 9-33.1.

MFD Mix

The MFD mix is a mixture of crushed rock (screened to 3/8" to #10 sieve), dolomite, gypsum, and perlite. The crushed rock provides the support matrix of the medium. The dolomite and gypsum additives serve to buffer acidic pH conditions and exchange light metals for heavy metals. Perlite is incorporated to improve moisture retention, which is critical for the formation of biomass epilithic biofilm to assist in the removal of solids, metals, and nutrients.

The MFD mix used in the construction of media filter drains consists of the amendments listed in Table 7.6. Mixing and transportation must be done in a manner that ensures the materials are thoroughly mixed prior to pouring into the ground, and that separation does not occur during transportation or pouring.

Table 7.6. Media Filter Drain Mix

Amendment	Quantity
Mineral aggregate: Crushed screenings 3/8-inch to #10 sieve Crushed screenings shall be manufactured from ledge rock, talus, or gravel in accordance with Section 3-01 of the *Standard Specifications for Road, Bridge, and Municipal Construction* (2002), which meets the following test requirements: Los Angeles Wear, 500 Revolutions 35% max. Degradation Factor 30 min. Crushed screenings shall conform to the following requirements for grading and quality: Sieve Size — Percent Passing (by weight) 1/ 2" square — 100 3/8" square — 90-100 U.S. No. 4 — 30-56 U.S. No. 10 — 0-10 U.S. No. 200 — 0-1.5 % fracture, by weight, min. — 75 Static stripping test — Pass The fracture requirement shall be at least one fractured face and will apply to material retained on the U.S. No. 10 if that sieve retains more than 4% of the total sample. The finished product shall be clean, uniform in quality, and free from wood, bark, roots, and other deleterious materials. Crushed screenings shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exists on more than 50% of the surface area of any size between successive laboratory sieves.	3 cubic yards
Perlite: Horticultural grade, free of any toxic materials 0-30% passing US No. 18 Sieve 0-10% passing U.S. No. 30 Sieve	1 cubic yard per 3 cubic yards of mineral aggregate.
Dolomite: CAMg(CO3)2 (calcium magnesium carbonate) Agricultural grade, free of any toxic materials 100% passing US No. 8 Sieve 0% passing U.S. No. 16 Sieve	10 pounds per cubic yard of perlite
Gypsum: Noncalcined, agricultural gypsum CaSO4+2H2O (hydrated calcium sulfate) Agricultural grade, free of any toxic materials 100% passing US No. 8 Sieve 0% passing US No. 16 Sieve	1.5 pounds per cubic yard of perlite.

Crushed Surfacing Base Course (CSBC)

If the design is configured to allow the media filter drain to drain laterally into a ditch, the crushed surfacing base course below the media filter drain shall conform to Section 9-03.9(3) of the WSDOT *Standard Specifications*. The designer should consult with a professional to ensure that the CSBC will not impede the flow of water out of the media filter drain mix. If needed, a different gradation may be specified to ensure the free flow of water out of the media filter drain mix.

Soil Mix for Grass Strip

The designer should consult a landscape architect for soil mix recommendations. The designer may consider adding aggregate to the soil mix to help minimize rutting problems from errant vehicles. The soil mix should ensure grass growth for the design life of the MFD.

Site Design Elements

Landscaping (Planting Considerations)

Landscaping is the same as for biofiltration swales (see BMP BF.01) unless otherwise specified and approved by Thurston County.

Signing

Non-reflective guideposts shall be installed to delineate the MFD. The guideposts shall indicate that the area is a stormwater treatment facility and not to disturb without contacting Thurston County. This practice allows road maintenance personnel to identify where the system is installed and to make appropriate repairs should damage occur to the system. If the MFD is in a critical aquifer recharge area for drinking water supplies, signage prohibiting the use of pesticides must be provided.

Construction and Maintenance

Maintenance will consist of routine roadside management. While herbicides should not be applied directly over the MFD, it may be necessary to periodically control noxious weeds with herbicides in areas around the MFD as part of a roadside management program. The use of pesticides may be prohibited if the MFD is in a critical aquifer recharge area for drinking water supplies. The designer should check with the local area water purveyor and Thurston County Environmental Health. Areas of the MFD that show signs of physical damage will be replaced based on the original design which should be included in the Maintenance Plan.

Chapter 8 - Oil and Water Separation BMPs

Oil and water separators treat stormwater runoff by removing oil floating on top of the water. There are two general types of separators: American Petroleum Institute (API) separators and coalescing plate (CP) separators. Both types use gravity to remove floating and dispersed oil. API separators (or "baffle" separators) are composed of three chambers, separated by baffles. Separator efficiency depends on detention time in the center, or detention chamber, and on droplet size. CP separators use a series of parallel plates to improve separation efficiency by providing more surface area, thus reducing space needed for the separator.

Oil and water separators must be located off-line from the primary conveyance and detention system, bypassing flows greater than the water quality design flow. Linear sand filters may also be used for oil removal. Oil control devices and facilities shall always be placed upstream of other treatment facilities and as close to the source of oil generation as possible.

Note: Thurston County will not accept ownership of some types of oil control facilities without prior acceptance.

8.1 Oil and Water Separation BMPs

Three oil and water separation BMPs are described in this section:

- OW.01 API (Baffle type) Separator Bay
- OW.02 Coalescing Plate (CP) Separator Bay
- OW.03 Oil Containment Booms.

8.1.1 OW.01 API (Baffle Type) Separator Bay

This type of separator uses internal baffles to separate the oil from the water. (API stands for American Petroleum Institute.)

Applicability

API separators are designed for use on sites larger than 2 acres.

Limitations

Ecology's 2005 *Stormwater Management Manual for Western Washington* (Ecology 2005) presents a design modification for using API separators in drainage areas smaller than 2 acres (e.g., fueling stations and commercial parking lots). However, Ecology also requires each developer to complete a detailed performance verification during at least one wet season when using their modified design. Given this requirement, Thurston County has elected not to allow the use of API separators on sites smaller than 2 acres. The following approach only applies to contributing drainage areas larger than 2 acres.

Submittals and Approval

As part of submittal required by Volume I include the following:

- Hydrologic modeling indicating design storm flows and volumes
- Design calculations demonstrating compliance with design criteria
- Manufacturer data for vault and appurtenances.

Pretreatment

No pretreatment required.

Hydrologic and Hydraulic Design Considerations

Design Storm

The separator shall be designed to treat the water quality design storm, as calculated using the Santa Barbara Urban Hydrograph (SBUH) method for a 6-month, 24-hour storm with a Type 1A rainfall distribution (See Volume III). If hydrologic calculations are performed using a continuous hydrologic model, the water quality design flow rate predicted by an approved continuous runoff model may be multiplied by the ratio in Figure 5.1a or 5.1b to obtain the design flow rate. This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures.

The separator shall be located off-line, receiving only the water quality design storm flows. If it is necessary to locate the separator online, try to minimize the size of the area needing oil control, and use the online water quality design flow rate multiplied by the ratio indicated in Figure 5.1b (if hydrologic calculations are being performed using a continuous hydrologic model).

Size the separator bay for the Water Quality design flow rate.

Sizing

The API design criteria is based on the horizontal velocity of the bulk fluid (V_h), the oil rise rate (V_t), the residence time (t_m), width, depth, and length considerations.

Size APIs using the following procedure:

- Step 1. Determine the oil rise rate, V_t, in centimeters per second, using Stokes' Law (Water Pollution Control Federation, 1985) or empirical determination.
    - Stokes Law equation for rise rate, V_t (ft/min):

      $$V_t = 1.97g(\sigma_w - \sigma_o)D^2 / 18\eta_w)$$

      Where: 1.97 = conversion factor (centimeters per second/ft per minute)

      g = gravitational constant (981 centimeters per second squared)

      D = diameter of the oil particle (centimeters).
    - Use:
        - oil particle size diameter, D = 60 microns (0.006 centimeters)
        - σ_w = water density = 0.999 grams per cubic centimeter (gm/cc) at 32°F
        - σ_o: Select conservatively high oil density,
        - For example, if diesel oil @ σ_o=0.85 gm/cc and motor oil @ σ_o = 0.90 gm/cc can be present then use σ_o=0.90 gm/cc
        - η_w = dynamic viscosity of water = 0.017921 poise (gm/cm-sec), at water temperature of 32°F, (see API publication 421, February, 1990)

- Step 2. Determine Q:
  - Q = the 15-minute Water Quality design flow rate in ft^3/min multiplied by the ratio indicated in Figure 5.1b for the site location (k). Note that WWHM gives the water quality design flow rate in ft^3/sec. Multiply this flow rate by 60 to obtain the flow rate in ft^3/min.
- Step 3. Calculate horizontal velocity of the bulk fluid, Vh (in ft/min), and depth (d), ft.

$$Vh = 15Vt$$

  - $d = (Q/2Vh)^{1/2}$, with
  - Separator water depth, $3 \leq d \leq 8$ feet (to minimize turbulence). If the calculated depth is less than 3 feet, an API separator is not appropriate for the site. If the calculated depth exceeds 8 feet, consider using two separators (American Petroleum Institute, 1990; U.S. Army Corps of Engineers, 1994).
- Step 4. Calculate the minimum residence time (tm), in minutes, of the separator at depth d:

$$t_m = d/V_t$$

  - Calculate the minimum length of the separator section, l(s), using:
    - F = 1.65
    - Depth/width (d/w) of 0.5 (American Petroleum Institute, 1990)
    - $l(s) = FQt_m/wd = F(V_h/V_t)d$
- Step 5. For other dimensions, including the length of the forebay, the length of the afterbay, and the overall length, L; refer to Figure 8.1.
- Step 6. Calculate V = l(s)wd = FQtm, and Ah = wl(s)
  - V = minimum hydraulic design volume, in cubic feet.
    A_h = minimum horizontal area of the separator, in square feet.

Design Criteria

Figure 8.1 provides a plan and section view of the API Separator.

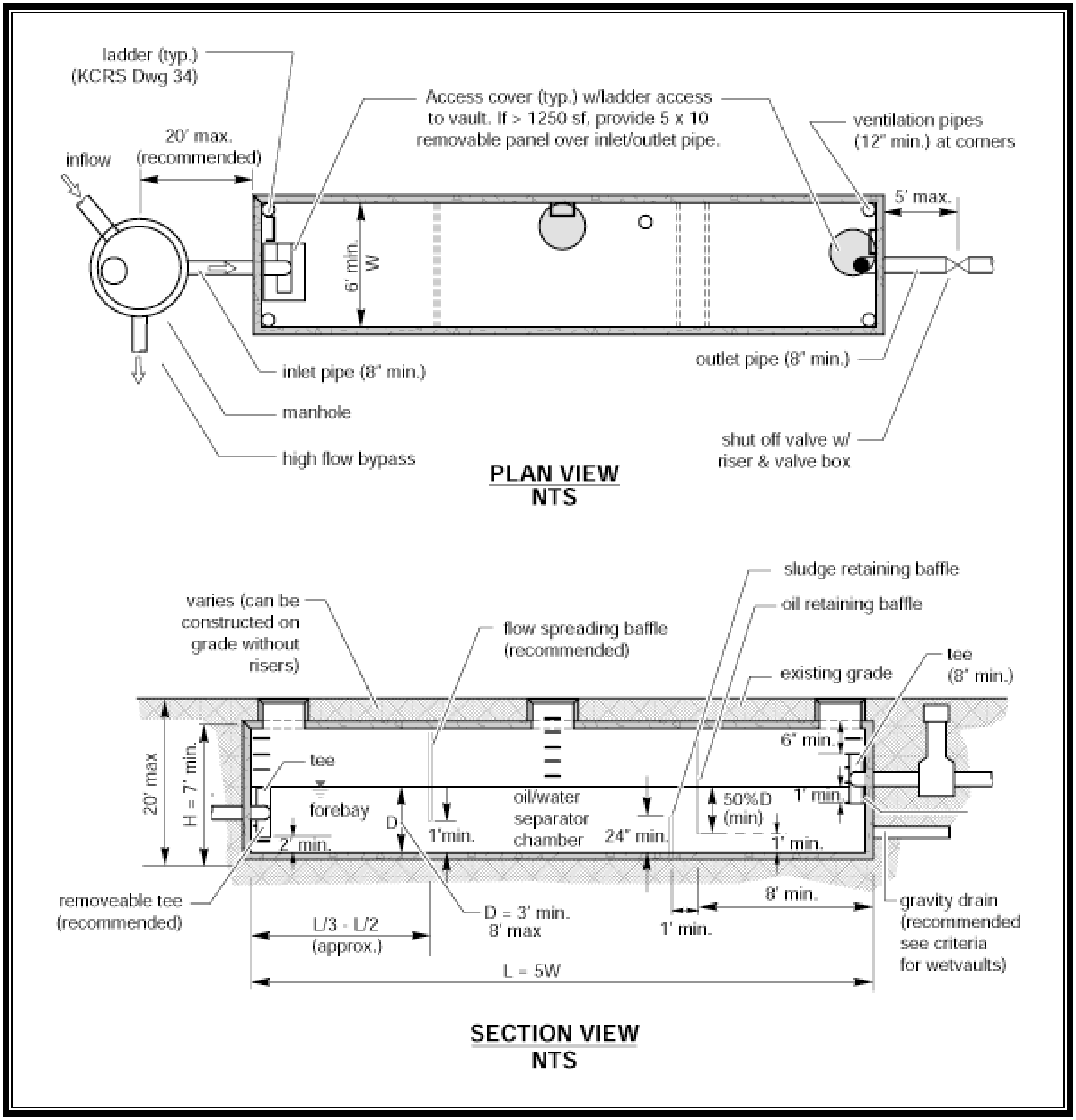


Figure 8.1. API (Baffle Type) Separator.

Geometry

Criteria for Separator Bays

To collect floatables and settleable solids, design the surface area of the forebay at ≥ 20 ft² per 10,000 ft² of area draining to the separator. The length of the forebay shall be one-third to one-half of the length of the entire separator.

Include a submerged inlet pipe with a turn-down elbow in the first bay at least 2 feet from the bottom. The outlet pipe shall be a Tee, sized to pass the design peak flow and placed at least 12 inches below the water surface.

Include a shutoff valve at the separator outlet pipe.

Criteria for Baffles

Oil retaining baffles (top baffles) shall be located at least at one-fourth of the total separator length from the outlet, and shall extend down at least 50 percent of the water depth and at least 1 foot from the separator bottom.

Baffle height to water depth ratios shall be 0.85 for top baffles and 0.15 for bottom baffles.

Materials

Include roughing screens for the forebay or upstream of the separator to remove debris. Screen openings should be about three-fourths inch.

Use only impervious conveyances for oil contaminated stormwater.

Structural Design Considerations

Conform to the structural and materials criteria specified for wet vaults.

Site Design Elements

Access, setbacks and right-of-way requirements are the same as for detention vaults (see Section 4.1.3, BMP D.03 of this Volume).

Construction and Maintenance

Thurston County may require a bypass/shutoff valve to enable the vault to be taken off-line for maintenance.

Inspect oil/water separators monthly during the wet season of October 1-April 30 (WEF & ASCE, 1998; Woodward-Clyde Consultants) to ensure proper operation, and, during and immediately after a large storm event of ≥ 1 inch per 24 hours

Clean oil/water separators regularly to keep accumulated oil from escaping during storms. They must be cleaned by October 15 to remove material that has accumulated during the dry season (Woodward-Clyde Consultants), after all spills, and after a significant storm. Coalescing plates may be cleaned in-situ or after removal from the separator. An eductor truck may be used for oil, sludge, and washwater removal. (King County Surface Water Management, 1998) Replace wash water in the separator with clean water before returning it to service.

Remove the accumulated oil when the thickness reaches 1-inch. Also remove sludge deposits when the thickness reaches 6 inches (King County Surface Water Management, 1998).

8.1.2 OW.02 Coalescing Plate (CP) Separator Bay

This type of device uses a series of stacked plates to coalesce the oil into larger droplets to enhance removal from the stormwater (see Figure 8.2).

Applicability and Limitations

Applicable for all sites requiring oil control.

Submittals and Approval

As part of submittal required by Volume I include the following:

- Hydrologic modeling indicating design storm flows and volumes
- Design calculations demonstrating compliance with design criteria
- Manufacturer data for vault and appurtenances.

Pretreatment

Add pretreatment for total suspended solids that could clog the coalescing plate separator or otherwise impair the long-term effectiveness of the separator.

Hydrologic and Hydraulic Design Considerations

Design inlet flow distribution and baffles in the separator bay to minimize turbulence, short-circuiting, and channeling of the inflow, especially through and around the plate packs of the CP separator. The Reynolds Number through the separator bay should be less than 500 (laminar flow).

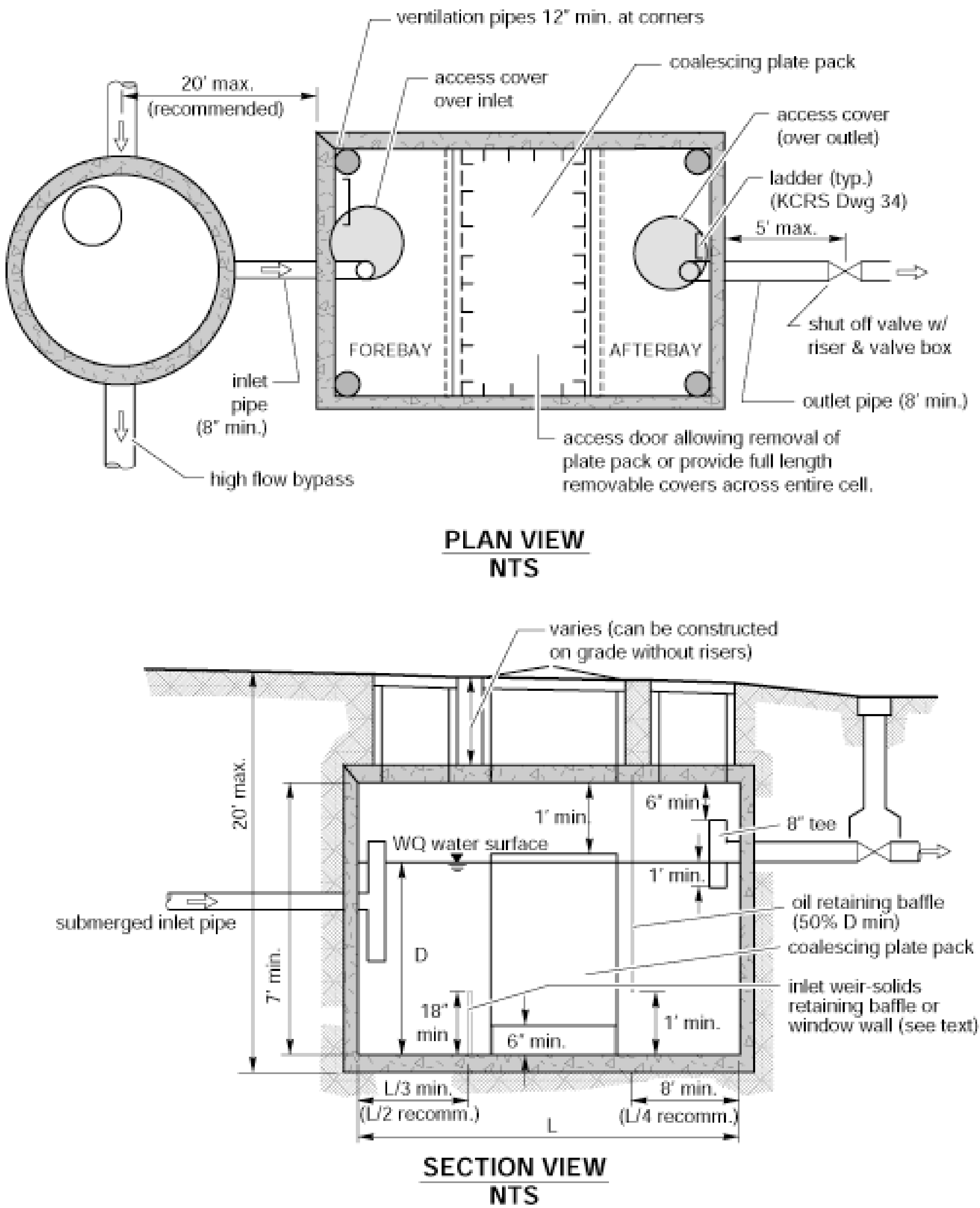
Locate the separator off-line and bypass the incremental portion of flows that exceed the off-line 15-minute, Water Quality design flow rate multiplied by the ratio indicated in Figure 5.1a of this volume. If it is necessary to locate the separator online, try to minimize the size of the area needing oil control, and use the online water quality design flow rate multiplied by the ratio indicated in Figure 5.1b.

Sizing

Calculate the projected (horizontal) surface area of plates needed using the following equation:

$$A_p = Q/V_t = Q/0.00386(\sigma_w\text{-}\sigma_o/\eta_w)$$

$$A_p = A_a(\text{cosine b})$$



Source: King County

Figure 8.2. Coalescing Plate Separator.

Where:

Q = k (the ratio appropriate for the project location) indicated by Figure 5.1b x the 15-minute water quality design flow rate, ft^3/min

V_t = Rise rate of 0.033 ft/min, or empirical determination, or Stokes Law based

A_p = projected surface area of the plate in ft^2; .00386 is unit conversion constant

σ_w=density of water at 32ºF

σ_o= density of oil at 32ºF

A_a = actual plate area in ft^2 (one side only)

b = angle of the plates with the horizontal in degrees (usually varies from 45-60 degrees).

η_w=viscosity of water at 32ºF.

Design Criteria

Geometry

Plate spacing shall be a minimum of three-fourths of an inch (perpendicular distance between plates) (WEF and ASCE, 1998; U.S. Army Corps of Engineers, 1994; US Air Force, 1991; Jaisinghani, R., 1979).

Select a plate angle between 45° to 60° from the horizontal.

Locate plate pack at least 6 inches from the bottom of the separator for sediment storage.

Add 12 inches minimum head space from the top of the plate pack and the bottom of the vault cover.

Include forebay for floatables and afterbay for collection of effluent (WEF and ASCE, 1998).

The sediment-retaining baffle must be upstream of the plate pack at a minimum height of 18 inches.

Design plates for ease of removal, and cleaning with high-pressure rinse or equivalent.

8.1.2 OW.03 Oil Containment Booms

The *oil containment boom* is a weather-resistant, hydrophobic, absorbent-filled boom for removing hydrocarbon sheens from water.

Applicability

Oil containment booms can be used to remove oil from the following stormwater facilities to meet performance goals at high use intersections in the public right-of-way where oil control is required:

- BMP WP.01 – Stormwater Treatment Wetland
- BMP WP.02 – Wet Pond
- BMP WP.03 – Wet Vault
- BMP WP.04 – Combined Detention/Wet Pool Facility
- BMP WP.05 – Pre-Settling Basin.

Oil containment boom technology is a low-cost, effective, and easily maintained option for surface ponds. Offers the following advantages over other treatment options:

- Fully functional at flow rates exceeding treatment flow criteria
- Easy and complete removal and disposal of absorbed oil
- Higher reliability because sediment clogging is avoided
- Effectiveness easily assessed due to aboveground installation
- Reduced exposure of maintenance workers to traffic and confined-space hazards.

Limitations

Oil containment booms may not be used in stormwater BMPs that manage runoff from private development.

The oil containment boom is used in a surface pond or treatment vault. If a surface stormwater pond or vault is not included as part of the project this BMP will not be available to meet oil control requirements.

Submittals and Approval

A description of the oil containment boom proposed by the applicant shall be included in the drainage report to include manufacturer data and specifications and manufacturer's recommendations.

Pretreatment

No pretreatment is required.

Hydrologic and Hydraulic Design Considerations

No hydrologic or hydraulic design considerations are involved in using an oil containment boom.

Design Criteria

Geometry

The boom must be cylindrical, with a minimum diameter of 2 inches. It should be installed near the outlet end of the facility so that the oil has a maximum amount of time to rise to the water surface. Maximizing boom distance from inlet currents also maximizes contact time between the boom and the oil. The boom must span the entire width of ponds when they are filled to capacity. The boom must be placed so that it is in direct contact with the water across the entire water surface. In treatment ponds, the boom must be installed diagonally across the water surface to maximize contact area and contact time between hydrocarbons and the boom. When used in a vault, the boom must completely encircle the outlet structure (see Figure 8.3).

Materials

The absorbent material must consist of high-molecular-weight polymers capable of absorbing (1) C5-C18 hydrocarbons associated with fuels, and (2) longer chain hydrocarbons with frequently attached cyclic hydrocarbon structures associated with lubricating oils.

The absorbent material must exhibit the following characteristics:

- Absorb and solidify a minimum of three times its weight in liquid hydrocarbons
- Have sufficient buoyancy at the exhausted condition to continue to trap oil
- Irreversibly absorb and permanently hold the hydrocarbons so that oil leachate is not released from the sorbent. U.S. EPA guidelines for solidified hazardous waste without chemical bonds being formed or broke must also be met.

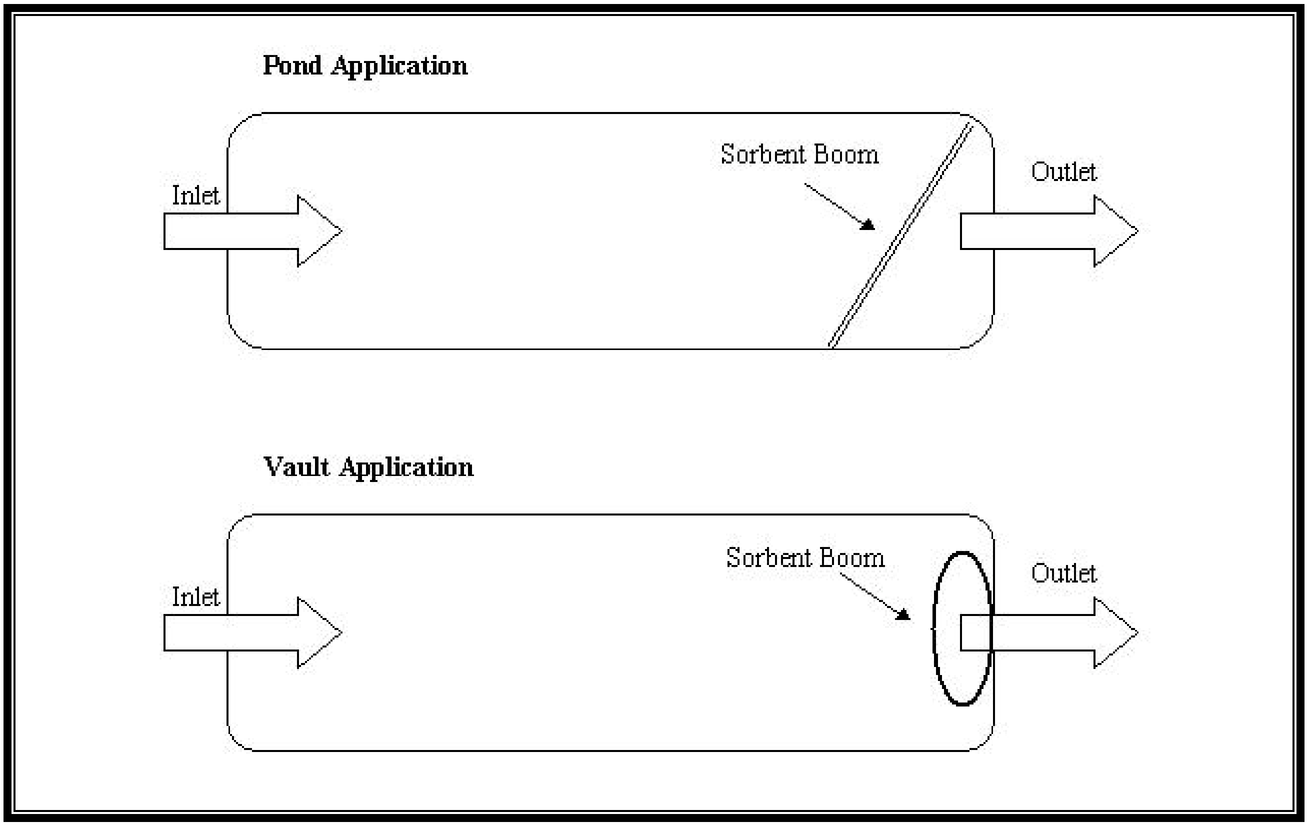


Figure 8.3. Oil Containment Boom.

- Contain a minimum of 99 percent active ingredient and no leachable toxicant to fish and other aquatic life. The supplier must provide appropriate information demonstrating that toxicity will not be a problem.

The absorbent boom cover fabric must meet the following criteria:

- Be fabricated of photo-resistant mesh that meets the ultraviolet (UV) stability requirement for permanent erosion control blankets in Section 9-14.5 of the *Standard Specifications*
- Be sized to allow for the expansion of the absorbent material to hold the specified absorption volume per foot.

Additional requirements for materials related to booms include the following:

- Booms must include a weather-resistant tag to enable labeling with installation and inspection dates for tracking long-term effectiveness and maintenance activities.
- Boom ends must be configured so that they can be secured to immobile structures or metal stakes with weather-resistant rope.

Chapter 9 - Chapter 9 - Emerging Technologies

This Chapter addresses emerging (new) technologies that have not been evaluated in sufficient detail to be acceptable for general usage in new development or redevelopment situations.

9.1 Background

It has become clear that the treatment BMPs described in Ecology's 1992 Stormwater Manual, in some situations, are either not applicable or do not provide reliable and cost-effective removal of pollutants. For these reasons a need to develop new stormwater treatment technologies has emerged in this State as well as nationwide.

Emerging technologies are new technologies that have not been evaluated using approved protocols, but for which preliminary data indicate that they may provide a desirable level of stormwater pollutant removal. Some emerging technologies have already been installed in Washington as parts of treatment trains or as stand-alone systems for specific applications. In some cases, emerging technologies are necessary to remove metals, hydrocarbons, and nutrients. Emerging technologies can also be used for retrofits and where land availability is unavailable

9.2 Ecology Role in Evaluating Emerging Technologies

Ecology currently facilitates a process to evaluate emerging permanent and construction site stormwater treatment technologies and to convey judgments made by local jurisdictions and others on their acceptance. Based on recommendations from Ecology's Volume V Stormwater Technical Advisory Committee (TAC), Ecology is implementing the following process:

- Maintaining a web site for publishing information on emerging technologies and the protocols (TAPE and C-TAPE) used in their evaluation, which is housed at:

  http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

- Organizing and convening Technical Review Committees (TRC) which evaluate emerging technologies, and

- Based on performance and other pertinent data from manufacturers, and recommendations of the review committees, Ecology assesses emerging technology development levels, and posts relevant decisions and supporting documentation at its stormwater website.

9.3 Emerging Technology Use in Retrofit Situations

To achieve the goals of the Clean Water Act and the Endangered Species Act, local governments may find it necessary to retrofit existing stormwater discharges. In retrofit situations, the use of any BMPs that make substantial progress toward these goals is a step forward and is encouraged by Ecology. To the extent practicable, the performance of these BMPs should be evaluated, using approved protocols.

9.4 Acceptable Evaluation Protocols (TAPE and C-TAPE)

To properly evaluate new technologies, performance data must be obtained using an accepted protocol. Ecology has published recommended protocols at its website for use by local governments, suppliers of new technologies, and consultants.

9.5 Acceptance and Use of Emerging Technologies for New Developments and Re-developments

New developments and re-developments may propose to use emerging technologies. These technologies must be:

- Approved and listed on Ecology's website,
- Proposed for use in accordance with Ecology's approval conditions,
- Appropriate to the development site, and
- Approved by the Administrator or designee.

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Appendix V-A – Structures

Control structures are catch basins or manholes with a restrictor device that controls outflow from a facility to meet the desired performance. Riser-type restrictor devices ("tees" or "FROP-Ts") also provide some incidental oil and water separation, temporarily detaining oil or other floatable pollutants entering runoff due to accidental spill or illegal dumping.

Bypass and diversion structures are used to isolate flows when only part of the contributing flows are being directed to water quality.

Control Structures

Control structures are used when there is a need to control outflow flow rates from a BMP facility.

Applicability

The structures included in this appendix apply to the following BMPs:

- BMP D.01 Detention Ponds
- BMP D.02 Detention Tanks
- BMP D.04 Detention Vaults
- BMP WP.02 Wet Ponds.

Bypass and diversion structures apply to any BMPs that are designed to be "off-line", where only part of the contributing stormwater flow is routed to the treatment BMP.

Hydrologic and Hydraulic Design Considerations

Control structure restrictor devices usually consist of two or more orifices and/or a weir section sized to meet performance requirements. Several publicly available and proprietary stormwater modeling programs are capable of designing control structures.

Methods of Analysis

This section presents methods and equations for design of *control structure restrictor devices*. Included are details for the design of orifices, rectangular sharp-crested weirs, v-notch weirs, sutro weirs, and overflow risers.

Rectangular notched weirs are typically most efficient and will result in the optimal detention system design using WWHM.

Orifices

Flow-through orifice plates in the standard tee section or turn-down elbow may be approximated by the general equation:

$$Q = C\,A\sqrt{2gh} \qquad \text{(equation 4)}$$

where:
- Q = flow (cfs)
- C = coefficient of discharge (0.62 for plate orifice)
- A = area of orifice (ft^2)
- h = hydraulic head (ft)
- g = acceleration of gravity (32.2 ft/sec^2)

Figure A-1 illustrates this simplified application of the orifice equation.

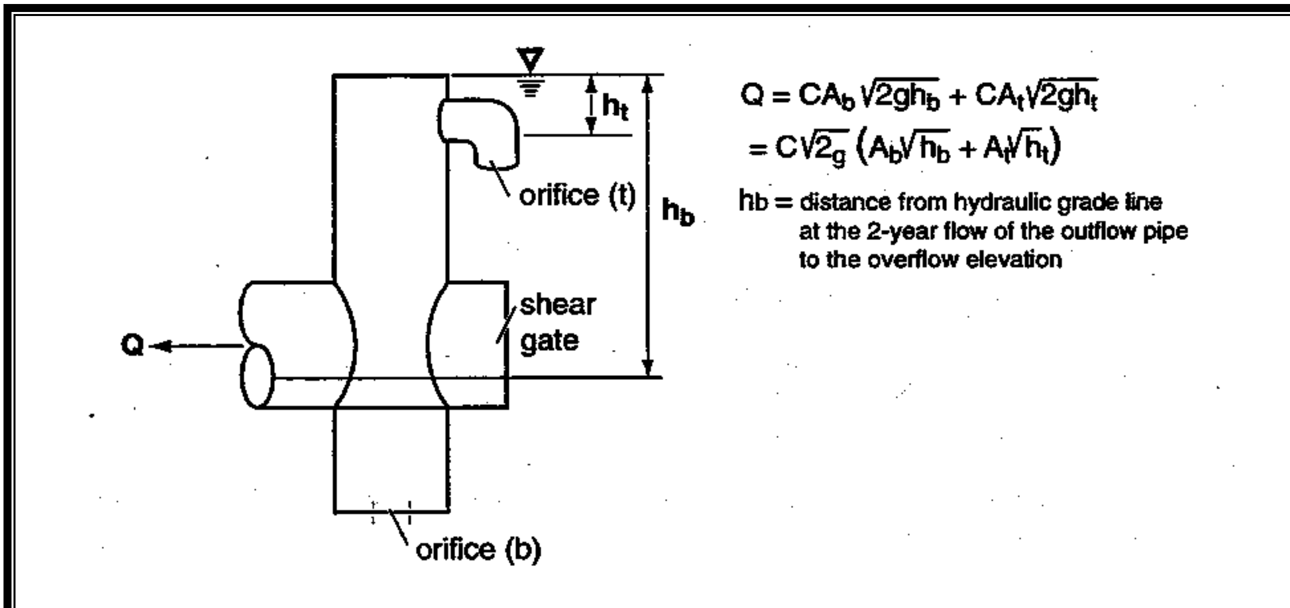


Figure A-1. Simple Orifice.

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \qquad \text{(equation 5)}$$

where
- d = orifice diameter (inches)
- Q = flow (cfs)
- h = hydraulic head (ft)

Rectangular Sharp-Crested Weir

The rectangular, sharp-crested weir design shown in Figure A-2 may be analyzed using standard weir equations for the fully contracted condition.

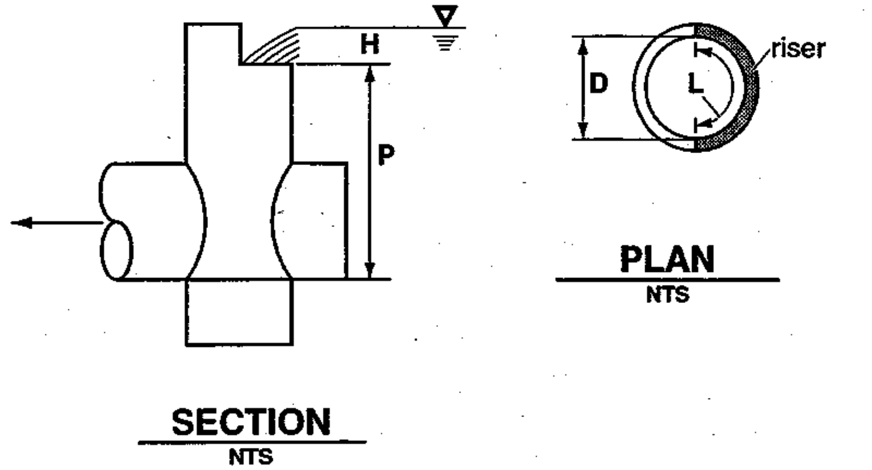


Figure A-2. Rectangular, Sharp-Crested Weir.

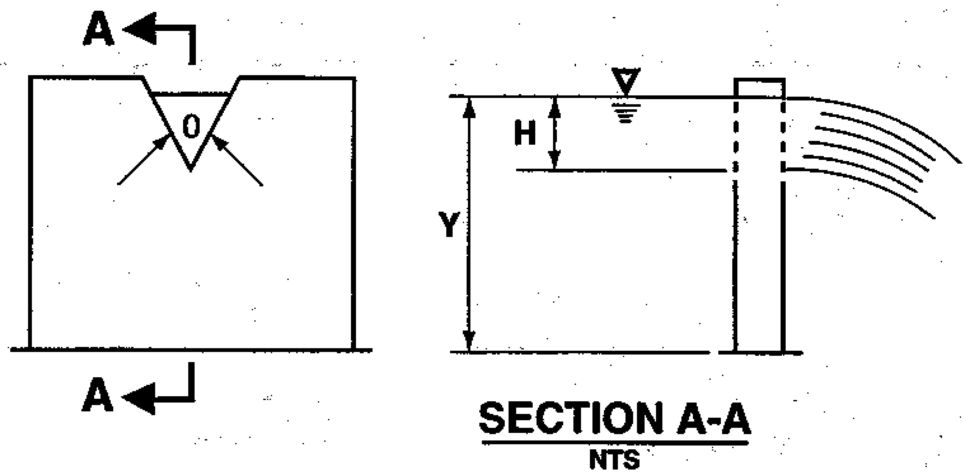
$$Q = C\,(L - 0.2H)H^{3/2} \qquad \text{(equation 6)}$$

where Q = flow (cfs)
C = 3.27 + 0.40 H/P (ft)
H, P are as shown above
L = length (ft) of the portion of the riser circumference as necessary not to exceed 50 percent of the circumference
D = inside riser diameter (ft)

Note that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.

V-Notch Sharp - Crested Weir

V-notch weirs as shown in Figure A-3 may be analyzed using standard equations for the fully contracted condition.



$Q = C_d(\text{Tan } \Theta/2)H^{5/2}$, in cfs

Where values of C_d may be taken from the following chart:

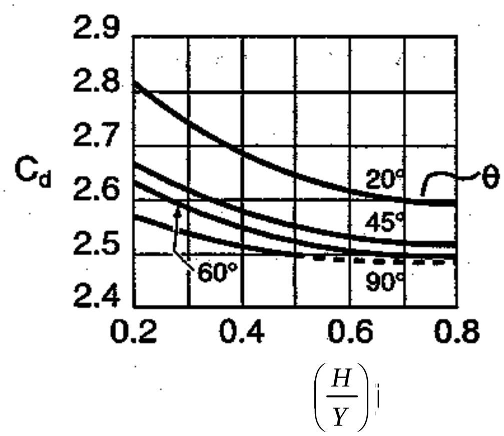


Figure A-3. V-Notch, Sharp-Crested Weir.

Proportional or Sutro Weir

Sutro weirs are designed so that the discharge is proportional to the total head. This design may be useful in some cases to meet performance requirements.

The sutro weir consists of a rectangular section joined to a curved portion that provides proportionality for all heads above the line A-B (see Figure A-4). The weir may be symmetrical or non-symmetrical.

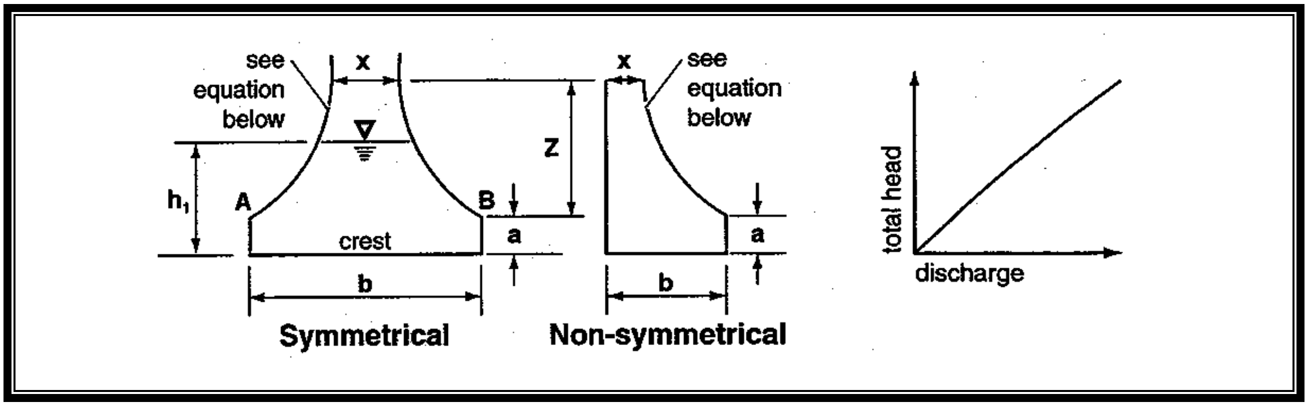


Figure A-4. Sutro Weir.

For this type of weir, the curved portion is defined by the following equation (calculated in radians):

$$\frac{x}{b} = 1 - \frac{2}{\pi} Tan^{-1} \sqrt{\frac{Z}{a}} \qquad \text{(equation 7)}$$

where a, b, x and Z are as shown in Figure A-4. The head-discharge relationship is:

$$Q = C_d\, b \sqrt{2ga(h_1 - \frac{a}{3})} \qquad \text{(equation 8)}$$

Values of *Cd* for both symmetrical and non-symmetrical sutro weirs are summarized in Table A-1.

Note: When b > 1.50 or a > 0.30, use Cd=0.6.

Table A-1. Values of C_d for Sutro Weirs

Cd Values, Symmetrical b (ft)					
a (ft)	0.50	0.75	1.0	1.25	1.50
0.02	0.608	0.613	0.617	0.6185	0.619
0.05	0.606	0.611	0.615	0.617	0.6175
0.10	0.603	0.608	0.612	0.6135	0.614
0.15	0.601	0.6055	0.610	0.6115	0.612
0.20	0.599	0.604	0.608	0.6095	0.610
0.25	0.598	0.6025	0.6065	0.608	0.6085
0.30	0.597	0.602	0.606	0.6075	0.608
Cd Values, Non-Symmetrical b (ft)					
a (ft)	0.50	0.75	1.0	1.25	1.50
0.02	0.614	0.619	0.623	0.6245	0.625
0.05	0.612	0.617	0.621	0.623	0.6235
0.10	0.609	0.614	0.618	0.6195	0.620
0.15	0.607	0.6115	0.616	0.6175	0.618
0.20	0.605	0.610	0.614	0.6155	0.616
0.25	0.604	0.6085	0.6125	0.614	0.6145
0.30	0.603	0.608	0.612	0.6135	0.614

Broad-Crested Weir

The equation for flow through a broad-crested weir that is used as a spillway section would be:

$$Q_{100} = C\,(2g)^{1/2}\left[\frac{2}{3} L H^{3/2} + \frac{8}{15}\,(\mathrm{Tan}\,\theta)\,H^{5/2}\right] \qquad \text{(equation 1)}$$

Where: Q_{100} = Peak flow for the 100-year runoff event (cfs)
C = Discharge coefficient (0.6)
g = Acceleration due to gravity (32.2 ft/sec^2)
L = Length of weir (ft)
H = Height of water over weir (ft)
θ = Angle of side slopes

Q_{100} is either the 100-year, 1-hour flow, indicated by an approved continuous runoff model, multiplied by a factor of 1.6, or the peak 10-minute flow computed from the 100-year, 24-hour storm and a Type 1A distribution.

Assuming C = 0.6 and Tan $\theta = 3$ (for 3:1 slopes), the equation becomes:

$$Q_{100} = 3.21[LH^{3/2} + 2.4\ H^{5/2}] \qquad \text{(equation 2)}$$

To find width L for the weir section, the equation is rearranged to use the computed Q_{100} and trial values of H (0.2 feet minimum):

$$L = [Q_{100}/(3.21H^{3/2})] - 2.4\ H \quad \text{or} \quad 6 \text{ feet minimum} \qquad \text{(equation 3)}$$

Riser Overflow

The nomograph in Figure A-5 can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100-year peak flow for developed conditions).

Standard control structure details are shown in Figures A-6 through A-8.

Multiple Orifice Restrictor

In most cases, control structures need only two orifices: one at the bottom and one near the top of the riser, although additional orifices may best utilize detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

- Minimum orifice diameter is 0.5 inches. In some instances, a 0.5-inch bottom orifice will be too large to meet target release rates, even with minimal head. In these cases, the live storage depth shall not be reduced to less than 3 feet in an attempt to meet the performance standards. Also, under such circumstances, flow-throttling devices may be a feasible option. These devices will throttle flows while maintaining a plug-resistant opening.

- Orifices may be constructed on a tee section as shown in Figure A-6 or on a baffle as shown in Figure A-7.

- In some cases, performance requirements may require the top orifice/elbow to be located too high on the riser to be physically constructed (e.g., a 13-inch diameter orifice positioned 0.5 feet from the top of the riser). In these cases, a notch weir in the riser pipe may be used to meet performance requirements (see Figure A-8).

- Consideration must be given to the backwater effect of water surface elevations in the downstream conveyance system. High tailwater elevations may affect performance of the restrictor system and reduce live storage volumes.

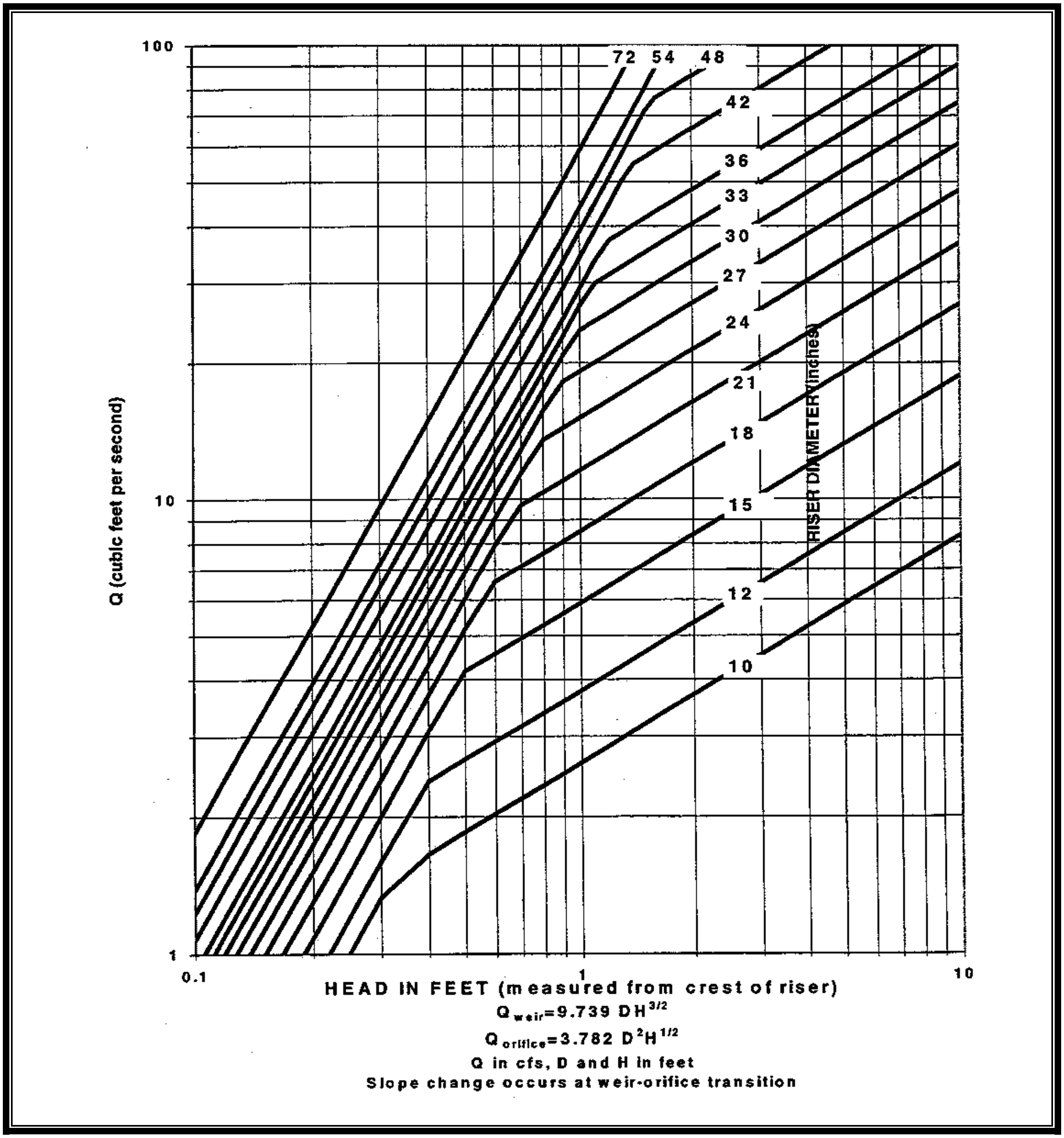
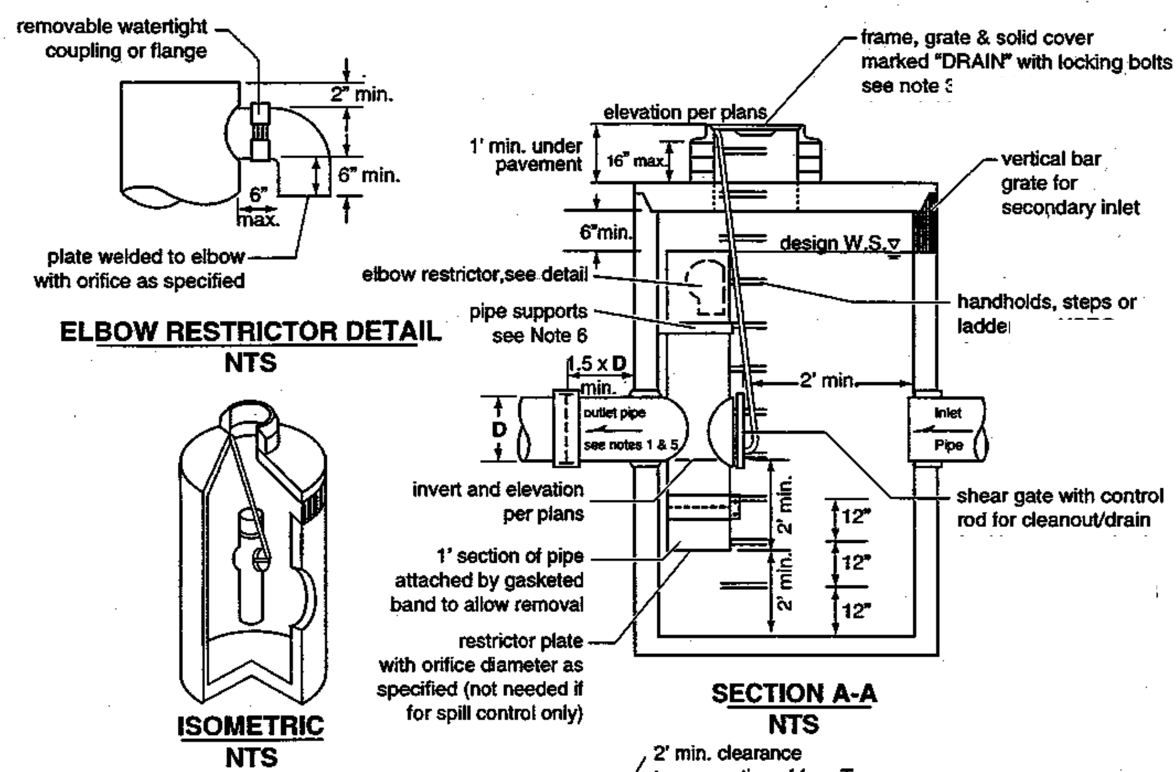
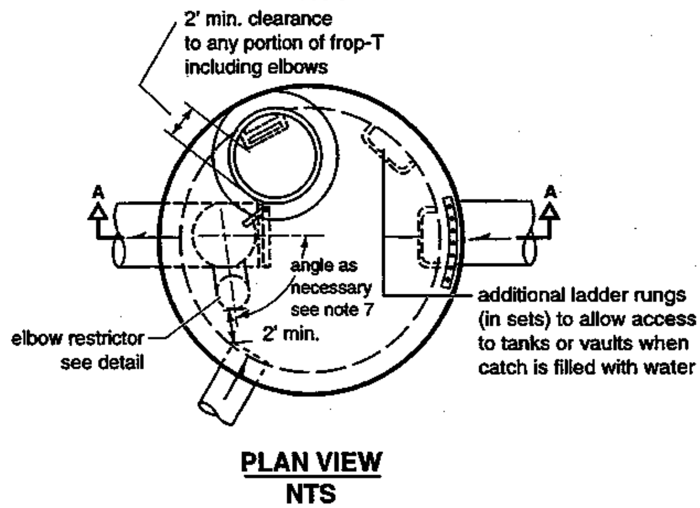


Figure A-5. Riser Inflow Curves.





NOTES:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-Year developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts perferred. Galvanized pipe parts to have asphalt treatment 1.
4. Frame and ladder or steps offset so:
   A. Cleanout gate is visible from top.
   B. Climb-down space is clear of riser and cleanout gate.
   C. Frame is clear of curb.
5. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less 1/4".
6. Provide at least one 3" X .090 inches support bracket anchored to concrete wall. (maximum 3'-0" vertical spacing)
7. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
8. Locate additional ladder rungs in structures used as access to tanks or vaults to allow access when catch basin is filled with water.

Figure A-6. Flow Restrictor (TEE).

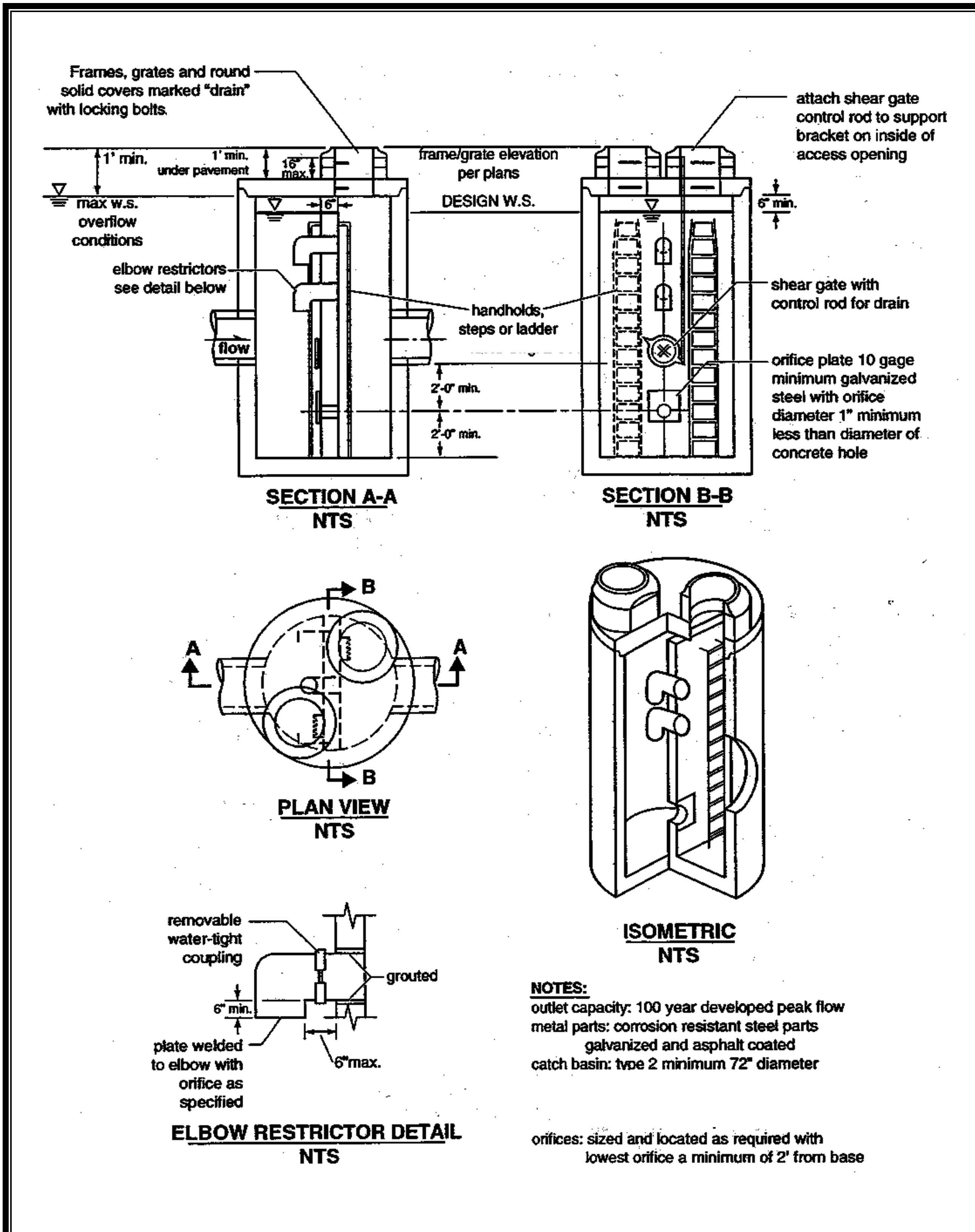
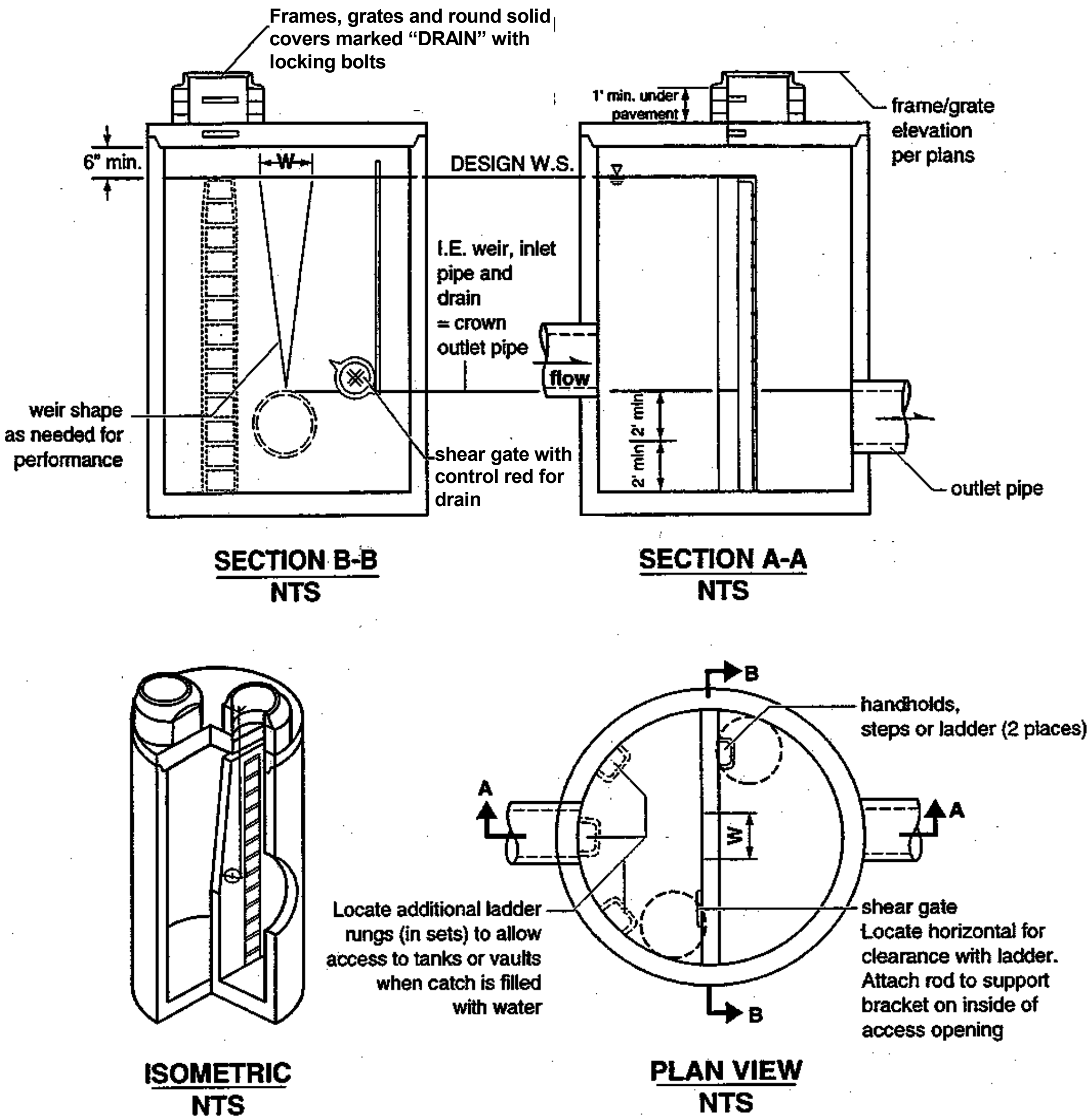


Figure A-7. Flow Restrictor (Baffle).



NOTES:
Outlet Capacity: 100-year developed peak flow.
Metal Parts: corrosion resistant steel parts galvanized and asphalt coated.
Catch Basin: type 2 Min. 72" diameter

Baffle Wall: to be designed with concrete reinforcing as required.
Spill containment must be provided to temporarily detain oil or floatable pollutants in runoff due to accidental spill or illegal dumping.

Figure A-8. Flow Restrictor (Weir).

Riser and Weir Restrictor

- Properly designed weirs may be used as flow restrictors (see Figure A-8). However, they must be designed to provide for primary overflow of the developed 100-year peak flow discharging to the detention facility.
- The combined orifice and riser (or weir) overflow may be used to meet performance requirements; however, the design must still provide for primary overflow of the developed 100-year peak flow assuming all orifices are plugged. Figure A-5 can be used to calculate the head in feet above a riser of given diameter and flow.

Information Plate

It is recommended that a brass or stainless steel plate be permanently attached inside each control structure with the following information engraved on it:

- Name and file number of project
- Name and company of (1) developer, (2) engineer, and (3) contractor
- Date constructed
- Date of manual used for design
- Outflow performance criteria
- Release mechanism size, type, and invert elevation
- List of stage, discharge, and volume at 1-foot increments
- Elevation of overflow
- Recommended frequency of maintenance.

Bypass and Diversion Structures

Bypass and diversion structures are used to isolate flows when only part of the contributing flows are being directed to water quality.

Applicability

Bypass and diversion structures apply to any BMPs that are designed to be "offline", where only part of the contributing stormwater flow is routed to the treatment BMP.

The structures included in this appendix are especially suited to the following BMPs:

- BMP BF.01 Basic Biofiltration Swale
- BMP MF.01 Sand Filter Basin
- BMP MF.02 Sand Filter Vault.

Hydrologic and Hydraulic Design Considerations

Offline sand filters placed ***upstream*** of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flow rate, as predicted by an approved continuous runoff model, to the treatment BMP. The sand filter must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).

Note: WWHM allows any bypasses and the runoff filtered through the sand to be directed to the downstream detention facility.

Offline sand filters placed ***downstream*** of a detention facility must have a flow splitter designed to send all flows at or below the 2-year recurrence interval flow from the detention pond (as predicted by an approved continuous runoff model) to the treatment facility. The treatment facility must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).

Design Criteria

Figures A-9 through A-11 provide examples of flow splitters and diversion structures.

Where flow restrictor manholes are to be used, they are to be designed in a manner similar to that shown in Appendix A, Figures A-3 and A-4. Manholes used to house flow restrictor assemblies shall have a minimum diameter of 54 inches. Assemblies shall be equipped with a chain-operated lift gate that can be opened in emergency situations. Flow restrictor devices may have multiple orifices as described in Chapter 4, or may use thin-plate slotted weirs in place of orifices.

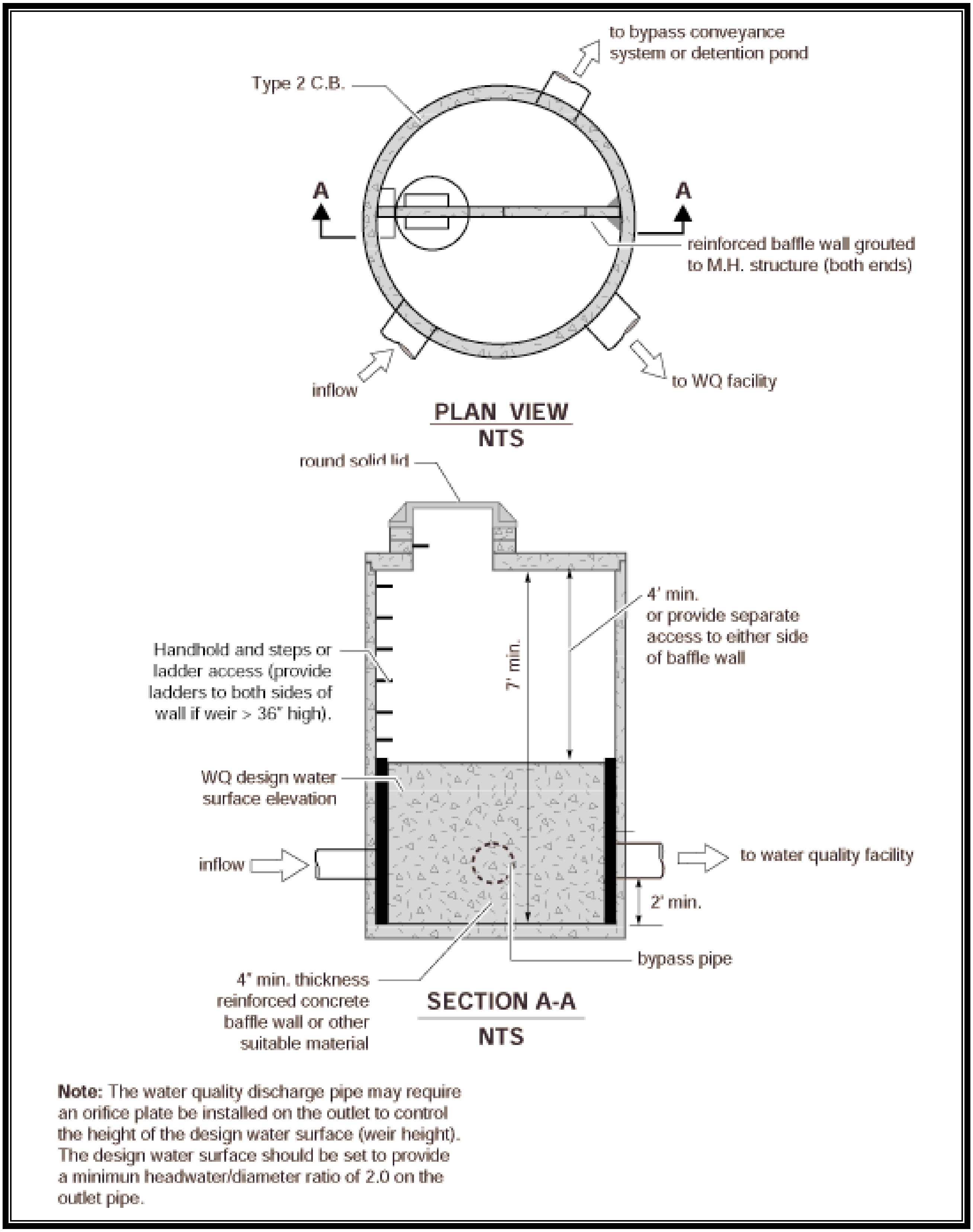


Figure A-9. Flow Splitter Option A.

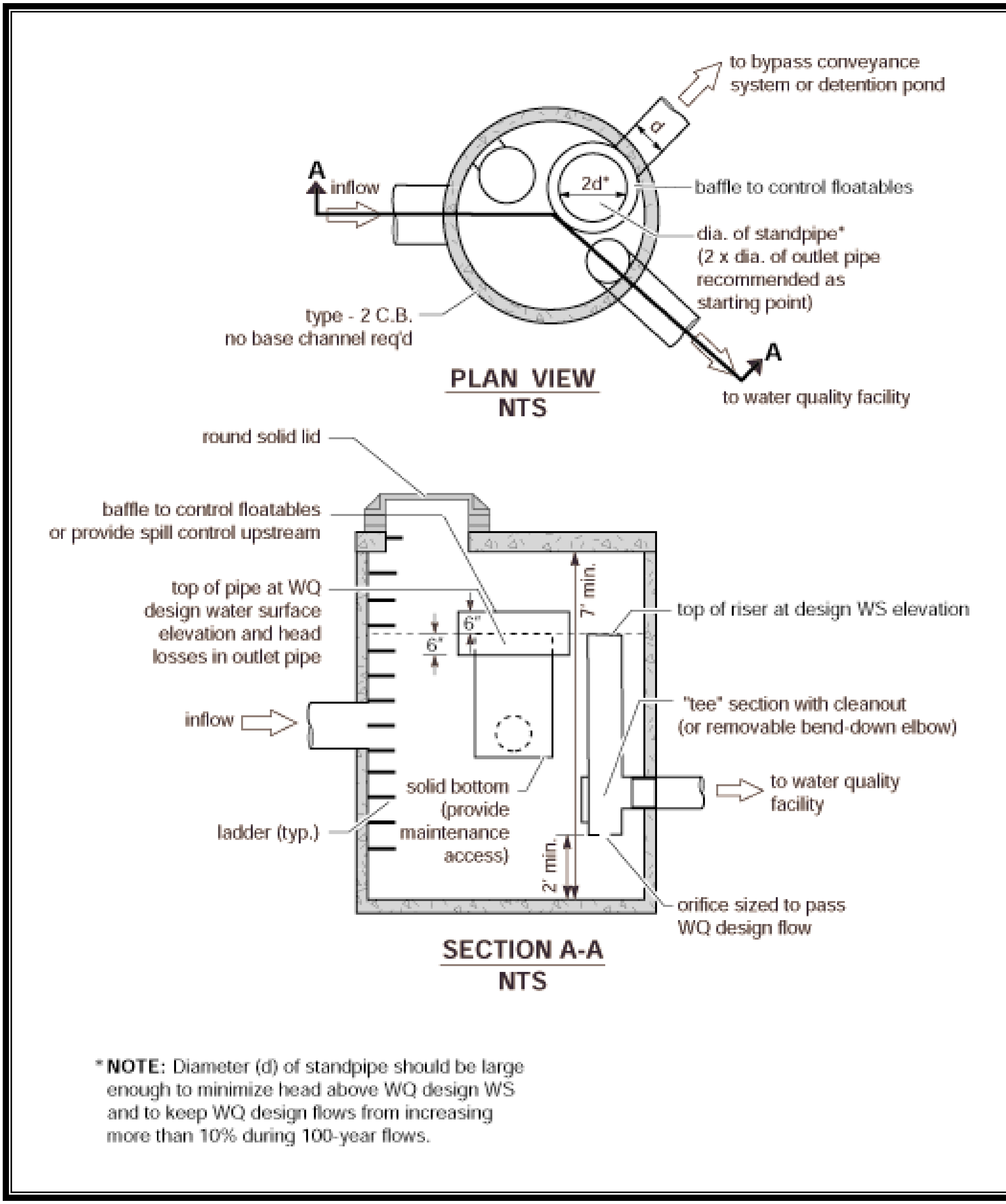
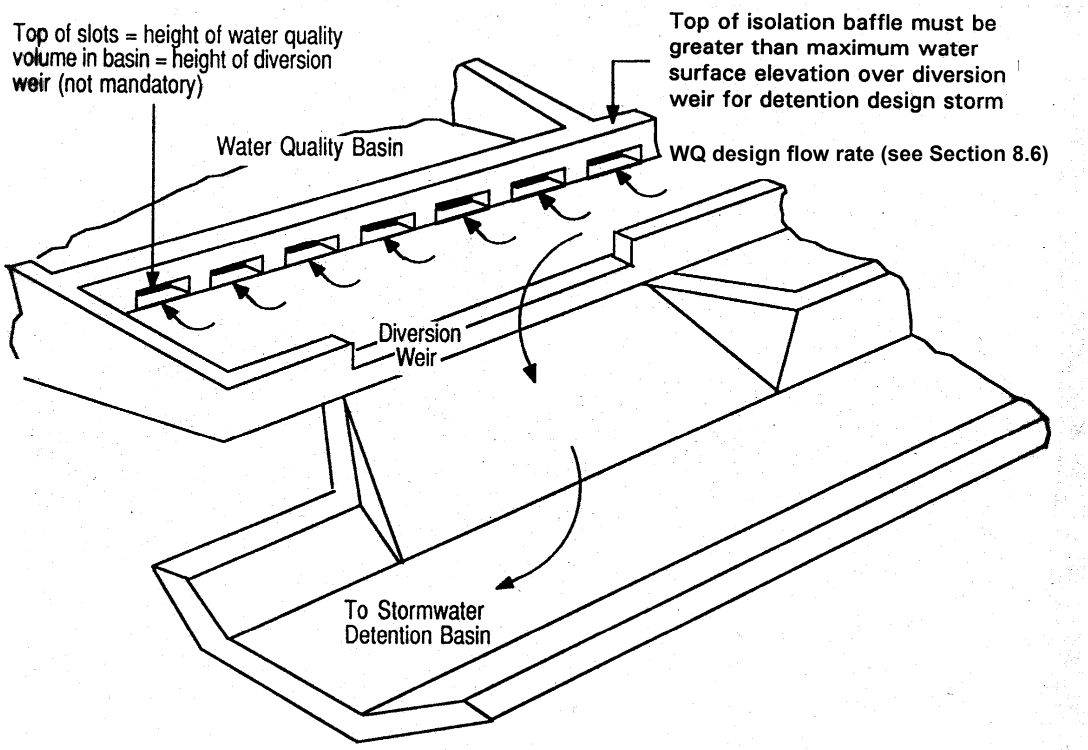


Figure A-10. Flow Splitter Option B.



Source: City of Austin

Figure A-11. Example Isolation/Diversion Structure.

Flow Spreading Options

Flow spreaders function to uniformly spread flows across the inflow portion of several water quality facilities (e.g., sand filter, biofiltration swale, or filter strip). There are five flow spreader options described in this section:

- Option A – Anchored plate
- Option B – Concrete sump box
- Option C – Notched curb spreader
- Option D – Through-curb ports
- Option E – Interrupted curb.

Options A through C can be used for spreading flows that are concentrated, and when spreading is required by facility design criteria. Options A through C can also be used for unconcentrated flows, and in some cases must be used, such as to correct for moderate grade changes along a filter strip.

Options D and E are only for flows that are already unconcentrated and enter a filter strip or continuous inflow biofiltration swale. Other flow spreader options are possible with acceptance of the Administrator or designee.

General Design Criteria

- Where flow enters the flow spreader through a pipe, it is recommended that the pipe be submerged to the extent practical to dissipate energy as much as possible.
- For higher inflows (greater than 5 cfs for the 100-year storm), a Type 1 catch basin shall be positioned in the spreader and the inflow pipe should enter the catch basin with flows exiting through the top grate. The top of the grate shall be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the v-notches.

Option A – Anchored Plate (Figure A-12)

- An anchored plate flow spreader shall be preceded by a sump with a minimum depth of 8 inches and minimum width of 24 inches. If not otherwise stabilized, the sump area shall be lined to reduce erosion and provide energy dissipation.

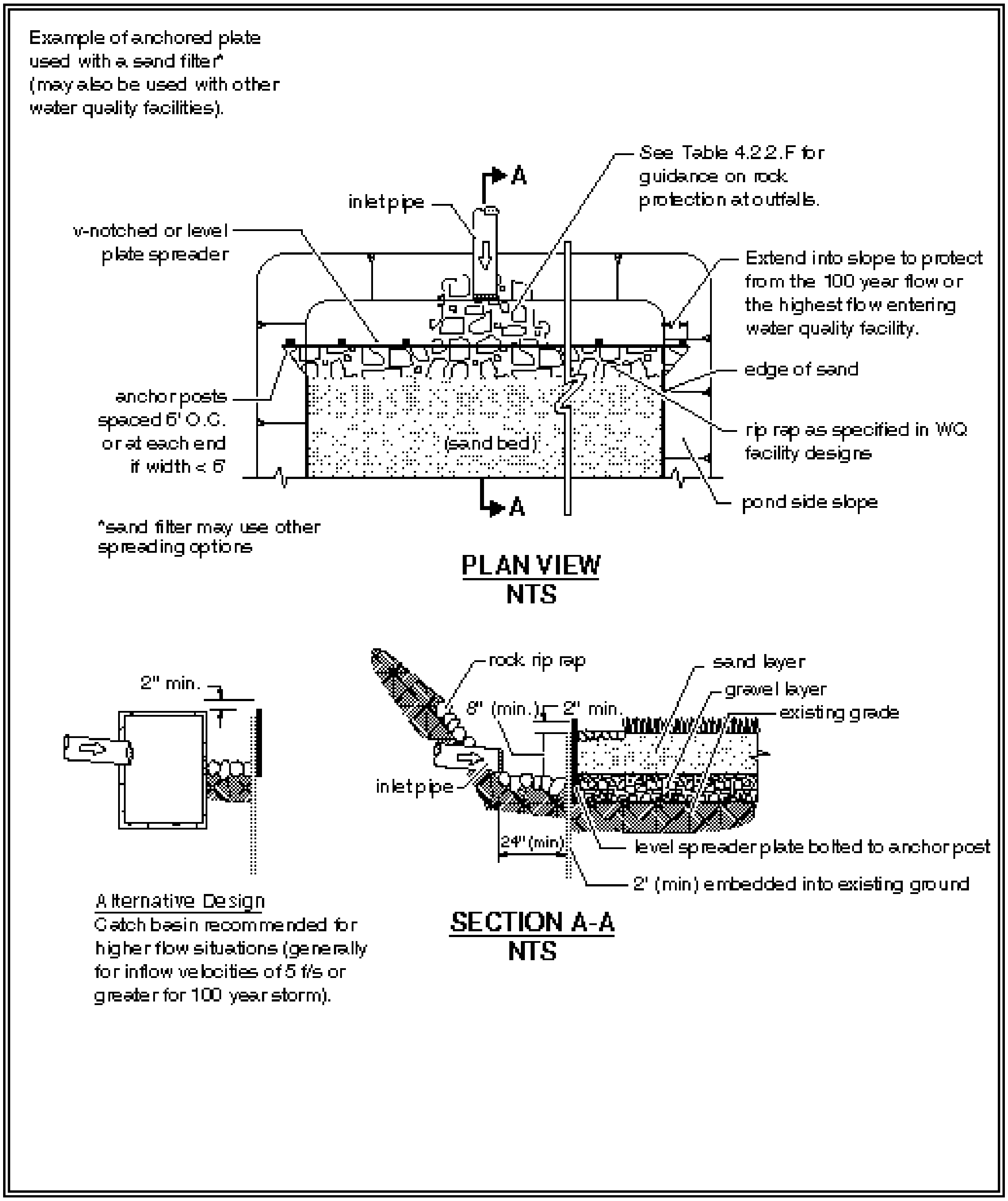


Figure A-12. Flow Spreader Option A: Anchored Plate.

- The top surface of the flow spreader plate shall be level, projecting at least 2 inches above the ground surface of the water quality facility, or V-notched with notches 6 to 10 inches on center and 1 to 6 inches deep (use shallower notches with closer spacing). Alternative designs may also be used.

- A flow spreader plate shall extend horizontally beyond the bottom width of the facility to prevent water from eroding the side slope. The horizontal extent shall be such that the bank is protected for all flows up to the 100-year flow or the maximum flow that will enter the runoff treatment facility.

- Flow spreader plates shall be securely fixed in place.

- Flow spreader plates may be made of either wood, metal, fiberglass reinforced plastic, or other durable material. If wood, pressure treated 4- by 10-inch lumber or landscape timbers are acceptable.

- Anchor posts shall be 4-inch square concrete, tubular stainless steel, or other material resistant to decay.

Option B – Concrete Sump Box (Figure A-13)

- The wall of the downstream side of a rectangular concrete sump box shall extend a minimum of 2 inches above the treatment bed. This serves as a weir to spread the flows uniformly across the bed.

- The downstream wall of a sump box shall have “wing walls” at both ends. Side walls and returns shall be slightly higher than the weir so that erosion of the side slope is minimized.

- Concrete for a sump box can be either cast-in-place or precast, but the bottom of the sump shall be reinforced with wire mesh for cast-in-place sumps.

- Sump boxes shall be placed over bases that consists of 4 inches of crushed rock, 5/8-inch minus to help assure the sump remains level.

Option C – Notched Curb Spreader (Figure A-14)

Notched curb spreader sections shall be made of extruded concrete laid side-by-side and level. Typically five “teeth” per 4 foot section provide good spacing. The space between adjacent “teeth” forms a v-notch.

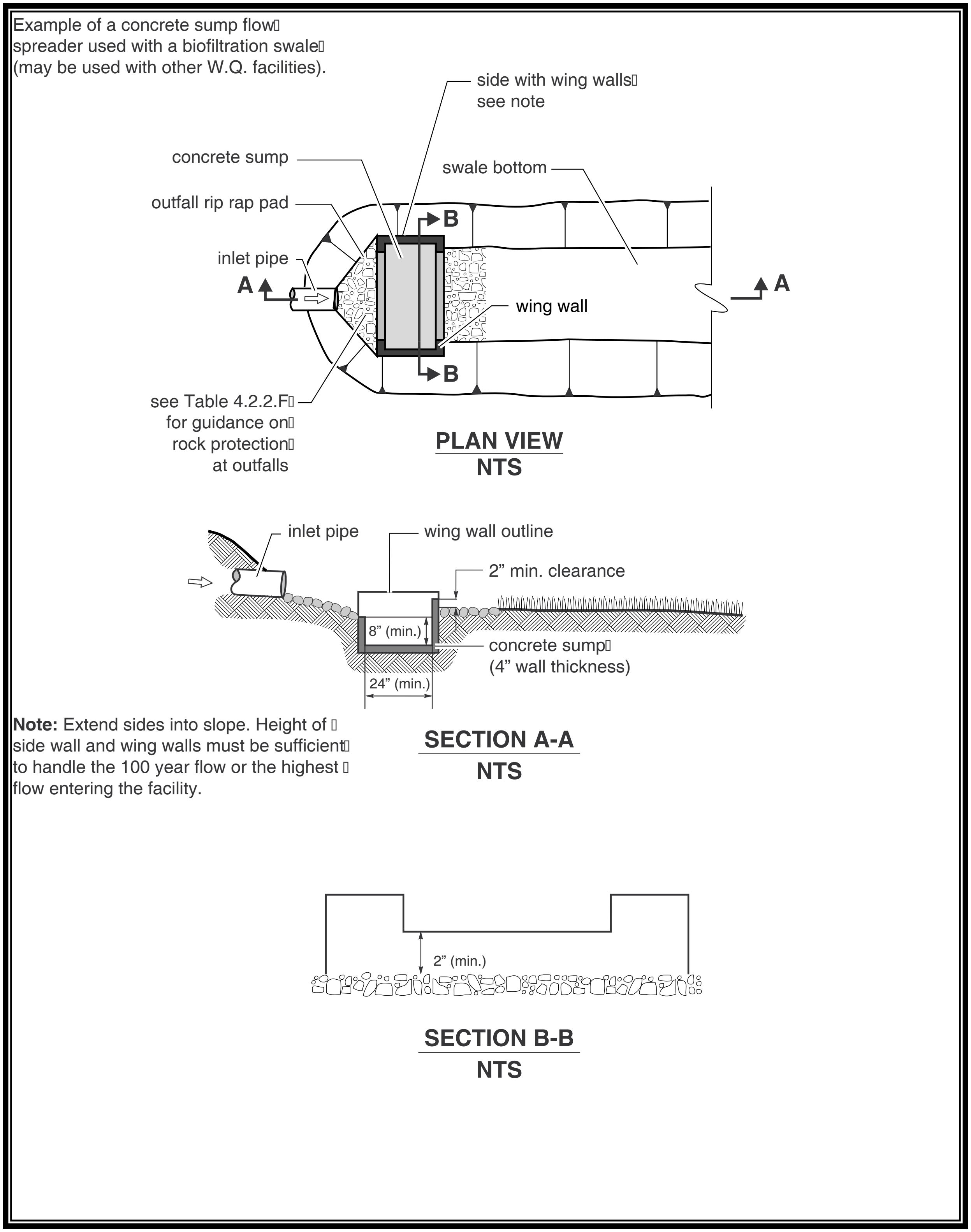


Figure A-13. Flow Spreader Option B: Concrete Sump Box.

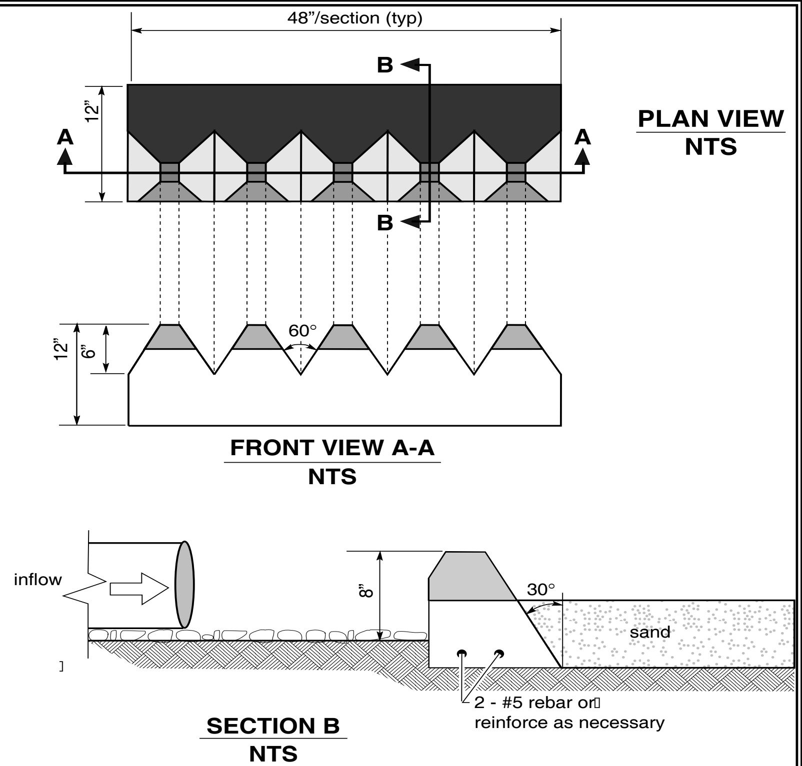
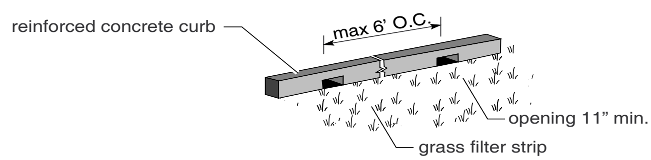


Figure A-14. Flow Spreader Option C: Notched Curb Spreader.

Option D –Through-Curb Ports (Figure A-15)

Unconcentrated flows from paved areas entering filter strips or continuous inflow biofiltration swales can use curb ports or interrupted curbs (Option E) to allow flows to enter the strip or swale. Curb ports use fabricated openings that allow concrete curbing to be poured or extruded while still providing an opening through the curb to admit water to the runoff treatment facility.

Openings in the curb shall be at regular intervals but at least every 6 feet (minimum). The width of each curb port opening shall be a minimum of 11 inches. Approximately 15 percent or more of the curb section length shall be in open ports, and no port shall discharge more than about 10 percent of the flow.



CURB PORT
NTS

Figure A-15. Flow Spreader Option D: Through-Curb Port.

Option E – Interrupted Curb (No Figure)

Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on facility) of the treatment area. At a minimum, gaps shall be every 6 feet to allow distribution of flows into the treatment facility before they become too concentrated. The opening shall be a minimum of 11 inches. As a general rule, no opening shall discharge more than 10 percent of the overall flow entering the facility.

Appendix V-B – Facility Liners and Geotextiles

Liners are intended to reduce the likelihood that pollutants in stormwater will reach groundwater when runoff treatment facilities are constructed.

Low permeability liners reduce infiltration to a very slow rate, generally less than 0.02 inches per hour (1.4×10^{-5} centimeters squared). These types of liners are used for industrial or commercial sites with a potential for high pollutant loading in the stormwater runoff. Low permeability liners may be fashioned from compacted till, clay, geomembrane, or concrete.

Applicability

Liners are used when there is a need to protect underlying soils from pollutants or retain permanent water for wet BMPs. Geotextiles are used in many BMPs and are not listed here.

This appendix applies to the following BMPs:

- BMP LID.04 Downspout Infiltration Systems
- BMP BF.01 Basic Biofiltration Swale
- BMP WP.05 Presettling Basins
- BMP WP.01 Stormwater Treatment Wetlands
- BMP WP.02 Wet Ponds
- BMP WP.04 Combined Detention and Wet Pool Facilities
- MF.01 Sand Filter Basin
- MF.03 Linear Sand Filter.

Liners Design Criteria

- Table B-1 shows the type of liner required for use with various runoff treatment facilities. Other liner configurations may be used with prior acceptance from the County.
- Liners shall be evenly placed over the bottom and/or sides of the treatment area of the facility as indicated in Table B-1. Areas above the treatment volumes that are required to pass flows greater than the water quality treatment flow (or volume) need not be lined. However, the lining must be extended to the top of the

interior side slope and anchored if it cannot be permanently secured by other means.

Table B-1. Lining Types Required for Runoff Treatment Facilities

Water Quality Facility	Area to be Lined	Type of Liner Required
Presettling basin	Bottom and sides	Treatment liner or Low permeability liner (If the basin will intercept the seasonal high groundwater table, a treatment liner may be recommended.)
Wet pond	First cell: bottom and sides to water quality design water surface -- Second cell: bottom and sides to water quality design water surface	Treatment liner or Low permeability liner -- Treatment liner
Combined detention/water quality facility	First cell: bottom and sides to water quality design water surface -- Second cell: bottom and sides to water quality design water surface	Treatment liner or Low permeability liner -- Treatment liner
Stormwater wetland	Bottom and sides, both cells	Low permeability liner
Sand filtration basin	Basin sides only	Treatment liner
Sand filter vault	Not applicable	No liner needed
Linear sand filter	Not applicable if in vault Bottom and sides of presettling cell if not in vault	No liner needed Treatment liner or Low permeability
Media filter (in vault)	Not applicable	No liner needed
Wet vault	Not applicable	No liner needed

Low Permeability Liners

This section presents the design criteria for each of the following four low permeability liner options: compacted till liners, clay liners, geomembrane liners, and concrete liners.

- For low permeability liners, the following criteria apply:
    - Where the seasonal high groundwater elevation is likely to contact a low permeability liner, liner buoyancy may be a concern. In these instances, use of a low permeability liner shall be evaluated and recommended by a geotechnical engineer.
    - Where grass must be planted over a low permeability liner per the facility design, a minimum of 6 inches of good topsoil or

compost-amended native soil (2 inches compost tilled into 6 inches of native till soil) must be placed over the liner in the area to be planted. Twelve inches of cover is preferred.

Compacted Till Liners

- Liner thickness shall be 18 inches after compaction.
- Soil shall be compacted to 95 percent minimum dry density, modified proctor method (ASTM D-1557).
- A different depth and density sufficient to retard the infiltration rate to 2.4×10^{-5} inches per minute (1×10^{-6} centimeters squared) may also be used instead of the thickness and density criteria above.
- Soil should be placed in 6-inch lifts.
- Soils may be used that meet the gradation in Table B-2 below:

Table B-2. Compacted Till Liners

Sieve Size	Percent Passing
6-inch	100
4-inch	90
#4	70 - 100
#200	20

Clay Liners

- Liner thickness shall be 12 inches.
- Clay shall be compacted to 95 percent minimum dry density, modified proctor method (ASTM D-1557).
- A different depth and density sufficient to retard the infiltration rate to 2.4×10^{-5} inches per minute (1×10^{-6} centimeters squared) may also be used instead of the above criteria.
- Plasticity index shall not be less than 15 percent (ASTM D-423, D-424).
- Liquid limit of clay shall not be less than 30 percent (ASTM D-2216).
- Clay particles passing shall not be less than 30 percent (ASTM D-422).

- The slope of clay liners must be restricted to 3H:1V for all areas requiring soil cover; otherwise, the soil layer must be stabilized by another method so that soil slippage into the facility does not occur. Any alternative soil stabilization method must take maintenance access into consideration.
- Where clay liners form the sides of ponds, the interior side slope shall not be steeper than 3H: 1V, irrespective of fencing. This restriction is to ensure that anyone falling into the pond may safely climb out.

Geomembrane Liners

- Geomembrane liners shall be ultraviolet (UV) light resistant and have a minimum thickness of 30 mils. A thickness of 40 mils shall be used in areas of maintenance access or where heavy machinery must be operated over the membrane.
- The geomembrane fabric shall be protected from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane determined to have a high survivability per the WSDOT standard specifications, specifically Section 9-33 Construction Geotextile (2006 or the latest version as amended). Equivalent methods for protection of the geomembrane liner will be considered. Equivalency will be judged on the basis of ability to protect the geomembrane from puncture, tearing, and abrasion.
- Geomembranes shall be bedded according to the manufacturer's recommendations.
- Liners must be covered with 12 inches of top dressing forming the bottom and sides of the water quality facility, except for linear sand filters. Top dressing shall consist of 6 inches of crushed rock covered with 6 inches of native soil. The rock layer is to mark the location of the liner for future maintenance operations. As an alternative to crushed rock, 12 inches of native soil may be used if orange plastic “safety fencing” or another highly visible, continuous marker is embedded 6 inches above the membrane.
- If possible, liners should be of a contrasting color so that maintenance workers are aware of any areas where a liner may have become exposed when maintaining the facility.
- Geomembrane liners shall not be used on slopes steeper than 5H:1V to prevent the top dressing material from slipping. Textured liners may be used on slopes up to 3H:1V upon recommendation by a geotechnical engineer that the top dressing will be stable for all site conditions, including maintenance.

Concrete Liners

- Concrete liners may also be used for sedimentation chambers and for sedimentation and filtration basins less than 1,000 square feet in area. Concrete shall be 5-inch thick Class 3000 or better and shall be reinforced by steel wire mesh. The steel wire mesh shall be six (6) gage wire or larger and 6 inch by 6 inch mesh or smaller. An "Ordinary Surface Finish" is required. When the underlying soil is clay or has an unconfined compressive strength of 0.25 ton per square foot or less, the concrete shall have a minimum 6 inch compacted aggregate base consisting of coarse sand and river stone, crushed stone or equivalent with diameter of 0.75 to 1 inch. Where visible, the concrete shall be inspected annually and all cracks shall be sealed.

- Portland cement liners are allowed irrespective of facility size, and shotcrete may be used on slopes. However, specifications must be developed by a professional engineer who certifies the liner against cracking or losing water retention ability under expected conditions of operation, including facility maintenance operations. Weight of maintenance equipment can be up to 80,000 pounds when fully loaded.

- Asphalt concrete may not be used for liners due to its permeability to many organic pollutants.

- If grass is to be grown over a concrete liner, slopes must be no steeper than 5H: 1V to prevent the top dressing material from slipping. Textured liners may be used on slopes up to 3H:1V upon recommendation by a geotechnical engineer that the top dressing will be stable for all site conditions, including maintenance.

Geotextiles

Applications

1. For sand filter drain strip between the sand and the drain rock or gravel layers specify Geotextile Properties for Underground Drainage, moderate survivability, Class A, from Tables 1 and 2 in the Geotextile Specifications.

2. For sand filter matting located immediately above the impermeable liner and below the drains, the function of the geotextile is to protect the impermeable liner by acting as a cushion. The specification provided below in Table 3 shall be used to specify survivability properties for the liner protection application. Table 2, Class C shall be used for filtration properties. Only nonwoven geotextiles are appropriate for the liner protection application.

3. For an infiltration drain specify Geotextile for Underground Drainage, low survivability, Class C, from Tables 1 and 2 in the Geotextile Specifications.

4. For a sand bed cover a geotextile fabric is placed exposed on top of the sand layer to trap debris brought in by the storm water and to protect the sand, facilitating easy cleaning of the surface of the sand layer. However, a geotextile is not the best product for this application. A polyethylene or polypropylene geonet would be better. The geonet material shall have high UV resistance (90% or more strength retained after 500 hours in the weatherometer, ASTM D4355), and high permittivity (ASTM D4491, 0.8 sec. -1 or more) and percent open area (CWO-22125, 10% or more). Tensile strength shall be on the order of 200 lbs grab (ASTM D4632) or more.

Table B-3. Geotextile Properties for Underground Drainage

Geotextile Property Requirements[1]			
		Low Survivability	**Moderate Survivability**
Geotextile Property	**Test Method**	**Woven/Nonewoven**	**Woven/Nonwoven**
Grab Tensile Strength, min. in machine and x-machine diretion.	ASTM D4632	189 lbs/115 lbs min.	250 lbs/160 lbs min.
Grab Failure Strain, in machine and x-machine direction.	ASTM D4632	<50% / >50%	<50%/>50%
Seam Breaking Strength (if seams are present)	ASTM D4632 and ASTM D4884 (adapted for grab test)	160 lbs/100 lbs min.	220 lbs/140 lbs min.
Puncture Resistance	ASTM D4833	67 lbs/40 lbs min.	80 lbs/50 lbs min.
Tear Strength, min. in machine and x-machine direction.	ASTM D4533	67 lbs/40 lbs min.	80 lbs/50 lbs min.
Ultraviolet (UV) Radiation stability	ASTM D4355	50% strength retained min., after 500 hrs. in weatherometer	50% strength retained min., after 500 hrs. in weatherometer

1 All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

Table B-4. Geotextile for Underground Drainage Filtration Properties

Geotextile Property Requirements [1]				
Geotextile Property	**Test Method**	**Class A**	**Class B**	**Class C**
AOS[2]	ASTMD4751	0.43 mm max (#40 sieve)	0.25 mm max (#60 sieve)	0.18 mm max. (#80 sieve)
Water Permittivity	ASTMD4491	0.5 sec-1 min	0.4 sec -1 min.	0.3 sec -1 min.

[1] All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

[2] Apparent Opening Size (measure of diameter of the pores in the geotextile).

Table B-5. Geotextile Strength Properties for Impermeable Liner Protection

Geotextile Property	Test Method	Geotextile Property Requirements [1]
Grab Tensile Strength, min. in machine and x-machine direction	ASTM D4632	250 lbs min.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	>50%
Seam Breaking Strength (if seams are present)	ASTM D43632 and ASTM D4884 (adapted for grab test)	220 lbs min.
Puncture Resistance	ASTM D4833	125 lbs min.
Tear Strength, min. in machine and x-machine direction	ASTM D4533	90 lbs min.
Ultraviolet (UV) Radiation	ASTM D4355	50% strength stability retained min., after 500 hrs in weatherometer

[1] All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

Reference for Tables B-3 and B-4: Section 9-33.2 “Geotextile Properties,” 1998 Standard Specifications for Road, Bridge, and Municipal Construction

Appendix V-C – Maintenance Guidelines

This appendix provides facility-specific maintenance standards. The standards are intended to provide conditions for determining, through inspection, if maintenance actions are required. Failure to meet these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, the inspection and maintenance schedules must be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Instructions for Use of Maintenance Checklists

The following pages contain maintenance tables for most of the BMPs included in Volume V. Where private developers, rather than Thurston County staff, are responsible for facility maintenance, they should plan to complete a checklist for all system components on the following schedule:

- (M) Monthly from October through April.
- Annually, once in late summer (preferably September)
- (S) Storm-based, after any major storm (use 1 inch in 24 hours as a guideline).

The tables contained in this appendix may be used as checklists. Maintenance personnel may use photocopies of these pages and check off items inspected and problems noted during each inspection. Actions taken and corrective action recommended should also be noted.

Table C-1. Maintenance Checklist for Bioretention Facilities (BMP LID.08)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
S	General		Erosion	Look for signs of erosion in flow entrance, ponding area, and surface overflow. If erosion has occurred, reassess flow volumes, cell sizing, velocities, and flow dissipation.	Replace soil, plant material and/or mulch layer. If needed, cell geometry and erosion protection measures have been modified to prevent future erosion problems.
S			Drawdown	Look for standing water beyond 48-hours after a storm event. If standing water lingers beyond 48 hours risk of mosquito and other pests increases and ability of facility to handle larger storms is restricted.	Facility should drawdown after a storm event within 48-hours. If needed rehabilitate treatment soils and clean debris from surface of soils to restore infiltration capacity. Scarify surface soils to a depth of 2-6 inches & add mulch.
A	Plants		Dead or unhealthy plants	Dead plants, sparse vegetation. If a specific plant type has a high mortality rate, assess cause and replace with appropriate species. Consider analyzing soils for fertility and adding soil amendment if needed.	Prune plants as needed. Remove dead plant material. Replace all dead plants.
M			Weeds	Weeds or invasive plant species present.	Weeds are removed.
A			Mulch	Gaps in depth or coverage of mulch.	Place additional mulch so that there is 2 to 3 inch depth. Where heavy metal deposition is likely (e.g., contributing areas that include parking lots and roads), all mulch shall be replaced annually.

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

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

Table C-2. Maintenance Checklist for Detention Tanks (BMP D.01), Detention Vaults (BMP D.02), and Wet Vaults (BMP WP.03)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	Storage Area		Plugged Air Vents	One-half of the cross-section of a vent is blocked at any point or the vent is damaged. Plugged vent can cause storage area to collapse.	Vents open and functioning.
M			Debris and Sediment	Accumulated sediment depth exceeds 10 percent of the diameter of the storage area for one-half length of storage vault or any point depth exceeds 15 percent of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than one-half length of tank.)	All sediment and debris removed from storage area.
A			Joints Between Tank Section	Any crack allowing material to leak into facility.	All joint between tank sections are sealed.
A			Tank Bent Out of Shape	Any part of tank is noticeably bent out of shape.	Tank repaired or replaced to design. Contact a professional engineer for evaluation.
A			Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2 inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications and is structurally sound.
A				Cracks wider than 1/2 inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls	No cracks more than 1/4 inch wide at the joint of the inlet/outlet pipe.
M, S	Crest Gage		Crest Gage Missing/Broken	Crest gage is not functioning properly, has been vandalized, or is missing.	Repair/replace

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A	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 one-half 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 rings, misalignment, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.

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

Tanks and vaults are a confined space. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

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

Table C-3A. Maintenance Checklist for Detention Ponds (BMP D.01), and Wetponds (BMP WP.02)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M,S	General		Trash and 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 Thurston County Department of Resource Stewardship.
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, stinging nettles, devilsclub.	Remove poisonous vegetation. Do not spray chemicals on vegetation without obtaining guidance from the County.
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 grassy ponds, selectively thatch, aerate, and reseed ponds. Grass cutting unnecessary unless dictated by aesthetics. Contact the Thurston County Noxious Weed program for direction on invasive species such as purple loosestrife and reed canary grass. Pond bottoms shall have uniform dense coverage of desired plant species.
M			Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents destroyed and dam or berm repaired. Contact the Thurston County Public Health and Social Services Department for guidance.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
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. Remove species that are not part of recorded planting plan.
M	Side Slopes of Pond		Erosion on berms or at entrance/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 percent 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 reseeded if necessary to control erosion.
A	Pond Dikes		Settlements	Any part of dike which has settled 4 inches lower than the design elevation.	Dike is 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.
A	Wet Pond		Permanent Water Volume	Check that pond has a permanent water volume and does not drain between storm events.	A permanent water volume is necessary to provide water quality treatment. If no water volume, pond lining needs to be evaluated.
One time	Emergency Overflow/ Spillway		Overflow Missing	Side of pond has no area with large rocks to handle emergency overflows.	Contact County for guidance.

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

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

Table C-3B. Maintenance Checklist for Stormwater Wetland (BMP WP.01)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M,S	General		Trash and Debris buildup in pond or wetland.	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 Thurston County Department of Resource Stewardship.
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, poison ivy, stinging nettles, devilsclub.	Remove poisonous vegetation. Do not spray chemicals on vegetation without obtaining guidance from the County. Contact Thurston County Noxious Weeds program.
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	Plants are sparse or invasive species are present.	Hand-plant nursery-grown wetland plants in baser areas. Contact the Thurston County Noxious Weed program for direction on invasive species such as purple loosestrife and reed canary grass. Pond bottoms shall have uniform dense coverage of desired plant species.
M			Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents destroyed and dam or berm repaired. Contact the Thurston County Public Health and Social Services 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.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
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. Remove species that are not part of recorded planting plan.
M	Side Slopes of Pond		Erosion on berms or at entrance/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.
A	Internal berm or embankment		Settlements	Any part of dike which has settled 4 inches lower than the design elevation.	Dike is built back to the design elevation.
			Irregular surface on internal berm	Top of berm not uniform and level.	Top of berm graded flat to 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			Overflow Missing	Side of pond has no area with large rocks to handle emergency overflows.	Contact County for guidance.
A	Pond Areas		Sediment accumulation (first cell / forebay)	Sediment accumulations in pond bottom that exceeds the depth of sediment storage (1 foot) plus 6 inches.	Sediment storage contains no sediment.
A			Sediment accumulation (wetland cell)	Accumulated sediment that exceeds 10% of the designed pond depth.	Sediment cleaned out to designed pond shape and depth.
A			Liner damaged (if applicable)	Liner is visible or pond does not hold water as designed.	Liner repaired or replaced.
A			Water level (first cell / forebay)	Cell does not hold 3 feet of water year round.	3 feet of water retained year round.
A			Water level (wetland cell)	Cell does not retain water for at least 10 months of the year or wetland plants are not surviving.	Water retained at least 10 months of the year or wetland plants are surviving.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A			Algae mats (first cell / forebay)	Algae mats develop over more than 10% of the water surface should be removed.	Algae mats removed (usually in the late summer before Fall rains.
A			Vegetation	Vegetation dead, dying, or overgrown (cattails) or not meeting original planting specifications.	Plants in wetland cell surviving and not interfering with wetland function.
A	Gravity Drain		Inoperable valve	Valve will not open and close	Valve opens and closes normally.
A			Valve won't seal	Valve does not seal completely.	Valve completely seals closed.
A	Inlet/Outlet pipe		Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipes clear of sediment.
A			Trash and debris	Trash and debris accumulated in inlet/outlet pipes (includes floatables and non-floatables).	No trash or debris in pipes.
A			Damaged	Cracks wider than ½ inch at the joint of the inlet / outlet pipe or any evidence of soil entering at the joints of the inlet / outlet pipes.	No cracks more than ¼ inch wide at the joint of the inlet/outlet pipe.

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

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

Table C-4. Maintenance Checklist for Infiltration Basins (BMP IN.01), Infiltration Trenches (BMP IN.02), and Bioinfiltration Swale (BMP IN.03)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M,S	General		Trash and 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 Thurston County Department of Resource Stewardship.
M			Poisonous Vegetation	Any poisonous vegetation which may constitute a hazard to the public. Examples of poisonous vegetation include: tansy ragwort, poison oak, stinging nettles, devilsclub.	Remove poisonous vegetation. Do not spray chemicals on vegetation without obtaining guidance from the County.
A			Tree Growth	Tree growth in pond or swale bottoms, side slopes and maintenance access areas.	Trees removed from facility bottom, side slopes and maintenance access areas. Remove species that are not part of recorded planting plan.
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	Grass cover is sparse and weedy or is overgrown. Plants are sparse or invasive species are present.	Selectively thatch, aerate, and reseed ponds. Grass cutting unnecessary unless dictated by aesthetics. Contact the Thurston County Noxious Weed program for direction on invasive species such as purple loosestrife and reed canary grass. Pond bottoms shall have uniform dense coverage of desired plant species.
M			Rodent Holes	If the facility is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm.	Rodents destroyed and dam or berm repaired. Contact the Thurston County Public Health and Social Services Department for guidance.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
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	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 County for information on its requirements regarding excavation.
M			Sediment trapping area	Any sediment and debris filling area to 10 percent 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 County for more guidance.
M	Rock filters		Sediment and debris	By visual inspection little or no water flows through filter during heavy rain storms.	Replace gravel in rock filter.

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

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

Table C-5. Maintenance Checklist for Media Filter Drain (BMP MF.04)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	No Vegetation Zone adjacent to pavement		Erosion, Scour, or Vehicular Damage	No vegetation zone uneven or clogged so that flows are not uniformly distributed.	Level the area and clean so that flows are spread evenly.
M			Sediment Accumulation on Edge of Pavement	Flows no longer sheeting off of roadway. Sediment accumulation on pavement edge exceeds top of pavement elevation.	Remove sediment deposits such that flows can sheet off of roadway.
M	Vegetated Filter		Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through Media Filter Drain.
M			Excessive Vegetation or Undesirable Species	When the grass becomes excessively tall; when nuisance weeds and other vegetation starts to take over or shades out desirable vegetation growth characteristics.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height that encourages dense even herbaceous growth.
M			Erosion, Scour, or Vehicular Damage	Eroded or scoured areas due to flow channelization, high flows or vehicular damage.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with suitable topsoil. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re- seeded. For smaller bare areas, overseed when bare spots are evident.
M	Media Bed		Erosion, Scour, or Vehicular Damage	Eroded or scoured areas due to flow channelization, high flows or vehicular damage.	For ruts or areas less than 12 inches wide, repair the damaged area by filling with suitable media. If bare areas are large, generally greater than 12 inches wide, the media bed should be re-graded.
M			Sediment Accumulation on Media Bed	Sediment depth inhibits free infiltration of water.	Remove sediment deposits, re-level so slope is even and flows pass freely through Media Bed.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	Underdrains		Sediment	Depth of sediment within perforated pipe exceeds 1/2 inch.	Flush underdrains through access ports and collect flushed sediment.
M	General		Trash and Debris Accumulation	Trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one 32 gallon garbage can). In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Remove trash and debris.
M			Flows are Bypassing Media Filter Drain	Evidence of significant flows downslope (rills, sediment, vegetation damage, etc.) of Media Filter Drain.	Remove sediment deposits, re-level so slope is even and flows pass evenly through Media Filter Drain. If Media Filter Drain is completely clogged it may require a more extensive repair or replacement.

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

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

Table C-6. Maintenance Checklist for Sand Filter Basins (BMP MF.01)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	General		Sediment Accumulation on top layer	Sediment depth exceeds 1/2 inch.	No sediment deposit on grass layer of sand filter that would impede permeability of the filter section.
M			Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	Trash and debris removed from sand filter bed.
M			Sediment/ Debris in Clean-Outs	When the clean-outs become full or partially plugged with sediment and/or debris.	Sediment removed from clean-outs.
M			Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24 hours, and/or flow through the overflow pipes occurs frequently.	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material). Other options include removal of thatch, aerating the filter surface, tilling the filter surface, replacing the top 4 inches of filter media, and inspecting geotextiles for clogging.
M			Prolonged Flows	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities (consider 4-8 hour drawdown tests).	Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
M			Short Circuiting	Drawdown greater than 12 inches per hour. When flows become concentrated over one section of the sand filter rather than dispersed (consider 4-8 hour drawdown tests).	Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M			Erosion Damage to Slopes	Erosion over 2 inches deep where cause of damage is prevalent or potential for continued erosion is evident.	Slopes stabilized using proper erosion control measures.
A			Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Rock pad replaced or rebuilt to design specifications.
M			Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter. Rills and gullies on the surface of the filter can indicate improper function of the inlet flow spreader.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.
M			Damaged Pipes	Any part of the piping that is crushed or deformed more than 20 percent or any other failure to the piping.	Pipe repaired or replaced.

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

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

Table C-7. Maintenance Checklist for Sand Filter Vault (BMP MF.02) and Linear Sand Filter (MF.03)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	Below Ground Vault		Sediment Accumulation on Sand Media Section	Sediment depth exceeds 1/2 inch.	No sediment deposits on sand filter section that which would impede permeability of the filter section.
M	Below Ground Vault		Sediment Accumulation in Presettling Portion of Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	No sediment deposits in first chamber of vault.
M	Below Ground Vault		Trash/Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault and inlet/outlet piping.
M	Below Ground Vault		Sediment in Drain Pipes/Cleanouts	When drain pipes, cleanouts become full with sediment and/or debris.	Sediment and debris removed.
M	Below Ground Vault		Clogged Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, and/or flow through the overflow pipes occurs frequently (consider 4-8 hour drawdown tests).	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material). Other options include removal of thatch, aerating the filter surface, tilling the filter surface, and replacing the top 4 inches of filter media.
M	Below Ground Vault		Short Circuiting	Drawdown greater than 12 inches per hour. When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area (consider 4-8 hour drawdown tests).	Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal. Erosion protection added to dissipate force of incoming flow and curtail erosion.
A	Below Ground Vault		Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
M	Below Ground Vault		Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	Below Ground Vault		Ventilation	Ventilation area blocked or plugged	Blocking material removed or cleared from ventilation area. A specified percentage of the vault surface area must provide ventilation to the vault interior (see design specifications).
A	Below Ground Vault		Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover. Maintenance person cannot remove cover using normal lifting pressure.	Cover repaired to proper working specifications or replaced.
A	Below Ground Vault		Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than 1/2 inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
A	Below Ground Vault		Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than 1/2 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4 inch at the joint of the inlet/outlet pipe.
A	Below Ground Vault		Baffles/Internal walls	Baffles or walls corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
A	Below Ground Vault		Access Ladder	Damaged ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

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

Sand filter vaults are confined spaces. Visual inspections should be performed aboveground. If entry is required it should be performed by qualified personnel.

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

Table C-8. Maintenance Checklist for Compost Amended Soil for Post-Construction Soil Quality and Depth (BMP LID.02) and Compost-Amended Vegetated Filter Strip (BMP BF.06)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A	General		Soil media (maintain high organic soil content	Vegetation not fully covering ground surface.	Re-mulch landscape beds with 2-3 inches of mulch until the vegetation fully closes over the ground surface
Ongoing				None. Preventative maintenance.	Return leaf fall and shredded woody materials from the landscape to the site as mulch.
Ongoing				None. Preventative maintenance.	On turf areas, “grasscycle” (mulch-mow or leave the clippings) to build turf health
Ongoing				None. Preventative maintenance.	Avoiding broadcast use of pesticides (bug and weed killers) like “weed & feed,” which damage the soil life.
A				None. Preventative maintenance.	Where fertilization is needed (mainly turf and annual flower beds), a moderate fertilization program which relies on natural organic fertilizers (like compost) or slow release synthetic balanced fertilizers.
A			Compaction	Soils become waterlogged, do not appear to be infiltrating.	To remediate, aerate soil, till or further amend soil. If drainage is still slow, consider investigating alternative causes (e.g., high wet-season groundwater levels, low permeability soils). Also consider land use and protection from compacting activities. If areas are turf, aerate compacted areas and top dress them with 1/4 to 1/2 inch of compost to renovate them.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A			Erosion/scouring	Areas of potential erosion are visible.	Take steps to repair or prevent erosion. Identify and address the causes of erosion.
A			Grass/vegetation	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions (e.g., remove/replace plants)
M			Noxious weeds	Listed noxious vegetation is present. See Pierce County noxious weed list.	By law, noxious weeds must be removed and disposed immediately. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.
Q			Weeds	Weeds are present.	Remove and dispose of weed material. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.

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

Key:
A = Annual (March or April preferred)
M = Monthly (see schedule)
S = After major storms.
Q = Quarterly

Table C-9. Maintenance Checklist for Basic Biofiltration Swales (BF.01) and Continuous Inflow Biofiltration Swales (BF.03)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	General		Sediment Accumulation on Grass	Sediment depth exceeds 2 Inches or inhibits vegetation growth in 10 percent or more of swale.	Remove sediment deposits on grass treatment area of the bioswale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
M	General		Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
M	General		Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
M	General		Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.
M	General		Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10 percent of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or re-seed into loosened, fertile soil.
M	General		Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
A			Vegetation	Trees growing in swale bottom or side slopes. Other invasive vegetation interfering with function of swale (scot's bloom).	Trees removed from swale bottom and slopes. Trees removed that are not part of planting plan. Invasive plants removed.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	General		Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
M	General		Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
M	General		Trash and Debris Accumulation	Trash and debris accumulated in the bioswale.	Remove leaves, litter, and oily materials, and re-seed or resod, and regrade, as needed. Clean curb cuts and level spreaders as needed.
M	General		Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

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

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

Table C-10. Maintenance Checklist for Wet Biofiltration Swales

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	General		Sediment Accumulation	Sediment depth exceeds 2 inches in 10 percent of the swale treatment area.	Remove sediment deposits in treatment area.
M			Water Depth	Water not retained to a depth of about 4 inches during the wet season.	Build up or repair outlet berm so that water is retained in the wet swale.
M			Wetland Vegetation	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Determine cause of lack of vigor of vegetation and correct. Replant as needed. For excessive cattail growth, cut cattail shoots back and compost offsite. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
M			Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Remove clogging or blockage in the inlet and outlet areas.
M			Trash and Debris Accumulation	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one 32 gallon garbage can). In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Remove trash and debris from wet swale.
M			Erosion/ Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.	Check design flows to assure swale is large enough to handle flows. By-pass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as Juncus effusus (soft rush) in wet areas or snowberry (*Symphoricarpos albus*) in dryer areas.

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

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

Table C-11. Maintenance Checklist for Basic Filter Strip (BMP BF.04) and Narrow Area Filter Strip (BMP BF.05)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	General		Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
M	General		Vegetation	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
A			Trees	Trees growing in swale bottom or side slopes.	Trees removed from swale bottom and slopes. Trees removed that are not part of planting plan.
M	General		Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
M	General		Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re- seeded. For smaller bare areas, overseed when bare spots are evident.
M	General		Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width

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

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

Table C-12. 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 1-1/2 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 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 holes.
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.	
M,S				Chain leading to gate is missing or damaged.	
A				Gate is rusted over 50% of its surface.	
M,S			Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	
M,S	Overflow pipe		Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	

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

Key:
A = Annual (March or April preferred)
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Table C-13. Maintenance Checklist for Catch Basins and Inlets

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M,S	General		Trash and Debris	Trash, debris, and sediment in or on basin	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 (1-ft minimum storage remaining) 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 outlet 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 3/4 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 1/4 inch (intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
M				Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
A			Cracks in Basin Walls/ Bottom	Cracks wider than 1/2 inch and longer than 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 1/2 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 1/4 inch wide at the joint of inlet/outlet pipe.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
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.
A			Illicit discharges to Catch Basin	Look for connections from adjacent businesses, residences that are not part of drainage plan. If detected identify source of connection and notify Thurston County.	No connections to Catch Basins are allowed that are not part of the approved plans or authorized by permit from Thurston County.
M			Vegetation	Vegetation growing across and blocking more than 10 percent of the basin opening.	No vegetation blocking opening to basin.
M			Vegetation	Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart.	No vegetation or root growth present.

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

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

Table C-14. Maintenance Checklist for Energy Dissipators

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 pad		Vegetation	Vegetation growth in and around dispersion pad area prevents proper inspection or interferes with flows.	Remove vegetation growth and plants that are not part of approved planting plan.
A	Rock-filled trench for discharge from pond		Missing or moved rock	Trench is not full of rock.	Add large rock (~30 lbs 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 1/2 of perforations in pipe are plugged with debris and sediment.	Clean or replace perforated pipe.
M,S			Not discharging water properly	Visual evidence of water discharging at concentrated points along trench (under normal conditions, there should be a “sheet flow” of water along trench.) Intent is to prevent erosion damage.	Trench must be rebuilt or redesigned to standards. Pipe is provably plugged or damaged and needs replacement.
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.
A	Gabions		Damaged mesh	Mesh of gabion broken, twisted or deformed so structure is weakened or rock may fall out.	Mesh is intact, no rock missing.
A			Corrosion	Gabion mesh shows corrosion through more than ¼ of its gage	All gabion mesh capable of containing rock and retaining designed form.
A			Collapsed or deformed baskets	Gabion basket shape deformed due to any cause.	All gabion baskets intact, structure stands as designed.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A			Missing rock	Any rock missing that could cause gabion to loose structural integrity	No rock missing.
A	Manhole/Chamber		Worn or damaged post, baffles or side of chamber	Structure dissipating flow deteriorates to ½ of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure is in no danger of failing.
A			Damage to wall, frame, bottom, and/or top slab	Cracks wider than ½-inch or any evidence of soil entering the structure through cracks. Or maintenance inspection personnel determine that the structure is not structurally sound.	Manhole/chamber is sealed and structurally sound.
A			Damaged pipe joints.	Cracks wider than ½-inch at the joint of the inlet/outlet pipes or any evidence of soil entering the structure at the joint of the inlet/outlet pipes.	No soil or water enters and no water discharges at the joint of inlet/outlet pipes.

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

<u>Key</u>:
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Table C-15. Maintenance Checklist for Fencing

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 1.5 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 2.5 inches between posts.	Barbed wire in place with less than 3/4 inch sag between posts.
A				Extension arm missing, broken, or bent out of shape more than 1.5 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.

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

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

Table C-16. 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 backhoe. If a lock is used, make sure the county field staff have a key.
M				Broken or missing hinges such that gate cannot be easily opened and closed by one 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.

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

Key:
A = Annual (March or April preferred)
M = Monthly (see schedule)
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Table C-17. 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 County permits and construct gravel (or equal) access road. If not report lack of easement to County attention.
M			Block 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 access to less than 15 feet width.	Obstruction removed to allow at least a 15 foot wide access.
A	Easement Markers		Easement Not Clearly Identified	Check that easement markers are in place identifying limits of easement	Easement markers installed at 100-ft intervals and changes in direction along easement lines.
A,S	Road surface		Settlement, potholes, mush spots, ruts	When any surface 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, mush 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 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 Thurston County and ask for technical assistance.

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

Table C-18. Conveyance Pipes and Ditches

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 solid waste regulations.
M			Sediment buildup	Accumulated sediment that exceeds 20% of the design depth.	Ditch cleared 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. Grass vegetation should be left alone.
M			Erosion on	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.
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.

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

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

Table C-19. Debris Barriers (E.G. Trash Racks)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M,S	Site		Trash and debris	Trash and debris plugging more than 20% of the area of the barrier.	Barrier clear to receive capacity flow.
A			Sediment accumulation	Sediment accumulation of greater than 20% of the area of the barrier	Barrier clear to receive capacity flow
A	Structure		Cracked, broken or loose	Structure with bars attached to is damaged – pipe is loose or cracked or concrete structure is cracked, broken or loose.	Structure barrier attached to is sound.
A	Bars		Bar spacing	Bar spacing exceeds 6-inches	Bars have at most 6-inches spacing
A			Damaged or missing bars	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than ¾ inch.
A				Bars are missing or entire barrier missing.	Bars in place according to design.
A				Bars are loose and rust is causing 50% deterioration to any part of barrier.	Repair or replace barrier to design standards.

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

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

Table C-20. Maintenance Checklist for Grounds (Landscaping)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	General		Weeds (non poinsonous)	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, poison oak or other poisonous vegetation or insect nests.	No poisonous vegetation or inspect nests present in landscaped area.
M,S			Trash or litter	Trash/debris exceeds 5 cubic feet (this is about equal to the amount of trash in one standard garbage can) per 1,000 square feet. In general there should be no evidence of visual dumping.	Remove/dispose of waste in accordance with solid waste regulations.
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				Tree or shrubs that have been blown down or knocked over.	Replant tree, inspecting for injury to stem or roots. Replace if severely damaged.
A				Tree 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.
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 Thurston County and ask for technical assistance.

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

Table C-21. Maintenance Checklist for Dispersion BMPs (BMP LID.05,06,07,11,12,13)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	General		Vegetation management	Any presence invasive plants, poison ivy, poison oak or other poisonous vegetation or insect nests.	No poisonous vegetation or inspect nests present in landscaped area.
M			Disturbance	Area designated for dispersion is no encroached upon vegetation is healthy and functioning.	Restore disturbed native vegetation areas (see BMP LID.01). Remove encroachments.
M,S			Trash or litter	In general there should be no evidence of visual dumping.	Remove/dispose of waste in accordance with solid waste regulations.
M,S			Erosion of ground surface	Noticeable rills or channeling is seen in dispersion areas.	Causes of erosion are identified and steps taken to slow down/spread out the water. Eroded areas are filled, contoured, and seeded.
A	Drainage		Bypass flow	Dispersed flow concentrates and isn't spread evening through dispersion area.	No evidence of dispersed flow bypassing dispersion area.
M			Inlets & Outlets	Dispersion pads and spreaders functioning correctly. See outfall maintenance checklist.	Dispersion device functions as designed.
A	Controls		Signage & fencing	Signs removed, fencing damaged or missing.	Restore fencing & signage per design.
M,S	Sedimentation		Sediment buildup	Sediment buildup around outlet of dispersion device.	Hand remove sediment buildup and replant disturbed area.

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

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

Table C-22. Maintenance Checklist for Vegetated Roof (BMP LID.10)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A	Soil/Growth Medium		Growth Medium	Water does not permeate growth media (runs off surface)	Aerate or replace media
M			Fallen leaves/ debris	Fallen leaves or debris are present.	Remove/dispose.
M,S			Erosion/scouring	Areas of potential erosion are visible.	Take steps to repair or prevent erosion. Stabilize with additional soil substrate growth medium and additional plants.
A	System Structural Components		General	Structural components are present.	Inspect structural components for deterioration or failure. Repair/replace as necessary.
M			Inlet Pipe	Sediment, vegetation, or debris blocks 35% or more of inlet structure.	Clear blockage, identify and correct any problems that led to blockage.
M				Inlet pipe is in poor condition.	Repair/replace
M				Inlet pipe is clogged	Remove roots or debris.
A	Vegetation		Coverage	Vegetative coverage falls below 75% (unless design specifications stipulate less than 75% coverage)	Install more vegetation.
M			Noxious weeds	Listed noxious vegetation is present. See Thurston County noxious weed list.	By law, noxious weeds must be removed and disposed of immediately. Herbicides and pesticides shall not be used in order to protect water quality.
M			Weeds	Weeds are present	Remove and dispose of weed material. Herbicides and pesticides shall not be used in order to protect water quality.
A			Plants	Dead vegetation is present	Remove dead vegetation when covering greater than 10% of basin area. Replace dead vegetation annually or immediately if necessary to control erosion.
Startup	Irrigation		Irrigation system (if any)	Irrigation system present.	Follow manufacturer's instructions for O&M
Weekly at startup			Plant watering	Plant establishment period (1-3 years)	Water weekly during periods of no rain to ensure plant establishment.
On-going				Longer term period (3+ years)	Water during drought conditions or more often if necessary to maintain plant cover.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
As needed	Spill Prevention and Response		Spill prevention	Storage or use of potential contaminants in the vicinity of the facility.	Exercise spill prevention measures whenever handling or storing potential contaminants.
As needed			Spill response	Release of pollutants. Call to report any spill to the Washington Dept. of Emergency Management. 1-800-258-5990	Cleanup spills as soon as possible to prevent contamination of stormwater.
Startup	Training and documentation		Training/written guidance	Training/written guidance is required for proper O&M	Provide property owners and tenants with proper training and a copy of the O&M Manual and Maintenance Plan.
On-going	Safety		Access and Safety	Egress and ingress routes	Maintain egress and ingress routes to design standards and fire codes.
M	Aesthetics		Aesthetics	Damage / vandalism / debris accumulation	Restore facility to original aesthetic conditions.
A			Grass / vegetation	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions (e.g. remove / replace plants, amend soils, etc.)
A	Pest Control		Mosquitoes	Standing water remains for more than three days following a storm	Remove standing water. Identify cause of the standing water and take appropriate action to address the problem (improve drainage).

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

Key:
A = Annual (March or April preferred)
M = Monthly (see schedule)
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Table C-23. Porous Pavement (BMP LID.09)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A	Surface		Porous asphalt or cement concrete	Maintenance to prevent clogging with fine sediment.	Use convential street sweepers equipped with vacuums.
Ongoing					Prohibit use of sand and sealant application and protect from construction runoff.
A				Major cracks or trip hazards	Fill with patching mixes. Large cracks and settlement may require cutting and replacing the pavement section.
As required				Utility cuts	Any damage or change due to utility cuts must be replaced in kind.
A			Fallen leaves / debris	Fallen leaves or debris	Remove / dispose
As required			Interlocking concrete paver blocks	Interlocking paving block missing or damaged	Replace paver block
As required				Settlement of surface	May require resetting
A				Sediment or debris accumulation between paver blocks	Remove / dispose.
A				Loss of void material between paver blocks	Refill per manufacturer’s recommendations.
On going				Varied conditions	Perform O&M per manufacturer’s recommendations.

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

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A = Annual (March or April preferred)
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Table C-24. Baffle Oil/Water Separator (BMP OW.01)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	Site		Trash and debris	Any trash or debris which impairs the function of the facility.	Trash and debris removed from facility.
M			Contaminants and pollution	Floating oil in excess of 1 inch in first chamber, any oil in other chambers or other contaminants of any type in any chamber.	No contaminants present other than a surface oil film.
A	Vault treatment area		Sediment accumulation	Sediment accumulation exceeding 6 inches in the vault.	No sediment in the vault.
M			Discharge water not clear.	Inspection of discharge water shows obvious signs of poor water quality – effluent discharge from vault shows thick visible sheen.	Effluent discharge is clear.
A			Trash or debris accumulation	Any trash and debris accumulation in vault (floatables and non-floatables).	Vault is clear of trash and debris.
M			Oil accumulation	Oil accumulations that exceed 1 inch, at the surface of the water in the oil/water separator chamber.	No visible oil depth on water.
A	Vault structure		Damage to wall, frame, bottom and/or top slab.	Cracks wider than ½ inch or evidence of soil particles entering the structure through the cracks, or maintenance / inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications.
A			Baffles damaged	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance inspection personnel.	Repair or replace baffles to specifications.
A	Gravity drain		Inoperable valve	Valve will not open and close	Valve opens and closes normally.
A			Valve won't seal	Valve does not seal completely.	Valve completely seals closed.
A	Inlet/outlet pipe		Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipe clear of sediment.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
A			Trash and debris	Trash and debris accumulated in inlet / outlet pipes (includes floatables and non-floatables)	No trash or debris in pipes.
A			Damaged	Cracks wider than ½ inch at the joint of the inlet/outlet pipes or any evidence of soil entering the joints of the inlet / outlet pipes.	No cracks more thatn ¼ inch wide at the joint of the inlet/outlet pipe.
M	Access manhole		Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open manhole requires immediate maintenance.**	Manhole access covered.
M			Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
M			Cover/lid difficult to remove.	One maintenance person cannot remove cover/lid after applying 80 lbs of lift.	Cover/lid can be removed an reinstalled by one maintenance person.
A			Ladder rungs unsafe	Missing rungs, misalignment, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
M	Large access doors / plate		Damaged or difficult to open.	Large access doors or plates cannot be opened / removed using normal equipment.	Replace or repair access door so it can be opened as designed.
M			Gap doesn't cover completely	Large access doors not flat and/or access opening not completely covered.	Doors close flat and cover access opening completely.
M			Lifting Rings missing, rusted.	Lifting rings not capable of lifting weight of door or cover/lid.	Lifting rings sufficient to lift or remove cover/lid.

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

Key:
A = Annual (March or April preferred)
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S = After major storms

Table C-25. Coalescing Plate Oil/Water Separator (BMP OW.02)

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
M	Site		Trash and debris	Any trash or debris which impairs the function of the facility.	Trash and debris removed from facility.
M			Contaminants and pollution	Floating oil in excess of 1 inch in first chamber, any oil in other chambers or other contaminants of any type in any chamber.	No contaminants present other than a surface oil film.
A	Vault treatment area		Sediment accumulation in forebay	Sediment accumulation exceeding 6 inches in the forebay.	No sediment in the forebay.
M			Discharge water not clear.	Inspection of discharge water shows obvious signs of poor water quality – effluent discharge from vault shows thick visible sheen.	Repair function of plates so effluent is clear.
A			Trash or debris accumulation	Any trash and debris accumulation in vault (floatables and non-floatables).	Vault is clear of trash and debris.
M			Oil accumulation	Oil accumulations that exceed 1 inch, at the surface of the water in the coalescing plate chamber.	No visible oil depth on water and coalescing plates clear of oil.
	Coalescing Plates		Damaged	Plate media broken, deformed, cracked and/or showing signs of failure.	Replace that portion of media pack or entire plate pack depending on severity of failure.
			Sediment accumulation	Any sediment accumulation which interferes with the operation of the coalescing plates.	No sediment accumulation interfering with the coalescing plates.
A	Vault structure		Damage to wall, frame, bottom and/or top slab.	Cracks wider than ½ inch or evidence of soil particles entering the structure through the cracks, or maintenance / inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications.
A			Baffles damaged	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance inspection personnel.	Repair or replace baffles to specifications.

Frequency	Drainage Systems Feature	√	Problem	Conditions to Check For	Conditions that Shall Exist
	Ventilation pipes		Plugged	Any obstruction to the ventilation pipes.	Ventilation pipes are clear.
A	Shutoff valve		Damaged or inoperable	Shutoff valve cannot be opened or closed.	Shutoff valve operates normally.
A	Inlet/outlet pipe		Sediment accumulation	Sediment filling 20% or more of the pipe.	Inlet/outlet pipe clear of sediment.
A			Trash and debris	Trash and debris accumulated in inlet / outlet pipes (includes floatables and non-floatables)	No trash or debris in pipes.
A			Damaged	Cracks wider than ½ inch at the joint of the inlet/outlet pipes or any evidence of soil entering the joints of the inlet / outlet pipes.	No cracks more thatn ¼ inch wide at the joint of the inlet/outlet pipe.
M	Access manhole		Cover/lid not in place	Cover/lid is missing or only partially in place. **Any open manhole requires immediate maintenance.**	Manhole access covered.
M			Locking mechanism not working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts cannot be seated. Self-locking cover/lid does not work.	Mechanism opens with proper tools.
M			Cover/lid difficult to remove.	One maintenance person cannot remove cover/lid after applying 80 lbs of lift.	Cover/lid can be removed an reinstalled by one maintenance person.
A			Ladder rungs unsafe	Missing rungs, misalignment, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
M	Large access doors / plate		Damaged or difficult to open.	Large access doors or plates cannot be opened / removed using normal equipment.	Replace or repair access door so it can be opened as designed.
M			Gaps, doesn't cover completely	Large access doors not flat and/or access opening not completely covered.	Doors close flat and cover access opening completely.
M			Lifting Rings missing, rusted.	Lifting rings not capable of lifting weight of door or cover/lid.	Lifting rings sufficient to lift or remove cover/lid.

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

Key:
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Appendix V-D – Access Roads and Ramps

Access roads provide access from main arterials to inspect or maintain BMPs. They are a critical part of BMP development but also create disturbances complicating facility design and construction. Use this appendix to ensure that safe, proper access is created.

Access ramps allow vactor trucks and other maintenance vehicles to drive into a detention pond or other open facility to remove sediment, inspect underdrain piping and outlets and perform other activities that require access to the bottom of the facility.

On large, deep ponds, truck access to the pond bottom via an access ramp is necessary for loading in the pond bottom. On small, deep ponds, the truck can remain on the ramp for loading. On small shallow ponds, a ramp to the bottom may not be required if the trackhoe can load a truck parked at the pond edge or on the internal berm of a wet pond or combined pond (trackhoes can negotiate interior pond side slopes).

Access Roads

Applicability

Access roads shall provide access to the control structure(s). Where the access road is to provide maintenance to a pond or basin, the access road shall provide access alongside the pond as necessary for vehicular maintenance access to each pond cell.

This appendix applies to the following BMPs:

- BMP IN.04 Infiltration Basins
- BMP D.01 Detention Ponds
- BMP D.02 Detention Tanks
- BMP D.04 Detention Vaults
- BMP WP.02 Wet Ponds
- BMP WP.05 Presettling Basins.

Design Criteria

The design guidelines for access road are given below.

Geometry

- Maximum grade shall be 15 percent.
- Outside turning radius will be a minimum of 40 feet.
- Access roads shall be a minimum of 15 feet in width.

Materials

- A paved apron must be provided where access roads connect to paved public roadways.
- Access roads may be constructed with an asphalt or gravel surface, or modular grid pavement. All surfaces must conform to the jurisdictional standards and manufacturer's specifications.

Fencing

- Vehicle access shall be limited by a double-posted gate if a pond is fenced or by bollards if the pond is not fenced. A minimum of one locking access road gate shall be provided that meets WSDOT Standard Plan L-3. Gates may be 14, 16, 18, or 20 feet in width. Bollards shall consist of two fixed bollards, on the outside of the access road and two removable bollards equally spaced between the fixed bollards (or all four removable if placed in the traveled way). Any fenced pipe stem access to a facility shall be fenced with a WSDOT Type 4 chain link fence with a 14 to 20 foot wide gate set at the same height, or bollards.
- Fence gates shall be located only on straight sections of road.

Site Design Elements

- Maintenance access road(s) will be provided to the control structure and other drainage structures associated with the pond (e.g., inlet or bypass structures).
- It is recommended that manhole and catch basin lids be in or at the edge of the access road and at least three feet from a property line.
- Pond access roads shall be located in the same tracts when the ponds themselves are in tracts. When ponds are located in open space, the pond access roads may be located in open space also, provided that they are constructed so as to be aesthetically compatible with the open space use.
- When the length of a pond access road to control structure or pond exceeds 75 feet, a vehicle turn-around must be provided, designed

to accommodate vehicles having a maximum length of 31 feet and having an inside wheel path radius of 40 feet. Access roads to control structures shall have a maximum slope of 12 percent.

Access Ramps

An access ramp is needed for removal of sediment with a trackhoe and truck.

Applicability

For all ponds cell bottoms which cannot be accessed from the access road by a trackhoe with a maximum reach of 20 feet, an access ramp shall be constructed extending to the bottom of the pond.

Design Criteria

Geometry

- The access ramp shall have a minimum width of 15 feet.
- The maximum grade for the access ramp is 15 percent if paved to access road standard, or 12 percent if constructed of alternate ramp surface (see below).
- The ramp must extend to the pond bottom if the pond bottom is greater than 1,500 square feet (measured without the ramp) and it may end at an elevation 4 feet above the pond bottom, if the pond bottom is less than 1,500 square feet (measured without the ramp).

Materials

An alternate ramp surface can be constructed with a maximum slope of 12 percent by laying a geotextile fabric over the native soil, placing quarry spalls (2”-4”) 6 inches thick, then providing a 2-inch thick crushed rock surface.

Structural Design Considerations

- The internal berm of a wet pond or combined detention and wet pond may be used for access if it is no more than 4 feet above the first wet pool cell, if the first wet pool cell is less than 1,500 square feet (measured without the ramp), and if it is designed to support a loaded truck, considering the berm is normally submerged and saturated.
- Access ramps must meet the requirements for design and construction of access roads specified above.

Appendix V-E – Site Design Elements

This appendix provides guidelines for various BMPs, including fencing requirements, proper signage use, right of way information, setback requirements, landscaping and planting requirements, and guidelines for naturalistic plantings. All of these factors will help provide an overall safe, effective and aesthetically pleasing BMP.

Fencing

Applicability

A fence is required around all public stormwater facility tracts. On private facilities fences need only be constructed for those slopes steeper than 3H:1V, at the emergency overflow water surface elevation, or higher. A fence is also needed where the impoundment is a wall greater than 30 inches in height. Other regulations such as the International Building Code may require fencing of vertical walls. If more than 10 percent of slopes are steeper 3H:1V, it is recommended that the entire pond be fenced.

This section applies to the following BMPs:

- BMP D.01 Detention Ponds
- BMP IN.01 Infiltration Basins
- BMP WP.02 Wet Ponds
- BMP WP.04 Combined Detention/Wet Pool Facilities.

Design Criteria

- Fencing of public drainage ponds shall consist of a minimum 6 foot high WSDOT Type 1 chain link fence, per State Standard Plan L-2. A minimum of one locking access road gate shall be provided that meets WSDOT Standard Plan L-3. Gates may be 14, 16, 18, or 20 feet in width. Fence material shall be No. 9 gauge galvanized steel fabric with bonded vinyl coating. Vinyl coating shall be green or black. All posts, cross bars, fasteners, and gates shall be painted or coated the same color as the vinyl clad fence.
- Any fencing shall be placed 1 foot inside the tract or easement boundary, or a minimum of 5 feet from the top slope catch point.
- Any pipe stem access to a basin shall be fenced with a WSDOT Type 4 chain link fence with a 14-foot gate.
- Pedestrian access gates (if needed) shall be 4 feet in width and meet WSDOT Standard Plan L-3.

- Vertical metal balusters or 9 gauge galvanized steel fabric with bonded vinyl coating can be used as fence material. For steel fabric fences, the following aesthetic features may be considered:
  - Vinyl coating that is compatible with the surrounding environment (e.g., green in open, grassy areas and black or brown in wooded areas). All posts, cross bars, and gates may be painted or coated the same color as the vinyl clad fence fabric.
  - Fence posts and rails that conform to WSDOT Standard Plan L-2 for Types 1, 3, or 4 chain link fence.
- Wood fences may be used in subdivisions where the fence will be maintained by homeowners associations or adjacent lot owners.
- Wood fences shall have pressure treated posts (ground contact rated) either set in 24-inch deep concrete footings or attached to footings by galvanized brackets. Rails and fence boards may be cedar, pressure-treated fir, or hemlock.

Signage

Applicability

Detention ponds, infiltration ponds, wet ponds, and combined ponds shall have a sign with educational information and emergency contact information (Figure E-1). Applicant shall submit sign design and proposed location for Administrator acceptance.

Figure E-1. Informational Sign for Wet Pond in Olympia, Washington.

This section applies to the following BMPs:

- BMP D.01 Detention Ponds
- BMP IN.01 Infiltration Basins
- BMP WP.02 Wet ponds
- BMP WP.04 Combined Detention/Wet pool Facilities.

Design Criteria

Signs shall be placed for maximum visibility from adjacent streets, sidewalks, and paths.

An example of sign specifications for a permanent surface water control pond is provided as follows:

Sample Specifications

Size:	48 inches by 24 inches
Material:	0.125-gauge aluminum
Face:	Non-reflective vinyl or 3 coats outdoor enamel (sprayed).
Lettering:	Silk screen enamel where possible, or vinyl letters.
Colors:	Beige background, teal letters.
Type face:	Helvetica condensed. Title: 3 inch; Sub-Title: 1½ inch; Text: 1 inch; Outer border: 1/8 inch border distance from edge: 1/4 inch; all text 1¾ inch from border.
Posts:	Pressure treated, beveled tops, 1½ inch higher than sign.
Installation:	Secure to chain link fence if available. Otherwise install on two 4"x4" posts, pressure treated, mounted atop gravel bed, installed in 30-inch concrete filled post holes (8-inch minimum diameter). Top of sign no higher than 42 inches from ground surface.
Placement:	Face sign in direction of primary visual or physical access. Do not block any access road. Do not place within 6 feet of structural facilities (e.g., manholes, spillways, pipe inlets).
Special Notes:	This facility is lined to protect groundwater (if a liner that restricts infiltration of stormwater exists).

A sample informational sign is presented in Figure E-1. For Homeowners Associations, the contact can be a residence address or P.O. Box.

Setbacks and Easements

Applicability

This section provides information on setbacks and easements for conveyance systems and stormwater BMPs from Volumes III and V.

Design Criteria

Natural Systems

The easements below apply to the following natural features:

- Stream channels
- Lake shores
- Wetlands
- Potholes
- Estuaries
- Gullies
- Ravines.

All natural systems shall be located within easements. Easements shall contain the natural features and shall allow Thurston County access to them for purposes of inspection, maintenance, flood control, water quality monitoring, and other activities permitted by law.

Conveyance Systems

The setbacks below apply to the following facilities (design criteria are provided in Volume III):

- Channels
- Pipes
- Outfalls.

All man-made drainage facilities and conveyances shall be located within easements. Easements shall contain the facilities and shall allow Thurston County access to them for purposes of inspection, maintenance, flood control, water quality monitoring, and other activities permitted by law.

Easements for Access

A minimum 15-foot wide access easement shall be provided to drainage facilities from a public street or right-of-way. Access easements shall be surfaced with a minimum 12-foot width of lattice block pavement, crushed rock, or other acceptable surface to allow year-round equipment access to the facility. The easement shall include easement boundary markers which shall be fiberglass utility markers with a reflective easement tag, located at each corner of the easement, at angle points and at least every 100-ft along the length of the easement. Contact Thurston County Water Resources for additional information on easement marker requirements.

Easements for Conveyance Systems

See Volume III for required easement widths and other requirements for conveyance systems.

Infiltration Facilities

The setbacks below apply to the following BMPs:

- LID.04 – Downspout Infiltration Systems
- LID.08 – Bioretention Facilities
- IN.01 – Infiltration Basins
- IN.02 – Infiltration Trenches
- IN.03 – Bio-Infiltration Swales
- IN.04 – Infiltration Vaults.

If the depth of the infiltration facility being considered is greater than the largest surface dimension, it is considered an injection well and is subject to the requirements of the Underground Injection Control Program, Chapter 173-218 WAC. See also Volume V, Section 3.1.3.

All infiltration facilities shall maintain minimum setback distances as follows:

Horizontal Clearances

- 10 feet – from open water maximum surface elevation or edge of infiltration facility to property lines and onsite structures
- 50 feet – from top of slopes steeper than 15 percent and greater than 10 feet high. The Administrator or designee may

require a geotechnical report to evaluate whether a slope exceeding 15 percent is a landslide hazard area. Increased setbacks or prohibition of infiltration facilities may result from this report. The geotechnical analysis and report shall address the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

- 10 feet – from open water maximum surface elevation or edge of infiltration facility to building sewer
- 50 feet – from septic tank, holding tank, containment vessel, pump chamber, and distribution box
- 100 feet – from edge of septic drainfield and drainfield reserve area.
- 100 feet – from drinking water wells and springs used for drinking water supplies.
- 300 feet – from landslide hazard area (as defined by Thurston County Code Title 17.15.600 – Geologic Hazard Areas) unless the slope stability impacts of such systems have been analyzed and mitigated by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.
- 100 feet – from building foundation or basement, where infiltration facilities are located upgradient from building. The Project Engineer shall perform calculations to ensure that the line of saturation, measured from the design storm elevation in the facility, at a gradient acceptable to the Administrator or designee, falls a minimum of 1 foot below the lowest floor elevation. Setbacks shall be increased as necessary to allow for saturation effects.
- 20 feet – from building foundation or basement, where infiltration facilities are located downgradient from building. The Project Engineer shall perform calculations to ensure that the line of saturation, measured from the design storm elevation in the facility, at a gradient acceptable to the Administrator or designee, falls a minimum of 1 foot below the

lowest floor elevation. Setbacks shall be increased as necessary to allow for saturation effects.

Vertical Clearances

- 1 foot – vertical clearance from the maximum water surface surface elevation of any open water pond/facility to built structures within 25 feet.

Ponds

The setbacks below apply to the following BMPs:

- D.01 – Detention Pond
- WP.01 – Stormwater Treatment Wetland
- WP.02 – Wet Pond
- WP.04 – Combined Detention/Wet Pool Facilities
- WP.05 – Presettling Basin.

All ponds shall maintain minimum setback distances as follows:

what part of structure? foundation? finished floor?

- 1 foot – positive vertical clearance from maximum water surface to structures within 25 feet
- 10 feet – from maximum water surface to property lines and onsite structures
- 10 feet – from maximum water surface to building sewer
- 10 feet – from maximum water level location to nearest tract property boundary lines
- 30 feet – from maximum water surface to septic tank or distribution box
- 30 feet – from maximum water surface to septic drainfields and drainfield reserve areas for single family onsite sewage disposal systems
- 100 feet – from maximum water surface to septic drainfields and drainfield reserve areas for community onsite sewage disposal systems

- 50 feet – from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on the slope. The geotechnical report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

- 100 feet – from well to stormwater control and water quality facility, maximum water surface.

In addition, all underground stormwater facilities without infiltration (BMP D.02, D.03, WP.03, MF.02, MF.03, MF.05) shall be setback from any structure or property line a distance equal to the depth of the ground disturbed in setting the structure. These facilities shall also be within tracts or easements with widths equivalent to those listed for conveyance systems in Volume III.

Planting and Landscaping Requirements

Applicability

All disturbed or exposed soil must be planted and/or landscaped. Landscaping is encouraged for most stormwater tract areas (see below for areas not to be landscaped). Landscaped stormwater tracts may, in some instances, provide a recreational space. In other instances, "naturalistic" stormwater facilities may be placed in open space tracts. Bioretention facilities also have specific planting requirements.

This appendix applies to the following BMPs:

- BMP IN.02 Bioretention Facilities or Rain Gardens

- BMP D.01 Detention Ponds

- BMP BF.01 Basic Bioinfiltration Swale

Other facilities may be subject to these requirements if they include landscaping.

Design Criteria

Exposed earth on pond interiors side slopes shall be sodded or seeded with an appropriate seed mixture. Exposed earth on the pond bottom should also be sodded or seeded. All remaining areas of the tract should be planted with grass or be landscaped and mulched with a 4-inch cover of hog fuel or shredded wood mulch. Shredded wood mulch is made from shredded tree trimmings, usually from trees cleared on site. The mulch must be free of garbage and weeds and shall not contain excessive resin, tannin, or other material detrimental to plant growth.

General Landscaping Guidelines

The following guidelines shall be followed if landscaping is proposed for facilities.

Setbacks from Structures and Pipes

No trees or shrubs may be planted within 25 feet of inlet or outlet pipes or manmade drainage structures such as spillways or flow spreaders. Species with roots that seek water, such as willow or poplar, shall be avoided within 50 feet of pipes or manmade structures.

Berms

Planting shall be restricted on berms that impound water either permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.

- Trees or shrubs may not be planted on portions of water-impounding berms taller than 4 feet high. Only grasses may be planted on berms taller than 4 feet.

- Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.

- Trees planted on portions of water impounding berms less than 4 feet high must be small, not higher than 20 feet mature height, and have a fibrous root system. These trees reduce the likelihood of blow-down trees, or the possibility of channeling or piping of water through the root system, which may contribute to dam failure on berms that retain water.

  Note: *The internal berm in a wet pond is not subject to this planting restriction since the failure of an internal berm would be unlikely to create a safety problem.*

- All landscape material, including grass, shall be planted in good topsoil. Poor underlying soils may be made suitable for planting if amended with 4 inches of well-aged compost tilled into the subgrade. General information and links on soil amendment and can be found at the Soils for Salmon web site: <www.soilsforsalmon.org>.

- Soil in which trees or shrubs are planted may need additional enrichment or additional compost top-dressing. Consult a nursery, landscape professional, or arborist for site-specific recommendations.

Trees and Shrubs

- For a naturalistic effect as well as ease of maintenance, trees or shrubs should be planted in clumps to form *"landscape islands"* rather than evenly spaced.

- The landscaped islands should be a minimum of 6 feet apart, and if set back from fences or other barriers, the setback distance should also be a minimum of 6 feet. Where tree foliage extends low to the ground, the 6-foot setback should be counted from the outer drip line of the trees (estimated at maturity).

- This setback allows a 6-foot wide mower to pass around and between clumps.

- Evergreen trees and trees which produce relatively little leaf-fall (such as Oregon ash, mimosa, or locust) are preferred in areas draining to the pond.

- Deciduous trees must be set back so that branches do not extend over the pond (to prevent leaf-drop into the water).

Naturalistic Planting

Two generic kinds of naturalistic planting are outlined below, but other options are also possible. Native vegetation is preferred in naturalistic plantings.

Open Woodland

In addition to the general landscaping guidelines above, the following are recommended.

- Landscaped islands (when mature) shall cover a minimum of 30 percent or more of the tract, exclusive of the pond area.

- Shade-tolerant shrubs and groundcover plants should be planted under tree clumps. The goal is to provide a dense understory that need not be weeded or mowed.

- Landscaped islands should be placed at several elevations rather than "ring" the pond, and the size of clumps should vary from small to large to create variety.

- Not all islands need to have trees. Shrub or groundcover clumps are acceptable, but lack of shade should be considered in selecting vegetation.

  Note: *Landscaped islands are best combined with the use of wood-based mulch (hog fuel) or chipped onsite vegetation for erosion control (only for slopes above the flow control water surface). It is often difficult to sustain a low-maintenance understory if the site was previously hydroseeded. Compost or composted mulch (typically used for constructed wetland soil) can be used below the flow control water surface (materials that are resistant to and preclude flotation). The method of construction of soil landscape systems can also cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations.*

Northwest Savannah or Meadow

In addition to the general landscape guidelines above, the following are recommended.

- Landscape islands (when mature) shall cover 10 percent or more of the site, exclusive of the pond area.
- Planting groundcovers and understory shrubs is encouraged to eliminate the need for mowing under the trees when they are young.
- Landscape islands should be placed at several elevations rather than “ring” the pond.

The remaining site area shall be planted with an appropriate grass seed mix, which may include meadow or wildflower species. Native or dwarf grass mixes are preferred. Table E-2 below gives an example of dwarf grass mix developed for central Puget Sound. Grass seed should be applied at 2.5 to 3 pounds per 1,000 square feet.

Note: *Amended soil or good topsoil is required for all plantings.*

Creation of areas of emergent vegetation in shallow areas of the pond is recommended. Native wetland plants, such as sedges (*Carex* sp.), bulrush (*Scirpus* sp.), water plantain (*Alisma* sp.), and burreed (*Sparganium* sp.) are recommended. If the pond does not hold standing water, a clump of wet-tolerant, non-invasive shrubs, such as salmonberry or snowberry, is recommended below the detention design water surface.

Note: *This landscape style is best combined with the use of grass or sod for site stabilization and erosion control.*

Seed Mixes. The seed mixes listed in Tables E-2 through E-4were developed for central Puget Sound.

Seed Mixes for Specific Bioinfiltration Swales

The seed mixes listed below were developed for central Puget Sound.

Plant Recommendations for Bioretention Facilities

Bioretention facilities generally feature three planting zones, reflecting the different soil moisture and frequency of inundation. Tables E-5 through E-7 provide planting recommendations for the different planting zones. Tables E-5 through E-7 include both native and non-native plant species commonly available in the Puget Sound region and suitable for bioretention facilities. Refer to the bioretention facility design guidelines (BMP LID.08 in Chapter 2) for additional planting requirements. Consultation with a landscape architect is recommended for site-specific planting recommendations.

Table E-2. Stormwater Tract "Low Grow" Seed Mix

Seed Name	Percentage of Mix
Dwarf tall fescue	40%
Dwarf perennial rye "Barclay"*	30%
Red fescue	25%
Colonial bentgrass	5%

* If wildflowers are used and sowing is done before Labor Day, the amount of dwarf perennial rye can be reduced proportionately to the amount of wildflower seed used.

Table E-3. Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas

Mix 1		Mix 2	
75-80 percent	tall or meadow fescue	60-70 percent	tall fescue
10-15 percent	seaside/colonial bentgrass	10-15 percent	seaside/colonial bentgrass
5-10 percent	Redtop	10-15 percent	meadow foxtail
		6-10 percent	alsike clover
		1-5 percent	marshfield big trefoil
		1-6 percent	Redtop

Note: all percentages are by weight.
* based on Briargreen, Inc.

Table E-4. Groundcovers and Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington

Groundcovers	
kinnikinnick*	*Arctostaphylos uva-ursi*
Epimedium	*Epimedium grandiflorum*
creeping forget-me-not	*Omphalodes verna*
--	*Euonymus lanceolata*
yellow-root	*Xanthorhiza simplissima*
--	*Genista*
white lawn clover	*Trifolium repens*
white sweet clover*	*Melilotus alba*
--	*Rubus calycinoides*
strawberry*	*Fragaria chiloensis*
broadleaf lupine*	*Lupinus latifolius*
Grasses (drought-tolerant, minimum mowing)	
dwarf tall fescues	*Festuca* spp. (e.g., Many Mustang, Silverado)
hard fescue	*Festuca ovina duriuscula* (e.g., Reliant, Aurora)
tufted fescue	*Festuca amethystine*
buffalo grass	*Buchloe dactyloides*
red fescue*	*Festuca rubra*
tall fescue grass*	*Festuca arundinacea*
blue oatgrass	*Helictotrichon sempervirens*

Table E-5. Plant Species Appropriate for Area of Periodic or Frequent Standing or Flowing Water (Zone 1)

Species	Common Name	Exposure	Mature Size/Spread	Comments
Trees				
*Alnus rubra**	Red alder	Sun/partial shade	30-120 feet/ 25 ft. spread	Prefers moist, rich soils, highly adaptable, drought tolerant; nitrogen fixer; rapid growing, relatively short-lived (60-90 years)
*Fraxinus latifolia**	Oregon ash	Sun/partial shade	30 ft. spread	Moist, saturated or ponded soils; flood tolerant; small green-white flowers
*Malus fusca**	Pacific crabapple	Sun/partial shade	To 40 feet/35 ft. spread	Tolerant of prolonged soil saturation; produces fruit (do not plant near public walkways)
*Salix lucida**	Pacific willow	Sun	40-60 feet/ 30 ft. spread	Wet soils; tolerates seasonal flooding should not be planted in areas near pavement or underground structures
Shrubs				
*Cornus sericea**	Red-osier dogwood, Red-twig dogwood	Sun/partial shade	To 15 feet	Prefers wet to moist organically rich soils, but is adaptable; tolerates seasonal flooding; small white flowers; berrylike fruits
Cornus sericea 'Kelseyi'	Dwarf dogwood	Sun	To 1.5 feet	Prefers wet to moist organically rich soils, but is adaptable; small white flowers; berrylike fruit; low growing, compact form; good ground cover.
Cornus sericea	'Flaviramea' Yellow dogwood	Sun/partial shade	6-8 feet	Prefers wet to moist organically rich soils, but is adaptable; easily transplanted and grown; small, white flowers; yellow stems and reddish, purple fall color
Cornus sericea 'Isanti'	Isanti dogwood	Sun/partial shade	4-5 feet	Prefers wet to moist organically rich soils, but is adaptable; deciduous shrub; tiny white flowers; red stems; purple fall color
*Lonicera involucrata**	Black twinberry	Partial shade/ Shade	2-8 feet	Moist soils; prefers loamy soils; tolerant of shallow flooding; yellow, tubular flowers attract hummingbirds
*Myrica californica**	Pacific wax myrtle	Sun/partial shade	To 30 feet	Evergreen shrub preferring moist soils; inconspicuous spring flowers; drought tolerant; if drought tolerance is not an issue try the smaller Washington native, *Myrica gale**
*Physocarpus capitatus**	Pacific ninebark	Sun/partial shade	6-13 feet	Moist or dry soils; drought tolerant; snowball shaped; white flowers; seeds persist into winter

Species	Common Name	Exposure	Mature Size/Spread	Comments
Shrubs (continued)				
*Rosa pisocarpa**	Clustered wild rose	Sun/partial shade	6-8 feet	Moist soils, tolerates seasonal flooding but also tolerant of dry conditions; pink clustered flowers; fruits persist
Salix purpunea 'Nana'	Dwarf Arctic willow	Sun/partial shade	3-5 feet	Grows well in poor soils; moderately drought tolerant; small yellow flowers in the fall
*Spiraea douglasii**	Douglas spirea, Steeplebush	Sun/partial shade	4-7 feet	Moist or dry, to seasonally inundated soils; spikes of small, pink flower clusters
Emergents				
*Carex obnupta**	Slough sedge	Sun/partial shade	1-5 feet	Moist to seasonally saturated soils; shiny foliage; excellent soil binder; drought tolerant
*Carex stipata**	Sawbeak sedge	Partial shade	10 inches-3 feet	Wet soils; excellent soil binder
*Juncus effusus**	Common rush	Sun/partial shade	1-2 feet	Wet soils; evergreen perennial; hardy and adaptable; drought tolerant; small, non-showy flowers
*Juncus ensifolius**	Daggerleaf rush	Sun	12-18 inches	Wet soils; shallow water; excellent soil binder
*Juncus tenuis**	Slender rush	Sun	.5–2.5 feet	Moist soils; tufted perennial
*Scirpus acutus**	Hardstem bulrush	Sun	4-8 feet	Wet soils; favors prolonged inundation; excellent soil binder
*Scirpus microcarpus**	Small-fruited bulrush	Sun/shade	2-4 feet	Wet soils; tolerates prolonged inundation; good soil binder; drought tolerant

Source: Adapted from PSAT 2005.
* Denotes native plant species.

Table E-6. Plant Species Appropriate for Bioretention Facility Areas Subject to Periodic Saturation During Large Storms (Zone 2)

Species	Common Name	Exposure	Mature Size	Comments
Trees				
Acer truncatum	Pacific sunset maple	Sun	To 25 feet/ 20 ft. spread	Prefers moist, well-drained soils, but drought tolerant; very cold hardy; deciduous tree with moderate growth rate
*Amelanchier alnifolia**	Western serviceberry	Sun/partial shade	10-20 feet/ 25 ft. spread	Moist to dry, well-drained soils; drought tolerant; large white flowers; purple to black berries; deciduous
*Corylus cornuta**	Beaked hazelnut	Sun/partial shade	20–30 feet/ 15 ft. spread	Moist, well-drained soils; edible nuts; intolerant of saturated soils; catkins throughout winter add interest; deciduous
*Crataegus douglasii**	Black hawthorn	Sun/partial shade	3-30 feet/ 25 ft. spread	Moist to dry, well drained, gravelly soils; small white flowers, black berries; 1 inch spines; forms thickets; deciduous
Fraxinus oxycarpa	Raywood ash	Sun	25-50 feet/ 25 ft. spread	Drought tolerant; grows in varying soil types; deciduous; can take extreme temperatures; does not tolerate constant wind or fog; resists pests and disease better than other non-native ashes; inconspicuous flowers
*Rhamnus purshiana**	Cascara sagrada	Sun/shade	20-40 feet/ 25 ft. spread	Moist to fairly dry soils; small greenish-yellow flowers; deciduous; sensitive to air pollution; yellow fall color
*Salix scouleriana**	Scouler willow	Sun/partial shade	6-40 feet/ 15 ft. spread	Moist to dry soils; drought tolerant; deciduous tree; do not plant near paved surfaces or underground structures
*Salix sitchensis**	Sitka willow	Sun/partial shade	3-26 feet/ 25 ft. spread	Moist soils; tolerates seasonal flooding; deciduous tree; do not plant near paved surfaces or underground structures
*Thuja plicata**	Western red cedar	Partial shade/shade	200 feet+/ 60 ft. spread	Moist to swampy soils; tolerates seasonal flooding and saturated soils; long-lived; prefers shade while young
Shrubs – Deciduous				
*Acer circinatum**	Vine maple	Filtered sun/shade	To 25 feet	Dry to moist soils; tolerant of shade and clay soils; excellent soil binder; beautiful fall color
Hamamelis intermedia	Diane witchhazel	Sun/partial shade	10-20 feet/ 10 ft. spread	Moist, fertile, acidic soil; showy fall color – yellow to yellow-orange; long-lasting, slightly fragrant, coppery-red flowers; not drought tolerant; may require watering in dry season

Species	Common Name	Exposure	Mature Size	Comments
Shrubs – Deciduous (continued)				
*Oemleria cerasiformis**	Indian plum/Osoberry	Sun/partial shade	5-16 feet	Moist to dry soils; prefers shade; tolerates fluctuating water table
Philadelphus x lemoinei	'Belle Etoile' Mock-orange	Sun/partial shade	5-6 feet	Prefers moist, well-drained soils, high in organic matter, but soil and pH adaptable; easily transplanted and established; fragrant, large white flowers, tinged red at the base; other cultivars available
*Ribes lacustre**	Black swamp gooseberry	Partial shade	1.5–3 feet	Moist soils; deciduous shrub; reddish flowers in drooping clusters; dark purple berries; *R. divaricatum** (Wild gooseberry) grows to 5 feet and is also an option; attracts butterflies, but is very thorny
*Rosa nutkana**	Nootka rose	Sun/partial shade	6-10 feet	Moist to fairly dry soils; tolerates inundation and saturated soils; aggressive spreader; fruits persist; less thorny that *R. rugosa*
Rosa rugosa	Rugosa rose	Sun	To 8 feet	Drought resistant; hardy, vigorous and aggressive; highly prickly; fragrant white to purple flowers; fruits persist
*Rubus parviflorus**	Thimbleberry	Sun/partial shade	4-10 feet	Moist to dry soils; white flowers; red berries; makes thickets and spreads easily
*Rubus spectabilis**	Salmonberry	Partial sun/shade	5-10 feet	Prefers moist, wet soils; good soil binder; magenta flowers; yellow/ orange fruit; early nectar source for hummingbirds; makes thickets
*Sambucus racemosa**	Red elderberry	Partial sun/partial shade	To 20 feet	Moist to dry soils; small white flowers; bright red berries; vase shaped; pithy stems lead to "messy" form – prune for tidiness
*Symphoricarpos albus**	Snowberry	Sun/shade	2-6 feet	Wet to dry soils, clay to sand; excellent soil binder; drought and urban air tolerant; provides good erosion control; spreads well in sun; white berries; flowers attract hummingbirds
*Vaccinium parvifolium**	Red huckleberry	Partial shade/shade	4-10 feet	Slightly moist to dry soils; prefers loamy, acid soils or rotting wood; tolerant of dry, shaded conditions; red fruit; tricky to transplant

Herbaceous				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Aquilegia formosa /* Western columbine	Sun/partial shade	1-3 feet	Spring	Moist soils of varying quality; tolerant of seasonal flooding; red and yellow flowers attract hummingbirds and butterflies
Asarum caudatum /* Wild ginger	Partial shade/shade	To 10 inches	Mid spring	Moist organic soils; heart-shaped leaves; reddish-brown flowers
Aster chilensis /* Common California aster	Sun	1.5 – 3 feet	June - September	Moist soils; white to purple flowers
Aster subspicatus /* Douglas aster	Sun	.5 – 2.5 feet	June - September	Moist soils; blue to purple flowers
Camassia quamash /* Common camas	Sun/partial shade	To 2.5 feet	May - June	Moist to dry soils; lots of watering needed to establish; loose clusters of deep blue flowers
Camassia leichtlinii / Giant camas		2–4 feet	May - June	Moist to dry soils; lots of watering to establish; large clusters of white, blue or greenish-yellow flowers
*Iris douglasiana** / Pacific coast iris	Sun/partial shade	1-2 feet	Spring	Tolerates many soils; withstands summer drought and seasonal flooding; white, yellow, blue, reddish purple flowers; fast growing; velvety purple flowers; vigorous
Iris foetidissima / Gladwin iris	Sun/partial shade	1-2 feet	May	Moist to dry, well-drained soils; pale lilac flower; also called Stinking Iris
Juncus tenuis /* Slender rush	Sun	6 inches – 2.5 feet		Moist soils; yellow flowers
Iris sibirca / Siberian Iris	Sun	1-2.5 feet	Late spring – early summer	Moist soils; deep blue, purple to white flowers
Tellima grandiflora /* Fringecup	Partial sun/shade	1-3 feet	March - June	Perennial preferring moist soils; yellowish-green to pink flowers
*Tiarella trifoliata** / Foamflower	Partial sun/shade	To 1 foot	Early - mid summer	Moist soils; perennial with some drought tolerance after established; can form dense colonies; white flowers
Tolmiea menziesii /* Youth-on-age/Piggy-back plant	Partial shade/shade	1-2 feet	April - August	Moist soils; brownish-purple flowers; also makes and effective groundcover
Viola species* / Violets	Partial shade/shade	6-12 inches	Late spring – early summer	Moist soils; yellow to blue flowers

Table E-7. Plant Species Appropriate for Rarely Inundated Areas of Bioretention Facility (Zone 3)

Trees				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Arbutus unedo / Strawberry tree	Sun/partial shade	8-35 feet/ 8-20 ft. spread	November - December	Tolerant of extremes; tolerant of urban/ industrial pollution; white or greenish white flowers
*Calocedrus decurrens** / Incense cedar	Sun	75-90 feet/ 12 ft. spread		Tolerant of poor soils; drought tolerant after established; fragrant evergreen with a narrow growth habit; slow growing
Chamaecyparis obtusa / Hinoki false cypress	Sun/partial shade	40-50 feet/ 15-30 ft. spread		Moist, loamy, well-drained soils; very slow growing; prefers sun, but tolerates shade; does not transplant well or do well in alkaline soils. Note there are
				many alternative varieties of false cypress of varying sizes and forms from which to choose
Cornus spp. / Dogwood	Sun/partial shade	20-30 feet/ 30 ft. spread	May	Reliable flowering trees with attractive foliage and flowers; may need watering in dry season; try *C. florida* (Eastern dogwood), or *C. nuttallii** (Pacific dogwood) or hybrid 'Eddie's White Wonder'. Also, *C. kousa* for small tree/ shrub which is resistant to anthracnose
Pinus mugo / Swiss mountain pine	Sun/partial shade	15-20 feet/ 25-30 ft. spread		Prefers well-drained soil; slow growing, broadly spreading, bushy tree; hardy evergreen
Pinus thunbergiana / Japanese black pine	Sun	To 100 feet/ 40 ft. spread		Dry to moist soils; hardy; fast growing
*Prunus emarginata** / Bitter cherry	Sun/partial shade	20-50 feet/ 20 ft. spread	May - June	Dry or moist soils; intolerant of full shade; bright red cherries are attractive to birds; roots spread extensively
Prunus virginiana / Choke cherry		15-25 feet/ 15-20 ft. spread	Late spring – Early summer	Dry or moist soils; deep rooting; attractive white fragrant flowers; good fall color
*Pseudotsuga menziesii** / Douglas-fir	Sun	100-250 feet/ 50-60 ft. spread		Does best in deep, moist soils; evergreen conifer with medium to fast rate of growth; provides a nice canopy, but potential height will restrict placement
*Quercus garryana** / Oregon white oak	Sun	To 75 feet		Dry to moist, well-drained soils; slow growing; acorns

Shrubs				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Holodiscus discolor** / Oceanspray	Sun/partial shade	To 15 feet	June - July	Dry to moist soils; drought tolerant; white to cream flowers; good soil binder
*Mahonia aquifolium** / Tall Oregon grape	Sun/partial shade	6-10 feet	March - April	Dry to moist soils; drought resistant; evergreen; blue-black fruit; bright yellow flowers; 'Compacta' form averages 2 feet tall; great low screening barrier
*Philadelphus lewisii** / Mock-orange	Sun/partial shade	5-10 feet	June - July	Adapts to rich moist soils or dry rocky soils; drought tolerant; fragrant flowers

▶ ZONE 3

Shrubs				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Pinus mugo pumilio / Mugho pine	Sun	3-5 feet/ 4-6 ft. spread		Adapts to most soils; slow growing and very hardy; newer additions with trademark names such as 'Slo-Grow' or 'Lo-Mound' are also available
Potentilla fruticosa / Shrubby cinquefoil	Sun	To 4 feet	May - September	Moist to dry soils; several cultivars available with varying foliage and flower hues; try 'Tangerine' or 'Moonlight'
*Ribes sanguineum** / Red-flowering currant	Sun/partial shade	8-12 feet	March - April	Prefers dry soils; drought tolerant; white to deep-red flowers attract hummingbirds; dark-blue to black berries; thornless
*Rosa gymnocarpa** / Baldhip rose	Partial shade	To 6 feet	May - July	Dry or moist soils; drought tolerant; small pink to rose flowers

Shrubs-Evergreen				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Abelia x grandiflora / Glossy abelia	Partial Sun/Partial shade	To 8 feet/ 5 foot spread	Summer	Prefers moist, well-drained soils, but drought tolerant; white or faintly pink flowers
Arbutus unedo 'Compacta' / Compact strawberry tree	Sun/partial shade	To 10 feet	Fall	Prefers well drained soils; tolerant of poor soils; good in climate extremes; white to greenish-white flowers; striking red-orange fruit

Cistus purpureus / Orchid rockrose	Sun	To 4 feet	June - July	Moist to dry well-drained soils; drought resistant; fast growing; reddish purple flowers
Cistus salvifolius / White rockrose	Sun	2-3 feet/ 6 ft spread	Late spring	Moist to dry well-drained soils preferred, but can tolerate poor soils; tolerant of windy conditions and drought; white flowers
Escallonia x exoniensis 'fradesii' / Pink Princess	Sun/partial sun	5-6 feet	Spring - Fall	Tolerant of varying soils; drought tolerant when established; pink to rose colored flowers; good hedge or border plant; attracts butterflies
Osmanthus delavayi / Delavay Osmanthus	Sun/partial shade	4-6 feet	March - May	Tolerant of a broad range of soils; attractive foliage and clusters of white fragrant flowers; slow growing
Osmanthus x burkwoodii / Devil wood	Sun/partial shade	4-6 feet	March - April	Drought tolerant once established; masses of small, white fragrant flowers
Rhododendron / 'PJM' hybrids	Sun/partial shade	To 4 feet	Mid – late April	Moist to fairly dry soils; well drained organic soil; lavender to pink flowers
Stranvaesia davidiana	Sun	6-20 feet	June	Moist soils; white flowers in clusters; showy red berries
Stranvaesia davidiana / undulata	Sun	To 5 feet	June	Moist soils; lower growing irregularly shaped shrub; great screening plant
Vaccinium ovatum* / Evergreen huckleberry	Partial shade/ shade	3-15 feet	March	Moist to slightly dry soils; small pinkish-white flowers; berries in August

▶ ZONE 3

Groundcover – Evergreen				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Arctostaphylos uva-ursi** / Kinnikinnik	Sun/partial shade		April - June	Prefers sandy/rocky, well-drained soils; flowers pinkish-white; bright red berries; slow to establish; plant closely for good results
*Gaultheria shallon** / Salal	Partial shade/ shade	3-7 feet	March - June	Dry and moist soils; white or pinkish flowers; reddish-blue to dark-purple fruit
*Fragaria chiloensis** / Wild/Coastal strawberry	Sun/partial shade	10 inches	Spring	Sandy well drained soils; flowers white; small hairy strawberries; evergreen; aggressive spreader

Helianthemum nummularium / Sunrose	Sun	To 2 feet/ 2 ft. spread	May - July	Prefers well-drained soils, but will tolerate various soils; low-growing, woody sub shrub; many varieties are available with flowers in salmon, pink, red, yellow and golden colors
Lavandula angustifolia / Lavender	Sun/partial shade	To 1.5 feet	June - August	Adaptable to various soils; blue, lavender, pink to white flowers, semi-evergreen aromatic perennial
*Mahonia nervosa** / Cascade Oregon grape/Dull Oregon grape	Partial shade/ shade	To 2 feet	April – June	Dry to moist soils; drought resistant; evergreen; yellow flowers; blue berries
Mahonia repens / Creeping mahonia	Sun/partial shade	3 feet	April - June	Dry to moist soils; drought resistant; yellow flowers; blue berries; native of Eastern Washington
*Penstemon davidsonii** / Davidson's penstemon	Sun	To 3 inches	June - August	Low growing evergreen perennial; prefers well-drained soils; drought tolerant; blue to purple flowers

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
*Achillea millefolium** / Western yarrow	Sun	4 inches – 2.5 feet	June - September	Dry to moist, well-drained soils; white to pink/reddish flowers; many other yarrows are also available
Anaphalis margaritaceae / Pearly everlasting	Sun/partial shade	To 18 inches		Drought tolerant perennial; spreads quickly; attracts butterflies
*Bromus carinatus** / Native California brome	Sun/partial shade	3-5 feet		Dry to moist soils; tolerates seasonal saturation
Carex buchannii / Leather leaf sedge	Sun/partial shade	1-3 feet		Prefers well-drained soils; copper-colored foliage; perennial clumping grass; tolerant of a wide range of soils; inconspicuous flowers
Carex comans / 'Frosty curls' New Zealand hair sedge	Sun/partial shade	1-2 feet	June -August	Prefers moist soils; finely textured and light green; compact, clumping perennial grass; drought tolerant when established; inconspicuous flowers

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Coreopsis spp. / Tick-Seed	Sun	1-3 feet		Dry to moist soils; drought tolerant; seeds attract birds; annual and perennial varieties; excellent cut flowers
Echinacea purpurea / Purple coneflower	Sun	4-5 feet		Prefers well drained soils; hardy perennial; may need occasional watering in dry months
*Elymus glaucus** / Blue wildrye	Sun/partial shade	1.5-5 feet		Dry to moist soils; shade tolerant; rapid developing, but short lived (1-3 years); not good lawn grass
*Dicentra formosa** / Pacific bleeding-heart	Sun/shade	6-20 inches	Early spring - early summer	Moist, rich soils; heart-shaped flowers
*Erigeron speciosus** / Showy fleabane	Sun/partial shade	To 2 feet	Summer	Moist to dry soils; dark violet or lavender blooms; fibrous roots
Festuca ovina 'Glauca' / Blue fescue	Sun/partial shade	To 10 inches	May - June	Prefers moist, well-drained soils; blue-green evergreen grass; drought tolerant; shearing will stimulate new growth
*Festuca idahoensis** / Idaho fescue	Sun/partial shade	To 1 foot		Bluish-green bunching perennial grass; drought tolerant
*Fragaria vesca** / Wood strawberry	Partial shade	To 10 inches	Late spring - early summer	Dry to moist soils; white flowers
Gaura lindheimeri / Gaura	Sun	2.5-4 feet		Perennial; fairly drought tolerant and adaptable to varying soil types; long blooming period
*Geum macrophyllum** / Large-leaved avens	Sun/partial shade	To 3 feet	Spring	Moist, well-drained soil; bright yellow flowers; other Geum cultivars available, some which may require supplemental watering
Geranium maculatum / Spotted geranium	Sun/shade	To 1.5 feet	July	Moist, well-drained soils; low perennial; pale pink, blue to purple flowers
Geranium sanguineum / Cranesbill	Sun/partial shade	To 1.5 feet	May - August	Moist soils; deep purple almost crimson flowers
Helichrysum italicum / Curry Plant	Sun	To 2 feet	Summer	Moist or dry soils; hardy evergreen perennial; a good companion to lavender; bright yellow flowers; fragrant

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Helictotrichon sempervirens / Blue oat grass	Sun/partial shade	1-1.5 feet	June - August	Tolerant of a variety of soil types but prefers well-drained soil; clumping bright blue evergreen grass; bluish white flowers
Hemerocallis fulva / Day lilies	Sun/partial shade	1-4 feet	Summer	Tolerant of a variety of soil types; easy to grow and tolerant of neglect; hardy perennial; entire plant is edible
Heuchera americana / Coral bells (alumroot)	Sun/partial shade	1-2 feet	June - August	Moist to dry, well-drained soils; never wet; easily transplantable perennial; red, greenish-white flowers; may need supplemental watering in dry season
Heuchera micrantha / 'Palace purple' (alumroot)	Sun/partial shade	1-2 feet	June - August	Moist, well-drained soils; bronze to purple foliage in shade; small, yellowish-white flowers; perennial, evergreen; a number of other species and varieties are available. Try *H. sanguinea* for bright red flowers
*Lupinus** spp. / Lupines	Sun	3-5 feet	March - September	Moist to dry soils; various native varieties; blue to purple, violet to white flowers; both native and non-native varieties
*Lupinus bicolor** / Two-color lupine	Sun	4 inches - 1.5 feet	Spring	Dry gravelly soils; small-flowered; annual
*Lupinus latifolius** / Broadleaf lupine	Sun	To 1 foot	June - August	Dry to moist soils; perennial; bushy herb; bluish flowers
*Lupinus polyphyllus** / Large-leafed lupine	Sun	To 3 feet	Spring - summer	Dry to moist, sandy to gravelly soils; perennial
*Maianthemum dilatatum** / False lily-of-the-valley	Partial shade/ shade	3-12 inches	Spring	Prefers moist soils; small, white flowers; light-green to red berries
Pennisetum alopecuroides / Fountain grass	Sun/partial shade	1-2 feet	August - September	Moist, well-drained soils; tolerant of many soil types; clump-forming grasses. A number of varieties are available in different heights and bloom times. Try *P. caudatum* (White-flowering fountain grass) and *P. alopecuroides* cultivars 'Hameln' and 'Little Bunny' (Dwarf fountain grass)

Perennials & Ornamental Grasses				
Species / Common Name	**Exposure**	**Mature Size**	**Time of Bloom**	**Comments**
Pennisetum orientale / Oriental fountain grass	Sun/partial shade	1-3 feet	June - October	Prefers moist, well-drained soils; somewhat drought tolerant; small clumping, blooming grass, showy pink flowers; fountain grasses will benefit from annual shearing in late winter/early spring, but not required
Penstemon fruticosus / Shrubby penstemon	Sun	8–10 inches	May	Prefers well-drained soils; evergreen perennial; drought tolerant; violet-blue flowers 1 inch long attract hummingbirds
*Polystichum munitum** / Swordfern	Partial shade/ Deep shade	2-4 feet		Prefers moist, rich soil conditions, but drought tolerant; large evergreen fern
*Potentilla gracilis** / Graceful cinquefoil	Sun	1-2 feet	July	Moist to dry soils; yellow flowers
Rudbeckia hirta / Black-eyed susan	Sun/partial shade	3-4 feet	Summer	Moist to dry soils; showy flowers, hardy and easy to grow; several other varieties are available
*Smilacina racemosa** / False Solomon's seal	Partial sun/shade	1-3 feet	April - May	Moist soils; creamy white flowers; red berries