Volume II

Construction Stormwater Pollution Prevention
(Sediment and Erosion Control BMPs)

Drainage Design and Erosion Control Manual
For Olympia

October 2009
Acknowledgements

This manual volume largely incorporates the contents of Ecology’s 2005 Stormwater Management Manual for Western Washington, Volume II.

Acronym Glossary

AKART All known, available, and reasonable means have been taken
ATB Asphalt Treated Base
BFM Bonded Fiber Matrix
BMPs Best Management Practices
CESCL Contractor Erosion and Spill Control Lead
CESCP Contractor’s Erosion and Sediment Control Plan
CPESC Certified Professional in Erosion and Sediment Control
Ecology Washington State Department of Ecology
EPA Environmental Protection Agency
ESA Endangered Species Act
ESC Erosion and Sediment Control
FCWA Federal Clean Water Act
FEMA Federal Emergency Management Agency
IECA International Erosion Control Association
MBFM Mechanically Bonded Fiber Matrix
NOE No observed effects concentration
NOI Notice of Intent
NPDES National Pollutant Discharge Elimination System
NRCS Natural Resources Conservation Service
PAM Polyacrylamide
RUSLE Revised Universal Soil Loss Equation
SCS Soil Conservation Service
SWPPP Stormwater Pollution Prevention Plan
TESC Temporary Erosion and Sediment Control
TMDLs Total Maximum Daily Load
USDA United States Department of Agriculture
WSDOT Washington State Department of Transportation
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**Construction Stormwater Pollution Prevention**  
(Sediment and Erosion Control BMPs)

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Chapter 1 – Introduction to Construction Stormwater Pollution Prevention

1.1 Purpose of this Volume

Volume II of this Stormwater Management Manual is entirely devoted to stormwater effects and controls associated with construction activities. It addresses the planning, design, and implementation of stormwater management activities prior to and during the construction phase of projects.

The objective of this volume is to provide guidance for avoiding adverse stormwater impacts from construction activities on downstream resources and on-site stormwater facilities. Minimization of stormwater flows, prevention of soil erosion, capture of water-borne sediment that has been unavoidably released from exposed soils, and protection of water quality from on-site pollutant sources are all readily achievable when the proper Best Management Practices (BMPs) are planned, installed, and properly maintained.

The construction phase of a project is usually considered a temporary condition, which will be supplanted by the permanent improvements and facilities for the completed project. However, construction work may take place over an extended period of time, including several seasons of multiple years. All management practices and control facilities used in the course of construction should be of sufficient size, strength, and durability to readily outlast the longest possible construction schedule and the worst anticipated rainfall conditions.

Linear projects, such as roadway construction and utility installations, are special cases of construction activities and present their own, unique set of stormwater protection challenges. Many of the BMPs can be adapted and modified to provide the controls needed to adequately address these projects. It may be advantageous to segment long, linear projects into a series of separate units that can apply all necessary controls pertinent to that particular unit in a timely manner.

The goal of a Construction Stormwater Pollution Prevention Plan (SWPPP) is to avoid immediate and long-term environmental loss and degradation typically caused by poorly managed construction sites. Prompt implementation of a Construction SWPPP, designed in accordance with Chapters 3 and 4 of this volume, can provide a number of benefits. These include minimizing construction delays, reducing resources spent on repairing erosion, improving the relationship between the contractor and the permitting authority, and limiting adverse effects on the environment.
Many of the BMPs contained in this volume can be adapted and modified to provide the erosion and sediment controls needed for other activities such as mining.

1.2 Content and Organization of this Volume

Volume II consists of four chapters that address the key considerations and mechanics of preparing and implementing Construction SWPPPs.

Chapter 1 highlights the importance of construction stormwater management in preventing pollution of surface waters. The chapter briefly lists 12 elements of pollution prevention to be considered for all projects. The elements are fully detailed later in this volume. Erosion and sedimentation processes and impacts are discussed.

Chapter 2 contains the regulatory requirements that apply to construction sites and their stormwater discharges. The Department of Ecology’s (Ecology) National Pollutant Discharge Elimination System (NPDES) discharge permit and municipal construction site runoff control programs are discussed. Chapter 2 lists Washington’s Water Quality Standards pertaining to construction stormwater and explains how they apply to field situations.

Chapter 3 presents a step-by-step method for developing a Construction SWPPP. It encourages examination of all possible conditions that could reasonably affect a particular project’s stormwater control systems during the construction phase of the project.

Chapter 4 contains BMPs for construction stormwater control and site management. The first section of Chapter 4 contains BMPs for Source Control. The second section addresses runoff, conveyance, and treatment BMPs. Various combinations of these BMPs should be used in the Construction SWPPP to satisfy each of the 12 elements applying to the project.

Note that this stormwater management manual is based on revisions to Ecology’s Stormwater Management Manual for Western Washington, 2005. The local governments have edited the Ecology Manual to remove many of the background and supporting details. If the reader wishes to review those details, please refer to the Ecology Manual.

1.3 How to Use This Volume

This volume should be used in developing the Construction Stormwater Pollution Prevention Plan, which is a required component of a Stormwater Site Plan (see Volume I, Chapter 3). Users should refer to this introductory chapter for an overview of construction stormwater issues, particularly related to erosion and sedimentation. Chapter 2 should be consulted to determine the regulatory requirements that apply to a construction site, including permit requirements that deal with stormwater...
at construction sites. Users should read Chapter 3 to determine the organization and content of the Construction SWPPP. This chapter includes lists of suggested BMPs to meet each element of construction stormwater pollution prevention. Based on these lists, the project proponent should refer to Chapter 4 to determine which BMPs will be included in the Construction SWPPP, and to design and document application of these BMPs to the project construction site.

As a courtesy to design engineers, local governments have tried to identify all required elements and to reflect these in bold face print. Design engineers are advised to consider bolded passages as design requirements, to the extent applicable to their project. Design engineers should not assume that text not shown in bold face print is always optional—requirements may vary from project to project.

1.4 Twelve Elements of Construction Stormwater Pollution Prevention

The 12 Elements listed below must be included in the Construction SWPPP unless site conditions render the element unnecessary. If an element is considered unnecessary, the Construction SWPPP must provide the justification.

These elements cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources.

The 12 Elements are:

- Mark Clearing Limits
- Establish Construction Access
- Control Flow Rates
- Install Sediment Controls
- Stabilize Soils
- Protect Slopes
- Protect Drain Inlets
- Stabilize Channels And Outlets
- Control Pollutants
- Control De-Watering
- Maintain BMPs
- Manage the Project

A complete description of each element and associated BMPs is given in Chapter 3.
Chapter 2 - Regulatory Requirements

Construction site stormwater runoff is regulated on the local level and at the State level.

- The Puget Sound Water Quality Management Plan requires communities in the Puget Sound Basin to adopt ordinances implementing controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites.

- The Phase II NPDES municipal permit program will require Thurston County, Lacey, Olympia, and Tumwater to adopt ordinances implementing controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites.

- Construction projects must apply for coverage under the NPDES General Permit for Stormwater Associated with Construction Activities if:
  - the project results in the disturbance of one acre or more of land, including clearing, grading, and excavation activities, and
  - the project discharges stormwater from the site into a surface water or discharge to a storm drain system that discharges to a surface water.

- Some construction projects may require an individual NPDES permit.

2.1 Requirements Under the Puget Sound Water Quality Management Plan

The Puget Sound Water Quality Management Plan directs the approximately 120 cities and counties in the Puget Sound Basin to adopt and implement programs to prevent stormwater pollution and to enhance water quality within the municipal jurisdictions. The plan requires the municipalities to adopt ordinances implementing controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites. These ordinances must include all of the Minimum Requirements contained in Volume I of the Stormwater Management Manual, or requirements determined by the Department of Ecology (Ecology) to be technically equivalent.

Minimum Requirement #2, Construction Stormwater Pollution Prevention, requires that new development and redevelopment projects address stormwater pollution prevention during construction. Construction projects must consider all of the 12 elements of construction stormwater...
pollution prevention and develop controls for all of the elements that pertain to the project site.

Projects that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet must prepare a Construction Stormwater Pollution Prevention Plan (SWPPP) that is reviewed by the Local permitting authority of the local government. The Construction SWPPP must contain sufficient information to satisfy the Local permitting authority that the problems of pollution have been adequately addressed for the proposed project. Projects that add or replace less than 2,000 square feet of impervious surface or clearing projects of less than 7,000 square feet are not required to prepare a Construction SWPPP. However, these projects must consider all of the 12 elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site.

### 2.2 Other Applicable Regulations and Permits

Other regulations and permits may require the implementation of BMPs to control pollutants in construction site stormwater runoff. They include but may not be limited to the following:

- Total Maximum Daily Load (TMDLs) or Water Clean Up Plans (Ecology).
- Hydraulic Project Approval Permits (Washington Department of Fish and Wildlife).
- General provisions from the WSDOT (Washington Department of Transportation).
- Contaminated site remediation agreements (Ecology).
- Local permits and approvals, such as clearing and grading permits (local government permitting authorities).
- National Pollutant Discharge Elimination System (NPDES) permits (Ecology).
- Water Quality Standards (Ecology).
- Special-purpose Districts (e.g., drainage, wellhead protection, or shellfish protection districts).
- Critical Areas Ordinances (local government permitting authorities).
• Shoreline Master Plans (local government permitting authorities).
• Army Corps of Engineers permits.

See Volume I, Section 1.6 for further information on these regulations and permits. Contact the listed agency for more information.

2.2.1 Ecology General Permit for Stormwater Discharges Associated With Construction Activities

The goal of this Ecology-issued permit is to minimize harm to surface waters from construction activities.

Coverage under this general permit is required for any clearing, grading, or excavating that will disturb one or more acres and that will discharge stormwater from the site into surface waters or storm drainage systems leading to surface waters.

This permit is also required for projects or construction activities that disturb less than one acre, if the project or activity is part of a larger common development plan or sale that will ultimately disturb one or more acres. A common plan means any announcement, documentation, or physical demarcation indicating construction activities may occur on a specific plot. For example, this requirement includes building lots within residential plats, where the plat exceeded one acre and required coverage.

This permit is not required for routine maintenance performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site. For example, re-grading a dirt road or cleaning a roadside drainage ditch to maintain “as-built” status does not require permit coverage.

Any construction activity discharging stormwater that Ecology or the local permitting authority determines to be a “significant pollutant contributor” to waters of the state may also be required to apply for and obtain permit coverage, regardless of project size.

To obtain coverage, applicants should contact Ecology’s Water Quality Program, Stormwater Unit, at (360) 407-6437 or visit their website at http://www.ecy.wa.gov/programs/wq/stormwater/construction/.
2.3. Enforcement Guidelines

The compliance monitoring (inspection) objective is ensuring water resources and stormwater infrastructure protection, not punishing violators. Therefore, the initial and primary enforcement tool shall be a correction notice, stop work order, compliance order, or similar action. In most cases, all construction work will be halted 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 or repeated violations, the local permitting authority shall, at their discretion, issue infractions 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 and in accordance with Standard Methods for the Examination of Water and Wastewater, most recent edition, American Water Works Association. “Free of settleable solids” shall be defined as measuring less than 2.5 mL/L/hr, for storms up to the water quality design event.¹

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 or 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 the surface water.

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.

¹ 2.5 mL/L/hr is selected because it is a recognized sediment discharge standard in Colorado and Missouri.
Chapter 3 - Planning

This chapter provides an overview of the important components of, and the process for, developing and implementing a Construction Stormwater Pollution Prevention Plan (SWPPP).

Section 3.1 contains general guidelines with which site planners should become familiar. It describes criteria for plan format and content and ideas for improved plan effectiveness.

Section 3.2 outlines and describes a recommended step-by-step procedure for developing a Construction SWPPP from data collection to finished product. This procedure is written in general terms to be applicable to all types of projects.

Section 3.3 includes a checklist for developing a Construction SWPPP.

Design standards and specifications for Best Management Practices (BMPs) referred to in this chapter are found in Chapter 4.

The Construction SWPPP may be a subset of the Stormwater Site Plan or construction plan set. Full details on how to integrate the Construction SWPPP with a Stormwater Site Plan are provided in Volume 1.

3.1 General Guidelines

3.1.1 What is a Construction Stormwater Pollution Prevention Plan?

The Construction SWPPP is a document that describes the potential for pollution problems on a construction project. The Construction SWPPP explains and illustrates the measures to be taken on the construction site to control those problems. A Construction SWPPP for projects that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet must have a narrative as well as drawings and details. The local permitting authority will review these Construction SWPPPs. The local permitting authority may allow, and may provide a standard plan for, single-family home and similar small construction projects.

While it is a good idea to include standards and specifications from the Construction SWPPP in the contract documents, the Construction SWPPP should be a separate document that can stand alone. The Construction SWPPP must be located on the construction site or within reasonable access to the site for construction and inspection personnel, although a copy of the drawings must be kept on the construction site at all times.
As site work progresses, the plan must be modified to reflect changing site conditions, subject to the rules for plan modification by the local permitting authority.

The owner or lessee of the land being developed has the responsibility for Construction SWPPP preparation and submission to local authorities. The owner or lessee may designate someone (i.e., an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but he/she retains the ultimate responsibility.

### 3.1.2 What is an Adequate Plan?

The Construction SWPPP for projects adding or replacing 2,000 square feet of impervious surface or more or clearing 7,000 square feet or more must contain sufficient information to satisfy the local permitting authority of the local government that the problems of pollution have been adequately addressed for the proposed project.

An adequate Construction SWPPP includes a narrative and drawings. The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project. The narrative contains concise information about existing site conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings and notes describe where and when the various BMPs should be installed, the performance the BMPs are expected to achieve, and actions to be taken if the performance goals are not achieved.

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 must be included in the Construction SWPPP unless an element is determined not to be applicable to the project and the exemption is justified in the narrative. The step–by-step procedure outlined in Section 3.2 of this volume is recommended for the development of the Construction SWPPPs. The checklists in Section 3.3 may be helpful in preparing and reviewing the Construction SWPPP.

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. Several of the other elements are very important at these sites as well, such as marking the clearing limits, establishing the construction access, and managing the project.
3.1.3 BMP Standards and Specifications

Chapter 4 contains standards and specifications for the BMPs referred to in this Chapter. Wherever any of these BMPs are to be employed on a site, the specific title and number of the BMP should be clearly referenced in the narrative and marked on the drawings.

The standards and specifications in Chapter 4 of this volume are not intended to limit any innovative or creative effort to effectively control erosion and sedimentation. In those instances where appropriate BMPs are not in this chapter, experimental management practices can be considered. Minor modifications to standard practices may also be employed. However, such practices must be approved by the local permitting authority of the local government before they may be used. All experimental management practices and modified standard practices are required to achieve the same or better performance than the BMPs listed in Chapter 4.

Any BMP included in a SWPPP shall adhere to that BMP’s purpose, conditions of use, design and installation specifications, and maintenance standards, as stated elsewhere in this Manual, or on Ecology’s Internet website at http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html. Construction drawings shall include notes detailing each BMP’s design and installation specifications and maintenance standards, adequate to ensure contractor and local permitting authority plan reviewer and inspector understanding.

3.1.4 General Principles

The following general principles should be applied to the development of the Construction SWPPP.

- The duff layer, native topsoil, and natural vegetation should be retained in an undisturbed state to the maximum extent practicable.
- 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.
- Limit the extent of clearing operations and phase construction operations.
- Before reseeding a disturbed soil area, amend all soils with compost wherever topsoil has been removed.
• Incorporate natural drainage features whenever possible, using adequate buffers and protecting areas where flow enters the drainage system.
• Minimize slope length and steepness.
• Reduce runoff velocities to prevent channel erosion.
• Prevent the tracking of sediment off-site.
• Select appropriate BMPs for the control of pollutants other than sediment.
• Be realistic about the limitations of controls that you specify and the operation and maintenance of those controls. Anticipate what can go wrong, how you can prevent it from happening, and what will need to be done to fix it.

3.2 Step-By-Step Procedure

There are three basic steps in producing a Construction SWPPP:

Step 1 - Data Collection
Step 2 - Data Analysis
Step 3 - Construction SWPPP Development and Implementation

Steps 1 and 2 described below are intended for projects that are adding or replacing 2,000 square feet or more of impervious surface, or clearing 7,000 square feet or more. The local permitting authority may allow, and may provide a standard plan for, single-family home and similar small construction projects.

3.2.1 Step 1 - Data Collection

Evaluate existing site conditions and gather information that will help develop the most effective Construction SWPPP. The information gathered should be explained in the narrative and shown on the drawings.

Topography: Prepare a topographic drawing of the site to show the existing contour elevations at intervals of 1 to 5 feet depending upon the slope of the terrain.

Drainage: Locate and clearly mark existing drainage swales and patterns on the drawing, including existing storm drain pipe systems.

Soils: Identify and label soil type(s) and erodibility (low, medium, high, or an index value from the NRCS manual) on the drawing. Soils information can be obtained from a soil survey if one has been published for the county. 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, percent organic matter, and effective depth by a qualified soil professional or engineer. These qualities should be expressed in averaged or nominal terms for the subject site or project. This information is frequently available in published literature, such as the Soil Survey of Thurston County, which lists the following information for each soil mapping unit or designation (e.g., a Sultan silt loam):

- a sieve analysis of the soils
- permeability (in/hr)
- available water-holding capacity (in/in)
- the percent of organic matter

Ground Cover: Label existing vegetation on the drawing. Such features as tree clusters, grassy areas, and unique or sensitive vegetation should be shown. Unique vegetation may include existing trees above a given diameter. Local requirements regarding tree preservation should be investigated. In addition, existing denuded or exposed soil areas should be indicated.

Critical Areas: As specified in local permitting authority critical areas ordinances, delineate critical areas adjacent to or within the site on the drawing. Such features as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas, etc., should be shown. Delineate set backs 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.

Adjacent Areas: Identify existing buildings, roads, and facilities adjacent to or within the project site on the drawings. Identify existing and proposed utility locations, construction clearing limits and erosion and sediment control BMPs on the drawings.

Existing Encumbrances: Identify wells, existing and abandoned septic drainfield, utilities, and site constraints.

Precipitation Records: Determine the average monthly rainfall and rainfall intensity for the required design storm events. These records may be available from the local permitting agency.

3.2.2 Step 2 - Data Analysis

Consider the data collected in Step 1 to visualize potential problems and limitations of the site. Determine those areas that have critical erosion hazards. The following are some important factors to consider in data analysis:
**Topography:** 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.

**Drainage:** Natural drainage patterns that consist of overland flow, swales and depressions should be used 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 they are not properly stabilized. Care should also be taken to ensure that increased runoff from the site will not erode or flood the existing natural drainage system. Possible sites for temporary stormwater retention and detention should be considered at this point.

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.

**Soils:** 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. Infiltration sites should be properly protected from clay and silt which will reduce infiltration capacities.

**Ground Cover:** Ground cover is the most important factor in terms of preventing erosion. 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 such practices as 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.

**Critical Areas:** Critical areas may include flood hazard areas, mine hazard areas, slide hazard areas, sole source aquifers, wetlands, streambanks, fish-bearing streams, and other water bodies. Any critical areas within or adjacent to the development should exert a strong influence on land development decisions. Critical areas and their buffers shall be delineated on the drawings and clearly flagged in the field. Chain link 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.

**Adjacent Areas:** 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. The types,
values, and sensitivities of and risks to downstream resources, such as private property, stormwater facilities, public infrastructure, or aquatic systems, should be evaluated. Erosion and sediment controls should be selected accordingly.

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

**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.

### 3.2.3 Step 3 - Construction SWPPP Development and Implementation

After collecting and analyzing the data to determine the site limitations, the planner can then develop a Construction SWPPP. Each of the 12 elements below must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.

**Element #1: 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.
- Plastic, metal, or stake wire fence may be used to mark the clearing limits.
- The duff layer, native topsoil, and natural vegetation shall be retained in an undisturbed state to the maximum extent practicable.
- Suggested BMPs
  - BMP C101: Preserving Natural Vegetation
  - BMP C102: Buffer Zones
  - BMP C103: High Visibility Plastic or Metal Fence
  - BMP C104: Stake and Wire Fence

**Element #2: Establish Construction Access**

- Construction vehicle access and exit shall be limited to one route if possible.
• Access points shall be stabilized with quarry spall or crushed rock to minimize the tracking of sediment onto public roads.

• Wheel wash or tire baths should be located on site, if applicable.

• Roads shall be cleaned thoroughly as needed to protect stormwater infrastructure and downstream water resources. 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 or otherwise be prevented from discharging untreated into systems tributary to state surface waters.

• Construction access restoration shall be equal to or better than the pre-construction condition.

• 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, as required by local permitting authority.

• Downstream analysis is necessary if changes in offsite flows could impair or alter conveyance systems, streambanks, bed sediment, or aquatic habitat.

• Where necessary to comply with Minimum Requirement #7, stormwater 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).
  o The local permitting authority may require pond designs that provide additional or different stormwater flow control. This may be 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.
  o If permanent infiltration ponds are used for flow control during construction, these facilities shall be protected from siltation during the construction phase, and plans made for restoration after construction.
Suggested BMPs
BMP C240: Sediment Trap
BMP C241: Temporary Sediment Pond
Refer to Volume 3, Detention Facilities, and Volume 2, Infiltration, Stormwater Quantity, and Flow Control

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, bullet #1. 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 Local Permitting Authority will inspect and approve areas fully stabilized by means other than pavement or quarry spalls.

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 C230: Straw Bale Barrier
BMP C231: Brush Barrier
BMP C232: Gravel Filter Berm
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

- Soils shall be stabilized as outlined below, where downstream water resources or stormwater infrastructure may be negatively affected by sediments (e.g., runoff leaves the development site).

- From October 15 through April 1, no soils shall remain exposed and unworked for more than 2 days. From April 2 to October 14, no soils shall remain exposed and unworked for more than 7 days. This stabilization requirement applies to all soils on site, whether at final grade or not. The local permitting authority may adjust these time limits if it can be shown that a development site’s erosion or runoff potential justifies a different standard.

- Soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on the weather forecast.

- 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.

- Selected soil stabilization measures shall be appropriate for the time of year, site conditions, estimated duration of use, and the 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 located away from storm drains, waterways, or drainage channels.

- Linear construction activities such as 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 15 through April 1 no soils shall remain exposed and unworked for more than 2 days and
  - from April 2 to October 14, 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
Element #6: Protect Slopes

- Design, construct, and phase 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 continuous length of slope with terracing and diversions, reduce slope steepness, and roughen slope surface.
- Offsite stormwater (run-on) shall be diverted away from slopes and disturbed areas with interceptor dikes and swales. Offsite stormwater should be managed separately from stormwater generated on the site.
- To prevent erosion, at the top of slopes collect drainage in pipe slope drains or protected channels. Temporary pipe slope drains shall handle the peak flow from a 10-year, 24-hour event; permanent slope drains shall be sized for a 25-year, 24-hour event. Check dams shall be used within channels that are cut down a slope.
- Provide drainage to remove ground water intersecting the slope surface of exposed soil areas.

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

- As needed to protect stormwater infrastructure and downstream water resources, storm drain inlets 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.

- 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.

- Inlets should be inspected weekly at a minimum and daily during storm events. Inlet protection devices should be cleaned or removed and replaced before six inches of sediment can accumulate.

- Suggested BMPs
  BMP C220: Storm Drain Inlet Protection

Element #8: Stabilize Channels and Outlets

- Temporary on-site conveyance channels shall be designed, constructed, and stabilized to prevent erosion from the expected peak 10-minute flow velocity of a Type 1A 10-year, 24-hour frequency storm for the developed condition.

- 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 on site during construction shall be handled and disposed of in a manner that does not cause contamination of stormwater. Woody debris may be chopped and spread on site.

- Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and non-inert wastes present on the site (see Chapter 173-304 WAC for the definition of inert waste). 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 shall be conducted using spill prevention measures, such as drip pans. Contaminated surfaces shall be cleaned immediately following any discharge or spill incident. Spills should be reported to 911. Emergency repairs may be performed on-site using temporary plastic placed beneath and, if raining, over the vehicle.

- Wheel wash or tire bath wastewater shall be discharged to a separate on-site 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 sources include 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.
- 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 shall be discharged into a controlled conveyance system prior to discharge to a 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:

  1. infiltration

  2. transport off site in vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters,

  3. Ecology-approved on-site chemical treatment or other suitable treatment technologies,

  4. sanitary sewer discharge with local sewer district approval, or

  5. use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

**Element #11: Maintain BMPs**

- 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.

- 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 project 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, consideration should be given to minimizing removal of existing trees and minimizing disturbance and 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 local jurisdictions, shall be delineated on the site plans and the development site.**
All plats shall include lot-specific grading plans, including information as specified by the local permitting authority, such as finished grades, finished floor elevations, buildable areas, and identified drainage outlets. This information would normally be submitted with the construction drawings, but may be required prior to preliminary plat approval.

- Seasonal Work Limitations

In Olympia—except where approved chemical treatment, full dispersion or infiltration is practiced—clearing, grading, and other soil disturbing activities are prohibited in all watersheds between October 15 and April 1.

Based on the information provided and local weather conditions, the local permitting authority may expand or restrict the seasonal limitation on site disturbance. The local permitting authority may 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 discharge or surface water quality standard; or

- If clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained.

Local governments may restrict clearing and grading activities where site conditions may present a significant risk of impact to property or critical areas. Contact the local government permitting authority for information on specific site restrictions.

The following activities are exempt from the seasonal clearing and grading limitations:

1. Routine maintenance and necessary repair of erosion and sediment control BMPs;
2. Routine maintenance of public facilities or existing utility structures that do not (a) expose the soil or (b) result in the removal of the soil’s vegetative cover; and
3. Self-contained project sites, where there is complete infiltration of the water quality design event runoff within the state.

- 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

  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 by a person who is knowledgeable in the principles and practices of erosion and sediment control. The person shall have the skills to (1) assess site conditions and construction activities that could impact stormwater runoff quality, and (2) assess erosion and sediment control measure effectiveness.

  A Certified Erosion and Sediment Control Specialist shall be identified in the Construction SWPPP and shall be onsite or on-call at all times. Certification may be obtained an approved training program that meets the erosion and sediment control training criteria established by Ecology. If a pre-construction meeting is held, this person shall attend.

  Sampling and analysis of the stormwater discharges from a construction site may be necessary on a case-by-case basis to ensure compliance with standards. The local permitting authority may establish monitoring and reporting requirements when necessary. The local discharge and surface water standards are:

  **Discharge:** Runoff leaving the construction site shall be free of settleable solids, as measured with an Imhoff Cone and in accordance with Standard Methods for the Examination of Water and Wastewater, most recent edition, American Water Works Association. “Free of settleable solids” shall be defined as measuring less than 2.5 mL/L/hr, for storms up to the water quality design event.\(^2\)

  **Surface Water:** 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 or less, and may not increase more than 10 percent, if upstream turbidity is over 50 NTU. To the extent practicable, samples should be taken far enough downstream so that the construction site discharge has been well-mixed with the surface water.

  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

\(^2\) 2.5 mL/L/hr is selected because it is a recognized sediment discharge standard in Colorado and Missouri.
of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.

- Maintaining an Updated Construction SWPPP - The SWPPP shall be retained onsite or within reasonable access to the site.

  The SWPPP shall be updated within 7 days to reflect any significant changes in the design, construction, operation, or maintenance at the construction site that have, or could have, a significant effect on the discharge of pollutants to waters of the state.

  The SWPPP shall be updated within 7 days if during inspections or investigations by site staff or local or state officials, it is determined that the SWPPP is ineffective in controlling pollutants such that applicable discharge or surface water standards violations are apparent.

### 3.3 Construction SWPPP Requirements

The Construction SWPPP shall consist of two parts: a narrative and the drawings. The following two sections describe the contents of the narrative and the drawings. A checklist is included that can be used as a quick reference to determine if all the major items are included in the Construction SWPPP.

#### 3.3.1 Narrative

- Twelve (12) Elements – Describe how the Construction SWPPP addresses each of the 12 required elements. Include the type and location of BMPs used to satisfy the required element. If an element is not applicable to a project, provide a written justification for why it is not necessary.

- Project description - Describe the nature and purpose of the construction project. Include the size of the project area, any increase in existing impervious area, the total area expected to be disturbed by clearing, grading, excavation or other construction activities, including offsite borrow and fill areas, and the volumes of grading cut and fill that are proposed.

- Existing site conditions - Describe the existing topography, vegetation, and drainage. Include a description of any structures or development on the parcel including the area of existing impervious surfaces.

- Adjacent areas - Describe adjacent areas, including streams, lakes, wetlands, residential areas, and roads that might be affected by
the construction project. Provide a description of the downstream drainage leading from the site to the receiving body of water.

- **Critical areas** - Describe areas on or adjacent to the site that are classified as critical areas. Critical areas that receive runoff from the site shall be described up to ¼ mile away. The distance may be increased by the local permitting authority. Describe special requirements for working near or within these areas.

- **Soil** - Describe the soil on the site, giving such information as soil names, mapping unit, erodibility, settleability, permeability, depth, texture, and soil structure.

- **Potential erosion problem areas** - Describe areas on the site that have potential erosion problems.

- **Construction phasing** - Describe the intended sequence and timing of construction activities.

- **Construction schedule** - Describe the construction schedule. If the schedule extends into the wet season, describe what activities will continue during the wet season and how the transport of sediment from the construction site to receiving waters will be prevented.

- **Financial/ownership responsibilities** - Describe ownership and obligations for the project. Include bond forms and other evidence of financial responsibility for environmental liabilities associated with construction.

- **Engineering calculations** – Attach any calculations made for the design of such items as sediment ponds, diversions, and waterways, as well as calculations for runoff and stormwater detention design (if applicable). Engineering calculations must bear the signature and stamp of an engineer licensed in the state of Washington.

- **A responsible, certified erosion control specialist shall be identified.** Telephone and/or pager numbers should be included.

### 3.3.2 Drawings

- **Vicinity map** - Provide a map with enough detail to identify the construction site location, and roads and waters of the state within one mile of the site.

- **Site map** - Provide a site map(s) showing the following features. The site map requirements may be met using multiple plan sheets for ease of legibility.

  1. A legal description of the property boundaries or an illustration of property lines (including distances) in the drawings.
2. The direction of north in relation to the site.
3. Existing structures and roads, if present.
4. The boundaries of and label the different soil types.
5. Areas of potential erosion problems.
6. Any on-site and adjacent surface waters, critical areas, their buffers, FEMA base flood boundaries, and Shoreline Management boundaries.
7. Existing contours and drainage basins and the direction of flow for the different drainage areas.
8. Final grade contours, drainage basins, and flow directions.
9. Areas of soil disturbance, including all areas affected by clearing, grading, or excavation.
10. Locations of stormwater discharge into surface waters.
11. Existing unique or valuable vegetation and the vegetation that is to be preserved.
12. Cut and fill slopes indicating top and bottom of slope catch lines.
13. Stockpile, waste storage, and vehicle storage/maintenance areas.
14. Total cut and fill quantities and the method of disposal for excess material.

- **Conveyance systems - Show on the site map the following temporary and permanent conveyance features:**

  1. Locations for swales, interceptor trenches, or ditches.
  2. Drainage pipes, ditches, or cut-off trenches associated with erosion and sediment control and stormwater management.
  3. Temporary and permanent pipe inverts and minimum slopes and cover.
  4. Grades, dimensions, and direction of flow in all ditches and swales, culverts, and pipes.
  5. Details for bypassing off-site runoff around disturbed areas.
  6. Locations and outlets of any dewatering systems.

- **Location of detention BMPs - Show on the site map the locations of stormwater detention BMPs.**

- **Erosion and Sediment Control BMPs - Show on the site map all major structural and non-structural ESC BMPs, including:**

  1. The location of sediment pond(s), pipes and structures.
2. Dimension pond berm widths and inside and outside pond slopes.
3. The trap/pond storage required and the depth, length, and width dimensions.
4. Typical section views through pond and outlet structure.
5. Typical details of gravel cone and standpipe, and/or other filtering devices.
6. Stabilization technique details for inlets and outlets.
7. Control/restrictor device location and details.
8. Stabilization practices for berms, slopes, and disturbed areas.
9. Rock specifications and detail for rock check dam, if used.
10. Spacing for rock check dams as required.
11. Front and side sections of typical rock check dams.
12. The location, detail, and specification for silt fence.
13. The construction entrance location and a detail.

- Detailed drawings - Any structural practices used that are not referenced in this manual or other local manuals should be explained and illustrated with detailed drawings.

- Other pollutant BMPs - Indicate on the site map the location of BMPs to be used for the control of pollutants other than sediment.

- Monitoring locations - Indicate on the site map the water quality sampling locations, if required by the local permitting authority. Sampling stations shall be located in accordance with applicable permit requirements, such as upstream and downstream of the project site discharge point, or where treated or untreated runoff discharges from the site.

- Standard notes are suggested in Appendix II-A. Notes addressing construction phasing and scheduling shall be included on the drawings.
Construction Stormwater Pollution Prevention Plan Checklist (p. 1)

Project Name: ______________________________________________________
City/County Reference No. _______________________________________________
Review Date: _______________________________________________________
On-site Inspection Review Date: _______________________________________
Construction SWPPP Reviewer: ________________________________________

Section I – Construction SWPPP Narrative

1. Construction Stormwater Pollution Prevention Elements

___ a. Describe how each of the Construction Stormwater Pollution Prevention Elements has been addressed through the Construction SWPPP.
___ b. Identify the type and location of BMPs used to satisfy the required element.
___ c. Written justification identifying the reason an element is not applicable to the proposal.

12 Required Elements - Construction Stormwater Pollution Prevention Plan

___ 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.
___ 11. Maintain BMPs
___ 12. Manage the Project.

2. Project Description

___ a. Total project area.
___ b. Total proposed impervious area.
___ c. Total proposed area to be disturbed, including offsite borrow and fill areas.
___ d. Total volumes of proposed cuts and fills.

3. Existing Site Conditions

___ a. Description of the existing topography.
___ b. Description of the existing vegetation.
___ c. Description of the existing drainage.
4. Adjacent Areas

___ I. Description of adjacent areas which may be affected by site disturbance

___ a. Streams
___ b. Lakes
___ c. Wetlands
___ d. Residential Areas
___ e. Roads
___ f. Other

___ II. Description of the downstream drainage path leading from the site to the receiving body of water. (Minimum distance of 400 yards.)

5. Critical Areas

___ a. Description of critical areas that are on or adjacent to the site.
___ b. Description of special requirements for working in or near critical areas.

6. Soils

___ Description of on-site soils.

___ a. Soil name(s)
___ b. Soil mapping unit
___ c. Erodibility
___ d. Settleability
___ e. Permeability
___ f. Depth
___ g. Texture
___ h. Soil Structure

7. Erosion Problem Areas

___ Description of potential erosion problems on site.

8. Construction Phasing

___ a. Construction sequence
___ b. Construction phasing (if proposed)
Construction Stormwater Pollution Prevention Plan Checklist (p. 3)

Project Name: ______________________________________________________
City/County Reference No. _____________________________________________

9. Construction Schedule

___ I. Provide a proposed construction schedule.

___ II. Wet Season Construction Activities
   ___ a. Proposed wet season construction activities.
   ___ b. Proposed wet season construction restraints for environmentally sensitive/critical areas.

10. Financial/Ownership Responsibilities

___ a. Identify the property owner responsible for the initiation of bonds and/or other financial securities.
___ b. Describe bonds and/or other evidence of financial responsibility for liability associated with erosion and sedimentation impacts.

11. Engineering Calculations

___ I. Provide Design Calculations.
   ___ a. Sediment Ponds/Traps
   ___ b. Diversions
   ___ c. Waterways
   ___ d. Runoff/Stormwater Detention Calculations
Construction Stormwater Pollution Prevention Plan Checklist (p. 4)

Project Name: ______________________________________________________
City/County Reference No. ______________________________________________

Section II - Erosion and Sediment Control Plans

1. General
   ___ a. Vicinity map with roads and waters of the state within one mile of the site
   ___ b. City/County of _____________ Clearing and Grading Approval Block
   ___ c. Erosion and Sediment Control Notes

2. Site Plan
   ___ a. Legal description of subject property.
   ___ b. North Arrow
   ___ c. Indicate boundaries of existing vegetation, e.g. tree lines, pasture areas, etc.
   ___ d. Identify and label areas of potential erosion problems.
   ___ e. Identify any on-site or adjacent surface waters, critical areas and associated buffers.
   ___ f. Identify FEMA base flood boundaries and Shoreline Management boundaries (if applicable)
   ___ g. Show existing and proposed contours.
   ___ h. Indicate drainage basins and direction of flow for individual drainage areas.
   ___ i. Label final grade contours and identify developed condition drainage basins.
   ___ j. Delineate areas that are to be cleared and graded.
   ___ k. Show all cut and fill slopes indicating top and bottom of slope catch lines.

3. Conveyance Systems
   ___ a. Designate locations for swales, interceptor trenches, or ditches.
   ___ b. Show all temporary and permanent drainage pipes, ditches, or cut-off trenches required for erosion and sediment control.
   ___ c. Provide minimum slope and cover for all temporary pipes or call out pipe inverts.
   ___ d. Show grades, dimensions, and direction of flow in all ditches, swales, culverts and pipes.
   ___ e. Provide details for bypassing off-site runoff around disturbed areas.
   ___ f. Indicate locations and outlets of any dewatering systems.

4. Location of Detention BMPs
   ___ a. Identify location of detention BMPs.
Construction Stormwater Pollution Prevention Plan Checklist (p. 5)

Project Name: ______________________________________________________
City/County Reference No. ____________________________________________

5. Erosion and Sediment Control Facilities

___ a. Show the locations of sediment trap(s), pond(s), pipes and structures.
___ b. Dimension pond berm widths and inside and outside pond slopes.
___ c. Indicate the trap/pond storage required and the depth, length, and width dimensions.
___ d. Provide typical section views through pond and outlet structure.
___ e. Provide typical details of gravel cone and standpipe, and/or other filtering devices.
___ f. Detail stabilization techniques for outlet/inlet.
___ g. Detail control/restrictor device location and details.
___ h. Specify mulch and/or recommended cover of berms and slopes.
___ i. Provide rock specifications and detail for rock check dam(s), if applicable.
___ j. Specify spacing for rock check dams as required.
___ k. Provide front and side sections of typical rock check dams.
___ l. Indicate the locations and provide details and specifications for silt fabric.
___ m. Locate the construction entrance and provide a detail.

6. Detailed Drawings

___ a. Any structural practices used that are not referenced in the Ecology Manual should be explained and illustrated with detailed drawings.

7. Other Pollutant BMPs

___ a. Indicate on the site plan the location of BMPs to be used for the control of pollutants other than sediment, e.g. concrete wash water.

8. Monitoring Locations

___ a. Indicate on the site plan the water quality sampling locations, if applicable.
Chapter 4 - Standards and Specifications for Best Management Practices

Best Management Practices (BMPs) are defined as 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 to waters of Washington State. This chapter contains standards and specifications for temporary BMPs to be used as applicable during the construction phase of a project.

Section 4.1 contains the standards and specifications for Source Control BMPs.

Section 4.2 contains the standards and specifications for Runoff Conveyance and Treatment BMPs.

The standards for each individual BMP are divided into four sections:

1. Purpose
2. Conditions of Use
3. Design and Installation Specifications
4. Maintenance Standards

Note that the “Conditions of Use” always refers to site conditions. As site conditions change, BMPs must be changed to remain in compliance.


http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html also provides information on emerging erosion and sediment control BMPs.

Chapter 6 of WSDOT’s Highway Runoff Manual (which may be found at http://www.wsdot.wa.gov/fasc/EngineeringPublications-Manuals/HighwayRunoff2004.pdf) provides further potentially useful design guidance.
4.1 Source Control BMPs

All BMPs shall be designed and installed in accordance with their specifications.

BMP C101: Preserving Natural Vegetation

Purpose

The purpose of preserving natural vegetation is to reduce erosion wherever practicable. Limiting site disturbance is the single most effective method for reducing erosion. For example, conifers can hold up to about 50 percent of all rain that falls during a storm. Up to 20-30 percent of this rain may never reach the ground but is taken up by the tree or evaporates. Another benefit is that the rain held in the tree can be released slowly to the ground after the storm.

Conditions of Use

- Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.
- As required by local governments through tree preservation ordinances.

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:

- Consider the location, species, size, age, vigor, and the work involved. Local governments may also have ordinances to save natural vegetation and trees.
- Fence or clearly mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- Construction Equipment - This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Placing a fenced buffer zone around plants to be saved prior to construction can prevent construction equipment injuries.
- Grade Changes - Changing the natural ground level will alter grades, which affects the plant's ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary and should be checked. Trees
can tolerate fill of 6 inches or less. For shrubs and other plants, the fill should be less.

When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade. The tile system should be laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches of the soil and cuts of only 2-3 inches can cause serious injury. To protect the roots it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant.

- **Excavations** - Protect trees and other plants when excavating for drainfields, power, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers. If it is not possible to route the trench around plants to be saved, then the following should be observed:

  Cut as few roots as possible. When you have to cut, cut clean. Paint cut root ends with a wood dressing like asphalt base paint.

  Backfill the trench as soon as possible.

  Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

Some problems that can be encountered with a few specific trees are:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken 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. These can cause trouble in sewer lines and infiltration fields. On the other hand, they 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.
BMP C102: Buffer Zones

Purpose
An undisturbed area or strip of natural vegetation or an established suitable planting that will 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 be used to protect natural swales and can be incorporated into the natural landscaping of an area.

Critical-areas buffer zones should not be used as sediment treatment areas. These areas shall remain completely undisturbed. The local permitting authority 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 generally 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. Steel construction fencing is the most effective method in protecting sensitive areas and buffers. Alternatively, 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 local permitting authority 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.
BMP C103: High Visibility Plastic or Metal Fence

**Purpose**
Fencing is intended to: (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and, (4) protect areas where marking with survey tape may not provide adequate protection.

**Conditions of Use**
To establish clearing limits, plastic or metal 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 four 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 six 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.
- Metal fences shall be designed and installed according to the manufacturer's specifications.
- Metal fences shall be at least 3 feet high and must be highly visible.
- Fences shall not be wired or stapled to trees.

**Maintenance Standards**
- If the fence has been damaged or its visibility reduced, it shall be repaired or replaced immediately and visibility restored.
BMP C104: Stake and Wire Fence

**Purpose**
Fencing is intended to: (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and, (4) protect any areas where marking with survey tape may not provide adequate protection.

**Conditions of Use**
To establish clearing limits, stake or wire 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**
- See Figure 4.1 for details.
- More substantial fencing shall be used if the fence does not prevent encroachment into those areas that are not to be disturbed.

**Maintenance Standards**
- If the fence has been damaged or its visibility reduced, it shall be repaired or replaced immediately and visibility restored.

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**Figure 4.1 – Stake and Wire Fence**

Survey Flagging  Baling Wire  Do Not Nail or Staple Wire to Trees

3′ MIN.  10′–20′  12′ MIN.

Metal Fence Post
BMP C105: Stabilized Construction Entrance

**Purpose**

Construction entrances are stabilized 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 be leaving a construction site and traveling on paved roads or other paved areas within 1,000 feet of the site.

On large commercial, highway, and road projects, the designer shall include enough extra materials (such as through a force account) 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 4.2 for details. Note that the minimum 100-foot length shall be reduced to “as long as practicable” where the site geometry does not enable the minimum length.
- 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)
- Consider early installation of the first lift of asphalt in areas that will paved; this can be used as a stabilized entrance. Also consider the installation of excess concrete as a stabilized entrance. During large concrete pours, excess concrete is often available for this purpose.
- Fencing (see BMPs C103 and C104) 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 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 street sweeping, 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 that are loosened from the pad, which 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 BMPs C103 and C104) 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.

![Figure 4.2 - Stabilized Construction Entrance](image-url)
BMP C106: Wheel Wash

Purpose
Wheel washes 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 generally an effective BMP when installed with careful attention to topography. For example, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where the water from the dripping truck can run unimpeded into the street.

• 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 4.3. The Local Permitting Authority may allow other designs. 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 the wheel wash before paving. Either a belly dump or lowboy will work well to test clearance.

• 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.

• Wheel wash systems should be designed 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. A drainpipe with a 2- to 3-foot riser should be installed 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. Polyacrylamide (PAM) added to the wheel wash water at a rate of 0.25 - 0.5 pounds per 1,000 gallons of water increases effectiveness and reduces cleanup time. If PAM is already being used for dust or erosion control and is being applied by a water truck, the same truck can be used to change the wash water.

Maintenance Standards

• The wheel wash should start out the day with fresh water.

• The wash water should be changed a minimum of once per day. On large earthwork jobs where more than 10-20 trucks per hour are expected, the wash water will need to be changed more often.

• Wheel wash or tire bath wastewater shall be discharged to a separate on-site treatment system, such as closed-loop recirculation or land application, or to sanitary sewer with local sewer district approval.
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 4.3 – Wheel Wash
### BMP C107: Construction Road/Parking Area Stabilization

**Purpose**

Stabilizing subdivision roads, parking areas, and other onsite vehicle transportation routes immediately after grading reduces 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 BMPs C103 and C104) 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 as part of the project, 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 generally 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 from 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.
BMP C120: Temporary and Permanent Seeding

Purpose
Seeding is intended 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 may be used throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.
- Channels that will be vegetated should be installed before major earthwork and hydroteed with a Bonded Fiber Matrix. 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, erosion control blankets should be installed over the hydroteed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch over hydromulch and blankets.
- Retention/detention ponds should 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.
- 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 will require 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 should be roughened no matter what the 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 the subgrade should be initially ripped 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 the rototilling process should be done 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 2-10 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 hydrosed, chemical fertilizer may not be necessary. Cottonseed meal is a good source of long-term, slow-release, available nitrogen.

Hydrosed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. Mulch may be made up of 100 percent: cottonseed meal; fibers made of wood, recycled cellulose, hemp, and 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. Generally, mulches come in 40-50 pound bags. Seed and fertilizer are added at time of application.

Mulch is always required for seeding. Mulch can be applied on top of the seed or simultaneously by hydrosedding.

On steep slopes, Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products should be used. 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 24-36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.

In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFM and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.

- When installing seed via hydoseeding 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:
  1. Phase 1 - Install all seed and fertilizer with 25-30 percent mulch and tackifier onto soil in the first lift;
  2. 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 800-1000 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:

  1. Irrigation
  2. Reapplication of mulch
  3. 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 should 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. Native topsoil should be re-installed on the disturbed soil surface before application.

- Seed that is installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed that is 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. Local suppliers or the local conservation district should be consulted for their 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 local authority may be used.

Table 4.1 represents the standard mix for those areas where just a temporary vegetative cover is required.

<table>
<thead>
<tr>
<th>Temporary Erosion Control Seed Mix</th>
<th>% Weight</th>
<th>% Purity</th>
<th>% Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chewings or annual blue grass</td>
<td>40</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>Festuca rubra var. commutata or Poa anna</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perennial rye - Lolium perenne</td>
<td>50</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>Redtop or colonial bentgrass</td>
<td>5</td>
<td>92</td>
<td>85</td>
</tr>
<tr>
<td>Agrostis alba or Agrostis tenuis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White dutch clover</td>
<td>5</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td>Trifolium repens</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2 provides just one recommended possibility for landscaping seed. Also recommended for soil-amended areas, or where low water and low
pesticide use are being emphasized, is the ProTime 705 PDX Ecology Seed Mixture, manufactured by ProTime Lawn Seed. (http://www.protimelawnseed.com/pt_705.html). It produces a green cover without supplemental irrigation and normally requires no fertilizer after establishment.

<table>
<thead>
<tr>
<th>Table 4.2</th>
<th>Landscaping Seed Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Weight</td>
<td>% Purity</td>
</tr>
</tbody>
</table>
| 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 4.3 is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.

<table>
<thead>
<tr>
<th>Table 4.3</th>
<th>Low-Growing Turf Seed Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Weight</td>
<td>% Purity</td>
</tr>
</tbody>
</table>
| 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 4.4 presents a mix recommended for bioswales and other intermittently wet areas.

<table>
<thead>
<tr>
<th>Table 4.4</th>
<th>Bioswale Seed Mix*</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Weight</td>
<td>% Purity</td>
</tr>
</tbody>
</table>
| 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 |

*Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix*

The seed mix shown in Table 4.5 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 4.5

<table>
<thead>
<tr>
<th>Wet Area Seed Mix*</th>
<th>% Weight</th>
<th>% Purity</th>
<th>% Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tall or meadow fescue</td>
<td>60-70</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td><em>Festuca arundinacea</em> or <em>Festuca elatior</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seaside/Creeeping bentgrass</td>
<td>10-15</td>
<td>98</td>
<td>85</td>
</tr>
<tr>
<td><em>Agrostis palustris</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meadow foxtail</td>
<td>10-15</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td><em>Alepocurus pratensis</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alsike clover</td>
<td>1-6</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td><em>Trifolium hybridum</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redtop bentgrass</td>
<td>1-6</td>
<td>92</td>
<td>85</td>
</tr>
<tr>
<td><em>Agrostis alba</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

The meadow seed mix in Table 4.6 is recommended for areas that will be maintained infrequently or not at all and where colonization by native plants is desirable. 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 4.6

<table>
<thead>
<tr>
<th>Meadow Seed Mix</th>
<th>% Weight</th>
<th>% Purity</th>
<th>% Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redtop or Oregon bentgrass</td>
<td>20</td>
<td>92</td>
<td>85</td>
</tr>
<tr>
<td><em>Agrostis alba</em> or <em>Agrostis oreganensis</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red fescue</td>
<td>70</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td><em>Festuca rubra</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White dutch clover</td>
<td>10</td>
<td>98</td>
<td>90</td>
</tr>
<tr>
<td><em>Trifolium repens</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 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 local authority 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 watered to the extent that it causes runoff.
BMP C121: Mulching

**Purpose**

The purpose of mulching soils is to provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches that can be used. Only the most common types are discussed in this section.

**Conditions of Use**

As a temporary cover measure, mulch should be used:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed during the wet season and during the 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 4.7. 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 4.7
Mulch Standards and Guidelines

<table>
<thead>
<tr>
<th>Mulch Material</th>
<th>Quality Standards</th>
<th>Application Rates</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>Air-dried; free from undesirable seed and coarse material.</td>
<td>2&quot;-3&quot; thick; 5 bales per 1000 sf or 2-3 tons per acre</td>
<td>Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw 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 as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits. Straw should be used only if mulches with long-term benefits are unavailable locally. It should also not be used within the ordinary high-water elevation of surface waters (due to flotation).</td>
</tr>
<tr>
<td>Hydromulch</td>
<td>No growth inhibiting factors.</td>
<td>Approx. 25-30 lbs per 1000 sf or 1500 - 2000 lbs per acre</td>
<td>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 ¾-1 inch clog hydromulch equipment. Fibers should be kept to less than ¾ inch.</td>
</tr>
<tr>
<td>Composted Mulch and Compost</td>
<td>No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit (unless exempt).</td>
<td>2&quot; thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)</td>
<td>More effective control can be obtained by increasing thickness to 3&quot;. 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.</td>
</tr>
<tr>
<td>Chipped Site Vegetation</td>
<td>Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.</td>
<td>2&quot; minimum thickness</td>
<td>This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is 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.</td>
</tr>
<tr>
<td>Wood-based Mulch</td>
<td>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.</td>
<td>2&quot; thick; approx. 100 tons per acre (approx. 800 lbs. per cubic yard)</td>
<td>This material is often called “hog or hogged fuelThe 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).</td>
</tr>
</tbody>
</table>
BMP C122: Nets and Blankets

**Purpose**
Erosion control nets and blankets are intended to prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to 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 instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). They 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**
Erosion control nets and blankets should be used:

- 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 (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches may be easily reused as temporary ditch liners.

**Design and Installation Specifications**

- See Figure 4.4 and Figure 4.5 for typical orientation and installation of blankets used in channels and as slope protection. Note: these are typical only; all blankets must be installed per 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.

- Installation of Blankets on Slopes:
  1. Complete final grade and track walk up and down the slope.
  2. Install hydromulch with seed and fertilizer.
  3. Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.
  4. Install the leading edge of the blanket into the small trench and staple approximately every 18 inches. NOTE: Staples are metal, "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.
5. Roll the blanket slowly down the slope as installer walks backwards. NOTE: 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. The blanket is not to be allowed to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, no one is allowed to walk on the blanket after it is in place.

6. If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.

• With the variety of products available, it is impossible to cover all the details of appropriate use and installation. 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 WSDOT, Texas Transportation Institute, and other websites. For all products, provide information and specifications for local government review and approval.

• 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 (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.

• Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches and other high-energy environments. If synthetic blankets are used, the soil should be hydromulched 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 may 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.

- 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.
Figure 4.4 – Channel Installation

**Slope surface shall be smooth before placement for proper soil contact.**

Stapling pattern as per manufacturer’s recommendations.

If there is a berm at the top of slope, anchor upslope of the berm.

Do not stretch blankets/matting tight - allow the rolls to mold to irregularities.

For slopes less than 3H:1V, rolls may be placed in horizontal strips.

Lime, fertilize, and seed before installation. Planting of shrubs, trees, etc. Should occur after installation.

Figure 4.5 - Slope Installation

Notes:
1. Check slots to be constructed per manufacturer specifications.
2. Staking or stapling layout per manufacturer's specifications.
BMP C123: Plastic Covering

**Purpose**

Plastic covering provides immediate, short-term erosion protection to 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. Note: The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than six 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.
- 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 convey 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:
  1. Temporary ditch liner;
  2. Pond liner in temporary sediment pond;
  3. Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored;
  4. Emergency slope protection during heavy rains; and,
  5. Temporary drainpipe (“elephant trunk”) used to direct water.
**Design and Installation Specifications**

- Plastic slope cover must be installed as follows:
  
  1. Run plastic up and down slope, not across slope;
  2. Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet;
  3. Minimum of 8-inch overlap at seams;
  4. On long or wide slopes, or slopes subject to wind, all seams should be taped;
  5. 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;
  6. 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;
  7. 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;
  8. 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.

- Dispose of old tires appropriately.
BMP C124: Sodding

**Purpose**  
The purpose of sodding is to establish permanent turf for immediate erosion protection and to 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 should 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.
BMP C125: Topsoiling

Purpose
To provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling is an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but they 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

- Native soils should be left undisturbed to the maximum extent practicable. Native soils disturbed during clearing and grading should be restored, to the maximum extent practicable, to a condition where moisture-holding capacity is equal to or better than the original site conditions. This criterion can be met by using on-site native topsoil, incorporating amendments into on-site 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 uncompact ed 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. Commercially available mycorrhiza products should be used when topsoil is brought in from off-site.

Design and Installation Specifications
If topsoiling is to be done, the following items should be considered:

- 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. Organic amendments should be incorporated 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 should 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 fines should be limited 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). Areas of natural ground water recharge should be avoided.
- 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 15 and April 1. Between April 2
and October 14, 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 15 through April 1) or 7 days (April 2 through October 14) 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:
  1. Topsoil is to be re-installed within 4 to 6 weeks;
  2. Topsoil is not to become saturated with water;
  3. Plastic cover is not allowed.

**Maintenance Standards**

- Inspect stockpiles regularly, especially after large storm events.

Stabilize any areas that have eroded.
BMP C126: Polyacrylamide for Soil Erosion Protection

**Purpose**
Polyacrylamide (PAM) is used on construction sites to prevent soil erosion.

Applying PAM to bare soil in advance of a rain event 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 not be directly applied to water or allowed to enter a water body.

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, PAM should be used 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 1000 gallons water (80 mg/L) per 1 acre of bare soil. Table 4.8 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>
<thead>
<tr>
<th>Disturbed Area (ac)</th>
<th>PAM (lbs)</th>
<th>Water (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>0.33</td>
<td>500</td>
</tr>
<tr>
<td>1.00</td>
<td>0.67</td>
<td>1,000</td>
</tr>
<tr>
<td>1.50</td>
<td>1.00</td>
<td>1,500</td>
</tr>
<tr>
<td>2.00</td>
<td>1.33</td>
<td>2,000</td>
</tr>
<tr>
<td>2.50</td>
<td>1.67</td>
<td>2,500</td>
</tr>
<tr>
<td>3.00</td>
<td>2.00</td>
<td>3,000</td>
</tr>
<tr>
<td>3.50</td>
<td>2.34</td>
<td>3,500</td>
</tr>
<tr>
<td>4.00</td>
<td>2.66</td>
<td>4,000</td>
</tr>
<tr>
<td>4.50</td>
<td>3.00</td>
<td>4,500</td>
</tr>
</tbody>
</table>
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 (1/2 pound PAM/1000 gallons/acre).
- PAM has infinite 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 5-10 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 3 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 off-site.
- 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.

Some PAMs are more toxic and carcinogenic than others. Only the most environmentally safe PAM products should be used.

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 local permitting authority. 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 2-30 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 (12-15 mg/mole), highly anionic (>20% 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 0.5-1 lb. per 1000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at a rate of 3 – 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 two 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.
BMP C130: Surface Roughening

**Purpose**
Surface roughening aids in the establishment of vegetative cover, reduces runoff velocity, increases infiltration, and provides 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 should 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 4.6 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 diskng, harrowing, raking, or seed-planting machinery operated on the contour.
- Graded areas with slopes greater than 3:1 but less than 2:1 should 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**
- Areas that are graded in this manner should be seeded as quickly as possible.
- Regular inspections should be made of the area. If rills appear, they should be re-graded and re-seeded immediately.
‘TRACKING’ with machinery up and down the slope provides grooves that will catch seed, rainfall and reduce runoff.

Contour Furrows

50’ (15m)
6” min (150mm)
3 Maximum
1

Grooves Will Catch Seed, Fertilizer, Mulch, Rainfall and Decrease Runoff.

Figure 4.6 – Surface Roughening by Tracking and Contour Furrows
BMP C131: Gradient Terraces

**Purpose**  
Gradient terraces 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 4.7 for gradient terraces.

**Design and Installation Specifications**  
- The maximum spacing of gradient terraces should be determined by the following method:

\[
VI = (0.8)s + y
\]

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 should meet the design dimensions.

- The top of the constructed ridge should 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 should 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 should not exceed that which is nonerosive for the soil type with the planned treatment.

- All gradient terraces should 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. Vegetative cover should be used in the outlet channel.

- The design elevation of the water surface of the terrace should 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 should not exceed the area that would be drained by a terrace with normal spacing.

The terrace should 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 should have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should 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**

- Maintenance should be performed as needed. Terraces should be inspected regularly; at least once a year, and after large storm events.

---

**Figure 4.7 - Gradient Terraces**
BMP C140: Dust Control

**Purpose**
Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.

**Conditions of Use**
- In areas (including roadways) subject to surface and air movement of dust where on-site and off-site impacts to roadways, 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 street, refer to Stabilized Construction Entrance (BMP C105).
- Irrigation water can be used for dust control. Irrigation systems should be installed 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. Used oil is prohibited from use as a dust suppressant. Local governments 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, especially in eastern Washington. Since the wholesale cost of PAM is about $4.00 per pound, this is 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 your local Air Pollution Control Authority for guidance and training on other dust control measures. Compliance with the local Air Pollution Control Authority constitutes compliance with this BMP.

**Maintenance Standards**

Respray area as necessary to keep dust to a minimum.
**BMP C150: Materials on Hand**

**Purpose**
Quantities of erosion prevention and sediment control materials can be kept on the project site at all times to be used for emergency situations such as unexpected heavy summer rains. Having these materials on-site reduces the time needed to implement BMPs when inspections indicate that existing BMPs are not meeting the Construction SWPPP requirements. In addition, contractors can save money by buying some materials in bulk and storing them at their office or yard.

**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:

<table>
<thead>
<tr>
<th>Material</th>
<th>Measure</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Plastic, 6 mil</td>
<td>100 foot roll</td>
<td>1-2</td>
</tr>
<tr>
<td>Drainpipe, 6 or 8 inch diameter</td>
<td>25 foot section</td>
<td>4-6</td>
</tr>
<tr>
<td>Sandbags, filled</td>
<td>each</td>
<td>25-50</td>
</tr>
<tr>
<td>Straw Bales for mulching,</td>
<td>approx. 50# each</td>
<td>10-20</td>
</tr>
<tr>
<td>Quarry Spalls</td>
<td>ton</td>
<td>2-4</td>
</tr>
<tr>
<td>Washed Gravel</td>
<td>cubic yard</td>
<td>2-4</td>
</tr>
<tr>
<td>Geotextile Fabric</td>
<td>100 foot roll</td>
<td>1-2</td>
</tr>
<tr>
<td>Catch Basin Inserts</td>
<td>each</td>
<td>2-4</td>
</tr>
<tr>
<td>Steel “T” Posts</td>
<td>each</td>
<td>12-24</td>
</tr>
</tbody>
</table>

**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.
BMP C151: Concrete Handling

**Purpose**
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. This BMP is intended 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. 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.
- 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. 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.
BMP C152: Sawcutting and Surfacing Pollution Prevention

**Purpose**

Sawcutting and surfacing operations generate slurry and process water that contain fine particles and high pH (concrete cutting), both of which can violate the water quality standards in the receiving water. This BMP is intended 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. 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.
BMP C153: Material Delivery, Storage and Containment

Purpose

Prevent, reduce, or eliminate the discharge of pollutants from material delivery and storage to the stormwater system or watercourses by minimizing the storage of hazardous materials onsite, 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

The following steps should be taken to minimize risk:

- Temporary storage area should be located away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Material Safety Data Sheets (MSDS) should be supplied for all materials stored. Chemicals should be kept in their original labeled containers.
- Surround with earth berms.
- Hazardous material storage on-site should be minimized.
- Hazardous materials should be handled as infrequently as possible.
- During the wet weather season (Oct 15 – April 1), consider storing materials in a covered area.
- Store materials in secondary containments, such as earthen dike, 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. Keep bungs secured. 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% of the total enclosed container volume of all containers, or 110% 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.

• Sufficient separation should be provided between stored containers to allow for spill cleanup and emergency response access.

• During the wet weather season (Oct 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.

• Accumulated rainwater shall be pumped or drained out regularly. If contaminated, it must be handled according to applicable waste regulations.
BMP C160: Certified Erosion and Sediment Control Lead (CESCL)

**Purpose**

The project proponent designates at least one person as the responsible representative in charge of erosion and sediment control, and water quality protection. The designated person shall be the Certified Erosion and Sediment Control Lead (CESCL) who is responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements.

**Conditions of Use**

If a Construction SWPPP or coverage under Ecology’s Construction General Permit is required, a CESCL is required. For single-family residential lots and similarly sized construction projects, the local permitting authority may allow the projects to proceed without a CESCL, or may set lesser certification standards, duties, or responsibilities than those listed below.

**Design and Installation Specifications**

- The CESCL shall:
  - Have a current certificate proving attendance in an erosion and sediment control training course that meets the Ecology’s minimum ESC training and certification requirements (see below). A training and certification provider list is available online at [http://www.ecy.wa.gov/programs/wq/stormwater/index.html](http://www.ecy.wa.gov/programs/wq/stormwater/index.html); OR
  - Be a Certified Professional in Erosion and Sediment Control (CPESC) or a Certified Professional in Stormwater Quality (CPSWQ). Training and certification available online at [http://www.cpesc.net](http://www.cpesc.net).

- 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, 24-hour telephone number, fax number, and address of the designated CESCL.

- A CESCL may provide inspection and compliance services for multiple active construction projects.

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 should include:
  ✓ Inspection locations, dates and times
  ✓ Weather information, including conditions during the inspection and recent rainfall events.
  ✓ A summary list of BMPs implemented, including field observations. The list should include the following:
    – List of all BMPs on the project site
    – BMPs inspected
    – BMPs needing maintenance
    – BMPs failed and needing replacement
    – Recommended replacements or other actions
    – Visual observations or water quality monitoring conducted
    – Monitoring results
    – Comments and notes

• Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.

Ecology’s Minimum ESC Training and Certification Course Requirements

General Requirements

1. The course shall teach the construction stormwater pollution prevention guidance provided in the most recent version of:
   b. Other equivalent stormwater management manuals approved by Ecology.

2. Upon completion of course, each attendee shall receive an 8 ½ x 11” certificate and a wallet-sized card that certifies completion of the course. Certification shall remain valid for three 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. SWPPP is a living document – should be revised 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), Certified Professional in Stormwater Quality (CPSWQ), 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.
BMP C161: Payment of Erosion Control Work

**Purpose**
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 shall be a separate bid item in the contract.

Several acceptable ways to bid erosion control work are described in the most recent edition of *WSDOT Standard Specifications for Road, Bridge, and Municipal Construction*. These include:

- Temporary Erosion and Sediment Control (TESC) Lump Sum.
- TESC-Force Account.
- Unit Prices.
- Lump Sum.
BMP C162: Scheduling

**Purpose**
Sequencing a construction project reduces 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.
BMP C180: Small Project Construction Stormwater Pollution Prevention

**Purpose**
To prevent the discharge of sediment and other pollutants to the maximum extent practicable 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: Clearing limits should be flagged 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. Soil piles shall be covered until the soil is either used or removed. Piles shall be situated 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, a trench or berm should be installed 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.
- The construction entrance shall be stabilized where traffic will be leaving the construction site and traveling on paved roads or other paved areas within 1,000 feet of the site.
• Provide for street cleaning as needed to remove any sediment that may have been tracked out. Sediment shall be removed 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 seven 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.
4.2 Runoff Conveyance and Treatment BMPs

BMP C200: Interceptor Dike and Swale

Purpose
Provide 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 to convey stormwater. Use the dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent storm runoff from entering the work area or sediment-laden runoff from leaving the construction site.

Conditions of Use
- Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility which can safely convey 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 should be one acre or less.
- Design capacity for 10-year, 24-hour storm for temporary facilities, 25-year, 24-hour storm for permanent facilities.

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%, maximum is 1%.

Compaction Minimum of 90 percent ASTM D698 standard proctor.

Horizontal Spacing of Interceptor Dikes:

<table>
<thead>
<tr>
<th>Average Slope</th>
<th>Slope Percent</th>
<th>Flowpath Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>20H:1V or less</td>
<td>3-5%</td>
<td>300 feet</td>
</tr>
<tr>
<td>(10 to 20)H:1V</td>
<td>5-10%</td>
<td>200 feet</td>
</tr>
<tr>
<td>(4 to 10)H:1V</td>
<td>10-25%</td>
<td>100 feet</td>
</tr>
<tr>
<td>(2 to 4)H:1V</td>
<td>25-50%</td>
<td>50 feet</td>
</tr>
</tbody>
</table>
Stabilization depends on velocity and reach

Slopes <5%
Seed and mulch applied within 5 days of dike construction (see BMP C121, Mulching).

Slopes 5 - 40%
Dependent on runoff velocities and dike materials. Stabilization should 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.
BMP C201: Grass-Lined Channels

**Purpose**
To provide a channel with a vegetative lining for conveyance of runoff. See Figure 4.8 for 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.

- Channels that will be vegetated should be installed before major earthwork and hydrosossed with a bonded fiber mulch (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, erosion control blankets should be installed over the hydros seeded. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed 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, vegetation type, and revegetation method, but shall not exceed 5 ft/sec for 10-year return frequency, 24-hour storm, assuming a Type IA rainfall distribution.

- 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 special mulch protection such as fiberglass roving or straw and netting provide stability until the vegetation is fully established. See Figure 4.9.

- 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.
- 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.
- 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.
Figure 4.8 – Typical Grass-Lined Channels
Excavate Channel to Design Grade and Cross Section

**OVERCUT CHANNEL**
2” (50mm) TO ALLOW BULKING DURING SEEDBED PREPARATION

Shingle-lap spliced ends or begin new roll in an intermittent check slot

Prepare soil and apply seed before installing blankets, mats or other temporary channel liner system

**TYPICAL INSTALLATION WITH EROSION CONTROL BLANKETS OR TURF REINFORCEMENT MATS**

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 4.9 Temporary Channel Liners
BMP C202: Channel Lining

**Purpose**
To protect erodible channels by providing a channel liner using either blankets or riprap.

**Conditions of Use**
- 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.
- The Federal Highway Administration recommends not using flexible liners whenever the slope exceeds 10 percent or the shear stress exceeds 8 lbs/ft².

**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 should 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. It should be used in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.
**BMP C203: Water Bars**

**Purpose**
A small ditch or ridge of material is constructed diagonally across a road or right-of-way to divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch.

**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:

<table>
<thead>
<tr>
<th>Slope %</th>
<th>Spacing (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>125</td>
</tr>
<tr>
<td>5 - 10</td>
<td>100</td>
</tr>
<tr>
<td>10 - 20</td>
<td>75</td>
</tr>
<tr>
<td>20 - 35</td>
<td>50</td>
</tr>
<tr>
<td>&gt; 35</td>
<td>Use rock lined ditch</td>
</tr>
</tbody>
</table>

- 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.
**BMP C204: Pipe Slope Drains**

**Purpose**
To use a pipe to convey stormwater anytime water needs to be diverted away from or over bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

**Conditions of Use**
Pipe slope drains should be used

- When a temporary or permanent stormwater conveyance is needed to move the water down a steep slope to avoid erosion (Figure 4.10).

- On highway projects, at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches. 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.

- Where water can be collected, channeled with sand bags, Triangular Silt Dikes, berms, or other material, and piped to temporary sediment ponds.

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; and,

- 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. Permanent pipe slope drains shall be sized for the 25-year, 24-hour peak flow.
- 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.
- Piping of water through the berm at the entrance area is a common failure mode.
- 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.
- Thrust blocks should be installed anytime 90 degree bends are utilized. 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. This should be done every 10-20 feet of pipe length or so, depending on the size of the pipe and quantity of water to 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 shall be set by the local government.
- 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, the headwall should be reinforced 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.

**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, the headwall should be reinforced 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.

**Figure 4.10 - Pipe Slope Drain**
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, or to reduce hydrostatic pressure to improve slope stability.

Conditions of Use

Use when excessive water must be removed 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 should 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.

- The outlet shall be kept clean and free of debris.

- Surface inlets shall be kept open and free of sediment and other 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. Drain placement should be planned to minimize this problem.
BMP C206: Level Spreader

**Purpose**

To provide a temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope. To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

**Conditions of Use**

Used when a concentrated flow of water needs to be dispersed over a large area with existing stable vegetation.

- Items to consider are:
  1. What is the risk of erosion or damage if the flow may become concentrated?
  2. Is an easement required if discharged to adjoining property?
  3. Most of the flow should be as ground water and not as surface flow.
  4. 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.
- 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 should be at least 6 feet.
- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.
Level spreaders shall be setback from the property line unless there is an easement for flow.

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 4.11 and 4.12 provide a cross-section and a detail of a level spreader.

**Maintenance Standards**

- The spreader should be inspected 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.

![Cross Section of Level Spreader](image)

**Figure 4.11 - Cross Section of Level Spreader**
Densely vegetated for a Min. of 100' and slope less than 5:1

Pressure-Treated 2" x 10"

1' Min.

3' Min.

Figure 4.12 - Detail of Level Spreader
BMP C207: Check Dams

**Purpose**
Construction of small dams across a swale or ditch reduces the velocity of concentrated flow and dissipates energy at the check dam.

**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 a 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. A deep sump should be provided 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. Numerous new products are also available for this purpose. They tend to be re-usable, quick and easy to install, effective, and cost efficient.
- Check dams should be placed 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 4.13 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.
View Looking Upstream

NOTE:
Key stone into channel banks and extend it beyond the abutments a minimum of 18" (0.5m) to prevent flow around dam.

Section A - A

FLOW

24" (0.6m)

8' (2.4m)

Spacing Between Check Dams

`L` = the distance such that points `A` and `B` are of equal elevation.

POINT `A`

POINT `B`

Figure 4.13 - Check Dams

NOT TO SCALE
BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)

**Purpose**
Triangular silt dikes (TSDs) may be used as check dams, for perimeter protection, for temporary soil stockpile protection, for drop inlet protection, or as a temporary interceptor dike.

**Conditions of use**
- May be used in place of straw bales 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:
  1. sediment ponds;
  2. diversion ditches;
  3. concrete wash out facilities;
  4. curbing;
  5. water bars;
  6. level spreaders; and,
  7. berms.

**Design and Installation Specifications**
- 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 should be No. 11 gauge wire and should 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.
- Check dams should be located and installed as soon as construction will allow.
- Check dams should be placed 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.
BMP C209: Outlet Protection

**Purpose**
Outlet protection prevents scour at conveyance outlets and minimizes 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:
  1. 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.
  2. 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.
  3. 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 should 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 V 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.
BMP C220: Storm Drain Inlet Protection using Catch Basin Filters

**Purpose**

To prevent coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

**Conditions of Use**

Where storm drain inlets are to be made operational before permanent stabilization of the disturbed drainage area. Protection should be provided 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.

Drainage areas should be limited 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 controls may be needed.

Note: Wrapping or placing a filter fabric strip over or under a catch basin grate is not an acceptable BMP.

- *Catch basin Filters* - Inserts should be designed by the manufacturer for use at construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. This type of inlet protection provides flow bypass without overflow and therefore is a better method for inlets located along active rights-of-way. The catch basin filter is inserted in the catch basin just below the grating. It should include:

  - At least 5 cubic feet of sediment storage.
  - Dewatering provisions.
  - High-flow bypass that will not clog under normal use at a construction site.
  - Submit manufacturer specifications for permitting agency approval.

**Maintenance Standards**

- Catch basin filters should be inspected frequently, especially after storm events. If the insert becomes clogged, it should be cleaned or replaced.

- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area and stockpile and stabilize as appropriate.
BMP C233: Silt Fence

**Purpose**

Use of a silt fence reduces 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 4.14a for details on silt fence construction.

**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.

![Figure 4.14a – Silt Fence](image)

**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 4.10):
Table 4.9
Geotextile Standards

<table>
<thead>
<tr>
<th>Description</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymeric Mesh AOS (ASTM D4751)</td>
<td>0.60 mm maximum for slit 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).</td>
</tr>
<tr>
<td>Water Permittivity (ASTM D4491)</td>
<td>0.02 sec⁻¹ minimum</td>
</tr>
<tr>
<td>Ultraviolet Resistance (ASTM D4355)</td>
<td>70% minimum</td>
</tr>
</tbody>
</table>

- 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, if permitted by local regulations.
- Standard Notes for construction plans and specifications follow. Refer to Figure 4.14a 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, around, 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 above the adjacent uphill 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 guy ing to prevent overturning of the fence due to sediment loading.

Silt fences shall be located on contour (same elevation at all points of the fence), 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. The local permitting authority may require the contractor to verify fence elevation.

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 4.14b 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 to 7 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.

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, each tie should be positioned to hang on a post nipple when tightening to prevent sagging.

Wrap approximately 6 inches of fabric around the end posts and secure with 3 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 trap or 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.
Figure 4.14b – Silt Fence Installation by Slicing Method
BMP C234: Vegetated Strip

**Purpose**
Vegetated strips 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 4.11, flowpath length refers to slope length uphill of the vegetated strip):

<table>
<thead>
<tr>
<th>Average Slope</th>
<th>Slope Percent</th>
<th>Flowpath Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5H:1V or less</td>
<td>67% or less</td>
<td>100 feet</td>
</tr>
<tr>
<td>2H:1V or less</td>
<td>50% or less</td>
<td>115 feet</td>
</tr>
<tr>
<td>4H:1V or less</td>
<td>25% or less</td>
<td>150 feet</td>
</tr>
<tr>
<td>6H:1V or less</td>
<td>16.7% or less</td>
<td>200 feet</td>
</tr>
<tr>
<td>10H:1V or less</td>
<td>10% or less</td>
<td>250 feet</td>
</tr>
</tbody>
</table>

**Design and Installation Specifications**
- The vegetated strip shall consist of a minimum of a 25-foot wide continuous strip of dense vegetation with a permeable topsoil. 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.
BMP C235: Straw Wattles

Purpose
Straw wattles are temporary erosion and sediment control barriers consisting of straw that is wrapped in biodegradable tubular plastic or similar encasing material. They reduce the velocity and can spread the flow of rill and sheet runoff, and can capture and retain sediment. Straw wattles 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 4.15 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 three to six months.
- 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.

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, the trenches should be dug 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. Excavated material should be spread evenly along the uphill slope and compacted using hand tamping or other methods.
- Construct trenches at contour intervals of 3 to 30 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 should be approximately 3/4 x 3/4 x 24 inches. Willow cuttings or 3/8-inch rebar can also be used for stakes.
- Stakes should be driven through the middle of the wattle, leaving 2 to 3 inches of the stake protruding above the wattle.

**Maintenance Standards**

- 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.

**Figure 4.15 – Straw Wattles**

**NOTE:**
1. Straw roll installation requires the placement and secure staking of the roll in a trench, 3" x 5" (75-125mm) deep, dug on contour. Runoff must not be allowed to run under or around roll.
BMP C240: Sediment Trap

**Purpose**

A sediment trap is a small temporary ponding area with a gravel outlet used to collect and store sediment from sites cleared and/or graded during construction. 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 on-site 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 six 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 and ponds 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 or pond. 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 and ponds. This includes combined facilities and infiltration facilities. 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 Local Permitting Authority.

**Design and Installation Specifications**

- See Figures 4.16 and 4.17 for details.

- If permanent runoff control facilities are part of the project, they should be used for sediment retention.

- To determine the sediment trap geometry, first calculate the design surface area ($S_A$) of the trap, measured at the invert of the weir. Use the following equation:

$$ S_A = FS \left( \frac{Q_2}{V_s} \right) $$

where

$Q_2$ = Design inflow based on the peak discharge from the developed 2-year runoff event from the contributing drainage area as computed in the hydrologic analysis. The 10-year 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:

$$ S_A = 2 \times \frac{Q_2}{0.00096} \text{ or } 2080 \text{ square feet per cfs of inflow} $$

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 mark 1-foot 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.

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**Figure 4.16 Cross Section of Sediment Trap**

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**Figure 4.17 Sediment Trap Outlet**
**BMP C241: Temporary Sediment Pond**

**Purpose**
Sediment ponds remove sediment from runoff originating from disturbed areas of the site. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they usually 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 basins 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. Compliance with local ordinances regarding health and safety must be addressed. If fencing of the pond is required, 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 ft³) or more are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).
- See Figure 4.18, Figure 4.19, and Figure 4.20 for details.
- If permanent runoff control facilities are part of the project, they should be used for sediment retention. The surface area requirements of the sediment basin must be met. This may require enlarging the permanent basin 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 basin.
- Use of infiltration facilities for sedimentation basins 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 basin to help prevent clogging.
Determining Pond Geometry

Obtain the discharge from the hydrologic calculations of the peak flow for the 2-year runoff event \( (Q_2) \). The 10-year 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:

\[
SA = 2 \times \frac{Q_2}{0.00096} \text{ or } 2080 \text{ square feet per cfs of inflow}
\]

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 basin 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 storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year storm. However, an attempt to provide a separate emergency spillway should always be made. The runoff calculations should be based on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the 100-year 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 basin 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 basin, the control structure for the permanent pond can be used to maintain predevelopment discharge limitations. The size of the basin, 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 4.21 for riser inflow curves.
The pond length shall be 3 to 6 times the maximum pond width.

Figure 4.18 – Sediment Pond Plan View

Wire-backed silt fence staked haybales wrapped with filter fabric, or equivalent divider.

Figure 4.19 – Sediment Pond Cross Section

Perforated polyethylene drainage tubing, diameter min. 2" larger than dewatering orifice. Tubing shall comply with ASTM F667 and AASHTO M294.

Figure 4.20 – Sediment Pond Riser Detail
Figure 4.21 – Riser Inflow Curves

\[ Q_{\text{weir}} = 9.739 \, \text{DH}^{3/2} \]

\[ Q_{\text{orifice}} = 3.782 \, D^2 \text{H}^{1/2} \]

Q in cfs, D and H in feet

Slope change occurs at weir-orifice transition.
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 (Q₁₀). Use Figure 4.22 to determine this diameter (h = 1-foot). Note: A permanent control structure may be used instead of a temporary riser.

Emergency Overflow Spillway: Determine the required size and design of the emergency overflow spillway for the developed 100-year peak flow using the method contained in Volume III.

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:

\[
A_o = \frac{A_s(2h)^{0.5}}{0.6 \times 3600Tg^{0.5}}
\]

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/second²)

Convert the required surface area to the required diameter \(D\) of the orifice:

\[
D = 24 \times \sqrt{\frac{A_o}{\pi}} = 13.54 \times \sqrt{A_o}
\]

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. The size and number of perforations in the tubing should be large enough 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 one 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, one-foot intervals shall be prominently marked on the riser.

If an embankment of more than 6 feet is proposed, the pond must comply with the criteria contained in Volume III regarding dam safety for detention BMPs.

- The most common structural failure of sedimentation basins 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.
- 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.
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 (as applicable) and the Local Permitting Authority is required for the use of chemical treatment regardless of site size. Ecology’s written approval is not required if the selected treatment chemical is on Ecology’s approved list (see [http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html](http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html) for approved BMPs). The intention to use Chemical Treatment should 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 (as applicable) and the local permitting authority.

- The SEPA review authority 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 will 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 following protocol shall be used to evaluate chemicals proposed for stormwater treatment at construction sites.
Authorization to use a chemical in the field based on this protocol does not relieve the applicant from responsibility for meeting all discharge and receiving water criteria applicable to a site.

- Treatment chemicals must be approved by EPA for potable water use.
- Petroleum-based polymers are prohibited.
- Prior to authorization for field use, jar tests shall be conducted to demonstrate that turbidity reduction necessary to meet the receiving water criteria can be achieved. Test conditions, including but not limited to raw water quality and jar test procedures, should be indicative of field conditions. Although these small-scale tests cannot be expected to reproduce performance under field conditions, they are indicative of treatment capability.
- Prior to authorization for field use, the chemically treated stormwater shall be tested for aquatic toxicity. Applicable procedures defined in Chapter 173-205 WAC, Whole Effluent Toxicity Testing and Limits, shall be used. Testing shall use stormwater from the construction site at which the treatment chemical is proposed for use or a water solution using soil from the proposed site.
- The proposed maximum dosage shall be at least a factor of five lower than the no observed effects concentration (NOEC).
- The approval of a proposed treatment chemical shall be conditional, subject to full-scale bioassay monitoring of treated stormwater at the construction site where the proposed treatment chemical is to be used.
- Treatment chemicals that have already passed the above testing protocol do not need to be reevaluated. Contact the Department of Ecology Southwest Regional Office or the local permitting authority for a list of treatment chemicals that have been evaluated and are currently approved for use.

**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 may not be possible to fully incorporate all of the classic concepts into the design because of practical limitations at construction sites. Nonetheless, it is important to recognize the following:

- The right chemical must be used at the right dosage. A dosage that is either too low or too high will not produce the lowest turbidity. There is an optimum dosage rate. This is a situation where the adage “adding more is always better” is not the case.
- The coagulant must be mixed rapidly into the water to insure 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.

Since the volume of the basin is a determinant in the amount of energy per unit volume, the size of the energy input system can be too small relative to the volume of the basin.

Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. The discharge should be directed through a physical filter such as a vegetated swale that would catch any unintended floc discharge.

**Treatment System Design:** Chemical treatment systems shall be designed as batch treatment systems using either ponds or portable trailer-mounted tanks. Flow-through continuous treatment systems are not allowed at this time.

A chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), a storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

The treatment system shall use a minimum of two lined treatment cells. 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 six feet high require special engineering analyses. Portable tanks may also be suitable for some sites.

The following equipment should be located in an operations shed:

- the chemical injector;
- secondary containment for acid, caustic, buffering compound, and treatment chemical;
- emergency shower and eyewash, and
- monitoring equipment, which consists of a pH meter and a turbidimeter.

**Sizing Criteria:** The combination of the storage pond or other holding area and treatment capacity should be large enough to treat stormwater during multiple day storm events. It is recommended that at a minimum the storage pond or other holding area should be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event. Bypass should be provided around the chemical treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods...
presented in Volume 3, Chapter 2. If no hydrologic analysis is required for the site, the Rational Method may be used.

Primary settling should be encouraged in the 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 two hours of settling.

The permissible discharge rate governed by potential downstream effect can be used to calculate the recommended size of the treatment cells. The following discharge flow rate limits shall apply:

- If the discharge is directly or indirectly to a stream, the discharge flow rate shall not exceed 50 percent of the peak flow rate of the 2-year, 24-hour event for all storm events up to the 10-year, 24-hour event.
- If discharge is occurring during a storm event equal to or greater than the 10-year, 24-hour event, the allowable discharge rate is the peak flow rate of the 10-year, 24-hour event.
- Discharge to a fish-bearing stream should not increase the stream flow rate by more than 10 percent.
- If the discharge is directly to a lake, a major receiving water listed in Volume I, or to an infiltration system, there is no discharge flow limit.
- 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.
- Runoff rates shall be calculated using the methods presented in Volume 3, Chapter 2 for the predeveloped condition. If no hydrologic analysis is required for the site, the Rational Method may be used.

**Maintenance Standards**

**Monitoring:** The following monitoring shall be conducted. Test results shall be recorded on a daily log kept on site:

**Operational Monitoring**

- pH, conductivity (as a surrogate for alkalinity), turbidity and temperature of the untreated stormwater
- Total volume treated and discharged
• Discharge time and flow rate
• Type and amount of chemical used for pH adjustment
• Amount of polymer used for treatment
• Settling time

**Compliance Monitoring**

• pH and turbidity of the treated stormwater
• pH and turbidity of the receiving water

**Biomonitoring**

Treated stormwater shall be tested for acute (lethal) toxicity. Bioassays shall be conducted by a laboratory accredited by Ecology, unless otherwise approved by Ecology. **The performance standard for acute toxicity is no statistically significant difference in survival between the control and 100 percent chemically treated stormwater (“whole effluent”).** Biomonitoring is not required for polymers on Ecology’s “approved” list.

Acute toxicity tests shall be conducted with the following species and protocols:

• Fathead minnow, *Pimephales promelas* (96 hour static-renewal test, method: EPA/600/4-90/027F). Rainbow trout, *Oncorhynchus mykiss* (96 hour static-renewal test, method: EPA/600/4-90/027F) may be used as a substitute for fathead minnow.

• Daphnid, *Ceriodaphnia dubia*, *Daphnia pulex*, or *Daphnia magna* (48 hour static test, method: EPA/600/4-90/027F).

All toxicity tests shall meet quality assurance criteria and test conditions in the most recent versions of the EPA test method and Ecology Publication # WQ-R-95-80, Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.

Bioassays shall be performed on the first five batches and on every tenth batch thereafter, or as otherwise approved by Ecology. Failure to meet the performance standard shall be immediately reported to Ecology.

**Discharge Compliance:** Prior to discharge, each batch of treated stormwater must be sampled and tested for compliance with pH and turbidity limits. These limits may be established by the water quality standards or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. Turbidity must not exceed 5 NTUs above the background turbidity. Background is measured in the receiving water, upstream from the treatment process discharge point. 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. It is often possible to discharge treated stormwater that has a lower turbidity than the receiving water and that matches the pH.

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:** Facility operators shall demonstrate proficiency to the satisfaction of the local permitting authority.

**Standard BMPs:** Chemical treatment shall not be used alone or in lieu of appropriate erosion prevention practices.

**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 may be incorporated into the site away from drainages.
BMP C251: Construction Stormwater Filtration

Purpose
Filtration removes 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.
- Unlike chemical treatment, the use of construction stormwater filtration does not require approval from Ecology.
- Filtration may also be used in conjunction with polymer treatment in a portable system to assure capture of the flocculated solids.

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. Filters should be sequenced 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.

**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.
BMP C252: High pH Neutralization using CO₂

**Purpose**

**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. 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.

**Conditions of Use**

**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 CO₂ Sparging**

- Rapidly neutralizes high pH water.
- Cost effective and safer to handle than acid compounds.
- CO₂ is self-buffering. It is difficult to overdose and create harmfully low pH levels.
- Material is readily available.

**The Chemical Process:** When carbon dioxide (CO₂) is added to water (H₂O), carbonic acid (H₂CO₃) is formed which can further dissociate into a proton (H⁺) and a bicarbonate anion (HCO₃⁻) as shown below:

\[
\text{CO}_2 + \text{H}_2\text{O} = \text{H}_2\text{CO}_3 = \text{H}^+ + \text{HCO}_3^-
\]

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.

**Design and Installation Specifications**

**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, the appropriate jurisdiction should be notified in accordance with the regulations set by the jurisdiction.

- 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 CO₂ is necessary for clearer water. This information should be recorded.

- In the pH adjustment structure, add CO₂ until the pH falls in the range of 6.9-7.1.

- 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% 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% 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.

**Maintenance Standards**

**Operator Records**

Each operator should provide:
- A diagram of the monitoring and treatment equipment and
- A description of the pumping rates and capacity the treatment equipment is capable of treating.

Each operator should 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 CO₂ needed to adjust water to a pH range of 6.9-7.1,
- pH of treated water and,
- discharge point location and description.

A copy of this record should be given to the client/contractor who should retain the record for three years.
BMP C253: pH Control for High pH Water

**Purpose**

**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.

**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.

**Conditions of Use**

**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).

**Design and Installation Specifications**

**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 7.

**Dispersion**

- Use BMP T5.30 Full Dispersion

**Sanitary Sewer Disposal**

- Local sewer authority 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

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.


Appendix II-A
Required Standard Notes for Erosion Control Plans

The following standard notes are required for use in erosion control plans. Local jurisdictions may have additional mandatory notes for construction plans that are applicable. Plans should also identify with phone numbers the persons or firms responsible for the preparation of (design engineer) and maintenance of (CESCL) the erosion control plan.

Standard Notes

- A Certified Erosion and Sediment Control Lead (CESCL) is required for all construction projects. The named person or firm shall be on-site or on-call at all times. For this site, the person/firm is ______________________________________ and their office and cell telephone numbers are __________________________.

- Approval of this erosion/sedimentation control (ESC) plan does not constitute an approval of permanent road or drainage design (e.g. size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.).

- The implementation of these ESC plans and the construction, maintenance, replacement, and upgrading of these ESC facilities is the responsibility of the applicant/contractor until all construction is completed and approved and vegetation/landscaping is established.

- The clearing limit boundaries 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 ensure that sediment and sediment-laden water do not enter the drainage system, roadways, or violate applicable surface water, ground water, or discharge 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 on active sites shall be inspected daily by the applicant/contractor--and maintained, repaired, or augmented as necessary--to ensure their continued functioning.

- The ESC facilities on inactive sites shall be inspected monthly, or within 48 hours following a major storm event, by the applicant/contractor--and maintained, repaired, or augmented as necessary—to ensure their continued functioning.

- Storm drain inlets 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 catch basins and conveyance lines shall be cleaned prior to project completion and acceptance. The cleaning operation shall not flush sediment-laden water offsite without treatment.

- 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 ensure that all paved areas are kept clean for the duration of the project.

- Roads shall be cleaned thoroughly as needed to protect downstream water resources or stormwater infrastructure. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area.

- From October 15 through April 1, no soils shall remain exposed and unworked for more than 2 days. From April 2 to October 14, no soils shall remain exposed and unworked for more than 7 days. Soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on the weather forecast. Linear construction activities, such as right-of-way and easement clearing, roadway development, pipelines, and trenching for utilities, shall comply with these requirements. These stabilization requirements apply to all soils on site, whether at final grade or not. The local permitting authority may adjust these time limits if it can be shown that a development site’s erosion or runoff potential justifies a different standard.

- From October 15 through April 1, clearing, grading, and other soil-disturbing activities shall only be permitted if shown to the satisfaction of the local permitting authority that the transport of sediment from the construction site to receiving waters will be prevented.

- Soil stockpiles must be stabilized and protected with sediment-trapping measures.

- All pollutants, including waste materials and demolition debris, that occur on site during construction shall be handled and disposed of in a manner that does not cause contamination of stormwater. Woody debris may be chopped and spread on site.

- Maintenance and repair of heavy equipment and vehicles 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. Report all spills to 911.

- Water from most dewatering operations shall be discharged into a sediment trap or pond. Clean, non-turbid water may be discharged to state surface waters, provided the discharge does not cause erosion or flooding. 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 and properly disposed.
Appendix II-B
Background Information on Chemical Treatment

Coagulation and flocculation have been used for over a century to treat water. It is used less frequently for the treatment of wastewater. The use of coagulation and flocculation for treating stormwater is a very recent application. Experience with the treatment of water and wastewater has resulted in a basic understanding of the process, in particular factors that affect performance. This experience can provide insights as to 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 in NTUs. 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. Largely because of these two factors, small size and negative charge, these particles tend to stay in suspension for extended periods of time. Thus, removal is not practical by gravity settling. These are called stable suspensions. Polymers, as well as inorganic chemicals such as alum, speed the process of clarification. The added chemical destabilizes the suspension and causes the smaller particles to agglomerate. The process consists of three steps: coagulation, flocculation, and settling or clarification. Each step is explained below as well as the factors that affect the efficiency of the process.

Coagulation: Coagulation is the first step. It is the process by which negative charges on the fine particles that prevent their agglomeration are disrupted. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals that are 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 are not readily separated by clarification until flocculation occurs.

Flocculation: Flocculation is the process by which fine particles that have been destabilized bind together to form larger particles that settle rapidly. Flocculation begins naturally following coagulation, but is enhanced by gentle mixing of the destabilized suspension. Gentle mixing helps to bring particles in contact with one another such 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.

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. Water temperature is important during settling. Both the density and viscosity of water are affected by temperature; these in turn affect settling. Cold temperatures increase water’s viscosity and density, thus slowing down the rate at which the particles settle.
The conditions under which clarification is achieved can affect performance. 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. Given that flocs are relatively 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 fairly modest velocities.

**Coagulants:** Polymers are large organic molecules that are 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 on-site 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
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.


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. 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, 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. 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.

**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.