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EROSION AND SEDIMENT CONTROL MANUAL

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SECTION 1
INTRODUCTION

Summary

The objectives of this manual are to provide the user a standardized set of tools: best management practices (BMPs) for implementation on construction projects throughout the State of Oregon. The goal is to facilitate the reduction of water quality impacts by land-disturbing activities through design and implementation of a comprehensive system of erosion prevention , sediment control and non-storm water BMPs.

1.1 Purpose of the Manual

The purpose of this manual is to provide standardized and comprehensive erosion and sediment control best management practices (BMPs) for implementation on construction projects throughout the State of Oregon. This manual is intended to provide detailed and comprehensive guidance for the engineers and designers in the construction industry, contractors, state and local inspectors, and other interested parties to facilitate effective implementation of erosion and sediment control measures and reduction of construction-related water quality impacts. This manual also addresses non-storm water BMPs, as well as specialized biotechnical erosion and sediment control - techniques that are particularly relevant to many areas and projects in Oregon.

This manual is organized into the sections described below:

- Section 1 - Introduction. This section describes the purpose, content, regulatory background, and use of this manual and presents definitions of erosion and sediment control.

- Section 2 – Why is Erosion a Problem? This section discusses the impacts of erosion and sedimentation and the advantages of compliance.

- Section 3 – Site Planning and Management. This section describes influences on erosion and considerations in construction planning and scheduling for effective erosion prevention. It also presents a ten-step process to guide the preparation of an effective Erosion and Sediment Control Plan (ESCP) and the selection of BMPs, including information on BMP costs and effectiveness.

- Section 4 – Runoff Controls. This section describes runoff control methods and presents runoff control BMPs.

- Section 5 – Erosion Prevention Methods. This section describes erosion prevention methods and presents erosion prevention BMPs.

- Section 6 – Sediment Controls. This section describes sediment control methods and presents sediment control BMPs.

- Section 7 – Non-Storm Water Pollution Controls. This section describes non-storm water pollution control methods and presents non-storm water pollution control BMPs.

- Section 8 – Inspection and Maintenance. This section presents inspection and maintenance guidelines.

1.2 How to Use the Manual

This manual is designed to be user friendly and to assist with the identification of BMPs appropriate for use on a specific site or project to provide environmental protection. This manual is appropriate for use by design and construction professionals involved with the planning, design, construction, and oversight of projects throughout the State of Oregon. Personnel that do not have extensive expertise in designing and implementing erosion and sediment control measures will benefit from review of the entire manual. Personnel that have previous experience with the planning, design and implementation of construction storm water BMPs may benefit primarily from the information provided in individual BMP sections.

Symbols and highlighted text are provided to facilitate a better understanding of a specific point. For example:

The light bulb and the green text box highlights important principles or practices

The magnifying glass indicates a reference or source where more detailed information can be found.

The scales and red text emphasize an important regulatory point.

The stop sign and yellow text box indicate caution in applying the general recommendations provided in the text to site-specific situations.

Key terms, defined within the text, are provided for review at the end of each section.

A summary checklist is provided at the end of each section to review the most important points and principles of that section.

The BMP Selection Process (Section 3) is designed to aid users of this manual through the BMP selection process. Throughout the selection process, users should take into account the benefits and limitations of each of the BMPs considered. Finally, BMP success is contingent not only appropriate design and implementation, but on proper maintenance and the coordination and communication between the designers, engineers, and the field construction teams.

1.3 Definitions of Erosion Prevention and Sediment Control

In planning, implementing, and maintaining an erosion and sediment control system, it is important to understand the difference between erosion prevention and sediment control.

Erosion prevention is any practice that protects the soil surface and prevents the soil particles from being detached by rainfall or wind.

Erosion prevention, therefore, is a source control (i.e., a prevention technique) that treats the soil as a resource that has value and should be kept in place.

Sediment Control is any practice that traps the soil particles after they have been detached and moved by wind or water. Sediment control measures are usually passive systems that rely on filtering or settling the particles out of the water or wind that is transporting them. Sediment control treats the soil as a waste product that must be removed from where it has been transported and accumulated and disposed of at another location.

Which are more effective, erosion or sediment controls?

Generally speaking, erosion prevention controls are more effective than sediment controls, and are preferred because they keep the soil in place and enhance the protection of the site resources.

Whenever possible, the primary protection at the site should be erosion prevention controls, with sediment controls used as a secondary system.

1.4 Regulatory Background

1.4.1 Federal Clean Water Act

In 1972, the Federal Water Pollution Control Act (later referred to as the Clean Water Act (CWA)) was amended to provide that the discharge of pollutants to waters of the United States from any point source is effectively prohibited unless the discharge complies with a National Pollutant Discharge Elimination System (NPDES) Permit. Amendments to the CWA in 1987 added Section 402(p) to the Act that establishes a framework for regulating municipal and industrial discharges of storm water under the NPDES program. The regulations require that construction activities disturbing an area of five acres or more must be regulated as an industrial activity, and covered by a NPDES permit. Final regulations that established application requirements for regulated storm water discharges, known as the "Phase I Rule," were published in the Federal Register on November 16, 1990.

Under the Phase I Rule, construction activities that are subject to NPDES storm water permitting include clearing, grading, or excavation that results in the disturbance of at least five acres of total land area. Construction activity on sites of less than five acres requires a permit if the construction is part of a larger common plan of development or sale. Construction activities do not include routine maintenance performed by public agencies to maintain original line and grade, hydraulic capacity, or original purpose of the facility, or emergency construction activities required to protect public health and safety. Reconstruction of facilities involving the removal and replacement of existing structures requires a construction permit.

In December 1999, the EPA finalized the “Phase II” regulations, which require controls on storm water discharges from a broader sector of municipalities, industries, and construction sites. Specifically for construction, the Phase II Rule requires construction sites disturbing equal to or greater than one acre and less than five acres to control pollutants in storm water runoff. Construction activity disturbing less than one acre requires a permit if it is part of a larger common plan of development or sale disturbing a total of one acre or greater, or is individually designated for permit coverage by the NPDES permitting authority. The Phase II regulations went into effect on March 10, 2003.

According to the Federal regulations, permit coverage for storm water discharges associated with construction activity can be obtained through individual permits or general permits. Individual permitting involves the submittal of specific data on a single construction project to the appropriate permitting agency that will issue a site-specific NPDES permit to the project. NPDES coverage under a general permit involves the submittal of a notice by the regulated construction project that they intend to comply with a general permit to be developed by EPA or a state with general permit authority.

1.4.2 NPDES Implementation in Oregon

The Federal regulations allow states that are authorized to implement the NPDES program and have general permit authority to issue general permits or individual permits to regulate storm water discharges associated with industrial (including construction) activity within their jurisdiction. In Oregon, the NPDES storm water permitting program is administered by the Oregon Department of Environmental Quality (DEQ).

DEQ issued two statewide NPDES general permits for storm water discharges associated with construction activities. Generally, projects that disturb one or more acres are required to comply with one of the two permits. The NPDES 1200-C General Permit applies to construction activities including clearing, grubbing, excavation, and stockpiling activities conducted by project owners or operators, except projects conducted by public agencies. A separate permit (the NPDES 1200-CA General Permit) is issued by DEQ that applies to construction land disturbance activities conducted by public agencies. NPDES 1200-C General Permit requirements are further discussed below.

Compliance with Permit 1200-C requires submittal of an application form, Land Use Compatibility Statement, and application fee. In addition, the NPDES 1200-C General Permit requires that an Erosion and Sediment Control Plan (ESCP) be submitted to and approved by DEQ or its agent (some specific cities and counties have chosen to act as agents to facilitate NPDES 1200-C General Permit implementation in their jurisdictions) and implemented by the permittee. Refer to Table 1-1 in DEQ's brochure, "NPDES Storm Water Regulations for Construction Activities – November 2002" (http://www.deq.state.or.us/wq/wqpermit/Gen1200CGuidance.pdf) for a listing of cities acting as DEQ's agent. Plans need to be submitted at least 30 days prior to construction. If the construction schedule will not allow for the 30-day review period, the plan must be submitted with the application.

The major provisions of the NPDES 1200-C General Permit require: no discharge of significant amounts of sediment to surface waters, implementation of the ESCP, maintenance of BMPs, proper material and waste handling, compliance with water quality standards in the Oregon Administrative Rule (OAR) 340-041 and any Total Maximum Daily Loads for specific basins, and inspection of BMPs. Each of these components must be completed in conformance with conditions specified in the NPDES 1200-C General Permit and in conformance with any applicable local requirements. Municipalities may have varying discharge standards or other requirements and permittees should contact the local municipality to obtain applicable requirements.

ESCPs must meet requirements set forth in the NPDES 1200-C General Permit. Plans are required to include narrative site description elements, site maps and construction plans, and a description of erosion and sediment controls to be implemented at the site. Specific plan requirements are identified in the NPDES 1200-C General Permit and outlined in the DEQ's brochure, "NPDES Storm Water Regulations for Construction Activities – November 2002" (http://www.deq.state.or.us/wq/wqpermit/Gen1200CGuidance.pdf). Note that ESCPs for activities covering 20 acres or more must be prepared by an Oregon Registered Professional Engineer, Oregon Registered Landscape Architect, or Certified Professional in Erosion and Sediment Control. In addition, if the plan requires any engineered facilities such as diversion structures or sediment basins, the plan must be prepared by an Oregon Registered Professional Engineer.

A Notice of Termination (NOT) form must be submitted once all soil disturbance activities and final stabilization of exposed soils have been completed. A copy of the NPDES 1200-C General Permit is available at http://www.deq.state.or.us/wq/wqpermit/ Gen1200C.pdf.

Application forms, the NOT form, and guidelines are available at:

http://www.deq.state.or.us/wq/wqpermit/Gen1200CGuidance.pdf.

1.4.3 Local NPDES Implementation and Implementation by Indian Tribes

In addition to complying with the NPDES 1200-C General Permit, permittees must also comply with any local storm water permits and requirements and in some cases local requirements may be more stringent than state requirements. Permittees must contact the appropriate local authorities directly to obtain requirements specific to the jurisdiction. Cities, counties and other jurisdictional entities may hold municipal storm water permits under NPDES Phase I or Phase II regulations. These permits may involve specific requirements related to construction storm water management where work is conducted in or runoff drains to a given jurisdiction. In addition, the local jurisdiction may have other ordinances and permit requirements that affect soil disturbing activities such as clearing or grading permits; grading ordinances; and local storm water ordinances.

Similarly, Indian Reservations are required to comply with NPDES requirements where they meet eligibility requirements for NPDES Municipal Permits and may have similar ordinances or permit requirements that affect construction. Construction projects greater than or equal to one acre of total disturbed soil area conducted on Indian land must comply with EPA's NPDES General Permit for Construction Activities (http://www.epa.gov/npdes/pubs/cgp2003_entirepermit.pdf). Section 9.F identifies specific requirements for construction projects on the Umatilla and Warm Springs Indian Reservations. More information about construction storm water requirements for projects conducted on or where runoff drains to Indian lands can be obtained from EPA Region 10 (http://www.epa.gov/region10/). The following tribes are federally recognized in Oregon:

- Burns Paiute Tribe of the Burns Paiute Indian Colony of Oregon
- Confederated Tribes of the Coos, Lower Umoqua and Siuslaw Indians of Oregon
- Confederated Tribes of the Grand Ronde Community of Oregon
- Confederated Tribes of the Siletz Reservation, Oregon
- Confederated Tribes of the Umatilla Reservation, Oregon
- Confederated Tribes of the Warm Springs Reservation of Oregon
- Coquille Tribe of Oregon
- Cow Creek Band of Umpqua Indians of Oregon
- Klamath Indian Tribe of Oregon

1.4.4 Oregon Water Quality Standards

As stated in the NPDES 1200-C General Permit, the ultimate goal of BMP implementation is to comply with the water quality standards in OAR 340-41. OAR 340-41 (http://www.deq.state.or.us/wq/wqrules/wqrules.htm) sets forth criteria for various pollutants including bacteria, dissolved oxygen, pH, total dissolved solids (TDS), toxic substances, and turbidity as well as basin-specific criteria. In cases where discharges associated with construction activity adversely impact water quality and are anticipated to contribute to exceedances of these standards, DEQ may require the permittee to implement additional BMPs, apply for an individual NPDES permit, or take other necessary action. Further discussion of OAR 340-41-0036, water quality standards for turbidity, is provided in Section 2.3.

1.4.5 TMDLs

Permittees must additionally comply with any Total Maximum Daily Loads (TMDLs) if construction activities will contribute pollutants for which a specific basin or receiving water is listed for impairment. If a stream is listed as impaired because of turbidity or sediment, construction sites may be designated as contributors to the impairment. Section 303(d) of the CWA established the TMDL process to guide the application of state water quality standards to individual water bodies and watersheds. A TMDL defines the amount of a particular pollutant that a water body can adsorb daily without violating applicable water quality standards. Once this load is established, DEQ allocates a portion to each source of that pollutant within a particular watershed. In the case of construction activities within an impaired watershed, DEQ may require the permittee to implement additional BMPs, apply for an individual NPDES permit, or take other necessary action to ensure compliance with TMDL discharge requirements. To find out if there are additional TMDL-related requirements for your project, please contact your DEQ regional office.

1.4.6 Underground Injection Control

Underground injection of fluids, including storm water, is regulated under Part C of the Federal Safe Drinking Water Act. Implementation is of particular importance in Oregon, where all groundwater is designated as a suitable source of drinking water under the Oregon Administrative Rules. Like the NPDES program, responsibility for implementing the Underground Injection Control (UIC) program in Oregon has been delegated to DEQ. Underground injection systems fall into five categories, with underground injection of storm water falling into a sub-category of Category V. All storm water injection systems must be registered with DEQ and all but systems that discharge roof runoff exclusively must be either “authorized by rule” or “authorized by permit” with specific provisions applying to both categories. As of March 2002, there were over 23,000 active UIC systems registered with DEQ, with over 95% of these systems used for storm water injection and the majority operated by federal, state, and local municipalities.

Municipalities are required to have storm water management plans in place that set forth system details, required BMPs for storm water discharging to UIC systems, monitoring requirements, and data management requirements. Some construction projects may discharge to municipal UICs and must comply with applicable local requirements as well as DEQ NPDES 1200-C General Permit requirements. Any construction project discharging to a UIC system must comply with requirements set forth in the applicable municipality's UIC storm water management plan, including source control and treatment BMPs; BMPs for segregation of storm water from areas where hazardous and toxic materials are used, handled, or stored; implementation of a spill prevention and response plan; and employee training. Local requirements may also involve sampling of construction site runoff to ensure compliance. More information on UIC requirements is available at http://www.deq.state.or.us/wq/groundwa/uichome.htm Local jurisdictions should be contacted for specific UIC system requirements applicable to the project site.

1.4.7 Endangered Species Act

The Endangered Species Act (ESA) is of concern for construction sites because of the potential adverse impacts to receiving waters from discharges of sediment and other pollutants including increased turbidity, toxicity, and abnormal pH. Specific adverse impacts include:

- suffocation of eggs or fry;
- displacement and elimination of aquatic invertebrates utilized for food;
- reduction in the biodiversity of aquatic invertebrates;
- reduction of foraging abilities in turbid water;
- irritation of gill tissue that can lead to disease or death; and
- filling of resting, feeding areas, or spawning gravels with sediment.

Any of these impacts could be considered a "take" under ESA. The term "take" applies to any activity that harasses, harms, kills, or injures a species listed under ESA. Any act that modifies or degrades the habitat of an endangered species in a manner that significantly impairs essential behavioral patterns such as breeding, spawning, rearing, migrating, feeding or sheltering and results in death or injury is considered harmful. The stranding of listed species behind erosion and sediment control features or the impairment of their access into certain areas due to the presence of erosion and sediment control features could also be determined to be a take under ESA.

For additional information on ESA implementation in Oregon and developing project-specific compliance strategies, refer to the ESA Assessment Manual prepared by the League of Oregon Cities, Oregon Water Utilities Council, and the Oregon Association of Clean Water Agencies (ACWA) available at http://www.oracwa.org (ACWA 2000). ACWA has also published a model program for "Fish Friendly" Erosion Control. Attachment A of the document provides a hypothetical model program for erosion and sediment control during construction to reduce impacts two ESA-listed fish, the Chinook salmon and the steelhead trout, and is a good resource in developing an erosion and sediment control program that minimizes impacts to aquatic endangered species. This "Fish Friendly" program is available at http://www.oracwa.org. Further information on ESA and how it affects your project, is available from the National Marine Fisheries Service at: http://www.nwr.noaa.gov/1salmon/salmesa/index.htm or the U.S. Fish and Wildlife Service at: http://endangered.fws.gov/endspp.html. (Washington DEQ 2001; Washington County et al. 2000)

1.4.8 Wetland Filing and In-Water Construction

There is both a state and federal removal/fill permit process in Oregon. Applicants proposing to conduct activities in waterways, including wetlands, may be required to obtain permits from the US Army Corps of Engineers (USACE) and/or the Oregon Department of State Lands (DSL), depending on the project scope and location.

DSL administers the state Removal/Fill Law (Oregon Revised Statute 141-085-0005 through 141-089-0615). Currently, applicants may be required to obtain either a General Authorization, which has defined parameters and conditions and an expedited permit timeline or an individual Removal/Fill permit from DSL.

The USACE administers Section 404 of the Federal Water Pollution Control Act [33 U.S.C. 1251 *et seq.*], commonly known as the Clean Water Act [CWA], Section 10 of the Rivers and Harbors Act of 1899 [33 U.S.C. 403], and the Marine Protection, Research and Sanctuaries Act of 1972. Under these jurisdictions, the USACE may issue a Nationwide (NW) permit, which has defined parameters and conditions and an expedited permit timeline or an Individual Permit as well. Though the DSL and USACE permit premises are somewhat similar, the jurisdictions, review requirements and processes are vastly different.

DEQ is involved in both the state and federal water-permit processes. DEQ administers Section 401 of the CWA (33 U.S.C. 1341) through issuance of a 401 Water Quality Certification (WQC). The WQC is a determination by DEQ that federally licensed or permitted activities, which may result in a discharge to waters of the state, comply with the states water quality standards. DEQ's WQC program is administered through OAR 340-048-0005 to 340-048-0050 and includes fees for projects that exceed certain thresholds. The federal permit cannot be issued without the issuance of the WQC unless DEQ provides a waiver or does not respond to the request for it within one year. The review and evaluation of a project requiring a WQC consists of state water quality standards which are approved by the Environmental Protection Agency (EPA). These approved standards cover beneficial uses, policies, and criteria, are listed in Oregon Administrative Rules (OAR) 340 Division 41, and include: Antidegradation, Narrative Criteria, Bacteria, Biocriteria, Dissolved Oxygen, Nuisance Phytoplankton Growth, pH, Temperature, Total Dissolved Gas, Total Dissolved Solids, Toxic Substances, Turbidity, Water Quality Limited Waters, Mixing Zones, Implementation at Wastewater Treatment Works, Other Implementation of Water Quality Criteria, and Basin-Specific Criteria. Additionally, conditions are based Load Allocations in approved Total Maximum Daily Loads (TMDLS) for water quality limited water bodies, subsequent TMDL implementation plans, specific management measures in Oregon's Coastal Nonpoint Source Program, and sediment contaminate, solid waste, and related clean-up issues.

DEQ provides WQC's through the USACE's CWA 404 and Rivers and Harbors Act Section 10 permit processes. DEQ works closely with a number of agencies through this process including, the USACE, NOAA Fisheries, US Fish and Wildlife Service (USFWS) Department of Land Conservation and Development, DSL, Oregon Department of Fish and Wildlife, Oregon Water Resources Department, and other local jurisdictions. If a proposed project is located in an area that contains endangered species, as determined by the Endangered Species Act of 1973, a consultation may be required by USFWS and/or NOAA Fisheries. Once the final project proposal has been determined, DEQ evaluates the proposal and determines if the project will be issued a WQC with conditions or will be denied a WQC.

The DSL permit process is somewhat different than the federal permit process. This is because DSL works primarily with all of the state natural resource agencies, which have varying regulations and requirements from the federal agencies involved in the process. DEQ comments on all DSL proposed projects that are published for public comment regarding any water quality issues and/or questions. All issues that have been raised by DEQ must be addressed prior to the issuance of permits by DSL or by conditioning the permit appropriately. DEQ works closely with the applicant, DSL and the USACE to ensure that any issues raised regarding water quality are coordinated efficiently and effectively throughout both permit processes.

Information regarding the DSL and USACE permit processes can be found at:

http://www.oregonstatelands.us/r-fintro.htm

https://www.nwp.usace.army.mil/op/g/

1.5 Minimum BMPs for Small Projects

This manual has been prepared primarily to support development of storm water best management programs for construction sites required to comply with the NPDES 1200-C General Permit. It should be noted that the concepts and BMPs presented in this manual may also be of use to smaller projects, such as those disturbing less than one acre of soil and projects involving single lots or small developments.

The most effective way to minimize the discharge of pollutants in runoff from any construction activity is to implement pollution prevention BMPs such as erosion prevention controls, sediment controls, non-storm water pollution controls, and runoff controls. For small projects, minimum BMPs to consider include:

- Scheduling to avoid earth disturbing activities during wet weather.
- Perimeter sediment controls.
- Storm drain inlet protection.
- Site entrance and exit controls.
- Non-storm water pollution controls, such as materials use and waste management BMPs.
- Covering or otherwise protecting stockpiles
- Projects that include slopes susceptible to erosion should also include runoff and erosion prevention measures.

BMPs should be inspected regularly to identify areas in need of maintenance or improvement to minimize pollutant discharges.

SECTION 2
WHY IS EROSION A PROBLEM?

Summary

This chapter identifies the causes of accelerated erosion as man-induced, land-disturbing activities that result in increased sediment delivery to down slope/downstream water bodies. Sedimentation impacts on in-stream and off-stream water quality are illuminated along with other resource base, agricultural and air quality impacts. Economic and environmental advantages of compliance with NPDES storm water regulations are discussed.

2.1 Natural versus Accelerated Erosion

Natural erosion is generally considered to be due to the influence of climatic forces on the surface of the earth. While we can learn from the processes of natural erosion, the practice of erosion prevention is usually limited to sites where human activities accelerate this natural process.

Erosion problems can be accelerated by a variety of human activities, including unrestricted development, overtaxed resources, removal of surface cover (such as vegetation), increased imperviousness (such as paving and rooftops) that increases runoff, and poor stewardship.

The goal of the EPA regulations on erosion is not to stop natural erosion. The goal of the regulations is to control accelerated erosion caused by human activities, so there is no net increase in sediment being discharged from a construction site over pre-construction conditions.

Erosion and sedimentation can result in impacts to public infrastructure such as creating both nuisance and larger scale problems when streets, streams and storm drains are clogged with sediment and are then prone to flooding. These impacts can result in problems that affect public safety and result in permanent infrastructure damage such as road failure and pipeline damage, as well as environmental impacts. Uncontrolled erosion is costly; violates state and Federal pollution laws; and exposes developers, contractors, and landowners to legal liabilities.

Construction-related erosion and sedimentation can cause problems for down slope property owners, result in turbidity plumes in downstream water bodies and can cover sensitive habitat areas (such as gravel streambeds used for salmon spawning) with sediment.

2.2 Sedimentation Impacts

Water quality parameters that reflect the level of sediment yield are turbidity and suspended solids. As turbidity increases within a stream environment, photosynthetic activity may decrease with a subsequent potential decrease in available free oxygen necessary to support aquatic life. An increase in the concentration of suspended solids may destroy water supplies for human, animal, and other wildlife consumption, as well as feeding and nesting habitats. Implementation of erosion prevention controls consistent with sound construction operations can minimize the adverse impacts associated with increased sediment yield.

Some of the in-stream and off-stream impacts of turbidity and sedimentation are provided below.

Sedimentation Impacts - In-stream Damages

- Destruction of spawning areas, food sources, habitat (elimination of aquatic invertebrates, filling of gravels with sediment)
- Reduction of foraging abilities in turbid water
- Direct toxicity to wildlife (suffocation of eggs, irritation of gill tissue leading to disease or death, reduction in biodiversity of invertebrates)
- Lake degradation
- Siltation of navigation channels
- Impacts to commercial fisheries
- Reduction of water storage capacities

Sedimentation Impacts - Off-stream Damages

- Clogging of streets, streams, and storm drains with sediment
- Increased flood hazards
- Decreased capacity in conveyance facilities and/or pipeline damage
- Resultant road failure and/or traffic problems
- Increased water treatment costs
- Fugitive dust impacts from wind erosion
- Health and safety risk of contaminated sediment transport/exposure

Turbidity from Suspended Solids

- Transports nutrients, pesticides, bacteria, toxic substances
- Harms aquatic wildlife
- Reduces beneficial uses

These in-stream and off-stream impacts may be translated into specific environmental impacts, as summarized below.

Resource Base Impacts:

Loss of soil as a resource results in the elimination of potential for future use and decreased biological diversity.

Agriculture Impacts:

Loss of soil results in reduced crop production and higher management costs (such as seed and fertilizer).

Water Quality Impacts:

Sediment can cause damage to fish and wildlife resources, water supply quality, recreational values, and habitat values.

Air Quality Impacts:

Fugitive dust can cause public health and safety problems such as airborne contaminants and traffic impacts.

2.3 Erosion Prevention to Reduce Turbidity

Turbidity measures the relative clarity of water and is defined by the American society of Testing and Materials (ASTM) as "an expression of the optical properties of a liquid that cause light rays to be scattered and absorbed rather than transmitted in straight lines through a sample." Turbidity is measured in nephelometric units (NTUs) which indicate light scattering associated with increased particle concentrations. Sources of turbidity include sediment and dissolved matter within a water body that are deposited both naturally and on an accelerated basis by human activity such as construction. Turbidity measurements are most influenced by smaller clay-sized particles that stay in suspension longer than larger sand-sized sediment particles. Turbidity has adverse impacts on aquatic plants and animals associated with reduced visibility and light transference in the water column. These conditions result in changes including fish behavior modification (breeding, feeding, etc.), physical impacts such as gill abrasion, increased algal activity, and reduced light for plant growth.

Oregon's current turbidity standard (OAR 340-41-0036) requires that "no more than a ten percent increase in natural stream turbidities be allowed, as measured relative to a control point immediately upstream of the turbidity causing agent." The standard makes allowances for emergency activities approved by DEQ and the Department of Fish and Game and dredging, construction or other legitimate activities authorized under Section 401 or 404 of the Federal Water Pollution Control Act.

A greater emphasis on erosion prevention controls and other source controls is required for sites with the potential to violate Oregon Water Quality Standards for turbidity.

Standard sediment controls are typically not effective in eliminating fine sediment particles (e.g., clay particles) that stay in suspension for prolonged periods and can result in high turbidity in discharges and receiving waters. A project should not rely on sediment basins and barriers to meet water quality criteria for turbidity. Sediment controls are typically more effective for larger particles (e.g., silt and larger) unless methods such as sediment basins are enhanced by flocculation or filtration to target fine-grained sediment particles. In order to meet turbidity standards, a project should rely heavily on erosion prevention controls.

2.4 Advantages of Compliance

2.4.1 Economic Advantages of Compliance

Compliance with applicable federal, state, and local erosion control and storm water pollution prevention regulations can result in economic advantages, particularly if one considers the costs of non-compliance in terms of stop work orders, fines, and lawsuits.

Some of the economic benefits accrued from an aggressive soil stabilization plan for a construction site may include:

1) The potential for fines for non-compliance can be reduced or eliminated
2) Stabilized slopes require less repair and are safer for maintenance crews
3) Reducing short- and long-term erosion will result in less soil loss
4) Negative public opinion, which can result in enforcement actions, can be minimized
5) Liability exposure can be decreased

Some measurable costs resulting from non-compliance include:

- Removal of silt deposits from storm drains and ultimately, water bodies
- Reduction of water storage capacities of reservoirs
- Increased water treatment costs
- Increase in flooding hazards
- Cost of stop work orders, fines, and lawsuits

2.4.2 Environmental Advantages of Compliance

Some of the environmental benefits of effective erosion and sediment control are:

1) Protection of fish spawning areas, their food sources and habitat
2) Reduction of toxic materials that are introduced into the environment by their attachment and transport by sediment particles
3) Lowered impact on commercial fisheries
4) Improved water storage capacities in lakes and reservoirs
5) Protection of soil as a resource, thereby maintaining a future of diverse and beneficial uses
6) Protection of human and well as wildlife uses of receiving waters

KEY TERMS

Natural Erosion	Accelerated Erosion
Surface Cover	Impervious
Turbidity	Stewardship
Compliance	Fugitive Dust
Economic Advantages	Environmental Advantages
Liability Exposure	

SUMMARY CHECKLIST

- While we can learn from the processes of natural erosion, erosion prevention is usually focused on sites where human activities accelerate this process.

- The goal of the EPA regulations on construction sites is for there to be no net increase in sediment discharge over pre-construction conditions.

- Some of the economic benefits accrued from an aggressive soil stabilization plan for a construction site may include:

  - Reduced potential for fines
  - Lower maintenance costs
  - Reduced soil loss
  - Enhanced public opinion
  - Decreased liability exposure

- Some of the environmental benefits of effective erosion and sediment control can be:

  - Protection of fish spawning areas, their food sources and habitat
  - Reduction of toxic materials in the environment
  - Lowered impact on commercial fisheries
  - Improved water storage capacities
  - Protection of soil as a resource
  - Protection of human and wildlife uses of receiving waters

SECTION 3
SITE PLANNING AND MANAGEMENT

Summary

This section presents the principles of Erosion and Sediment Control and a summary of regional climates in Oregon relevant to site planning and management, as well as considerations for construction scheduling, and presents a 10-step process for developing and implementing an ESCP.

3.1 Principles of Erosion and Sediment Control

Erosion and Sediment Control Principles

- **Fit the project to the existing topography, soils, and vegetation;**
- **Minimize disturbance and retain natural vegetation;**
- **Schedule construction to minimize soil exposure during rainy season;**
- **Vegetate and mulch denuded areas;**
- **Minimize concentrated flows and divert runoff away from slopes or critical areas;**
- **Minimize slope steepness and slope length by using benches, terraces, contour furrows, or diversion ditches;**
- **Utilize channel linings or temporary structures in drainage channels to slow runoff velocities;**
- **Keep sediment on site by using sediment basins, traps or sediment barriers; and**
- **Monitor and inspect sites frequently and correct problems promptly.**

3.2 Climate of Oregon and Influences on Erosion

General Regional Characteristics

Oregon's weather and climate are highly diversified due to large-scale atmospheric circulation; and by regional influences involving the Pacific Ocean, the Coastal range, inland valleys, the Cascade range, high plateaus, and high desert. Some of the localized characteristics that influence climatic effects and diversity include: distance from the coast, elevation, and terrain orientation (i.e., direction of the slope; north-facing, south-facing, etc.).

Generally, the Oregon coastline trends in a north-south orientation while the predominant atmospheric flows trend perpendicular to the coastline in a west-east orientation. The topography associated with the Coastal range and Cascades increase rapidly from the shoreline of the Pacific Ocean to the mountain tops. The result of this extreme regional topographic relief and atmospheric orientation is complex spatial variations of climate throughout Oregon.

Due to large regional variations within the United States, the National Climatic Data Center (NCDC) established "Climate Zones" to represent areas with similar precipitation and temperature characteristics. Appendix A presents and describes each of the "Climate Zones" located within Oregon.

Several sources discussing the climate of Oregon are available, including: http://www.ocs.orst.edu/ and The Climate of Oregon, by Taylor and Hannan (1999). Information presented below includes summaries from these references. Further discussion and specific climatic examples are available in these sources.

Precipitation

Western Oregon receives the bulk of its annual precipitation during winter (generally November through March). East of the Cascades the annual distribution is more uniform, with some locations receiving more precipitation in summer than in winter. The most important factors that influence regional precipitation amounts are elevation and distance from the coast. However, on a local scale elevation has the most influence on precipitation distributions.

The Coastal range and Cascades act as barriers to the flow of air. As warmer air is forced over the ranges, the air cools and releases its moisture on the windward side of the range. This process is known as orographic lifting and often results in precipitation and/or thunderstorms. Orographic influences usually occur at large spatial scales in response to large scale topographic variations. A major terrain barrier such as the Cascades results in abundant orographic precipitation, even though small ridges and valleys embedded in the mountain range may not show demonstrable effects (Taylor and Hannan, 1999).

Another result of the orographic influences is called the "rain shadow" effect where precipitation amounts drop significantly on the leeward side of a barrier or mountain range. This effect is very evident in eastern Oregon where large areas have annual precipitation less than 12 inches (30.5 cm). The northern Cascades receive an excess of 80 inches (203.2 cm) per year. Areas west of the Cascades receive 65 to 90 inches (165.1 to 228.6 cm) of precipitation annually at lower elevations along the coast (Zone 1); 40 to 80 inches (101.6 to 203.2 cm) of precipitation annually in the Willamette Valley (Zone 2); and southwestern Oregon (Zone 3) receives less than 20 inches (50.8 cm) at lower elevations and over 120 inches (304.8 cm) at high elevations annually.

Snow is relatively rare along the immediate coastline in Oregon. However many areas at higher elevations and higher latitudes receive much of their precipitation as snowfall. Specific areas are discussed in the climate zone discussions in Appendix A.

In general the following statements characterize precipitation trends in Oregon:

- Precipitation is highest near the coast and at higher elevations;
- Precipitation decreases as one moves eastward from the Coastal range and Cascades;
- July is consistently the driest month throughout Oregon;
- More that half of the days during the winter months in western Oregon have measurable precipitation;
- During summer months in western Oregon, approximately 10-15% of the days are wet.
- The seasonal precipitation pattern is nearly uniform in portions of Eastern Oregon.

Christopher Daly of Oregon State University developed a mapping and digital coverage model called PRISM (Parameter-elevation Regressions on Independent Slopes Model). With this model Mr. Daly created a map of average annual precipitation for Oregon (Figure 3-1). Evident from Figure 3-1 are the two major influences on precipitation discussed above; west of the Cascade Range precipitation is the highest at depths up to 200 inches (508 cm) per year due to intense orographic effects; and east of the Cascade range the lowest annual precipitation depths are found due to the "rain shadow" effect.

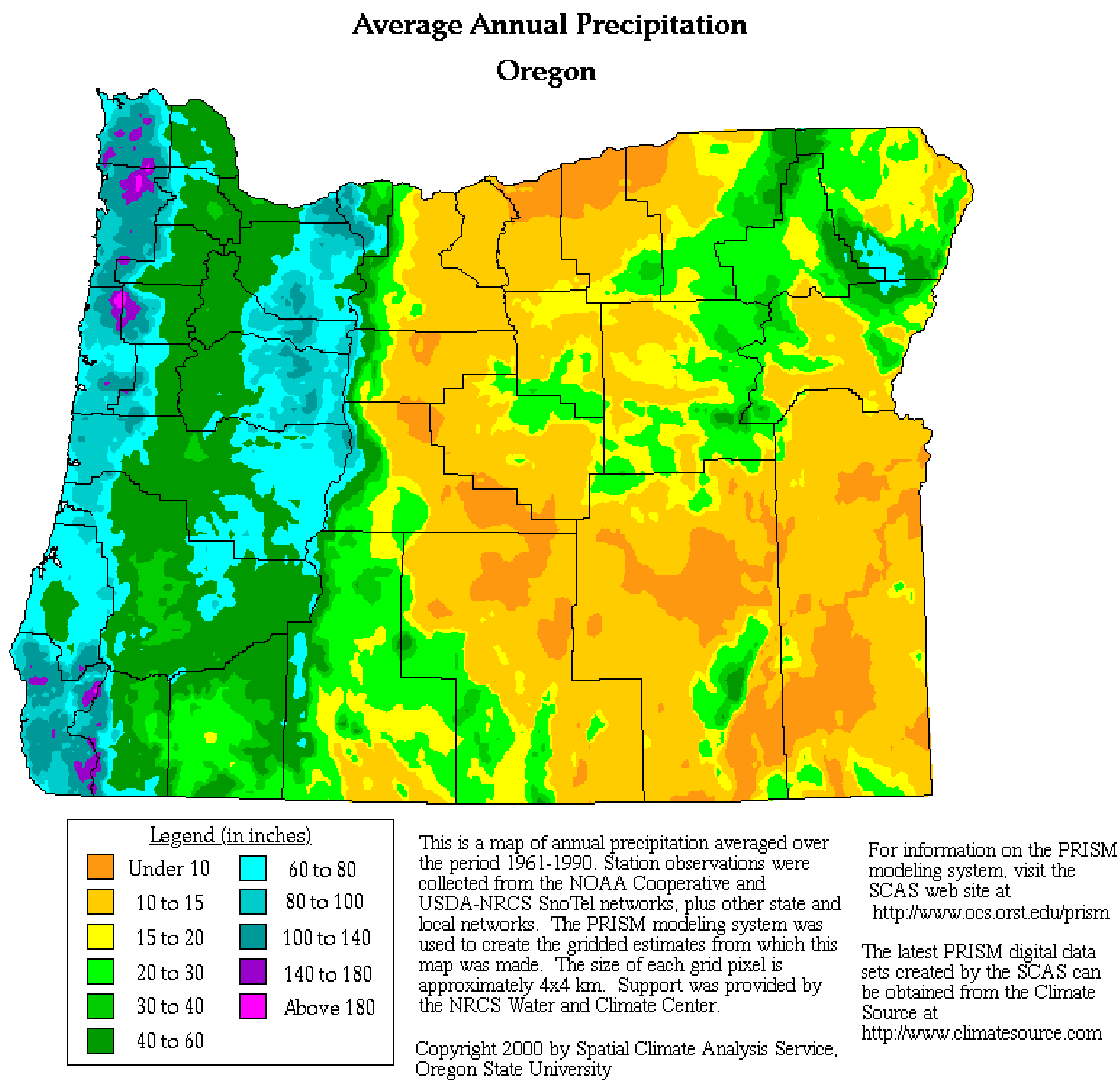


Figure 3-1 – Oregon Average Annual Precipitation.

Thunderstorms

In western Oregon thunderstorms occur only 4-5 times per year, mostly in the inland valleys and near the Cascades. Generally they are not severe and produce little damage. Eastern Oregon receives many more thunderstorms (typically 12-18 per year), and they tend to be much more severe, resulting in greater damage to crops and buildings. Mountains are especially susceptible to thunderstorm damage; each year a considerable number of forest fires are started by lightning (Taylor and Hannan, 1999).

Winds

Local winds in Oregon are dominated by large-scale pressure patterns over the North Pacific and onshore. During winter (and, to a lesser extent, autumn and spring), frequent cyclonic storms reach the area from the west, greatly influencing winds and other weather elements. Summer months see fewer strong storms, and are more typically characterized by sea-land breeze regimes.

Several times each year winds exceeding hurricane strength (74 mph; 119 kmph) strike Oregon, especially along the coast. These high wind events are usually associated with intense storm events and may cause damage to vegetation and structures. In the coastal region the wind can be characterized as sea or land breezes. However, throughout Oregon, occasional high intensity wind storms are evident (Taylor and Hannan, 1999).

Prevailing winds vary with season: Winter wind directions generally flow from the south or east; summer wind directions generally flow from the west or northwest. Note that local topography plays a significant role in the wind direction.

3.3 Considerations in Construction Scheduling

3.3.1 Construction Phases and BMP Implementation

The timing of soil-disturbing activities and the timing of implementation of BMPs are both critical to the prevention of accelerated erosion and transport of sediment off-site. The scheduling of grading should take into account the rainy season and should minimize the length of the time that soils are left exposed, and reduce the total area of exposed soil during the rainy season. Consideration should be made to phasing the grading and construction so that critical areas (such as highly erodible soils, areas adjacent to receiving waters, etc.) are not disturbed until the non-rainy season, and so the entire area that is disturbed at any one time is kept to a size that can be controlled effectively. Table 3-1 presents a suggested schedule for BMP implementation and sequencing.

Table 3-1. BMP Implementation and Sequencing

Step No.	Description	What to Do
1.	Before Construction	Identify, mark, and protect (by fencing off or other means) critical riparian areas and vegetation including important trees and associated rooting zones and vegetation areas to be preserved. Identify vegetative buffer zones between the site and sensitive areas (e.g., wetlands), and other areas to be preserved, especially in perimeter areas. Hold a pre-construction meeting to discuss the specifics of erosion and sediment control measures and construction limits.
2.	Site Access Areas (construction entrances, roadways equipment parking areas)	Stabilize site entrances and access roads prior to earthwork.
3.	Install Sediment Control Measures	Install perimeter sediment control, including storm drain inlet protection as well as all sediment basins, traps, and barriers. These should be in place before vegetation is disturbed.
5.	Non-Stormwater Pollution Control Measures	Concurrent with establishing construction access controls and sediment controls, the contractor must establish material and waste storage areas, concrete washouts and other non-storm water controls prior to the start of construction activities.
6.	Runoff Control	The next phase is to stabilize streambanks and construct the primary runoff control measures to protect areas from concentrated flows.
7.	Land Clearing and Grading	Begin land clearing, excavation, trenching, or grading after installing applicable sediment and runoff control measures. Install additional control measures as work progresses as needed.
8.	Surface Stabilization (temporary and permanent seeding, mulching)	Apply temporary or permanent soil stabilization measures immediately on all disturbed areas as grading progresses.
9.	Construction and Paving (install utilities, buildings, paving)	Erosion and sediment control measures should remain in place for the duration of construction, including protection for active storm drain inlets and appropriate non-storm water pollution controls.
10.	Final Stabilization and Landscaping	Provide permanent erosion prevention measures on all exposed areas and remove all temporary control measures as areas are stabilized.

3.3.2 The Optimum Grading Period

The optimum grading period is the non-rainy season. If grading is to continue into the rainy season, then the length of time that soils are exposed and the total area of exposed soil must be minimized. Additionally, materials used for erosion and sediment control should be available at all times during the rainy season for rapid deployment. In areas with less of a defined rainy season, materials used for erosion and sediment control should be available at all times. Local municipalities may have specific requirements related to grading and timing of grading activities. Contractors and ECSP preparers should check with local agencies and obtain applicable permits.

3.3.3 The Importance of Timing during Construction

Timing is critical. The timing of when erosion and sediment controls are installed during the rainy season can make the difference of whether a site will meet its requirements or not. A specified work schedule that coordinates the timing of land disturbing activities and the installation of erosion and sediment control practices to reduce on-site erosion and off-site sedimentation should be an important objective of project planning.

The following are considered critical considerations to prevent accelerated erosion:

- Minimize the length of time that soils are left exposed.
- Reduce the total area of exposed soil.
- Protect critical area such as drainage channels, streams, and natural watercourses.
- Stabilize exposed areas quickly.
- Monitor and maintain erosion and sediment control measures.

3.4 Planning and Construction Considerations for Areas of High Rainfall

During BMP selection it is particularly important to consider site factors such as anticipated rainfall and soil types in selection of BMPs. In Oregon, there are tremendous variations in rainfall and climate patterns as described in Section 3.2 and Appendix A, particularly between areas of Oregon west and east of the Cascade Range. Many areas east of the Cascades receive annual precipitation of less than 12 inches per year where as annual precipitation west of the Cascades ranges from 40 to 90 inches at lower elevations and up to 200 inches at high elevations.

Some BMPs and BMP installation methods may be very effective in low to moderate rain conditions and virtually ineffective with repeated rain events, events of longer duration, or higher rainfall intensities. In addition, BMP selection should consider predominant soil types (Appendix B), which can also vary significantly from one site to another. BMP selection considerations for areas with higher precipitation (typically western Oregon) are discussed below.

BMP selection considerations relevant to soil type are discussed in Section 2.3, “Erosion Prevention to Reduce Turbidity.”

BMP Selection Considerations for Western Oregon
(i.e., areas with greater precipitation)

1. Place a greater emphasis on Construction Scheduling and Timing of Construction Activities. Where possible, schedule earthwork (particularly significant grading operations or grading of critical areas) for the dry season or during periods of low forecasted rainfall. Reduce total exposed soil areas and duration of exposure.
2. Use a tire wash facility in addition to a stabilized entrance to reduce tracking.
3. Do not rely solely on sediment control measures such as perimeter controls (sediment fence, gravel bag berms, etc.), temporary sediment basins, and inlet protection. These measures alone will not adequately reduce discharges, particularly in areas of high rainfall.
4. Place a greater emphasis on diverting run-on around exposed soil areas. Design conveyances to carry larger design storm events.
5. Install runoff control measures before the rainy season to reduce the potential for scour from concentrated flows.
6. In areas of clayey soils, do not rely on sediment basins. Use source controls (i.e., erosion prevention controls) to keep the soils in place.
7. Increase the use of and reduce spacing of benches, terraces and other methods to reduce flow length on slopes.
8. Use more robust slope stabilization methods such as bonded fiber matrix, rolled erosion control products, or hydraulic mulch over the use of soil stabilizers/tackifiers alone, particularly in areas with steeper slopes and more erodible soils. Consider use of erosion control blankets for steep areas and areas of high rainfall.
9. Consider biotechnical soil stabilization measures to obtain more rapid erosion control effectiveness during the rainy season. Emphasize the use of on-site native vegetation.
10. Be sure to evaluate the fertility of finish grade soils, particularly on slopes, and use compost, or other approved soil amendments to promote rapid plant establishment.
11. Increase BMP inspection and maintenance frequency. Inspect BMPs early and often to assess BMP performance to get a handle on the effectiveness of the BMP design given site conditions. Adjust and increase BMPs accordingly.

3.5 Developing and Implementing an ESCP (10-Step Process)

The ESCP is a comprehensive plan designed to address the short-term mitigation of erosion and sedimentation hazards on a disturbed site (i.e., during construction). These short-term mitigation measures are designed to address the erosion of on-site soils and the transport of sediment off site. This transport of soils off site may occur through a number of mechanisms, including being blown off site by wind, being tracked off site by vehicles, or being carried off site in storm water runoff.

In developing the comprehensive erosion and sediment control system, the designer must answer three key questions:

- Where is erosion and sediment control needed?
- What kind of erosion and sediment control measures are appropriate?
- How much is enough?

To answer these questions, the designer must conduct an erosion control study which:

- Identifies potential erosion problems
- Develops design objectives
- Nominates and evaluates alternatives
- Selects the most appropriate erosion and sediment control measures
- Presents a comprehensive ESCP

The essential steps to be followed in developing (Steps 1 – 7) and implementing (Steps 8 – 10) an ESCP are as follows:

Step 1. Identify Issues and Concerns
Step 2. Develop Goals and Objectives
Step 3. Collect and Analyze Data
Step 4. Develop BMP Selection Criteria
Step 5. Nominate Candidate BMPs
Step 6. Screen and Select BMPs
Step 7. Develop ESCP
Step 8. Implement the ESCP
Step 9. Operate, Monitor, and Maintain the System
Step 10. Update the Plan

These steps are discussed below.

3.5.1 Step 1 - Identify Issues and Concerns

The first step in erosion and sediment control planning is to evaluate the local, regional, and statewide issues, concerns and requirements. This evaluation will influence all other aspects of planning, including the selection of the BMPs, the time frame for implementation, and the establishment of responsibilities for various aspects of the plan. The identified issues and concerns may include the following:

- The nature of the project
- Public opinion, environmental interest groups
- Contact with public agencies
- Proximity of sensitive receiving waters
- Regulatory environment

3.5.2 Step 2 - Develop Goals and Objectives

Once the issues and concerns are established, the goals and objectives for the project should be identified. These may include the following:

- Meeting storm water discharge permit conditions (Federal, State, and local)
- Minimizing disturbed soil area
- Stabilizing slopes
- Reducing short-term erosion
- Reducing long-term erosion
- Reducing sediment leaving the site
- Minimizing negative public opinion
- Reducing long-term maintenance
- Reducing or eliminating irrigation costs
- Maximizing the use of cost-effective solutions
- Improving aesthetics
- Enhancing the environment
- Decreasing liability exposure
- Establishing permanent vegetation

With these goals in mind, the designer can move forward with development of the plan. When possible, the designer is encouraged to coordinate with the contractor when designing the ESCP to promote development of a plan that is consistent with the contractor’s construction approach.

3.5.3 Step 3 – Collect and Analyze Data

After the issues and concerns and goals and objectives for the project have been established, the next step is to collect and analyze data to perform the erosion and sedimentation evaluation. This generally involves the following steps discussed below:

- Data collection
- Identification of critical areas
- Identification of timing of soil-disturbing activities
- Identification of site factors influencing erosion and evaluation of erosion potential

3.5.3.1 Data Collection

The potential for erosion at a site may be evaluated using a wide range of published resource material in combination with data collected by field investigation. Data collected should, at a minimum, include the following:

- Topographic information
- Photo documentation
- Field survey and evaluation
- Climate and rainfall information
- Identification of drainage areas and receiving waters
- Identification of critical habitat or sensitive areas
- Soils information

<u>What are the best sources of information?</u>

City and County - regulations and ordinances, prior land uses, adjacent and downstream uses, storm drain system information, rainfall data

NRCS/District Conservationist - soil survey, climatological information, vegetation/habitat, water management, recreation potential, aerial surveys

National Climatic Data Center (NOAA), National Weather Service, and Oregon Climate Service - climate data.

Department of State Lands

US Army Corps of Engineers

USGS - topographic maps, major waterways, rainfall and stream gauge data

State - regulations, stream surveys, pollution control programs, habitat/endangered species, wetlands, archaeological sites

3.5.3.2 Identification of Critical Areas

In developing an effective ESCP, the next step is to identify the critical areas of the site to be developed. This would include points of ingress/egress; graded slopes; areas where vegetation is to be removed; sensitive habitat areas; and sensitive receiving water bodies. These must all be explicitly addressed in the plan.

3.5.3.3 Consideration of Timing of Soil-Disturbing Activities

The timing of soil-disturbing activities and the timing of implementation of BMPs are both critical to the prevention of accelerated erosion and transport of sediment off site. The scheduling of grading should take into account the rainy season and should attempt to minimize the length of time that soils are left exposed. Scheduling should also address reducing the total area of soil that is exposed at any given time during the rainy season.

3.5.3.4 Identification of Site Factors and Evaluation of Erosion Potential

Once background information is gathered and reviewed, critical areas are identified and timing of soil disturbing activities is considered, the erosion and sedimentation potential for critical areas should be evaluated. The most common method of evaluating erosion potential is to estimate annual erosion rates using the Revised Universal Soil Loss Equation (RUSLE), which is a semi-empirical equation based on 10,000 plot-years of data.

REVISED UNIVERSAL SOIL LOSS EQUATION

$$A = R \times K \times LS \times C \times P$$

where

A = Annual rate of erosion in tons per acre per year

R = Rainfall Factor
K = Soil Erodibility
L = Length of Slope
S = Slope Steepness
C = Cover Factor
P = Conservation Practice Factor

The Agricultural Research Service (ARS) and Natural Resources Conservation Service (NRCS) are sections of the United States Department of Agriculture (USDA) that have developed a computer application (RUSLE2) to estimate erosion using the RUSLE equation. RUSLE2 uses methods developed over the past century to estimate soil loss, sediment yield, and sediment characteristics from rill and interrill (sheet and rill) erosion caused by rainfall and its associated overland flow. RUSLE2 relies on user input of site specific factors that represent the effects of climatic erosivity, soil erodibility, topography, cover management, and support practices to estimate erosion.

The RUSLE2 computer program, RUSLE databases, a tutorial that describes program mechanics, a slide set that provides an overview of RUSLE2, example calculations, and other supporting information are available for download from any of the following RUSLE2 internet sites:

University of Tennessee at http://bioengr.ag.utk.edu/RUSLE2/;

and

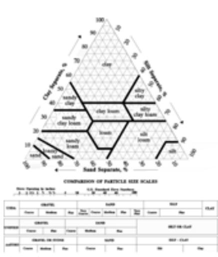
USDA- NRCS at ftp://fargo.nserl.purdue.edu/pub/RUSLE2/.

Each site factor that influences erosion (i.e., variable in the RUSLE) is described below.

Rainfall/Climate (R)

- Climate, and particularly rainfall intensity and duration are directly related to erosion:
- Droplet size is important from the aspect of splash erosion
- Other considerations include: storm patterns, types of vegetation native to the area, vegetation morphology and growth characteristics, and average annual soil temperatures

Soil Erodibility (K)

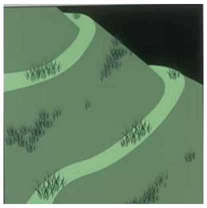


Soil erodibility is the propensity for soil particles to become detached by actions of water or wind. The K factor:

- Is a function of soil texture, organic matter content, soil structure and permeability
- Is expressed as numerical values in USDA/NRCS

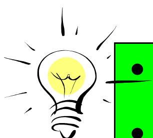
tables.

Flow Path Length and Slope (LS)



- The degree to which length and slope (LS Factor) play in erosion can be calculated using USDA/NRCS charts.
  - Slope Length: distance along flow path to a point where deposition is first likely to occur
- Slope Steepness: ratio of horizontal distance to vertical rise (e.g., 3:1 slope); percentage (e.g., 33% slope); or degrees (18 degree slope)

In general:



- The effect of flow path length is not as great as effect of slope steepness
- Long uninterupted slopes and especially long steep slopes (2:1 horizontal: vertical or greater) should not be constructed
- Long slopes should be shortened by creating contour diversions or benches every 25 feet.
- A convex slope shape increases runoff and magnifies slope erosion
- A concave slope shape enhances infiltration and reduces erosion

Aspect or orientation of slope is important with respect to:

- Vegetation establishment
- Moisture content

Cover

The rate of erosion is related to the amount of permanent or temporary cover. The functions of cover are to:

- Reduce rainfall impact on soil
- Reduce surface water velocities
- Enhance infiltration
- Filter sediment in surface runoff
- Retain soil particles in place and reinforce soil structure
- Promote permanent vegetation establishment

Conservation Practices (P)

Conservation practices are controllable, imaginative, experience-driven, and interactive factors such as slope roughening perpendicular to the direction of runoff. For the most part, they can:

- Enhance the factors of cover and soil texture
- Mitigate the influence of rainfall and runoff
- Modify velocity flow path length and steepness

3.5.4 Step 4 - Develop BMP Selection Criteria

The next step in the erosion and sediment control planning process is to develop the criteria that will be used to select the most appropriate BMPs. Examples of selection criteria include:

- Effectiveness
- Implementation cost
- Temporary vs. permanent BMP
- Cost of temporary BMP removal
- Long-term cost (maintenance)
- Environmental compatibility
- Regulatory acceptability (state and local)
- Availability
- Durability
- Longevity
- Ability to achieve vegetation establishment within project schedule.
- Technical feasibility
- Public acceptability
- Risk/liability
- Suitability for the site

3.5.5 Step 5 - Nominate Candidate BMPs

The next step is to nominate candidate BMPs for the site. An effective EP&SC plan must include a system of BMPs that will provide layers of insurance for the site. Therefore, it is important that BMPs be nominated from each of the primary functional categories:

- Erosion Prevention Measures
- Sediment Control Measures
- Runoff Control Measures
- Non-Storm Water Pollution Control Measures

This will preclude development of a plan that is reliant on only one type of BMP, which would not meet regulatory requirements nor result in an effective plan.

3.5.6 Step 6 - Screen and Select Best BMP Alternatives

The first step in the selection process is to screen the alternatives, and the second step is to select the best alternatives. The difference between screening the alternatives and selecting among the remaining alternatives is that the screening process is designed to eliminate from further consideration for any given location those alternatives that are not technically feasible or must be eliminated for some other obvious and tangible reason. Once the inappropriate alternatives have been screened out, then the best alternatives may be selected using the selection criteria described above in Step 4.

<u>Screen the Alternatives</u>

> The purpose of screening the alternatives is to eliminate those alternatives that are not feasible for use at a particular construction site, or within a watershed.

Part of this screening process may be determined by the evaluation of the data collected in the first step of the process. For example, a site with predominantly clayey soils or a shallow water table could make the use of infiltration basins infeasible. Or the screening process may be partly determined by the results of the quantification efforts. For example, high velocities in unlined channels may dictate the need for channel lining.

<u>Selection Criteria</u>

After screening the nominated alternatives, the six factors below highlight the six characteristics that most designers consider in the selection process: cost, effectiveness, availability, feasibility, durability, compatibility, and operation. Provided on Table 3-2 are approximate installed BMP costs and effectiveness information for erosion and sediment control BMPs from independent testing.

Cost-Effectiveness

Performance histories, both field and laboratory, should be evaluated for a number of materials and techniques and related to costs. Factors to be considered relative to costs include:

- Material costs
- Preparation costs
- Installation costs
- Maintenance costs
- Temporary BMP removal costs
- Local government requirements

Table 3-2
INSTALLED COSTS AND EFFECTIVENESS OF EP AND SC BMPS

BMP	Unit Cost Installed	Estimated Relative Erosion/ Sediment Control Effectiveness[1]
Sediment Control		
Sediment Fence	$1.50 – 2.00 per lineal foot	95%
Compost Berm (12-16 inch height)	$1.75 - 2.00 per lineal foot	95 - 99%
Fiber Rolls (9 inch)	$1.50 – 2.00 per lineal foot	58%
(12 inch)	$2.00 - 2.50 per lineal foot	95 - 99%
(9 inch with trackwalking)	$3.00 - 4.00 per lineal foot	84 %
Erosion Prevention Controls		
Fertilizer	$450 – 550 per acre	N/A
Seeding	$870 – 2,170 per acre	50%
Stolonizing	$2,200 per acre + cost of stolons	90%
Hydraulic Mulching	$900 – 1,200 per acre	50 – 60%
Compost Application (2,000 lbs/acre)	$900 – 1,200 per acre	40 – 50%
(2 inch blanket application)	$7,000 - 10,000 per acre	95 - 99%
(3-4 inch blanket application)	$10,000 - 15,000 per acre	95 - 99%
Straw Mulching	$1,800 – 2,100 per acre	90 – 95%
Soil Binders		
Plant Material-Based (Short-Term)	$700 – 900 per acre	85 - 99%
Plant Material-Based (Long-Term)	$1,200 – 1,500 per acre	60 – 65%
Polymeric Emulsion Blends (Including PAM)	$700 – 1,500 per acre	30 – 95%
Petroleum Resin-Based	$1,200 – 1,500 per acre	25 – 40%
Cementitious Binder-Based	$800 – 1,200 per acre	80 – 85%
Hydraulic Matrices (Wood mulch + Soil binder)	$1,000 - 2,000 per acre	65 - 99%
Bonded Fiber Matrices	$5,000 – 6,500 per acre	90 – 99%
Rolled Erosion Control Products		
Biodegradable		
Jute	$6,000 – 7,000 per acre	65 – 70%
Curled Wood Fiber	$8,000 – 10,500 per acre	90 – 99%
Straw	$8,000 – 10,500 per acre	90 – 99%
Wood Fiber	$8,000 – 10,500 per acre	90 – 99%
Coconut Fiber	$13,000 – 14,000 per acre	90 – 99%
Coconut Fiber Net	$30,000 – 33,000 per acre	90 – 99%
Straw Coconut	$10,000 – 12,000 per acre	90 – 99%
Non-Biodegradable		
Plastic Netting	$2,000 – 2,200 per acre	< 50%
Plastic Mesh	$3,000 – 3,500 per acre	75 – 80%
Synthetic Fiber w/Netting	$34,000 – 40,000 per acre	90 – 99%
Bonded Synthetic Fibers	$45,000 – 55,000 per acre	90 – 99%
Combination Synthetic and Biodegradable Fibers	$30,000 – 36,000 per acre	85 – 99%

Source: Erosion Control Pilot Study Report, Caltrans, June 2000, Table 4-1; Updated May 2004

1. Effectiveness is based on the percentage of sediment retained by weight in laboratory tests. A high effectiveness rating may not equate to meeting water quality standards because some controls such as sediment fence retain larger particles and allow fines to pass which remain in suspension.

Factors to be considered relative to BMP effectiveness include:

- Areal density (the amount of cover on the soil surface)
- Balance between runoff/infiltration (runoff should not be increased over baseline conditions)
- Sediment reduction capabilities (ability to trap and retain sediment and prevent mobilization of soil particles)
- Reduction in water velocity (lower water velocity means less erosion potential)
- Soil texture sensitivity (some practices work better on different types of soils; other practices are unaffected by soil texture)

Availability

The BMP materials must be readily available from a local supplier or be capable of immediate shipment to the area within the timeframe designated by the plans.

Feasibility

The BMP materials must be capable of relatively quick and easy application with minimal training required to orient crews or contractors to proper application procedures. Each BMP should be considered for its flexibility or applicability to a variety of field conditions. Factors to be considered relative to feasibility include:

- The number of steps needed to apply the BMP
- Whether or not hand labor or machinery is required
- Whether locally available materials can be utilized
- The time required for the BMP to dry, cure, or otherwise be unaffected by rainfall

Durability

Given the nature of the site conditions, the BMP materials must maintain their structural integrity during installation and persist until vegetation has established effective cover.

Compatibility

BMP materials should be selected with regard to public acceptability and environmental sensitivity. In this regard, primarily organic/biodegradable, recycled and/or photodegradable products are often preferable. Factors to be considered relative to compatibility include:

- Does the BMP fit the site?
- Environmental compatibility, including water quality impact
- Institutional acceptance
- Visual or aesthetic impact

An erosion prevention practice should be examined as to its effect on vegetation establishment, which as previously mentioned, is considered to be the best form of erosion prevention. Characteristics that should be examined include:

- Whether the BMP is compatible with native plants, either introduced by seeding operations or plant material remaining on site after grading
- The practice's effect on germination and growth of plants
- Whether or not the practice requires additional fertilization or soil amendments to work
- How the practice affects soil moisture and temperature

Operation

Regardless of the BMPs selected, follow-up is always required.

All erosion and sediment control BMPs have the need for maintenance (particularly those used for sediment control). While the cost of operation is seldom considered in erosion control planning, lack of maintenance is usually the primary cause of failure of an erosion and sediment control system and adds cost to the overall project.

Factors relative to operation of installed measures include:

- Maintenance and repair, particularly after storm events
- Additional fertility requirements to maintain quality of vegetation

- Irrigation requirements, if needed, to establish and maintain effective cover

Select the Best Alternatives

Once the alternatives have been screened so that the remaining alternatives are those that are feasible and appropriate for the given conditions, then the best alternatives must be selected. This is a challenge because in some cases there may still be a range of alternatives available to be applied to a given area of the site. In this situation, the most important selection criteria can be used to identify the best alternatives, a matrix can be developed with weighted selection criteria to identify the most appropriate alternatives, or alternatives could be optimized on a cost-effectiveness basis across an entire site or watershed to optimize erosion protection and sediment reduction based on available funding. It is up to the engineer/designer to establish an appropriate process for making final BMP selection.

3.5.7 Step 7 - Develop ESCP

Requirements for developing and implementing an ESCP in the State of Oregon are presented in the NPDES 1200-C General Permit which is available at http://www.deq.state.or.us/wq/wqpermit/Gen1200C.pdf. In order to assist permittees in preparing an ESCP, DEQ has developed specific guidance for developing an ESCP as well as an ESCP Worksheet. The DEQ guidelines and worksheet are available in Section 2 and Appendix C, respectively, of DEQ's publication, "NPDES Storm Water Regulation for Construction Activities, November 2002" (http://www.deq.state.or.us/wq/wqpermit/Gen1200CGuidance.pdf). As stated in Appendix C of the guidelines, correctly completing and submitting the worksheet forms along with the required site maps, construction plans, and erosion and sediment control details to DEQ will meet the NPDES 1200-C General Permit's ESCP requirement.

Required ESCP information is grouped into three sections: Narrative Site Description, Site Maps and Construction Plans, and Erosion and Sediment Controls. Requirements for each section are identified below. Please refer to the NPDES 1200-C General Permit, guidance materials and worksheet for more detail on each requirement.

An example ESCP is available in Appendix A of the Clean Water Services Erosion Prevention and Sediment Control Planning and Design Manual (http://www.cleanwaterservices.org/ShowPage.asp?ID={960577FF-A245-44C0-BC9C-11AC3D5A3854}).

Narrative Site Description (Guidance Section 2.4.1; Worksheet Questions 4-8)	
A	Nature of construction activity planned for the site
B	Total surface area of the site, broken down by construction phase if applicable
C	Total surface area disturbed by clearing, excavation, or grading
D	Timetable for sequence of major construction events
E	The type(s) of material used for fill
F	Soil types found on site and erosion potential
Site Maps and Construction Plans (Guidance Section 2.4.2; Worksheet Question 9)	
A	Total property boundary including surface area of the development
B	All areas of soil disturbance
C	All areas of cut and fill
D	Drainage patterns before and after finish grading; Locations, size, and type of discharge outfalls/points
E	Receiving water body for site drainage
F	Areas used for storage of soils or wastes
G	Erosion and sediment control facilities/structures including vegetative practices
H	Impervious structures added to the site (roads, buildings, parking lots, etc.)
I	Surface waters on or near the sites including springs and wetlands
J	Boundaries of the 100-yr flood plain on the site
Erosion and Sediment Controls – (Guidance Section 2.4.3; Worksheet Question 9, 10, and 11) – Controls to be shown on construction plans and described in appropriate areas of the Worksheet.	
Required for all sites	
A	Graveled, paved, or constructed entrances, exits, driveways, and parking areas to reduce off-site tracking of sediment. Unpaved roads shall be graveled or use other acceptable erosion and sediment controls.
B	Water tight trucks to be used when trucking saturated soils from the site

C	Describe / show details of correct installation or use of all erosion and sediment control measures
D	Describe maintenance procedures for BMPs, walls, dams, or other structures identified in the plan (Refer to Schedule A.4 of the NPDES 1200-C General Permit)
Additional Controls –	
Include the practices below if applicable	
A	Clearing and grading practices to minimize the area of exposed soil for the project duration.
B	Vegetative practices to preserve existing vegetation (e.g., identify, mark and protect critical areas) and establish cover on exposed soils after final grading.
C	Erosion control practices to protect exposed areas and prevent erosion by storm water.
D	Sediment control practices that will be used to divert, store, filter, or otherwise reduce sediment-laden runoff.
E	Stockpile protection.
F	Non-stormwater pollution control measures to prevent or minimize exposure to spills, cleaning and maintenance activities, and waste handling.
G	BMPs to remain in place until disturbed areas are stabilized with permanent vegetation and properly disposed when no longer needed.

In preparing the ESCP, the following factors should be considered:

- The plan should be adapted to the resources (i.e., labor, equipment and materials) available.
- The plan should minimize disturbed soil areas.
- The plan should emphasize erosion prevention measures with sediment control measures used as a last line of defense.
- To the extent possible, the BMPs should fit the existing terrain.

- Recommendations should be realistic, practical, easily understood, and easily implemented.
- Recommendations should be cost-effective and consider all other relevant criteria.
- The plan should have some flexibility to reflect possible changes in site conditions between plan development and plan implementation.
- The plan should include an effective maintenance program emphasizing preventative practices.
- The plan should include monitoring of BMP performance and off-site impacts.
- The plan should include procedures related to terminating construction including removal of temporary BMPs, complete stabilization of the site, and completing regulatory paperwork (NOT) and record keeping.

3.5.8 Step 8 - Implement the Plan

In scheduling and implementing an ESCP, the following are important:

- Means for open communication between engineer/designer, contractor, and municipality
- Clear and simple reports and instruction
- Clear schedule

Communication

The project engineer/designer should conduct an initial site orientation with contractors selected for implementing the ESCP as well as representatives from the local municipality if available. At this meeting, questions concerning contract administration, staging areas, access points, specifications, and so on should be discussed and resolved.

Clear and Simple Reports and Instructions

Contractors should be provided with exact specifications for the practices they are to apply. The quality of work conducted should be inspected routinely and on a "no-notice" basis.

Clear Schedule

The site manager should establish a schedule of activities, including shipment and disbursement of materials and labor so as to complete the job in a timely manner. Each contractor should be instructed as to the anticipated completion date for his portion of the project. The schedule should be provided to the local municipality if required.

3.5.9 Step 9 – Operate, Monitor, and Maintain the System

The ESCP must include a description of maintenance guidelines for all BMPs identified in the plan and should also identify minimum monitoring and inspection requirements as specified in the NPDES 1200-C General Permit. The Maintenance and Monitoring Guidelines should contain the following information described in subsections below:

- Operations and maintenance guidelines for all erosion and sediment control measures
- Site-specific maintenance and monitoring instructions
- Vegetation establishment criteria
- Inspection report requirements

Operations and Maintenance Guidelines

It is important that the selected BMPs be operated and maintained using specific guidelines that are consistent with maintenance requirements identified in Schedule A.4 of the NPDES 1200-C General Permit, Section 8 of this Manual, within the BMP detail sheets provided in the Appendices, and comply with local requirements. Always keep in mind that local requirements may be more stringent that requirements identified in this Manual. Specific maintenance requirements are provided in Section 8 and the BMP detail sheets.

Site-Specific Maintenance and Monitoring Instructions

Following installation of erosion and sediment control measures, a maintenance designee should meet with the contractor to review the maintenance and monitoring plan. A walk-through or on-site inspection should be conducted to be certain that all measures have been completed in the field, erosion is being controlled, and transport of sediment into critical areas is being prevented. Any improper installation or any repairs necessary to complete the job should be noted at this time.

An output from this post-construction inspection is the identification of critical monitoring points where measures will need to be checked for performance during storm events. These critical points might include:

- Slopes which border sensitive areas, such as water bodies
- Sediment control devices, such as gravel bags or sediment fences
- Inlet filters for protecting storm drains
- Construction site entrance/exit

These critical areas should be located on a map and prioritized in the maintenance and monitoring plan. Monitoring requirements are specified Schedule B of the NPDES 1200-C General Permit.

Inspection Frequency

For active sites, inspections must be conducted daily during storm water runoff or snowmelt runoff and at least once every seven calendar days and within 24 hours after any storm event greater than 0.5 inches of rain in a 24-hour period. During inactive periods of greater than seven (7) consecutive calendar days, inspections are required every two weeks. Local agencies may have requirements that exceed those of the NPDES 1200-C General Permit.

During storm events, the contractor should be prepared to call out maintenance crews to inspect the performance of erosion and sediment control measures. Appropriate materials and equipment should be kept on hand to affect a quick and rapid response. Following storm events, the contractor should conduct an overall site inspection and replace or repair damaged control measures.

Vegetation Establishment Criteria

The maintenance and inspection guidelines should provide information on monitoring vegetation establishment. Included in this section would be information on how to evaluate the kinds of vegetation that are growing; information from the appropriate agricultural agency on growing seasons; how to compare the vegetation types with those that were seeded; and how to estimate the percent ground cover at the time of inspection. Also included should be guidelines on the management of vegetation on the site that has been preserved. Any instances of unnecessary vegetation removal should be reported, since root disturbance can greatly increase erosion potential.

Based on regular evaluations of vegetation establishment, recommendations should be made as to whether the vegetation is establishing well, or whether additional measures should be taken, such as over-seeding, fertilizing, or irrigation.

Reporting Requirements for Inspections and Monitoring

The maintenance and monitoring guidelines included in the ESCP should provide instructions on the reporting requirements for periodic inspections. Reporting requirements in Schedule B of the NPDES 1200-C General Permit generally include preparing a written inspection report that lists the date, inspector's name, weather conditions, observations for all BMPs, and observations of a representative discharge sample. Inspection reports must be kept on-site or be maintained by the permittee and made available for agency inspections upon request. Inspection requirements are further identified in Section 8.

3.5.10 Step 10 - Update the Plan

It is the nature of construction sites that they change as they progress. The difference between the schedule for the ESCP and the actual progress of the project is one of the single most common sources of problems with erosion control at construction sites.

An ESCP is always based on a grading plan, which defines the sequence of grading and the schedule. However, the grading plan often undergoes modification, and all too often the ESCP is not updated accordingly. Therefore, as the rainy season draws near, the ESCP may be out of date. The ESCP must be considered a "living document" and updated regularly as conditions change to reflect current construction operations.

3.6 Stabilizing the Site and Terminating the Permit

In order to terminate coverage under the NPDES 1200-C General Permit, the permittee must complete a Notice of Termination (NOT) form and submit it to DEQ. In order for coverage to be terminated, the following conditions must be met.

- All disturbed areas of the site must be fully stabilized
- All elements of the ESCP must be completed and all temporary erosion and sediment controls as well as construction related materials or wastes must be removed from the site and disposed of properly.
- No potential exists for discharge of significant amounts of constructed related sediment to surface waters.

In general, the permittee should use the following steps to close-out a site and terminate permit coverage. Permittees should check with local municipalities/agencies to determine if other close-out or permit transfer requirements apply to their site.

1. Complete site stabilization.
2. Complete all construction activities with the potential to discharge pollutants, including non-grading activities (e.g., painting, stucco, roofing, pavement striping, etc.).
3. Remove all construction-related materials, wastes, and debris.
4. Remove all temporary erosion and sediment controls and non-storm water pollution BMPs and dispose of BMP wastes properly.
5. Complete the final self-inspection.
6. Mitigate and document any problems identified during the final self-inspection.
7. Take down any posted NPDES-related documentation (ESC drawings, NOI, etc.).
8. File NOT.
9. Retain permit-related documentation (ESCP, NOI, inspection reports etc) for a period of 1 year after the permit is terminated, in accordance with the requirements of the NPDES 1200-C General Permit.

KEY TERMS

Mitigation

Alternatives

Issues and Concerns

Liability exposure

Erosion potential

Flow path length

Critical areas

Environmental compatibility

Soil texture sensitivity

Site-specific

Design objectives

Comprehensive

Receiving waters

Relevant conditions

Soil erodibility

Cover

Cost-effectiveness

Longevity

Institutional acceptance

Living document

SUMMARY CHECKLIST

In planning for erosion and sediment control, three questions need to be asked:

- Where is erosion and sediment control needed?
- What kind of erosion and sediment control measures are appropriate?
- How much is enough?

The ten (10) key steps of the erosion and sediment control planning process are:

Step 1.	Identify Issues and Concerns
Step 2.	Develop Goals and Objectives
Step 3.	Collect and Analyze Data
Step 4.	Develop BMP Selection Criteria
Step 5.	Nominate Candidate BMPs
Step 6.	Screen and Select BMPs
Step 7.	Develop ESCP
Step 8.	Implement the ESCP
Step 9.	Operate, Monitor, and Maintain the System
Step 10.	Update the Plan

Sources of information for developing the ESCP include:

- **City of County**
- **NRCS/District Conservationist**
- **USGS**
- **State**

The timing of soil-disturbing activities and implementation of BMPs are critical

The scheduling of grading should minimize the length of time that soils are left exposed and reduce the total area of soil that is exposed at any given time during the rainy season.

Examples of selection criteria include:

- Effectiveness
- Implementation cost
- Long-term cost (maintenance)
- Environmental compatibility
- Regulatory acceptability
- Availability
- Durability
- Longevity
- Feasibility
- Public acceptability
- Risk/liability
- Suitability for the site

The factors to be considered in terms of BMP cost include:

- Material costs
- Preparation costs
- Installation costs
- Maintenance costs

✓ Lack of maintenance is usually the primary cause of failure of an erosion and sediment control system.

✓ The project engineer/designer should conduct an initial site orientation with contractors selected for implementing the ESCP.

✓ Contractors should be provided with exact specifications for the practices they are to apply. The quality of work conducted should be inspected routinely and on a "no-notice" basis.

✓ The site manager should establish a schedule of activities, including shipment and disbursement of materials and labor, so as to complete the job in a timely manner.

✓ The comprehensive ESCP should include Operations and Maintenance Guidelines, which should contain the following information:

- Operations and maintenance guidelines for all erosion and sediment control measures
- Site-specific maintenance and monitoring instructions
- Vegetation establishment criteria
- Periodic inspection reports

✓ Critical monitoring points include:

- Slopes which border sensitive areas, such as water bodies
- Sediment control devices, such as gravel bags or sediment fences
- Inlet filters for protecting storm drains

✓ The operations and maintenance guidelines should provide instructions on the preparation of periodic inspection reports.

✓ The difference between the schedule for the ESCP and the actual progress of the project is one of the single most common sources of problems with erosion control at construction sites.

SECTION 4

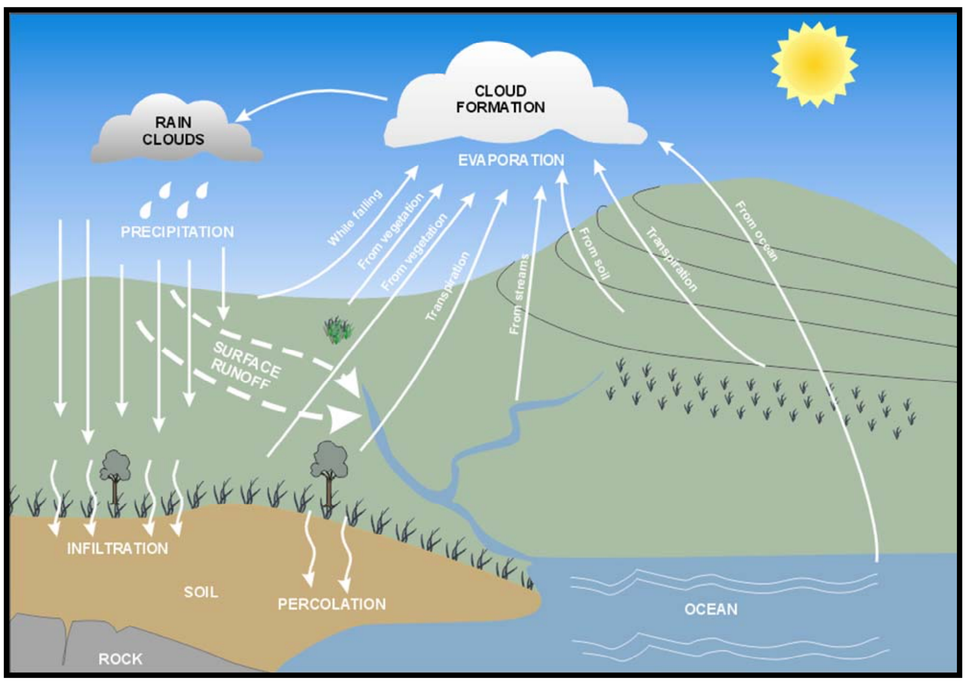
RUNOFF CONTROL

Summary

This section identifies the hydrologic cycle and the impact of construction activities on drainage patterns at a site. Runoff control measures must be designed into the ESCP and implemented at a construction site. This section identifies methods to predict surface runoff, factors affecting runoff and describes runoff control BMPs that can be used to divert and control runoff at a site.

4.1 Hydrologic Cycle and Drainage Patterns

The hydrologic cycle is the continual cycling of water between the surface and groundwater bodies and the atmosphere. Water falls on the land surface as rain or snow and runs off into the ocean, lakes, and rivers, from where it then evaporates into the atmosphere. Some of the water percolates into the soil and underlying rocks and moves as groundwater, eventually emerging into surface water bodies and evaporating.



Specific site drainage conditions change as a site is developed. Therefore, the site may have different drainage patterns under pre-developed conditions than during grading and construction and in post-development conditions. Changes to drainage patterns need to be anticipated and planned for in planning, designing, and implementing the ESCP for the site.

4.2 Runoff Considerations

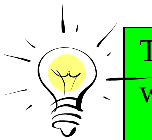
At a construction site, runoff conditions should be evaluated both within the site itself as well as along the site perimeter. For example, controlling internal site conditions involves diverting and directing sediment-laden water offsite through the implementation of temporary and permanent controls.

Along the site perimeter, controls should be selected based on consideration of run-on from adjacent areas, runoff from the site, and internal active inlets draining the site.

4.3 Surface Runoff Predictions

The runoff of water over the land has long been studied, and some rather sophisticated theories and methods have been proposed and developed for estimating runoff. Most attempts to describe the process have been only partially successful at best. This is due to the complexity of the process and interactive factors, such as soil type, antecedent moisture conditions, and soil cover type. As a result, different runoff predictive methods in common use may provide significantly different results for a specific site and local conditions.

Although hydrology is not an exact science, it is possible to obtain solutions that are functionally acceptable to form the basis for design of erosion and sediment control measures. The well-known and relatively simple "Rational Formula," an empirical method, is generally adequate for estimating the rate and volume of runoff for the design of erosion and sediment controls.



The **Rational Formula** is simple and easy to use and provides useful results when applied within the limits of this empirical formula.

Q =CiA

Q = Design discharge in cubic feet per second

C = Coefficient of runoff

i = Average rainfall intensity in inches per hour for the selected frequency and for a duration equal to the time of concentration

A = Drainage area in acres.

<u>Assumptions</u>

The Rational Formula assumes that the maximum flow from a drainage area results when rainfall of uniform intensity falls over the entire drainage area, and the duration of that rainfall is equal to the time required for storm runoff to travel from the most remote point of the drainage basin to the point of interest. This drainage area travel time is defined as the drainage area's time of concentration, “t_c”.

<u>Limitations</u>

The probability of rainfall of uniform intensity falling over an entire drainage area for a period of time equal to t_c decreases as the size of the drainage area increases. As a result, the Rational Formula should be used only when estimating runoff from small simple drainage areas, preferably no large than 20 acres. Where the drainage area is relatively small but complicated by a mainstream fed by one or more significant tributaries, the Rational Formula should be applied to each tributary stream and the tributary flows then routed down the main channel.

The NPDES 1200-C General Permit requires that the ESCP for any site that requires engineered facilities, such as diversion structures or sediment basins, to control runoff and sedimentation or meet other applicable standards during construction must be prepared by an Oregon Registered Professional Engineer. In accordance with these qualifications, the engineer is responsible for selecting the most appropriate method for estimating runoff and designing engineered facilities, even if they consist of temporary construction BMPs not permanent facilities. Note that ESCPs for activities covering 20 acres or more must be prepared by an Oregon Registered Professional Engineer, Oregon Registered Landscape Architect, or Certified Professional in Erosion and Sediment Control.

4.4 Factors Affecting Runoff

Numerous factors may affect the amount of runoff generated from a site, including:

- Precipitation
- Soil permeability
- Watershed area
- Ground cover
- Antecedent moisture
- Storage in the watershed
- Time parameters

These factors must all be considered in selecting and designing runoff control BMPs.

4.5 Runoff Control BMPs

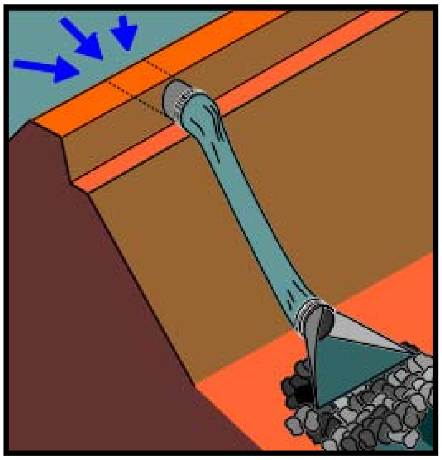
Even the best erosion control system cannot perform adequately without control of runoff. It is particularly important to control concentrated flow with measures to prevent gullying and scour of exposed soils. These measures must be in place before the start of the rainy season. Runoff control practices are BMPs that are designed to control the peak volume and flow rate and to prevent scour due to concentrated flows.

The following runoff control BMPs are discussed in this section and BMP details are provided in Appendix D:

RC-1 *Slope Drain*
RC-2 *Energy Dissipator*
RC-3 *Diversion of Run-on*
RC-4 *Temporary Diversion Dike*
RC-5 *Grass-lined Channel (Turf Reinforcement Mat)*
RC-6 *Trench Drain*
RC-7 *Drop Inlet*
RC-8 *Minimizing TSS During In-Stream Construction*
RC-9 *In-Stream Diversion Techniques*
RC-10 *In-Stream Isolation Techniques*
RC-11 *Check Dams*

Slope Drains (RC-1)

Slope drains (and subsurface drains) are used to intercept and direct surface runoff or groundwater into a stabilized watercourse, trapping device, or stabilized area. Slope drains are constructed with pipes or lined channels that convey surface runoff down slopes without causing erosion. Subsurface drains are constructed from tile, pipe, or tubing and are used to improve drainage and stabilize slopes in areas with saturated soils. Also refer to BMP EP-19, Live Pole Drains in Appendix E.



Energy Dissipator (RC-2)

Outlet protection and velocity dissipation devices are physical structures such as rock riprap, stone, or concrete flow spreaders placed at the outlet of drainage culverts and channels to reduce the velocity and/or energy of the exiting water.

Diversion of Run-on (RC-3)

Diversion channels, drainage swales, and lined ditches are all structures designed to intercept, divert, and convey surface runoff to prevent erosion and reduce pollutant loading. These structures are used to convey runoff down sloping land or divert runoff away from a sensitive area to avoid erosion. These structures can be used to direct runoff to a stabilized watercourse, drainage pipe, channel, or sediment-trapping device.

Drainage swales and lined ditches are drainage channels lined with grass, riprap, asphalt, concrete, or other materials. Drainage swales are designed to convey runoff without causing erosion.

Temporary Diversion Dike (RC-4)

A temporary diversion dike is a low berm or ridge of compacted soil that channels water away from a steep slope or embankment and toward a desired location. Earth dikes should be stabilized with vegetation.

Grassed-lined Channel – Turf Reinforcement Mats (RC-5)

Turf Reinforcement Mats (TRMs) are designed to provide protection to resist channel and streambank erosion and are useful when channel soils may subside or shift after installation. Installation of grass-lined channels with TRMs is typically part of the permanent drainage design for a site or could be "temporary" controls for a long-duration construction project.

Trench Drain (RC-6)

A trench drain is a gravel drain, construction with or without perforated pipe and filter fabric that is installed to intercept and divert shallow seepage away from the face of a streambank or divert surface runoff in a situation where a drainage swale or temporary diversion dike is not appropriate.

Drop Inlet (RC-7)

A drop inlet is used to convey concentrated overbank runoff to the toe of slope by installing a drop inlet at the top of slope that daylights at the toe of slope. This practice is used for large amounts of surface runoff (typically up to 200 cfs) across a steep, high slope/embankment. Small amounts of runoff flowing across a relative intact slope are best handled with a diversion dike and slope drains.

Minimizing TSS During In-Stream Construction (RC-8)

This BMP outlines techniques to minimize TSS during in-stream construction, including: timing; using padding to trap sediment; gravel injection; using large equipment to minimize stream disturbance; and partial dewatering.

In-Stream Diversion Techniques (RC-9)

A stream diversion is a temporary bypass through a pipe, flume, or excavated channel that carries water flow around work areas. Stream diversion is commonly used during culvert installation or replacement. Where possible, a stream diversion should be the first choice to control erosion and sediment during the construction of culverts or other in-stream structures.

In-Stream Isolation Techniques (RC-10)

An in-stream isolation technique is a temporary structure built into a waterway to enclose a construction area and reduce sediment pollution from construction work in or adjacent to water. The structures may be made of rock, sand bags, wood or water-filled geotextiles (aqua barriers). During construction in a watercourse, these structures are designed to reduce turbidity and sediment discharge.

Check Dams (RC-11)

A check dam is a small, temporary dam constructed of rocks, logs, or timbers placed across a natural or man-made channel or drainage ditch. Check dams reduce drainage ditch erosion caused by storm water runoff, by restricting the velocity of flow in the ditch. Check dams area often used as a temporary measure while a channel is being permanently lined with vegetation or other materials to prevent erosion.

KEY TERMS

Hydrologic cycle

Percolation

Runoff

Rational formula

Average rainfall intensity (i)

Tributary

Antecedent moisture

Diversions

Dikes

Grade control measures

Slope drains

Drainage patterns

Groundwater

Run-on

Design discharge (Q)

Drainage area

Culvert and storm drain flow

Grassed and lined waterways

Swales

Check dams

Outlet protection

Subsurface drains

SUMMARY CHECKLIST

- Specific site drainage conditions change as a site is developed. Therefore, the site may have different drainage patters under pre-developed conditions than during grading and construction and in post-development conditions. Changes to drainage patterns need to be anticipated and planned for in planning, designing, and implementing the ESCP for the site.

- Controlling internal site conditions involves diverting and directing sediment-laden water offsite through the implementation of temporary and permanent runoff and sediment controls.

- Along the site perimeter, controls should be selected based on consideration of run-on from adjacent areas, runoff from the site, and internal active inlets draining the site.

- The NPDES 1200-C General Permit requires that the ESCP for any site that requires engineered facilities, such as diversion structures or sediment basins, to control runoff and sedimentation or meet other applicable standards during construction must be prepared by an Oregon Registered Professional Engineer. In accordance with these qualifications, the engineer is responsible for selecting the most appropriate method for estimating runoff and designing engineered facilities, even if they consist of temporary construction BMPs not permanent facilities.

- Numerous factors may affect the amount of runoff generated from a site, including:

  - Precipitation
  - Soil permeability
  - Watershed area
  - Ground cover
  - Antecedent moisture
  - Storage in the watershed
  - Time parameters

- Even the best erosion control system cannot perform adequately without control of runoff.

- It is particularly important to control concentrated flow with measures to prevent gullying and scour of exposed soils.

- Runoff measures must be in place before the start of the rainy season.

- Runoff management practices are BMPs that are designed to control the peak volume and flow rate and to prevent scour due to concentrated flows.

SECTION 5

EROSION PREVENTION METHODS

Summary

This section summarizes a wide range of erosion prevention practices, materials and methods to be applied during earthwork activities including structural methods, techniques to prevent erosion on already graded surfaces, and biotechnical erosion control methods.

The best way to control the discharge of sediment and related pollutants from a construction site is to prevent erosion from occurring in the first place. Earlier in this manual the concepts of erosion prevention and sediment control were introduced and it has been emphasized that erosion prevention methods should be integrated into a project throughout planning, design, scheduling, and during construction itself. Important erosion prevention concepts related to planning, design, and scheduling (EP-1) are discussed in Section 3, such as limiting soil disturbance and establishing vegetative buffers (EP-2) prior to construction. This section (Section 5) focuses on measures to be implemented during earthwork activities to control erosion. The following erosion prevention BMPs are discussed in major subsections of this section:

Structural Erosion Prevention During Grading & Earthwork

EP-3	*Surface Roughening*

Preventing Erosion on Graded Surfaces

EP-4	*Topsoiling*
EP-5	*Temporary Seeding and Planting*
EP-6	*Permanent Seeding and Planting*
EP-7	*Mycorrhizae / Biofertilizers*
EP-8	*Mulches*
EP-9	*Compost Blankets*
EP-10	*Erosion Control Blankets and Mats*
EP-11	*Soil Binders*
EP-21	*Sodding*

Wind Erosion / Dust Control Measures

EP-13 *Wind Erosion / Dust Control*

Biotechnical Erosion Control Measures

EP-14 *Live Staking*
EP-16 *Live Fascines and Brush Wattles*

The following additional erosion prevention BMPs are not specifically addressed in this section but are provided along with details for the above listed BMPs in Appendix D.

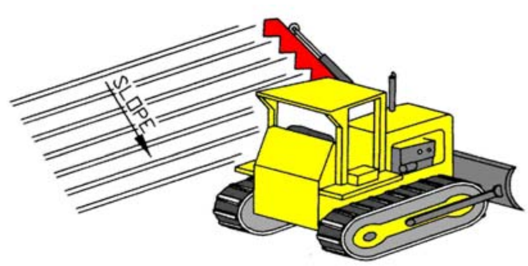
EP-12 *Stabilization Mats*
EP-15 *Pole Planting*
EP-17 *Brush Box*
EP-18 *Fascines with Subdrains*
EP-19 *Live Pole Drains*
EP-20 *Brush Packing or Live Gully Fill Repair*

5.1 <u>Structural Erosion Prevention During Grading and Earthwork Operations</u>

There are several important structural erosion prevention considerations to take into account during earthwork activities. These considerations involve controlling runoff throughout the site, constructing cut and fill slopes to minimize erosion, and applying soil roughening to graded cut and fill slopes.

<u>Runoff Control</u>

Every effort should be made to maintain runoff water in its natural course and direction of flow. Access road surfaces should be compacted to obtain a dense, smooth, and uniform surface for construction vehicles. Access roads should be sloped in a manner that will prevent ponding and damage from water flow. Roads that will remain unpaved for more than 21 days should provided with adequate drainage features to reduce erosion. These measures should include rolling dips, waterbars, crowning, drainage swales with check dams, and slope drains. See Section 4 for a more detailed discussion of runoff control BMPs and flow diversion techniques.



NOTE:
Groove by cutting serrations along the contour. Irregularities in the soil surface catch rainwater, seeds, mulch and fertilizer.

Cut and Fill Slopes

Cut and fill slopes should be no steeper than 2:1 (horizontal to vertical). For long slopes, benching may be required to reduce the slope length. To prevent the development of rills and gullies in graded slopes, runoff should be directed to stabilized conveyance channels and drains. No concentrated flow of water should be allowed to flow down a graded slope face. Fill slopes should be constructed in accordance with project specifications.

During construction, storm water runoff should be directed away from disturbed areas. Properly-installed temporary berms, earth dikes, sediment fences (with the toe embedded into the soil), sediment traps, and sediment basins should be used to limit the discharge of sediment and pollutants from the site.

Soil Roughening (EP-3)

While smoothly graded cut and fill slopes may be attractive to the eye, they are not beneficial from the standpoints of erosion prevention and the establishment of vegetative cover. Soil roughening is the creation of a soil surface roughness by mechanical means. Roughening is performed parallel to the slope contours and perpendicular to the direction of runoff. The benefits provided by soil roughening are slowing runoff, enhancing infiltration, moderating soil temperature, trapping moisture, and enhancing seed germination and root penetration. This is particularly important on cut slopes. Where the slope is too steep to allow construction traffic to travel parallel to the slope, cleated dozers traveling up and down the slope can produce a satisfactory texture on newly compacted soil. Table 5-1 presents comparative effectiveness of various soil roughening techniques are presented along with erosion rates for smooth slopes without trackwalking.

Means of soil roughening may include:

- Sheepsfoot rolling
- Track walking
- Scarifying
- Stair stepping
- Imprinting

Fiber Rolls (SC-7)

Fiber rolls are small, cylindrical barriers composed of biodegradable fibers encased in photodegradable open weave netting. They are primarily identified as a sediment control measure used for perimeter or inlet protection but also serve an important erosion prevention function when they are placed along the contours of the slope and staked into place.

Fiber rolls are porous and allow water to filter through them. They intercept runoff, reduce flow velocity, release runoff as sheet flow, and provide some sediment retention. Fiber rolls create a favorable environment for plant establishment by interrupting the slope length and trapping soil and moisture.

Appropriate applications for fiber rolls include:

- Along the face of exposed and erodible slopes to shorten slope length.
- Along the top of exposed and erodible slopes to spread runoff as sheet flow.
- At grade breaks where the slope transitions to a steeper gradient.
- In drainage swales to slow flows.
- Along streambanks to assist stabilization and revegetation.

Table 5-1
RESULTS OF RAINFALL SIMULATION TESTING FOR SOIL ROUGHNESS

Treatment	Measurement	Statistic	Storm						Average Increase (+) Decrease (-)
			5-yr (1)	5-yr (2)	10-yr (1)	10-yr (2)	50-yr (1)	50-yr (2)	
Smooth	Normalized Erosion Rate (kg/m²/mm)	Mean	0.06	0.07	0.16	0.09	0.12	0.09	
		St. Dev.	0.03	0.07	0.04	0.01	0.02	0.02	
		% of Smooth	100%	100%	100%	100%	100%	100%	0%
	Runoff (L)	Mean	255.7	364.4	419.2	470.3	422.3	611.0	
		St. Dev.	11.9	35.1	19.6	9.7	10.6	20.3	
		% of Smooth	100%	100%	100%	100%	100%	100%	0%
Imprinted	Normalized Erosion Rate (kg/m²/mm)	Mean	0.03	0.02	0.03	0.02	0.03	0.02	
		St. Dev.	0.03	0.19	0.11	0.12	0.04	0.05	
		% of Smooth	49%	26%	18%	25%	22%	19%	76% (-)
	Runoff (L)	Mean	222.3	415.6	380.8	446.6	464.4	501.8	
		St. Dev.	13.3	96.1	49.4	84.0	21.1	37.8	
		% of Smooth	87%	114%	91%	95%	110%	82%	4% (-)
Ripped	Normalized Erosion Rate (kg/m²/mm)	Mean	0.04	0.07	0.12	0.08	0.15	0.06	
		St. Dev.	0.18	0.03	0.07	0.04	0.01	0.09	
		% of Smooth	66%	99%	75%	88%	121%	71%	12% (-)
	Runoff (L)	Mean	154.2	276.3	387.3	416.3	373.5	443.4	
		St. Dev.	75.6	17.0	29.8	24.7	7.0	79.2	
		% of Smooth	60%	76%	92%	89%	88%	73%	19% (-)
Sheepsfoot	Normalized Erosion Rate (kg/m²/mm)	Mean	0.03	0.03	0.02	0.05	0.06	0.04	
		St. Dev.	0.03	0.14	0.06	0.03	0.04	0.03	
		% of Smooth	58%	46%	14%	56%	51%	46%	55% (-)
	Runoff (L)	Mean	361.3	374.8	525.1	511.8	503.3	584.4	
		St. Dev.	11.9	71.3	26.7	22.5	26.0	24.3	
		% of Smooth	141%	103%	125%	109%	119%	96%	12% (+)
Trackwalked	Normalized Erosion Rate (kg/m²/mm)	Mean	0.04	0.04	0.05	0.04	0.04	0.07	
		St. Dev.	0.11	0.05	0.08	0.06	0.09	0.04	
		% of Smooth	80%	60%	30%	40%	30%	80%	52% (-)
	Runoff (L)	Mean	218.7	448.3	460.7	468.5	410.6	579.9	
		St. Dev.	48.0	26.8	35.5	38.4	49.7	36.0	
		% of Smooth	86%	123%	110%	100%	97%	95%	2% (+)

Source: Erosion Control Pilot Study Report, Caltrans, June 2000, Table 4-1	Note: Testing was conducted at the San Diego State University tilting test bed (fill slope) on a 1:2 (V:H) slope using a clayey sand soil.

5.2 Protecting Graded Surfaces From Erosion

Erosion prevention methods to protect graded surfaces are presented below in two categories: 1) methods that involve establishing temporary or permanent vegetation and 2) non-vegetative methods that involve applying mulches, soil binders, hydraulic matrices, bonded fiber matrix, or erosion control blankets to stabilize soils.

5.2.1 Vegetative Measures (Temporary and Permanent Vegetation)

An overview of important factors in establishing vegetation is presented in this section including the erosion prevention benefits of vegetation, soil and climate conditions, soil amendments, and seeding. These concepts are presented in the BMP detail sheets for Temporary Seeding and Planting (EP-5) and Permanent Seeding and Planting (EP-6) as well as other BMP details referenced below.

Vegetation helps prevent erosion in the following ways:

- **Roots hold soil together**
- **Leaves and stems break up rainfall impact**
- **Ground cover slows down runoff and filters sediment out of water**
- **Plants evapotranspire moisture from soil**

Regional differences in weather and soil microclimate affect the available times for planting and are extremely important to seed and plant success. Altitude and aspect must also be taken into consideration. Different seed mixtures may germinate at different times of the year. Base seeding recommendations on when the seeding is supposed to occur. Irrigation can extend the planting season and ensure plant success without having to depend on natural rainfall and soil moisture.

Plants are site specific in terms of their growth requirements, and success is influenced by:

- Soil moisture
- Soil chemistry
- Temperature
- Sunlight
- Maintenance
- Soil Structure and Disturbance

The ideal soil for most plants is approximately 50% solid and 50% pore space. The solid component contains minerals and organic matter. Ideally, pore space contains roughly equal parts of air and water. Microorganisms (such as fungi) or invertebrates (such as earthworms) are present in a healthy soil and function to process organic matter, recycle nutrients, and nurture plants. Any disturbance to the soil alters and influences this complex system.

Disturbances include construction, fertilizer and pesticide application, soil compaction from foot traffic and equipment use, and altered hydrological patterns through irrigation, grade changes, and storm water retention. In other words, any management activity on the project site is a potential disturbance to the soil system. In areas where plant cover is desirable, construction management activities should be selected and timed to minimize harmful disturbances to the soil, and focused on long-term soil health.

During the project planning process, determine how and to what extent soils will be affected. Minimize the extent of disturbance activities to minimize impacts to soil outside the project's construction limits.

Soil Amendments

The decision to use a soil amendment depends on the existing soil and the desired outcome. Some soil amendments might encourage unwanted exotic vegetation, while the combination of other soil amendments with native soils might favor native vegetation. In addition, any local controls or restrictions on specific types of soil amendments, fertilizers, or slow release polyurethane-coated formulas, must be considered when selecting an amendment.

Much of a construction site is reduced to subsoil at the surface during a typical construction project. Subsoil has little or no organic matter, few pore spaces, and few microorganisms and therefore does not effectively support vegetation establishment and growth.

It is necessary to have healthy soil to revegetate a site. Revegetation is necessary to provide slope stabilization, erosion control, biofiltration and infiltration for water quality, aesthetics, habitat, and so forth. Revegetation might also be necessary to meet permit or environmental requirements. As a result, healthy topsoil is an important component of a construction project.

Following a project that exposes subsoils, soils can be amended to provide suitable conditions for revegetation. Plant life and water absorption capability require similar soil conditions: loose, friable soil with the right balance of organic matter, microorganisms, and minerals. Amendments to consider include topsoil, compost, fertilizer, mycorrhizal fungi, and biofertilization.

Topsoil (EP-4)

Topsoil is a biologically active system of minerals, organic matter, air, water, and microorganisms that can take thousands of years to develop. Topsoil nourishes and provides structural support for plant roots and absorbs water.

The act of stripping off, storing, and redistributing topsoil over disturbed areas is a beneficial practice for re-establishment of vegetation. The upper horizons of soil generally contain essential soil bacteria and viable plant materials such as seeds, roots, or rhizomes. Use of topsoil or "duff" materials can also augment graded subsoil that may not contain the necessary nutrients for plant establishment.

Some considerations in the use of existing topsoil include:

- Combining the top 6 inches (15.2 cm) of topsoil with on-site native vegetation such as native grasses or small shrubs that has been chipped to facilitate mixing with topsoil. This will contain the seed stock and nutrients to re-establish the native vegetation without the need for soil amendments, additional seed, or irrigation. Note this does not refer to using wood bark chips from large trees or other non-indigenous mulches. Care should be taken in amending topsoil with native chipped vegetation so that the resulting organic content of the amended topsoil is appropriate for the type of vegetation being established. If the percentage of chipped vegetation is too high, decomposition of chipped vegetation can tie up nutrients important to plant establishment. Recommended organic content of amended topsoil is 10 percent and 5 percent for planting beds and turf areas, respectively.
- Removal and immediate placement on final graded areas is preferred.
- Making sure that stockpiled material is protected from erosion.

- Analyzing material and supplementing with soil amendments and fertilizer if needed.
- Roughening the surface of graded subsoil to receive the topsoil replacement layer.
- Placing topsoil material on slopes no steeper than 2:1 and compacting it.

Topsoil may also be an amendment when it no longer exists on a site. Commercial topsoil generally consists of mineral soils mechanically combined with organic matter.

Compost / Green Material

Compost is highly decomposed organic matter that is used to add nutrients and improve soil structure for plant growth. Compost also provides resistance to weed growth in thicker applications (i.e., over 4 inches). Acceptable compost products originate a minimum of 65 percent by volume from recycled plant waste. Organic compost must be certified weed-free.

Fertilizer

Commercial fertilizers are labeled to document the content's ratio of nitrogen (N), phosphorus (P), and potassium (K) (usually listed in order: N-P-K). These are the three main elements associated with plant growth and health. Generally, nitrogen encourages green top growth, while phosphorus and potassium encourage root growth. Fertilizer is applied in various combinations (for example, 20-20-20 or 10-15-5), as determined to be necessary by the results of a soil analysis. A 10-15-5 fertilizer would be comprised of 10 percent nitrogen, 15 percent phosphorus, and 5 percent potassium.

Use of Slow-Release, Polyurethane-Coated Formulations

Timed-release nitrogen formulations work differently from other slow-release products, because they release in response to temperature rather than moisture. They can feed the plants when the plants need the nutrients and are less likely to encourage nonnative species.[1] These timed-release fertilizers are available in many different formulations (e.g., 12-5-7, 15-5-13, 15-7-7).

Mycorrhizal Fungi (EP-7)

Mycorrhizal fungi are a group of fibrous fungi existing naturally in topsoils that engulf soil particles and pore spaces to absorb water and nutrients in solution and transfer this solution to the roots of plants. The mycorrhizal fungi applied depend on the species of plant or mycorrhizal host.

Mycorrhiza come in about seven types, which differ by kind of fungus, kind of host plant, and the morphology of the interface. Mycorrhizal fungi plug into the *cortex* (a layer of cells found only on relatively young roots), and at the same time pass into the soil, forming a bridge to the plant. They all provide soil nutrients to the plant and draw energy compounds from the host.

Root development with mycorrhiza (left) and without (right).

1 (Vic Claassen, UC Davis, Personal Communication, 1999)

Germination without (left) and with mycorrhizal innoculum (right)

Biofertilization (EP-7)

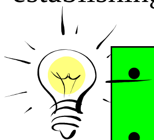
Soils need nitrogen, phosphorus, and potassium in order to produce healthy plants. Biofertilizers, which are fertilizers that contain living microorganisms, are alternatives to chemical fertilizers (N-P-K). Applying biofertilizers, which are readily available from a variety of soil conditioner manufacturers, increases microbial activity in soil. With biofertilizers, soil fertility is increased by bacteria that fix nitrogen from the air into chemicals that aid plant growth, such as nitrate or ammonia. Microbes can also improve the structure of the soil through secretions that make the soil particles stick together, forming larger particles and thus increasing soil porosity. Microbes also benefit plants by providing a natural defense against soil-borne diseases or pathogens.

Biofertilizers offer a more environmentally-friendly alternative to chemical fertilizers, which are often over-applied, resulting in polluted runoff. Although chemical fertilizers have their benefits, there are certain characteristics offered by biofertilizers that the typical N-P-K fertilizers can't match. Therefore, the chemical approach may be economical in the short term, but in the long term, biofertilizers may be less expensive.

The best approach may be to combine both chemical fertilizers and biofertility. This approach can provide vegetation with the jump start needed for immediate growth if there just isn't time to adjust to a completely organic application.

Seed Species

The following criteria should be considered when selecting seed species for establishing vegetation to stabilize disturbed areas on a construction site:



- **Satisfaction of the functional requirements of the design.**
- **Simplicity of appearance and compatibility with the overall landscape.**
- **Production of extensive root systems.**
- **Rapidity of establishment.**
- **Tolerance of site conditions.**
- **Resistance to insects and diseases.**
- **Availability from commercial suppliers.**
- **Ability to self-perpetuate (except temporary seeding which should be sterile).**
- **Compatibility with maintenance objectives.**
- **Selection of species native to the area wherever practical.**
- **Do not use forbs in roadside seed mixes where there are deer, to avoid animal hazards.**
- **Do not use lupine adjacent to agricultural or grazing areas, to avoid causing illness to grazing animals.**
- **Do not use seed mixes that include noxious weed species.**

Guidance for seed selection can be obtained from the following Oregon sources:

- Oregon State University Agricultural Extension Service http://agsci.oregonstate.edu/ext/index.html
- City of Eugene, Oregon Parks and Open Space Seed Program http://www.ci.eugene.or.us/parks/wetlands/seeds.htm
- Rogue Valley Council of Governments Plant List http://www.rvcog.org/
- City of Portland Bureau of Planning, Portland Plant List http://www.portlandonline.com/?c=35517

Permanent Seeding (EP-6)

Permanent seeding establishes a permanent vegetative cover that will prevent soil detachment by raindrop impact, reduce sheet and rill erosion, and stabilize slopes and channels. Permanent seeding can be used in conjunction with erosion control blankets and mats to provide both temporary and permanent erosion prevention controls. Perennial grasses, when used with turf reinforcement mats, provide a fibrous root network that anchors the channel lining. These treatments can greatly increase the maximum permissible velocities are useful in stabilizing channels and grass-lined channels. Perennial grasses and legumes improve wildlife habitat and improve aesthetics.

The potential for erosion will exist during the establishment stage. Failure to carefully follow sound plant establishment recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

Sodding (EP-21)

Sodding is the placement of permanent grass cover that has been grown elsewhere and brought to the site. Sodding stabilizes an area by immediately covering the soil surface with grass, thereby protecting the soil from erosion, enhancing infiltration, filtering sediment and other pollutants, and slowing runoff velocities.

Sodding is appropriate for areas that contained turf prior to construction, or for any graded or cleared area that might erode and where a permanent, long-lived plant cover is needed immediately. Examples of locations where sodding may be used include buffer zones, streambanks, grassed dikes, swales, slopes, outlets, level spreaders, and filter strips.

5.2.2 Non-Vegetative Measures (Mulches, Soil Binders, BFM, Erosion Control Blankets and Mats)

Non-vegetative erosion prevention measures such as mulches, soil binders, Bonded Fiber Matrix (BFM), and erosion control blankets and mats can be used in combination with seeding techniques to provide temporary erosion control and enhance vegetation growth during the plant establishment period. These methods can also be used alone to provide temporary erosion control.

Mulches (EP-8, EP-9)

Temporary mulches are temporary covers that protect the soil surface from erosion until vegetation can become established. Mulches can also be utilized to aid in the establishment of vegetation.

It is important that the longevity of temporary measures is taken into account relative to the time it takes for the vegetation to become established and provide effective erosion control.

Mulches function by:

- Moderating soil temperature
- Reducing soil moisture loss through evaporation
- Protecting the soil surface from compaction and increasing infiltration
- Reducing weed competition for desirable plants
- Armoring the soil against rain drop impact and sheet erosion from runoff

Some typical uses for mulches are:

- As a non-vegetated cover on disturbed sites to temporarily control erosion until permanent vegetation can be established
- In conjunction with seed and soil amendments to establish temporary or permanent vegetative cover
- To add organic matter, fertility, and improve structure of poor soils
- As a long-term, non-vegetative ground cover, usually around existing plants, such as trees or shrubs.

Some common types of organic mulch are:

- Plant fibers, like straw or hay
- Composted organic materials / green material
- Hydraulic mulches made from wood fiber or recycled paper
- Erosion control blankets and mats
- Hydraulic matrices (combinations of fibers and adhesives)

Their use and relative longevity is variable. Table 5-2 compares relevant criteria that can be used for mulch selection. Application rates and details for each type are provided in BMPs EP-8, EP-9, and EP-10.

Table 5-2
COMPARATIVE SELECTION CRITIERIA - MULCHING BMPs

Surface Mulch Category	Unit Cost Installed	Estimated Relative Erosion Control Effectiveness	Standard Application Rate	Ease of Installation	Longevity / Degradability
Hydraulic Mulching Types: Wood, paper, cellulose fiber	$900–1,200/ac	50 – 60%	2,000 lbs per acre	2	6 months
Compost Application	$900–1,200/ac $7,000-10,000/ac $10,000-15,000/ac	40 – 50% 95 - 99% 95 - 99%	(1 inch blanket application) (2 inch blanket application) (3 inch blanket application)	3 3 3	6 months 12 months 12-18 months
Straw Mulching Types: Rice and wheat	$1,800–2,100/ac	90 – 95%	2 tons per acre	3	6 months
Wood Chip Types: Blanket	$900–1,200/ac	Unk		3	24 months
Hydraulic Matrices Types: Wood mulch + Granular or liquid binder Paper mulch + Granular or liquid binder Cellulose mulch + binder	$1,000-2,000/ac	65 - 99%	2,000 lbs/ac mulch + 10% tackifier	2 2 2	6-12 months 3-6 months 3-6 months
Bonded Fiber Matrices	$5,000–6,500/ac	90 – 99%	3,500 – 4,000 lbs/ac	3	6-12 months
Erosion Control Blankets and Mats					
Types: Biodegradable					
Jute	$6,000–7,000/ac	65 – 70%	N/A	4	12-18 months
Curled Wood Fiber	$8,000–10,500/ac	90 – 99%	N/A	4	12 months
Straw	$8,000–10,500/ac	90 – 99%	N/A	4	12 months
Wood Fiber	$8,000–10,500/ac	90 – 99%	N/A	4	6-12 months
Coconut Fiber	$13,000–14,000/ac	90 – 99%	N/A	4	24-36 months
Coconut Fiber Net	$30,000–33,000/ac	90 – 99%	N/A	4	24-36 months
Straw Coconut	$10,000–12,000/ac	90 – 99%	N/A	4	18-24 months
Non-Biodegradable					
Plastic Netting	$2,000–2,200/ac	< 50%	N/A	4	24 months
Plastic Mesh	$3,000–3,500/ac	75 – 80%	N/A	4	24 months
Synthetic Fiber w/Netting	$34,000–40,000/ac	90 – 99%	N/A	4	permanent
Bonded Synthetic Fibers	$45,000–55,000/ac	90 – 99%	N/A	5	permanent
Combination Synthetic and Biodegradable Fibers	$30,000–36,000/ac	85 – 99%	N/A	5	variable
Criteria Definition					
Unit Cost Installed:	Cost of materials and labor to effect installation on a per acre basis				
Relative Erosion Control:	Reduction in soil loss when mulch is compared to bare soil (control) under similar conditions of soil, slope length and steepness and rainfall simulation				
Ease of Installation:	Ratings range from 1 (relatively easy or few steps required for application/installation) to 5 (labor intensive or numerous steps required for application/installation)				
Longevity/Degradability:	Functional longevity in terms of erosion control effectiveness				
Source: Erosion Control Pilot Study Report, Caltrans, June 2000, and Soil Stabilization for Temporary Slopes, Caltrans 1999. Adapted and Updated January 2005					

Plant Fiber Mulches (EP-8)

Plant fibers such as straw or hay as a mulch must be anchored in place either by punching or "crimping" them into the soil surface, or by holding them in place with a hydraulically-applied adhesive (see photo at right). The standard application rate for this practice is 2 tons (4,000 lbs)/ac (4,500 kg/ha) of the straw or hay so that 80-90% of the ground is covered.

<u>Composted Organic Materials /Green Material</u>

Composted organic materials or green materials act as mulches, but have a primary function as soil amendments. They are described previously in this section under Soil Amendments.

<u>Hydraulic Mulches (EP-8)</u>

Hydraulic mulches and hydraulic matrices are applied using standard hydraulic seeding equipment. The equipment usually consists of a large water tank (see photo on left) with some form of agitator which enables the operator to mix seed, soil amendments, and mulch in the tank, and a pump. The pump pushes the resulting slurry through a hose or cannon mounted on top of the machine for application on the soil surface.

When using hydraulic techniques there are requirements for successful vegetation establishment:

1. Select proper seed mixture adapted to climate that meets project requirements and those of the local municipality;

2. Use proper soil amendments and/or biostimulants to enhance soil fertility;

3. **Conduct work when there is adequate moisture in the ground to support plant germination and growth, preferably before the wet season, or provide supplemental irrigation (Note: In Oregon, compost tends to furnish its own moisture sufficient for seed germination);**

4. Apply seed, fertilizer, and mulch in a two-step process, with seed and fertilizer applied in the first step, and the mulch applied over the seed in a second step;

5. Use mulches with some form of tackifying agent to hold them on the soil;

6. Be aware that mulches applied at higher elevations on the north sides of slopes may hold soil temperatures down in the spring and slightly retard germination and growth; and,

7. Re-apply as necessary due to weathering - be prepared to budget for two seasons of inspection and maintenance.

Soil Binders (Hydraulic Soil Stabilizers) (EP-11)

Soil binders (also known as hydraulic soil stabilizers) are materials that are applied to the soil surface for dust control and temporary erosion control. When used in combination with plant materials (hay/straw) and hydraulic mulches, hydraulic soil stabilizers glue the mulch fibers together and are effective in controlling water-generated erosion.

Hydraulic soil stabilizers can be used in basically three types of applications:

- **As a stand alone application of liquid that forms a crust on the soil surface by binding soil particles together;**
- **As a tackifying agent applied over straw or hay mulch as an alternative to crimping; and**
- **In combination with hydraulic mulches to create a hydraulic matrix.**

In general, there are four common classes of hydraulic soil stabilizers:

- Plant-Material Based (Short Lived) – Guar, Psyllium, Starch, Chitosan

- Plant-Material Based (Long Lived) – Pitch and Rosin Emulsion
- Polymeric Emulsion Blends – Acrylic Copolymers and Polymers, Liquid Polymers of Methacrylates and Acrylates, Copolymers of Sodum Acrylates and Acrylamides, Poly-Acrylamide and Coplymer of Acrylamide, and Hydro-Collid Polymers
- Cementitious-Based Binders - Gypsum

Their use and relative longevity is variable. Table 5-3 compares relevant criteria that can be used for soil binder selection. Application rates and descriptions for each type are provided in BMP EP-11.

Bonded Fiber Matrices (EP-8)

Bonded Fiber Matrices (BFMs) are hydraulically-applied, erosion control systems composed of long strand mulch fibers joined together by high-strength adhesives, creating a continuous, three-dimensional blanket that adheres to the soil surface. The system is applied to the soil as a viscous mixture, and when it dries (depending on the product, BFMs require 12 to 24 hours to dry to become effective), creates a high-strength, porous and erosion-resistant mat.

BFMs are typically applied at rates from 1.5 to 2 tons/acre (3,400 to 4,500 kg/ha) based on the manufacturer’s recommendation.

Some characteristics of bonded fiber matrices are:

- They can be applied using standard hydraulic seeding equipment;
- All components -fiber and adhesives - are mixed together in one bag;
- The binder systems do not dissolve or disperse upon rewetting;
- The dried matrix is porous, allowing water to penetrate into the soil;
- They can be applied with or without seed and do not inhibit plant growth.

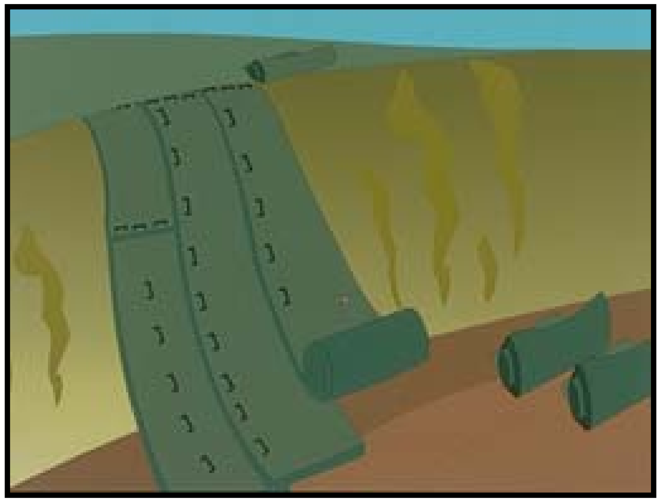
Table 5-3
COMPARATIVE SELECTION CRITERIA – SOIL BINDERS

Soil Binder (with out mulch)	Unit Cost Installed	Relative Erosion Control	Degradability / Longevity	Water Quality Impact	Ease of Cleanup	Mode of Application	Effect on Runoff	Drying Time (hours)
Plant Material-Based (PBS) • Guar, Psyllium, Starch, Chitosan	$700-900/ac	85-95%	3-6 months	+	+	B	0/-	12-18
Plant Material-Based (PBL) • Pitch or rosin-based	$1,200-1,500/ac	60-65%	6-12 months	-	V	B	+	19-24
Polymeric Emulsion Blends (PEB) • Acrylic copolymers, copolymers and hydrocolloids • Polyacrylamides (PAM)	$700-1,500/ac	30-95%	1-2 years	V	V	B	+ and/or – depending on chemistry	4-24 Depending on chemistry
Cementitious Binder-Based (CBB) • Generally used with trace mulch	$800-1,200/ac	75-85%	1-2 years	+	V	H	+	4-8

Criteria Definition	
Unit Cost Installed:	Cost of materials and labor to effect installation on a per acre basis
Relative Erosion Control:	Reduction in soil loss when binder compared to bare soil (control) under similar conditions of soil, slope length and steepness and rainfall simulation
Degradability/Longevity:	Based on manufacturers' standard recommended application rate and information/data sheets
Water Quality Impact:	Low, Medium or High based on the results of testing at the SDSU Soil Erosion Research Laboratory for Caltrans (See SSTS 1999). For detailed information on chemical constituents, ask the manufacturer for MSDS sheets and evidence of water quality testing.
Ease of Cleanup:	Positive (+) indicates that cleanup of overspray onto sidewalks, walls, etc. is generally not an issue. Negative (-) indicates that cleanup can be problematic. Variable (V) indicates that the chemistry of the particular binder can make a difference. Check with the manufacturer.
Mode of Application:	Indicates whether or not specific application equipment is required. Hydromulcher (H) indicates the need to mix and keep material in suspension by internal agitation; Water truck (W) means that the material is specifically designed for use with a standard water tank truck; Both (B) means that the material can be used in either a hydromulcher or a water truck with a recirculation pump or other means of preliminary mixing of binder with water.
Effect on Runoff:	A positive sign (+) indicates runoff is increased; a negative sign (-) means runoff is reduced; the symbol (0) indicates no-effect.

Source: Erosion Control Pilot Study Report, Caltrans, June 2000, and Soil Stabilization for Temporary Slopes, Caltrans 1999. Adapted and Updated January 2005.

Erosion Control Blankets and Mats (EP-10)



Erosion control blankets and mats are rolled, blanket-like materials used to stabilize and protect disturbed soils from raindrop impact and soil erosion, to increase infiltration and conserve soil moisture, to keep seed in place, and to enhance seed germination. This class of products includes manufactured mulch materials that are produced in a roll configuration that is placed on the ground and held in place by stakes, metal staples, geotextile pins or other fastening systems. The mulch within the blanket can be held in place by netting, sewing, adhesives or a combination of these methods. The various types of blankets are identified in BMP EP-10. Biodegradable blankets are typically composed of jute fibers, curled wood fibers, straw, coconut fiber, or a combination of these materials.

In order for blankets to be considered 100% biodegradable, the netting, sewing or adhesive system that holds the biodegradable mulch fibers together must also be biodegradable.

Non-biodegradable blankets are typically composed of polypropylene, polyethylene, nylon or other synthetic fibers. In some cases, a combination of biodegradable and synthetic fibers is used to construct the blanket. Netting used to hold these fibers together is typically non-biodegradable as well.

STOP **Always follow the manufacturer's recommendation on staple types, patterns and the number to use per square yard or meter.**

5.3 <u>Wind Erosion Control (EP-13)</u>

Wind erosion control consists of dust control applied to stabilize soil from wind erosion and to reduce dust generated by construction activities. Wind erosion control methods can consist of applying water over areas that are susceptible to wind erosion or applying other dust palliatives as approved by the local agency. Special attention shall be paid to stockpiled materials. Covering of small stockpiles or areas is an alternative to applying water or other dust palliatives.

5.4 Biotechnical Erosion Control

Biotechnical erosion control (also known as soil bioengineering) is the combined use of vegetative and structural inert materials to arrest and prevent slope failures and erosion. These systems entail the use of vegetation – living and/or dead – which is planted, inserted, driven, buried, or placed on the ground surface.

Live materials, specifically vegetation, may be used to control erosion and provide geotechnical stabilization to slopes and streambanks. Vegetative materials (biologic materials) combined with structural materials (rock, wood, etc.) for erosion control is referred to as "biotechnical erosion control." Vegetation that is properly incorporated into construction projects can enhance wildlife habitat and be aesthetically pleasing. In many cases, biotechnical techniques are more cost effective than conventional structural techniques, especially when long-term maintenance and repair is considered. Frequently, aesthetic and environmental design concerns can be addressed with the inclusion of biotechnical techniques at a nominal additional expense.

5.4.1 Principles of Biotechnical Erosion Control

The basic principles that apply to conventional soil erosion control (Section 3.1) also apply in general to biotechnical erosion control. In addition, there are eight other principles that are applicable to biotechnical erosion control:

1. **Biotechnical systems use vegetation components alone or in combination with structural and/or mechanical components to stabilize soils.**
2. Biotechnical systems are strong initially and grow stronger with time as the vegetation becomes established. Biotechnical erosion control systems may withstand heavy rainfall immediately after installation. Even if initial vegetation dies, its plant material and surface residue continues to

play an important mechanical and protective role during permanent vegetation establishment.

3. In a biotechnical erosion control system, the plant material itself may provide both the structural and vegetative components of the design.

4. Biotechnical systems are useful to stabilize and protect against shallow slope failures. While vegetation can alleviate many of the problems causing larger and deeper slope failures, the vegetative components are not intended to resist large lateral earth pressures.

5. **Biotechnical systems typically use indigenous or locally adapted plant species whenever possible.**

6. Biotechnical construction activities should be scheduled during the dormant season or during periods when climatic and/or site moisture conditions will favor vegetation establishment, or provide irrigation.

7. Biotechnical erosion control systems are often more cost effective than the use of vegetative or structural components alone. Labor costs may be higher due to the cost of harvesting and handling plant materials, while material costs are often correspondingly lower.

8. Biotechnical practices are considered especially appropriate for environmentally sensitive areas such as parks, woodlands, riparian areas, and scenic corridors where aesthetics, wildlife habitat or native plantings may be critical. Biotechnical systems can require minimal access for equipment and workers and therefore can result in minor site disturbance.

Biotechnical erosion control practices are limited by the available soil medium for plant growth; rocky or gravelly slopes may lack sufficient fines or moisture to support plant growth and hard pans or compacted soils may prevent the required root growth.

5.4.2 Biotechnical Erosion Control Methods

Biotechnical erosion control methods that may used to provide structural support to the soil mass either on a slope or in a channel include:

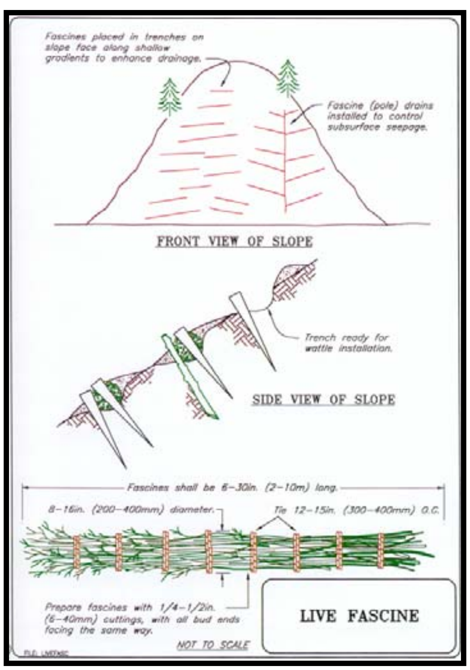
Live Staking (EP-13)

Live staking involves the insertion of live, vegetative cuttings, usually willows, into the ground in a manner that allows the cutting (stake) to take root and grow. Live stakes can create a root mat that stabilizes the soil by reinforcing and binding soil particles together. Live stake establishment can improve aesthetics and provide wildlife habitat. As a temporary measure, live staking performs an important function of stabilizing and modifying the soil,

Live stakes are appropriate for repairing small earth slips and slumps. The stakes can help buttress the soil and arching. Gullies and bare gully banks can benefit from live staking. Live stakes can be used to anchor and enhance the effectiveness of wattles, fascines, fiber rolls, turf reinforcement mats and other erosion control materials.

Live stakes may not be appropriate for areas where native willows or cottonwood are not naturally found.

Live stakes do not initially provide erosion control. They work best if used in conjunction with other erosion prevention techniques during establishment period.



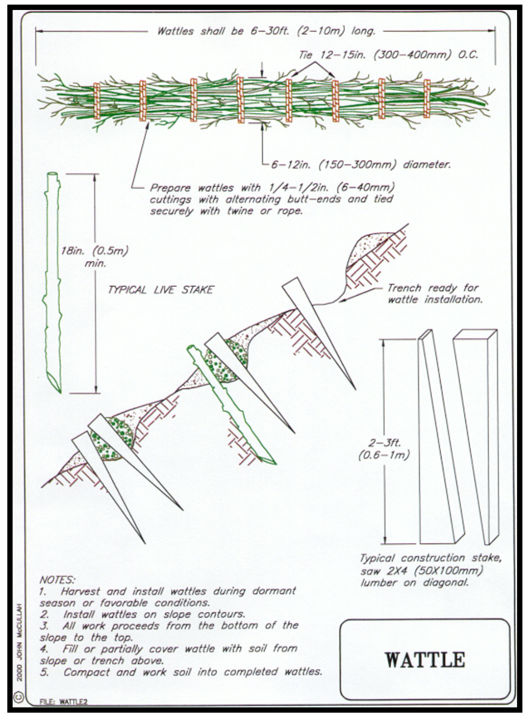
Live Fascines or Brush Wattles (EP-16).

Fascines consist of bundles of straight, long, and slender branches of shrubs and trees capable of propagation, usually willows, which are packed together in rolls that are secured with twine or rope. Fascines are prepared and installed differently from wattles in that they are assembled with the branches and bud ends oriented in the same direction.

Fascines are appropriate for use on slopes where the willow (woody branch) bundles should be placed on a gradient for intercepting and transporting surface and shallow subsurface drainage. Fascines are preferable over brush wattles in areas with high rainfall, deep snow pack or where the collection of excess water on the slope may not be desirable. Fascines and Brush Wattles are preferable over fiber rolls for slope interruption where it is feasible and desirable to establish shrubs on the slope using biotechnical erosion control techniques. Fascine drains can be used on wet slopes where there is evidence of subsurface seepage that is exacerbating erosion control problems.

The condition of adjacent sites, including identifying successful plant species, growth form, and soil types should be assessed and compared to conditions on the construction site prior choosing fascine plant species.

Brush Wattles (EP-14)



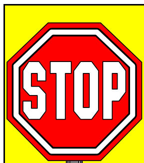
Brush Wattles consist of bundles of straight, long, and slender branches of shrubs and trees capable of propagation, usually willows, which are packed together in rolls that are secured with twine or rope. Wattles are prepared and installed differently from fascines in that they are assembled with the branches and bud ends oriented in alternating directions.

Wattles are appropriate for use on long slopes, road cuts, gullies, slumped areas, eroded slopes, or eroding streambanks. Wattling may be used to stabilize entire cut or fill slopes or localized gully areas of slopes. Wattles may be used to repair small earth slips and slumps or to protect slopes from shallow slides 1–2 feet (0.3-0.6 m) deep. Wattles may be installed on newly built slopes or as remedial action on existing slopes.

Wattling facilitates the natural invasion and establishment of plants from the surrounding plant community. Wattle stream deflectors are useful to protect disturbed streambanks resulting from road crossing excavations and watershed restoration activities.

A site reconnaissance is needed to identify species, growth form, soil and site conditions on adjacent sites and to compare their conditions to the construction site.

5.5 Proper Maintenance



The most frequent cause of BMP failure is poor maintenance. BMPs should be operated and maintained using specific guidelines and procedures identified in the BMP detail sheets. Also refer to common installation and maintenance mistakes identified in Section 8.

KEY TERMS

Erosion Control	Source Control
Best Management Practice (BMP)	Turbidity
Soil Roughening	Sheepsfoot Roller
Trackwalking	Imprinting
Biotechnical Erosion Control	Soil Bioengineering
Fiber Rolls	Wattles
Fascines	Brushlayering
Live Staking	Soil Amendments
Topsoil	Subsoil
Compost	N-P-K
Mycorrhizal Fungi	Biofertilization
Annual	Perennial
Legume	pH
Mulch	Hydraulic Mulch
Soil Stabilizer	Bonded Fiber Matrix (BFM)
Rolled Erosion Control Product (RECP)	Biodegradable
Synthetic	Maintenance

SUMMARY CHECKLIST

- Erosion Prevention is any practice that protects the soil surface and prevents the soil particles from being detached by rainfall or wind. Erosion control, therefore, is a source control that treats the soil as a resource that has value and should be kept in place.

- Whenever possible, the primary protection at the site should be erosion controls, with sediment controls used as a secondary system.

- A greater emphasis on erosion controls and other source controls is required for sites that discharge to sensitive areas and for sites with the potential to violate Oregon Water Quality Standards for turbidity.

- During construction, storm water runoff should be directed away from disturbed areas.

- Remember the Functions of Vegetation:

  - Roots hold soil together
  - Leaves and stems break up rainfall impact
  - Ground cover slows down runoff and filters sediment out of water
  - Plants evapotranspire moisture from soil

- Stripping off, storing, and redistributing topsoil over disturbed areas is a beneficial practice for re-establishment of vegetation.

- Commercial fertilizers are labeled to document the content's ratio of nitrogen (N), phosphorus (P), and potassium (K) (usually listed in order: N-P-K).

- Mycorrhizal fungi are a group of fibrous fungi existing naturally in top soils that engulf soil particles and pore spaces to absorb water and nutrients in solution and transfer this solution to the roots of plants.

- Use a seed blend to include annuals, perennials and legumes**.**

- Conduct soil test to determine pH and nutrient content.

- Roughen the soil by ripping, trackwalking, sheepsfoot rolling, or imprinting.

- Apply mulch or erosion control blanket, or other protective measure as specified, over the seeded areas.

- It is important that the longevity of temporary measures is taken into account relative to the time it takes for the vegetation to become established and provide effective erosion control.

- Conduct revegetation work when there is adequate moisture in the ground to support plant germination and growth, preferably before the wet season, or provide supplemental irrigation.

- Soil Binders have Three (3) Primary Uses:
    - As a stand alone application of liquid that forms a crust on the soil surface by binding soil particles together;
    - As a tackifying agent applied over straw or hay mulch as an alternative to crimping; and
    - In combination with hydraulic mulches to create an hydraulic matrix.

- Characteristics of Bonded Fiber Matrices Include:
    - They can be applied using standard hydraulic seeding equipment;
    - All components -fiber and adhesives - are mixed together in one bag;
    - The binder systems do not dissolve or disperse upon rewetting;
    - The dried matrix is porous, allowing water to penetrate into the soil;
    - They can be applied with or without seed and do not inhibit plant growth.

- In order for an RECP to be considered 100% biodegradable, the netting, sewing or adhesive system that holds the biodegradable mulch fibers together must also be biodegradable.
- Biotechnical erosion control is the combined use of vegetative and structural inert materials to stabilize soils.
- Biotechnical systems use vegetation components alone or in combination with structural and/or mechanical components to stabilize soils.
- The most frequent cause of BMP failure is poor maintenance. BMPs should be operated and maintained using specific guidelines and procedures

SECTION 6

SEDIMENT CONTROL

Summary

This section describes sediment control measures as passive systems that rely on filtering or settling the particles out of the water or wind that is transporting them. The most critical aspect of sediment control BMPs in a comprehensive erosion and sediment control plan is the need for their continuous monitoring, operation and maintenance.

6.1 Definition of Sediment Control

Sediment control is any practice that traps the soil particles after they have been detached and moved by wind or water. Sediment control measures are usually passive systems that rely on filtering or settling the particles out of the water or wind that is transporting them. Sediment control treats the soil as a waste product that must be removed from where it has been transported and accumulated and disposed of at another location.

Sediment control should be provided along the site perimeter and at all operational internal storm drain inlets at all times during construction. Active inlets should be considered part of the site perimeter because they provide an avenue for sediment and other pollutants to leave the site.

Emphasis should be placed on source controls and not sediment controls. Retaining natural vegetation as long as possible is one of the best and least expensive source control measures available. While important, sediment control measures should be considered the "last line of defense" before storm water runoff leaves the site and not a primary pollution control method. Additionally, all sediment control devices require more maintenance to perform properly than source control measures, so always keep in mind that the designation of sediment control measures on a site includes an obligation for future maintenance.

6.2 Sediment Control Measures

The following sediment control BMPs are discussed in this section and BMP details are provided in Appendix F:

SC-1 *Sediment Fence*
SC-2 *Sand Bag Barrier*
SC-3 *Gravel Bag Berm*
SC-4 *Straw Bale Dike*
SC-5 *Rock and Brush Filters*
SC-6 *Compost Berm/Compost Sock*
SC-7 *Fiber Rolls / Wattles*
SC-8 *Storm Drain Inlet Protection*
SC-9 *Temporary Sediment Basin*
SC-10 *Entrance / Exit Tracking Controls*
SC-11 *Entrance / Exit Tire Wash*
SC-12 *Undercut Lots*

6.2.1 Temporary Linear Barriers / Perimeter Controls

Linear barriers and perimeter controls are temporary measures that intercept sediment-laden runoff and filter or trap sediment or non-storm water flows behind the barrier. Linear barriers and perimeter controls are the last line of defense before storm water leaves the site, and must be carefully selected, properly installed, and diligently maintained. Examples include:

- Sediment fences (SC-1)
- Sand bag barriers (SC-2)
- Gravel bag berms (SC-3)
- Straw/hay bales (SC-4)
- Rock Filters (SC-5)
- Brush filters (SC-5)
- Compost berms and compost socks (SC-6)
- Fiber rolls or wattles (SC-7)
- Undercut lots (SC-12)

Fiber rolls used as perimeter control

Sediment fence and gravel bags used as perimeter control

Compost berm being applied in combination with gravel bags as perimeter control.

Brush filters being constructed for perimeter control.

These barriers are designed for sheet flow, not concentrated flow, and must never be placed across a stream or channel. Therefore, the topography and drainage patterns are important considerations in the design of the linear barriers. Barriers should be placed on the same contour, and it is important that barriers be properly installed and keyed into the soil to prevent undermining (i.e. flow passing under the barrier). For sediment fence in particular, the contributory drainage area should not exceed 100 square feet per lineal foot of fence.

It is important to select the correct BMP for the intended application, particularly for the use of sand bags versus gravel bags. Sand bags are much less permeable than gravel bags and are appropriate when used to block and contain non-storm water flows (e.g., discharges from concrete saw cutting) but can result in flooding when used to control storm water flows.

Similarly, it is important to understand that straw or hay bales are very dense and typically do not filter flow. Instead, they cause water to pond and spill over the top of the barrier. Some local governments may not approve straw or hay bale barriers as a BMP.

Undercut lots can provide an effective sediment retention area. By undercutting sidewalks, parkways, or lots early in the construction process there is room to store runoff and sediment in the area that is below the curb and prevent it from entering the gutter.

Gravel bags and other devices that allow filtration should be used for sediment control applications where the goal is to slow water and promote ponding behind the barrier but still allow flow through the device to discharge with a reduced flooding potential.

6.2.2 Temporary Inlet Protection (SC-8)

Gravel Bags

Temporary inlet protection must be provided for all active inlets for the duration of construction to keep sediment, trash, and other construction-related pollutants out of the storm drain system. A variety of temporary inlet protection devices are available that are designed to be installed on soil, on pavement, or inside the inlet, including:

- Block and gravel inlet protection
- Sediment fence inlet protection (alone or with gravel bags)
- Gravel bags (alone or combined with mesh screen). Important Note: Sand bags are not typically recommended for inlet protection unless they are being used on a short-term basis to block or divert non-storm water flows (e.g. water used during pavement saw-cutting)
- Weighted fiber rolls (i.e., fiber rolls with a gravel core designed for use on pavement)
- Under-grate filters
- Inlet insert devices
- Prefabricated inlet protection devices

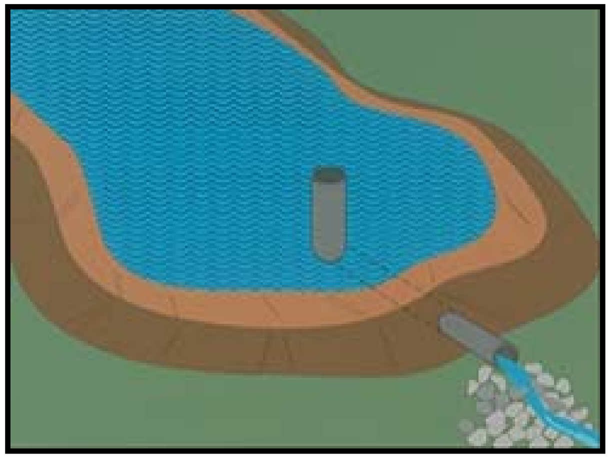
Sediment fence with gravel bags

Weighted fiber roll used in combination with heavy duty gravel bags for inlet protection

Prefabricated inlet protection device

Filter fabric inlet protection

6.2.3 Temporary Sediment Traps/Basins (SC-9)



Temporary sediment traps and basins are designed temporary hydraulic controls that function by modifying the storm runoff hydrograph by the following:

- Capturing and detaining sediment-laden storm water runoff from the site, thus providing an opportunity for suspended soil particles to gravitationally settle out
- Providing a temporary storage device for the captured sediment.

Temporary sediment traps and basins may be constructed by excavating below grade or by constructing an embankment to retain water. All basins should have an outlet device to release the water in a controlled manner and a stabilized emergency spillway for overflow. Outlet devices should be sized to empty the basin within 48 hours.

Basins should be sized and maintained in accordance with local requirements. If there are no local requirements, basins should be sized to retain 3600 cubic feet per acre of contributing watershed. Additional capacity should be added to store accumulated sediment between maintenance clean-outs. All engineered structures must be designed by a professional engineer licensed in the state of Oregon.

All sediment traps require continued maintenance to function properly. Excess sediment not removed reduces the basin capacity and trap efficiency.

> Sediment basins are typically not recommended for sites with fine-grained soils such as silts and clays, because these soils will stay in suspension for a long time. It may be infeasible to hold the water long enough for fine-grained suspended sediment to settle out of suspension. Additionally, water that is left standing for more than 48 hours may become a potential mosquito breeding area.

Sediment basins must be cleaned out when sediment storage zone is half full. Sediment removed from basins must be placed, compacted, and stabilized to avoid erosion and re-mobilization. The sediment shall not be deposited downstream from the embankment or in or adjacent to a stream or floodplain. If there is a potential for the sediment to be contaminated, it must be tested and disposed of properly.

Certain flocculants may be added to the water in a sediment basin to increase the suspended sediment settling rate. These flocculants include gypsum (a natural mineral product), chitosan (a shellfish product), and other materials. Manufacturer's recommendations should be followed regarding rate of application and care should be taken to avoid the release of flocculant from the basin. Always check local municipality requirements when planning to utilize flocculants.

Electrocoagulation may be used to remove suspended solids and other contaminants from storm water runoff. It is a process whereby a controlled electrical current is passed through the water, which causes the suspended particulates to become charged and bond together to form larger masses that settle to the bottom. This process is effective on any size of suspended solids, including sub-micron particles, and is typically combined with filtration to enhance effectiveness.

The removal efficiency of sediment basins can also be enhanced by using baffles, skimmers, or other devices to lengthen the flow path and/or improve the removal of suspended particles. The placement of baffles in a sediment basin creates a longer flow path through the basin, which results in a longer holding time, which results in increased settling of particulates. A skimmer is a device that is attached to the sediment basin outlet in lieu of a slotted riser, and floats on the water's surface above the settling zone. The skimmer has a designed orifice size that drains water out of the pond at a specific rate.

The basin configuration also has an effect on performance. To improve the sediment trapping efficiency of the basin, the effective flow length should be twice the effective width. This basin shape may be attained by properly selecting the site of the basin or by the use of baffles.

6.2.4 Tracking Controls

Tracking controls reduce offsite tracking of sediment and other pollutants by providing a stabilized entrance at defined construction site entrances and exits and/or providing methods to clean-up sediment or other materials to prevent them from entering a storm drain by sweeping or vacuuming. These measures include:

- Stabilized gravel construction entrances (SC-10)
- Entrances with shaker plates (SC-10)
- Wheel wash facilities (SC-11)
- Street sweeping or vacuuming (SC-10)

The points of entrance/exit to the construction site should be limited by designating combination or single purpose entrances and exits, and entrances and exits should be clearly marked with appropriate signage. All employees, subcontractors and others should be required to use the designated entrances, and the speed of vehicles on unpaved areas of the site should be limited to control dust.

It is important that the proper size of aggregate, underlying geotextile fabric, and length of pad be installed. In order to be effective, the pad should be long enough for at least 4 to 5 wheel rotations of the largest vehicle or equipment on site, and not less than 50 feet in length.

Stabilized entrance/exits should be designed to support the heaviest vehicles and equipment that will use it. The use of constructed or constructed/manufactured steel plates with ribs (e.g., rumble plates or corrugated steel shaker plates) for entrance/exit access is allowable, and may increase the effectiveness of a gravel entrance.

All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed as soon as possible. Visible sediment tracking should be swept or vacuumed as needed. Manual sweeping is appropriate for small jobs. For larger projects, it is preferred to use mechanical broom or vacuum sweepers that collect and contain removed sediment and material.

Washing of sediment from the public right-of-way shall be prohibited. If not mixed with debris or trash the removed sediment may be used on the project site or deposed of at an approved disposal site.

When necessary, wheels shall be cleaned to remove sediment prior to entrance onto public rights-of-way (see SC-11). The wheel wash, which should be incorporated with a stabilized construction entrance, must be designed and constructed/manufactured for anticipated traffic loads. It may be a drive-through facility or a hose and wash pad. It is important to provide a drainage conveyance that will convey the runoff from the wash area to a sediment trapping device. All employees, subcontractors, and others that leave the site with mud-caked tires and/or under-carriages should use the wheel wash facility.

6.2.5 Slope Interrupter Devices

Temporary slope interrupter devices such as fiber rolls (SC-7) may be provided to trap sediment and moisture on slopes until vegetation can provide long-term stabilization. Slope interrupter devices typically include a photodegradable mesh enclosing a biodegradable fiber, which may be staked to the slope approximately along the slope contours.

6.3 Proper Maintenance

The most frequent cause of BMP failure is poor maintenance. The BMPs should be operated and maintained using specific guidelines and procedures. Maintenance guidelines are summarized in Section 8. Detailed maintenance guidelines are provided in the BMP details in Appendix F. In addition to the maintenance guidelines in the BMP specifications, check local agency requirements.

KEY TERMS

Sediment Control	Passive system
Filtering	Settling
Sediment trap	Sediment basin
Retention	Detention
Trap efficiency	Flocculent
Linear barriers	Perimeter controls
Permeability	Inlet filters
Stabilized construction entrance	Wheel wash
Straw bales	Sediment fence
Fiber rolls	Gravel bag berms
Sand bag barriers	Gravel barriers
Compost berms and socks	

SUMMARY CHECKLIST

- All sediment traps require continued maintenance to function properly. Excess sediment not removed reduces the basin capacity and trap efficiency.

- Sediment basins are typically not recommended for sites with fine-grained soils such as silts and clays, because these soils will stay in suspension for a long time.

- Water that is left standing for more than 48 hours may become a potential mosquito breeding area.

- Certain flocculants may be added to the water in a sediment basin to increase the suspended sediment settling rate.

- Gravel bags and other devices that allow filtration should be used for sediment control applications where the goal is to slow water and promote ponding behind the barrier but still allow flow through the device to discharge with a reduced flooding potential.

- The most frequent cause of BMP failure is poor maintenance. The BMPs should be operated and maintained using specific guidelines and procedures.

- Sediment fences should be removed and the accumulated sediment dispersed to a stable area when the surrounding vegetation reaches effective erosion control coverage.

SECTION 7
NON-STORM WATER POLLUTION CONTROLS

Summary

This section defines and identifies ESCP requirements for non-storm water pollution controls and summaries individual control measures.

7.1 Definition of Non-Storm Water Pollution Controls

Non-storm water pollution controls consist of general site and materials management measures that directly or indirectly aid in minimizing the discharge of sediment and other construction related pollutants from the job site. Construction site work activities can generate a variety of pollutants, many of which are summarized in Table 7-1.

The NPDES storm water regulations for construction sites require that BMPs be included in the ESCP for control of non-storm water discharges. These BMPs must be in-place throughout the grading and construction phases.

The NPDES 1200-C General Permit requires that the following non-storm water pollution control measures be included on the ESCP where applicable. Note that local jurisdictions may have specific requirements regarding non-storm water pollution controls.

NPDES 1200-C General Permit required control measures

- Areas used for storage of soils or wastes.
- Stockpile protection.
- Non-storm water pollution control measures to prevent or minimize exposure to spills, cleaning and maintenance activities, and waste handling.

Controls should also be included for the following additional activities:

- Proper material use and storage
- Vehicle and equipment cleaning, fueling, and maintenance
- Paving and concrete management
- Contaminated soil management
- Ponded water management
- Any other activity with the potential to contribute to off-site pollutant discharges.

Table 7-1. Construction Site Work Activities and Associated Pollutants

General Work Activity/Products With Potential Storm Water Pollutants	Specific Work Activity/Products With Potential Storm Water Pollutants	Associated Visible Pollutant Indicator	Associated Non-Visible Potential Pollutants
Adhesives	• Adhesives, glues, resins, epoxy synthetics, PVC cement • Caulks, sealers, putty, sealing agents and • Coal tars (naphtha, pitch)	Oily sheen or other discoloration from some products.	Phenolics, formaldehydes, asbestos, benzene, phenols and naphthalene
Asphalt paving/curbs	• Hot and cold mix asphalt	Oil sheen	Oil, petroleum distillates
Cleaners	• Polishes (metal, ceramic, tile) • Etching agents • Cleaners, ammonia, lye, caustic sodas, bleaching agents and chromate salts	Discoloration / plume from some products	Metals, acidity/alkalinity, chromium
Concrete / Masonry	• Cement and brick dust • Colored chalks • Concrete curing compounds • Glazing compounds • Surfaces cleaners • Saw cut slurries • Tile cutting	Discoloration / plume from some products	Sediments, acidity, metals, asbestos, particulates
Drywall	• Saw-cutting drywall	Discoloration/plume from drywall dust	Copper, aluminum, sediments, minerals, and asbestos
Framing/Carpentry	• Sawdust, particle board dust, and treated woods • Saw cut slurries	Sawdust, slurry plume	BOD, formaldehyde, copper and creosote
Grading / Earthwork	• Blasting • Dewatering • Grading activities • Vegetation removal • Disturbance of contaminated soil	Sediment discharge/plume, non-storm water discharges, vegetation debris	Soil amendments (gypsum, lime), historic soil contaminants
Heating, Ventilation, Air Conditioning	• Demolition or construction of air condition and heating systems	None	Asbestos, freon
Insulation	• Demolition or construction involving insulation, venting systems	None	Asbestos, aluminum, zinc
Liquid waste	• Wash waters • Irrigation line testing/flushing	Non-storm water dishcharges, detergents, sediment, oily sheen, concrete rinse or other plume.	See non-visible pollutants listed in other categories.

Table 7-1. Construction Site Activities and Associated Pollutants

General Work Activity/Products With Potential Storm Water Pollutants	Specific Work Activity/Products With Potential Storm Water Pollutants	Associated Visible Pollutant Indicator	Associated Non-Visible Potential Pollutants
Painting	• Paint thinners, acetone, methyl ethyl ketone, stripper paints, lacquers, varnish, enamels, turpentine, gum spirit, solvents, dyes, stripping pigments and sanding	Paint plume	VOCs, metals, phenolics and mineral spirits
Planting / Vegetation Management	• Vegetation control (pesticides/herbicides) • Planting • Plant maintenance • Vegetation removal	Mulch, sediment, vegetation	BOD, fertilizers, pesticides, herbicides, nutrients (nitrogen, phosphorous, and potassium) acidity/ alkalinity, metals, aluminum sulfate, sulfur
Plumbing	• Solder (lead, tin), flux (zinc chloride), pipe fitting • Galvanized metal in nails, fences, and electric wiring	None	Lead, copper, zinc and tin
Pools/fountains	• Chlorinated water	Non-storm water discharges	Chlorine or other disinfectant
Removal of existing structures	• Demolition of asphalt, concrete, masonry, framing, roofing, metal structures.	Sediment, other particulates	Toxics (paint strippers, solvents, adhesives), trace metals (galvanized metal, painted surfaces, preserved wood),
Roofing	• Flashing • Saw cut slurries (tile cutting) • Shingle scrap and debris	Debris, slurry plume	Oil, petroleum distillates
Sanitary waste	• Portable toilets • Disturbance of existing sewer lines.	Visible sanitary waste	Bacteria, BOD, pathogens
Soil preparation/amendments	• Use of soil additives/amendments	Mulch, sediment	Soil amendments
Solid waste	• Litter, trash and debris • Vegetation	Plastic, paper, cigarettes, wood products, steel, vegetation waste, etc	
Utility line testing and flushing	• Hydrostatic test water • Pipe flushing	Non-storm water discharge, sediment	Chlorine
Vehicle and equipment use	• Equipment operation • Equipment maintenance • Equipment washing • Equipment fueling	Oil sheen, sediment	Total petroleum hydrocarbons, coolants, benzene and derivatives

During preparation of the ESCP, it is not always possible to know where a contractor will be performing certain activities. In order to provide the contractor with flexibility but to assure that proper control measures are implemented, it is appropriate to identify in the ESCP that specific BMPs will be implemented for certain activities regardless of where on the site those activities are performed.

7.2 Non-Storm Water Pollutant Control BMPs

The following non-storm water pollutant control BMPs are discussed in this section and BMP details are provided in Appendix G:

NS-1 *Dewatering and Ponded Water Mangement*
NS-2 *Paving Operation Controls*
NS-3 *Temporary Equipment Bridge*
NS-4 *Illicit Connection / Illegal Discharge*
NS-5 *Vehicle and Equipment Cleaning*
NS-6 *Vehicle and Equipment Fueling, Maintenance, and Storage*
NS-7 *Material Delivery and Storage Controls*
NS-8 *Material Use*
NS-9 *Stockpile Management*
NS-10 *Spill Prevention and Control Procedures*
NS-11 *Solid Waste Management*
NS-12 *Hazardous Materials and Waste Management*
NS-13 *Contaminated Soil Management*
NS-14 *Concrete Management*
NS-15 *Sanitary Waste Management*
NS-16 *Liquid Waste Management*
NS-17 *Training and Signage*

Dewatering and Ponded Water Mangement (NS-1)

Dewatering operations controls prevent or reduce the discharge of pollutants to the storm drain system or to watercourses from dewatering operations by using sediment controls and by testing the discharges for pollution.

Paving Operations Controls (NS-2)

Paving and grinding operations controls minimize pollution of storm water runoff during paving operations. The purpose is to prevent and reduce the discharge of pollutants by properly disposing of wastes and by implementing measures to control run-on and prevent runoff from picking up pollutants and carrying them into the storm drain system or to watercourses.

Temporary Equipment Bridge (NS-3)

Temporary equipment bridges are temporary structures placed across a waterway that allow vehicles to cross the waterway during construction without entering the water to prevent erosion caused by vehicles. Controls include culverts, fords, and bridges which must be designed properly to avoid flow restrictions, washouts, and scour. Note that use of temporary equipment bridges may require permits from the US Army Corps of Engineers (USACE) and/or the Oregon Department of State Lands (DSL), depending on the project scope and location.

Illicit Connection / Illegal Discharge Detection and Reporting (NS-4)

Illicit connections to the storm drain system and wastes discharged illegally are prohibited and can cause water quality impacts. This BMP identifies inspection and reporting procedures for contractors to identify illicit connections and illegal discharges at their job site.

Vehicle and Equipment Cleaning (NS-5)

Vehicle and equipment cleaning controls are procedures and practices to minimize or eliminate the discharge of pollutants from vehicle and equipment cleaning to the storm drain system or to watercourses.

Vehicle and Equipment Fueling, Maintenance, and Storage (NS-6)

Vehicle and equipment fueling, maintenance and storage controls are procedures and practices to minimize or eliminate the discharge of fuel and lubricant spills and leaks to the storm drain system or to watercourses.

Material Delivery and Storage (NS-7)

Material delivery and storage controls are procedures and practices for the delivery and storage of materials in a manner that minimizes or eliminates the discharge of these materials to the storm drain system or to watercourses.

Material Use (NS-8)

Material use controls are procedures and practices for use of construction materials in a manner that minimizes or eliminates the discharge of these materials to the storm drain system or to watercourses.

Stockpile Management (NS-9)

Stockpile management controls are procedures and practices to reduce or eliminate air and storm water pollution from stockpiles of soil, sand, and paving materials such as Portland cement and asphalt concrete rubble, asphalt concrete, aggregates, asphalt binder (so called "cold mix" asphalt) and pressure treated wood.

Spill Prevention and Control Procedures (NS-10)

Spill prevention and control measures are procedures and practices to prevent and control spills in a manner that minimizes or eliminates the discharge of spilt material to the storm drain system or to watercourses.

Solid Waste Management (NS-11)

Solid waste management controls are procedures and practices to minimize or eliminate the discharge of pollutants to the storm drain system or to watercourses as a result of the creation, stockpiling, and removal of construction site wastes.

Hazardous Materials and Waste Management (NS-12)

Hazardous materials and waste management controls are procedures and practices to minimize or eliminate the discharge of pollutants from construction site hazardous waste to the storm drain system or to watercourses.

Contaminated Soil Management (NS-13)

Contaminated soil management controls are procedures and practices to minimize or eliminate the discharge of pollutants to the storm drain system or to watercourses as a result of construction activity in or near contaminated soils.

Concrete Management (NS-14)

Concrete management controls are procedures and practices to minimize or eliminate the discharge of concrete residuals during material use and wastes to the storm drains system or to watercourses.

Sanitary Waste Management (NS-15)

Sanitary and septic waste management controls are procedures and practices to minimize or eliminate the discharge of construction site sanitary/septic waste materials to the storm drain system or to watercourses.

Liquid Waste Management (NS-16)

Liquid waste management is applicable to construction projects that generate non-hazardous by products, residuals, or wastes, such as drilling slurries and drilling fluids, grease-free and oil-free wastewater and rinse water, dredging spoils, or other non-storm water liquid discharges not permitted by separate permits. This BMP presents waste management and disposal requirements for liquid wastes.

Training and Signage (NS-17)

Training of contractor and subcontractor personnel is an essential component to good storm water management. When properly trained, site personnel are more capable of managing materials properly, preventing spills, and implementing control practices efficiently and correctly. This BMP presents general guidelines for personnel training including recommended signage requirements to inform personnel of storm water related information relevant to the site.

KEY TERMS

- Non-storm water
- Spill prevention
- Equipment cleaning
- Paving
- Contaminated
- Material storage
- Waste management
- Fueling and maintenance
- Concrete
- Ponded water

SUMMARY CHECKLIST

- The NPDES storm water regulations for construction sites also require that BMPs be included in the ESCP or control of non-storm water discharges. These BMPs must be in-place throughout the grading and construction phases.
- These BMPs must be in-place throughout the grading and construction phases.

SECTION 8
INSPECTION AND MAINTENANCE

Summary

This section presents site inspection requirements for the NPDES 1200-C General Permit as well as additional guidelines for conducting an initial site walk-through, vegetation monitoring, and reporting. Common BMP installation mistakes and maintenance guidelines are also presented.

8.1 Inspection Guidelines

The BMPs identified in an ESCP are designed to minimize the transport of contaminants to receiving waters. BMP performance is dependent on how the measures are implemented and maintained and the severity of weather conditions during their implementation.

To provide for the continued performance of the measures, BMPs should be inspected before, during, and after significant storm events. During grading and construction, the permittee's responsible for maintaining the storm water pollution control measures.

8.1.1 Contractor/Permittee's Inspection Responsibilities

In accordance with the NPDES 1200-C General Permit, active sites must be inspected by the permittee or the permittee's representative (typically the contractor) daily during storm water or snowmelt runoff and within 24 hours after any storm event greater than 0.5 inches in a 24-hour period. Active sites must be inspected at least every 7 days during periods of no runoff. Any site that is inactive for greater than 7 days must be inspected every two weeks. Exposed areas must be stabilized and inspected before a site is left in an inactive state.

The permittee's inspector should record any damages or deficiencies in the control measures on an inspection report form. The damage or deficiencies should be corrected as soon as practicable after the inspection but in no case later than 7 days after the inspection or sooner in accordance with local requirements. Any changes that may be required to correct deficiencies in the ESCP should also be made as soon as practicable after the inspection but in no case later than 7 days after the inspection or sooner in accordance with local requirements.

All disturbed areas of the site, areas for material storage, locations where vehicles enter or exit the site, and all the erosion, sediment, and pollution controls that are identified as part of the plan must be inspected. Problem areas must be documented, and control measures identified and implemented immediately. This effort must continue for the duration of time it takes for the site to be finally stabilized and any permanent measures required by the ESCP are in place and performing adequately.

During rainfall events, the permittee's inspector should be empowered to call out maintenance crews to inspect and immediately repair the erosion and sediment control measures. Appropriate materials and equipment should be kept on hand to enable a quick and rapid response. Also, some municipalities have specific "on-hand" emergency supply requirements that must be followed.

8.1.2 Initial Site Walk-Through and Agency Inspections

Following installation of erosion and sediment control measures, as well as other control measures, a walkthrough or site inspection should be conducted to ascertain that all measures have been implemented in the field, that erosion is being controlled, and that sediment and other pollutants are not being transported off-site or into critical areas on-site. Any improper installation or any repairs necessary to complete the job should be noted at this time and completed as soon as possible and in accordance with maintenance schedules required by the local municipality. It should be noted that some local municipalities may also have timeliness requirements based on the nature of repairs.

Another purpose of the site walkthrough is to identify critical inspection locations and monitoring points where control measures will need to be routinely checked for performance and checked after storm events.

The critical points for inspection must include:

- All disturbed areas of the site
- Material storage areas control of non-storm water pollutants
- Locations where vehicles enter or exit the site
- All erosion and sediment control BMPs
- Discharge outfall visual monitoring points

BMPs must be in good operating condition until the area they protect has been completely stabilized and the construction activity is complete. In the absence of significant storm events, all monitoring points must be inspected by the permittee in accordance with any schedule required by the local agency and before any predicted, significant rainfall.

Inspections by local jurisdictions with oversight responsibility as DEQ agents, or as authorized by local ordinances, should be conducted throughout the project at a frequency dictated by the agreement between DEQ and the jurisdiction, or by local policies and procedures.

8.1.3 Vegetation Establishment Criteria

Since vegetation typically is the primary form of permanent erosion control, it is important to ascertain how quickly and how well the vegetation is becoming established. Monitoring for vegetation establishment should be conducted for all applicable projects in accordance with local requirements. General guidelines for vegetation establishment monitoring are as follows. Vegetation should be monitored monthly to evaluate the following:

- The type of vegetation that is growing (as compared to the type of vegetation that was planted);
- The density of vegetation that is growing, including the percent of ground that is covered; and
- Any areas of erosion, including the type of erosion (such as sheet erosion, rilling, gullying, localized scour, etc.)

Based on regular evaluations of vegetation establishment, recommendations should be made as to whether the vegetation is establishing well, or whether additional measures should be taken, such as over-seeding, fertilizing, erosion repair, or irrigation. Vegetation monitoring should continue until the vegetation reaches maturity and is providing the anticipated erosion control effectiveness.

8.1.4 Inspection and Maintenance Reports

Inspection reports should be prepared during each inspection conducted by the permittee or contractor. Reports should include information on damages or deficiencies, maintenance or repair activities, monitoring information, and vegetation establishment. Inspection reports should be kept for a period of three years after completion of final site stabilization.

8.2 Common BMP Installation Mistakes and Maintenance Guidelines

The most frequent causes of BMP failure are lack of preventative practices and poor maintenance of installed BMPs. Erosion prevention and sediment control BMPs must be inspected regularly and operated and maintained using specific procedures to perform properly. Installation mistakes can also impair BMP performance. Inspectors should pay particular attention to BMP maintenance problems and installation mistakes during inspections. Common installation mistakes and maintenance problems for erosion prevention, sediment control, and runoff control BMPs are identified by BMP in Table 8-1. Additional information on BMP installation and maintenance can be found within the BMPs included in the appendices of this manual, local municipalities' manuals or and BMPs included with the site-specific ESCP.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
Erosion Prevention (EP)			
EP-1	Scheduling	• Failure to consider scheduling and timing of construction activities to limit work during the rain season or prior to or during anticipated storms. • Failure to minimize the amount of soil disturbed at any given time.	• Consider the scheduling and timing of construction activities relative to potential pollutant impacts throughout construction.
EP-2	Preservation of Existing Vegetation	• Protective fencing is placed too close to the tree instead of at the drip line, resulting in over-compaction over the root zone.	• Check that protective fencing is clearly marked and installed at appropriate areas, particularly to protect sensitive vegetation areas and buffer zones.
EP-3	Surface Roughening	• Roughening the slope in the wrong direction. Slope roughening should be performed parallel to the slope contours and perpendicular to the direction of flow. If a slope is roughened perpendicular to the slope contours, it can cause runoff to concentrate on the slope face and result in the development of rills and gullies.	• Check seeded slopes for signs of erosion such as rills and washes. Fill these areas slightly above original grade, then roughen, reseed, and mulch as soon as possible.
EP-4	Topsoiling	• Site topsoils are poor quality and not recognized as such. • Deficient topsoil not amended with necessary nutrients and microorganisms for sustainable plant growth and erosion-resistant topsoil.	• Soil horizons should be removed and stored in segregated piles, preferably less than 1 meter high, until reapplied as topsoil. • Topsoil stored longer than 6 months should be re-seeded to maintain microorganisms.
EP-5	Temporary Seeding and Planting	• Improper calculation of seeding rate, based on seed purity and germination information.	• Inspect frequently to verify that vegetation is growing. • Reseed areas to prevent sheet and rill erosion. Spot seed in small areas.
EP-6	Permanent Seeding and Planting	• Improper calculation of seeding rate, based on seed purity and germination information.	• Inspect frequently to verify that vegetation is growing. • Reseed areas to prevent sheet and rill erosion. Spot seed in small areas.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
EP-7	Mycorrhizae / Biofertilizers	• Applying mycorrihizae at incorrect application rates. • Applying too much phosphorous or applying fungicides that limit mycorrhizal effectiveness.	• If plants are not growing vigorously, analyze mycorrhizal density in soil to determine if more is needed.
EP-8	Mulches	• Improper calculation of amount of mulch needed resulting in inadequate coverage. It is important to calculate the slope area and take into account the roughness, which can affect how much mulch is needed to obtain the specified application rate. • Improperly applying bonded fiber matrix. If the matrix is not applied from multiple directions, it can result in “shadowing,” which results in inadequate coverage of the soil. • Placing straw[1] without properly crimping, netting, or tackifying the straw to the ground. This can result in loose straw becoming mobilized by wind or water, and an inadequately protected slope. • Insufficient straw depth to prevent erosion of soil and loss of seeds.	• Monitor for short-term performance (longevity of surface treatment) and long-term performance (vegetation establishment). • Loss of mulch material and seed through sheet or rill erosion should be repaired through reapplication. • General surface slippage or lack of vegetation establishment should be investigated and treated on a site specific basis. • Reapply sufficient thickness of straw to cover soil and seeds.
EP-9	Compost Blankets[2]	• Application in areas of concentrated flow and at less than optimal thicknesses (see BMP for recommendations).	• Check compost thickness and inspect for signs of rill or gully erosion. • Re-apply compost blanket to maintain specified

[1] Local straw sources should be used. State agriculture authority may disallow use of straw from elsewhere due to spread of noxious weeds, disease, and other concerns.

[2] To prevent cross-contamination of storm water, compost source materials should be derived from “green” feedstocks that are free of contaminants (e.g., manure, treated or painted wood), and preferably certified accordingly.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
			thickness. • Maintain runoff controls and divert upgradient flows.
EP-10	Erosion Control Blankets and Mats	• Not enough staples holding a rolled erosion control product (RECP) in-place can result in erosion occurring under the blanket (underrilling). • Stretching the RECP too tightly, rather than draping it across the terrain, can result in vegetation pushing the blanket up, losing contact with the soil. • Installing the overlaps in wrong direction can result in the blanket being lifted by the runoff. Providing inadequate overlaps between adjacent blankets can result in erosion occurring between the blankets. • Not trenching the blanket at the top of slope can result in the blanket being lifted by the runoff, or water flowing under the blanket. • Improper soil preparation	• Check for erosion and undermining. Repairs should be made immediately. • Repair slope if washout or breakage occurs and re-install material.
EP-11	Soil Binders	• Product not applied at manufacturer's specification • Applying stabilizers/tackifiers without sufficient drying time before rainfall (typically 24 hours). • Selecting a product that is not best suited for the area installed (considering longevity, curing time, resistance to abrasion, and compatibility with existing vegetation).	• Soil binders must be maintained by reapplying in high traffic areas, after storm events, or after being in-place for an extended period.
EP-12	Stabilization Mats	• Possible increased sedimentation or undesirable flow disruption if mats are placed incorrectly.	• Check vehicles and equipment using mats for gas, oil and fluid leaks.
EP-13	Wind Erosion Control	• Inadequate application rate is used or binder selection is inappropriate for the soil type.	• Water, tackifiers, or covers must be re-applied or maintained to maintain effectiveness.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
EP-14	Live Staking	• Improper handling of living vegetation. It is important that the living vegetation be cut during its dormant period and handled properly. Placing the bud end rather than the butt end of a live stake into the ground, for example, can preclude the stake from rooting and leafing. It is also important to keep the cuttings moist prior to placement.	• Irrigation required if installed in arid areas.
EP-15	Pole Planting	• Failure to soak the poles for 5 to 7 days or install the pole through the vadose zone and below the permanent water table.	• Inspect for vegetation growth in accordance with vegetation establishment criteria (Section 3.4)
EP-16	Live Fascines and Brush Wattles	• Toe erosion and/or flanking can cause loss of the structure, if not combined with a toe protection in areas where shear stresses and velocities exceed limits for the soils underlying the structure. Flanking can be caused by insufficient keying-in of the structure.	• Fascines should be keyed into the bank at least 3 ft (1 m) on both upstream and downstream ends. • Proper backfilling is essential to the successful rooting of the fascine. • Inspections should occur after each of the first few floods, and/or twice the first year, and at least once each year thereafter.
EP-17	Brush Box	• Proper backfilling is essential to the successful rooting of the brush box. The backfill shall be worked into the cutting interstices during construction and compacted behind and below the bundle by walking on and working from the brush box terrace.	• Inspect for vegetation growth in accordance with vegetation establishment criteria (Section 3.4) Check for proper backfill and that non-rooting species are not more than 50% of woody material.
EP-18	Fascines with Subdrains	• The subdrain must be properly designed, correctly sized and wrapped with a suitable geotextile to exclude fines and allow water through.	• Failure to inspect and flush the drain as necessary based on inspections via the clean-out access tube can lead to clogging and poor performance.
EP-19	Live Pole Drains	• Use of pole drains when a surface runoff control measure is necessary	• Stakes must be reinstalled if loosened due to saturation of the slope or frost action. • Rills and gullies around wattles must be repaired.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
EP-20	Brush Packing or Live Gully Fill Repair	• Seepage and runoff must be excluded from the fill area as much as possible to reduce risk of saturation and washout.	• Diversion of runon away from fill areas must be maintained during initial stages of vegetation establishment. • Check for wet spots or seeps in fill which indicate subsurface seepage problems. Examine surface of fill for evidence of runoff erosion such as rills.
EP-21	Sodding	• Failure to use certified materials, properly prepare the subgrade (even surface of healthy soil, free of weeds and debris), and roll sod after installation to ensure good contact with soil.	• Inspect for vegetation growth in accordance with vegetation establishment criteria (Section 3.4) • Maintenance should consist of mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth.
Sediment Control (SC)			
SC-1	Sediment Fence	• Sediment fence stake pockets should be placed on the uphill side of the sediment fence, so if the stitching of the pocket pulls out, the fabric will still drape against the stakes. • The bottom of the fabric of the fence should be trenched into the ground, or else water and sediment can flow under the sediment fence. • The sediment fence should be placed on the contour, or else a "flume" will be created where flow and sediment can concentrate. A failure is likely to occur at such a concentration point, and the flume will release concentrated flow and sediment down the face of the slope. • Sediment fence is designed for sheet flow only, and should never be placed over concentrated flows, such as channels or streams.	• Sediment fences should be cleaned of accumulated sediment after each major storm, or when deposition is 1/3 of the barrier height. • Breaks or overtopped areas should be replaced or repaired immediately. Fences should be repaired and the accumulated sediment dispersed to a stable area. • Sediment fence should be removed when the area being protected is fully stabilized and prior to termination of permit coverage.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
		• Sediment fence is designed for relatively small drainage areas, and should not be placed at the bottom of a large drainage area that will overwhelm the sediment fence in the first storm event.	
SC-2	Sand Bag Barrier	• Flooding when sand bags are used where gravel bags are appropriate. Sand bags are less permeable than gravel bags and should be used to block flow such as non-storm water discharges.	• Barriers should be cleaned of accumulated sediment after each major storm.
SC-3	Gravel Bag Berm	• Use of gravel bags when sand bags are more appropriate. Gravel bags should be used for most sediment control applications but should not be relied on solely to block flows such as non-storm water from entering storm drains.	• Barriers should be cleaned of accumulated sediment after each major storm.
SC-4	Straw Bale Dike[3] (note: some jurisdictions don't allow straw bale dikes)	• Not imbedding straw bales, or anchoring bales in place where required to reduce erosion under and around bales.	• Sediment should be removed when it reaches a depth of 6 inches (15 cm) behind the barrier. • Bales showing signs of degradation (e.g., broken binding, fungus and seed growth, etc.) should be replaced.
SC-5	Rock and Brush Filters	• Flooding when filters are installed without sufficient space to allow for ponding behind filter.	• Barriers should be cleaned of accumulated sediment after each major storm, or when deposition is 1/3 of berm height or 12 inches (30 cm), whichever comes first.
SC-6	Compost Berms and Socks	• Flooding when berms/socks are placed in areas without sufficient space for ponding behind the berm.	• Barriers should be cleaned of accumulated sediment after each major storm, or when deposition has reached

[3] Straw bales are considered to be one of the least preferred BMPs due to rigorous maintenance requirements. In addition, some jurisdictions don't allow the use of straw bale dikes.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
		• Placement in areas of concentrated flow.	1/3 of the exposed height of the berm.
SC-7	Fiber Rolls or Wattles	• When used as a slope interrupter device, fiber rolls must be properly trenched into the slope, and staked in place or flow will go underneath the slope interrupter devices and result in erosion.	• If used as a sediment barrier (e.g. drain inlet protection), rolls should be cleaned of accumulated sediment after each major storm.
SC-8	Storm Drain Inlet Protection	• Using inlet protection measures that divert flow, rather than filter flow, can result in flooding of adjacent areas, or overwhelming adjacent inlets. • Bypassing of inlet protection due to insufficient packing of the ends of Biofilter bags. • Bypassing of the inlet protection due to overflow slots on drain inlet insert devices.	• Inlet filters for storm drains should be inspected and cleaned after each significant storm event and repaired promptly. Sediment shall be removed after each significant storm event and deposited in a stable area where it will not be subject to erosion. • If the inlet protection device becomes clogged with sediment it must be carefully removed from the inlet and either cleaned or replaced.
SC-9	Temporary Sediment Basin	• Constructing a basin that is too wide and not long enough can result in short-circuiting of the basin and discharge of sediment out of the basin.	• Temporary and permanent sediment basins should be cleaned of accumulated sediment after every significant storm event, or when sediment reaches ten percent of the basin capacity. Removed sediment shall be properly disposed of in a stable area that is not susceptible to erosion.
SC-10	Entrance/Exit Tracking Controls	• While gravel for temporary construction entrances should be coarse enough (3-6 inches with no minus) to shake loose soil that adheres to the vehicles' wheels and undercarriage, it should not be so coarse and angular that it causes damage to tires.	• Stabilized gravel construction entrances shall be inspected for the transport of sediment onto public rights-of-way, and any tracked sediment shall be removed immediately by vacuum sweeping and not washed off by water trucks. If tracking is an ongoing problem, a wheel wash facility should be added to the site.
SC-11.	Entrance / Exit Tire Wash	• Installation of tire wash without other entrance/exit tracking controls, resulting in excessive sediment	• Failure to remove accumulated sediment from tire wash.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
		loading on tire wash.	
SC-12	Undercut Lots	• Not providing sufficient capacity in undercut area serving as a temporary sediment trap.	• Remove accumulated sediment to maintain capacity in undercut area.
Runoff Control (RC)		A common error on construction sites occurs when runoff control measures are not installed before the rainy season. Even the best erosion and sediment control measures cannot perform properly if runoff is not controlled. Uncontrolled runoff down the face of a slope can result in severe gullying.	
RC-1	Slope Drain	• Improper backfill around and under pipes can result in unstable contact between pipe and soil and water saturating soil and under pipe, causing undermining and erosion.	• Slope drains should be inspected after every significant storm event and repairs should be made promptly. Inspectors should check for scour holes and undermining, particularly at inlet and outlet points.
RC-2	Energy Dissipator	• Energy dissipaters and rip rap that are not sized appropriately to protect against design velocities.	• Lined drainage channels and energy dissipaters should be inspected at regular intervals and after major storms. Debris should be removed and repairs made where necessary. • Special attention should be given to outlets and points where concentrated flow enters the channel. Eroded areas should be repaired immediately. • Inspectors should check for sediment accumulation, piping, bank instability, and scour holes, and repairs should be made promptly.
RC-3	Diversion of Run-on	• Diversion channels must be properly sized to convey design flows around disturbed soil areas or other areas of concern.	• Diversion measures must be maintained to remove debris and sediment, repair linings, and replace lost rip rap as-needed.
RC-4	Temp. Diversion Dike	• Dike should be adequately sized to prevent overtopping / breaching.	• Excessive sediment accumulation in the ditch or swale behind the berm.
RC-5	Grass-lined Channel (Turf reinforcement mats)	• See installation problems for Erosion Control Blankets and Mats.	• Lined drainage channels and energy dissipaters should be inspected at regular intervals and after major storms. Debris should be removed and repairs made where

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
			necessary. Special attention should be given to outlets and points where concentrated flow enters the channel. Eroded areas should be repaired immediately. Inspectors should check for sediment accumulation, piping, bank instability, and scour holes, and repair promptly.
RC-6	Trench Drain[4]	• Failure to excavate the trench deep enough to reach the impermeable base of a perched groundwater system.	• Clogged drains can lead to loss of drainage capacity and saturation and buildup of pore pressure in the streambank.
RC-7	Drop Inlet	• Improper design of drop inlet can result in excessive sediment in runoff due to inadequate residence time in ponded area.	• Clogging of down-pipe resulting in overtopping of embankment and erosion of downstream dam face.
RC-8	Minimizing TSS During In-Stream Construction	• Conducting in-stream construction during low flow periods when sediment impacts are the greatest.	• Inspect the stability and performance of all erosion and sediment control measures used during in-stream construction on a daily basis or more frequently during critical stages of in-stream construction..
RC-9	In-Stream Diversion Techniques	• Conducting diversion activities without confirming local, state and federal permitting and design requirements .	• All stream diversions must be closely maintained and monitored. • Pumped diversions require 24-hour monitoring of pumps
RC-10	In-Stream Isolation Techniques	• Installing isolation methods such as cofferdams without obtaining applicable permits.	• Inspect isolation devices daily or more frequently during storm events. Inspect for sediment buildup and any gaps, holes or scour related to the structure. Repair areas immediately.

[4] Designed and maintained to drain or de-water an area (French Drain); not an underground injection control (UIC) device. Discharge must be to surface.

Table 8-1. Common BMP Installation Mistakes and Maintenance Problems

BMP No.	BMP Description	Common Installation/Application Mistakes	Inspection/Maintenance Guidelines
RC-11	Check Dams	• Placing a check dam or barrier so that the abutments are not at a higher elevation than the center of the barrier can result in flow around the ends of the barrier. • Not trenching the bottom of the check dam or barrier can result in undermining of the barrier.	• Check dams should be checked for undermining and/or short-circuiting and repaired or replaced if necessary. • Check dams should be cleaned after each significant storm event or when accumulated sediment reaches half the height of the check dam. • Check dams should be keyed into the channel banks a minimum of 18 inches to prevent flow around the dam.

KEY TERMS

Best Management Practice (BMP)
Performance
Inspection
Operation
Rainy Season
Frequency of Inspection
Site Walkthrough
Maintenance Guidelines
Documentation
Comprehensive
Monitoring
Maintenance
Significant Rainfall Event
Permanent Measures
Deficiency

SUMMARY CHECKLIST

- BMPs should be monitored before, during, and after significant storm events. During grading and construction, the permittee is responsible for maintaining the storm water pollution control measures.

- In accordance with the NPDES 1200-C General Permit, active sites must be inspected by the permittee or the permittee's representative (typically the contractor) daily during storm water or snowmelt runoff and within 24 hours after any storm event greater than 0.5 inches in a 24-hour period. Active sites must be inspected at least every 7 days during periods of no runoff. Any site that is inactive for greater than 7 days must be inspected every two weeks. Exposed areas must be stabilized and inspected before a site is left in an inactive state.

- An initial site inspection should be conducted to verify that all BMPs have been implemented in the field, that erosion is being controlled, and that sediment and other pollutants are not being transported off-site or into critical areas on-site. Critical inspection points should be identified on the initial site walk.

- During rainfall events, the permittee's inspector should be empowered to call out crews to inspect and immediately repair the erosion and sediment control measures. Appropriate materials and equipment should be kept on hand to enable a quick and rapid response. Also, some municipalities have specific "on-hand" emergency supply requirements that must be followed.

- Vegetation establishment should be monitored during BMP site inspections until the vegetation reaches maturity and is providing the anticipated erosion control effectiveness.

- Inspection reports should be prepared during each inspection conducted by the permittee or contractor. Reports should include information on damages or deficiencies, maintenance or repair activities, monitoring information, and vegetation establishment. Inspection reports should be kept for a period of three years after completion of final site stabilization.