Erosion Control and Stormwater Quality Guide

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Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
ASCE	American Society of Civil Engineers
BAT	Best Available Technology
BCT	Best Conventional Technology
BMP	Best Management Practice
BOD	biological oxygen demand
CAD	computer-aided design
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
CFR	Code of Federal Regulations
CFS	cubic feet per second
CRS	Colorado Revised Statutes
EA	Environmental Assessment
EC	Erosion Control - BMP
EIS	Environmental Impact Statement
EMC	event mean concentration
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Administration
FHWA	Federal Highway Administration
FIR	Field Inspection Review
FOR	Final Office Review
GP	General Pollution Prevention - BMP
MH	Materials Handling (and Spill Prevention) - BMP
MS4	municipal separate storm sewer system

MSDS	Material Safety Data Sheet
NEPA	National Environmental Policy Act of 1969
NPDES	National Pollutant Discharge Elimination System
NURP	National Urban Runoff Program
PCB	polychlorinated biphenyls
PCC	Portland Cement Concrete
OSHA	Occupational Safety and Health Administration
RECAT	Regional Erosion Control Advisory Team
ROW	right of way
SC	Sediment Control - BMP
SWMP	Stormwater Management Plan
TRM	turf reinforcement mat
VOC	volatile organic compound
UDFCD	Urban Drainage and Flood Control District
USDOT	U.S. Department of Transportation
UV	ultraviolet
WM	Waste Management - BMP
WQCD	Water Quality Control Division
WQCV	water quality capture volume

CHAPTER 1

Introduction

The Colorado Department of Transportation (CDOT) has the mission to "develop and maintain the best possible transportation system for Colorado." This mission includes the making of decisions "which are compatible with Colorado's quality of life, environmental, and economic goals," and has as one of its goals to "facilitate and support the development of safe and integrated transportation systems throughout the state." Meeting CDOT's mission and goals requires that the maintenance and upgrading of existing highways, as well as the construction of new highways, be integrated with Colorado's environmental goals.

Environmental regulation, in conjunction with Colorado's environmental goals, have encouraged CDOT to apply Best Management Practices (BMPs) for erosion and sediment control and stormwater quality management. These BMPs include the modification and/or creation of construction specifications, and documents such as this guide.

Erosion control is desirable not only for environmental reasons but also for highway safety purposes. Uncontrolled erosion during highway construction, and subsequent sedimentation, could cause adverse impacts on streams, damage to drainage structures and public (or private) lands, and public criticism. Stabilized slopes are desired because they are aesthetically pleasing, are protected against erosion, and yield a smooth roadside surface, which can assist errant vehicles in regaining control. Progressive design and construction techniques, including the use of BMPs, can prevent soil erosion and the resultant water pollution and sedimentation problems along highways. These techniques also can minimize the need for corrective actions during maintenance operations. Preventive measures are more economical and effective than corrective measures.

Pollutants found in highway stormwater runoff can contribute to water quality degradation. While the impacts from highway runoff on receiving waters have yet to be accurately determined, potential impacts can be reduced through the use of stormwater quality BMPs to reduce pollutant loads from highway runoff.

Finally, highway maintenance practices have the potential for creating adverse impacts on water quality. These practices must be evaluated, and BMPs must be applied to minimize those impacts.

This Erosion Control and Stormwater Quality Guide addresses the degradation of water quality and minimization of erosion associated with highway operations, and the prevention or minimization of that degradation through the implementation of planning, proper construction, and proper installation of BMPs.

CHAPTER 2

Stormwater Quality Regulations and Program

2.1 Water Quality Legislation

Since the National Environmental Policy Act of 1969 (NEPA), much attention has been given to the control of erosion and sedimentation by Federal, State, and local governments. Numerous laws and regulations governing land-disturbing activities have been developed and published. Some important pieces of legislation that affect construction activities in regard to erosion and sediment control are:

- The Clean Water Act (sections 401, 402, and 404)
- The Senate Bill 40 (SB40) Wildlife Certification (title 33, article 5, CRS)
- The Colorado Water Quality Control Act (title 25, article 8, CRS)

Of particular importance are the National Pollutant Discharge Elimination System (NPDES) Phase I and II stormwater regulations issued by the Environmental Protection Agency (EPA).

On November 16, 1990, EPA promulgated the Phase I Stormwater Regulations. Under Phase I, EPA required NPDES permit coverage for stormwater discharges from:

- Medium and large municipal separate storm sewer systems (MS4s) located in incorporated places or counties with populations of 100,000 or more; and
- Eleven categories of industrial activity, one of which is construction activity that disturbs five or more acres of land.

In 1999, the regulation was extended to include smaller municipalities as well. The Phase II Stormwater Permit Regulation, required small municipalities (<100,000 population) to obtain NPDES MS4 Permit coverage. The Phase II regulation also reduced the minimum size of construction projects requiring NPDES permits from 5 acres of disturbed area to just 1 acre.

Colorado is an NPDES state. This means that EPA's authority to issue NPDES permits is delegated to a state regulatory agency, which in this case is the Colorado Department of Public Health and Environment (CDPHE). CDPHE implements and enforces the NPDES Programs through the Colorado Discharge Permit System (CDPS) program.

2.2 Colorado Department of Transportation Water Quality Program

As a consequence of the NPDES regulations, planning and design for CDOT new highway or highway expansion projects must now include considerations not only for stormwater quantity but also for stormwater quality. This is an important impact since, historically, CDOT's standard drainage design practice has been to consider only stormwater quantity.

CDOT has developed several programs to comply with the NPDES regulation, specifically its CDPS MS4 Permit. The programs include:

- New Development and Redevelopment Planning Program
- Public Street Maintenance Program
- Herbicide, Pesticide, and Fertilizer Program
- Illicit Discharge Program
- Industrial Facilities Program
- Construction Sites Program
- Municipal Facility Runoff Control Program
- Structural Controls

The Erosion Control and Stormwater Quality Guide was developed in part to support these programs and provide guidance in the selection of stormwater quality BMPs.

2.2.1 Construction Program

CDOT has enhanced its construction program to include stormwater quality management. The program requires contractors to obtain appropriate construction permits and develop and implement a Stormwater Management Plan (SWMP) and an Inspection and Maintenance Program. The stormwater quality management aspects of the construction program are described in the following.

Permits

To ensure water quality is protected during construction, CDOT requires the contractor to obtain several permits before commencing with construction. The permits issued will depend on the construction activity and the potential water quality impact as a result of the activity. The next paragraph discusses several of the permits that may be required. The CDOT Water Quality Program Manager should be consulted to better understand the specific permit requirements of the construction project.

CDOT State Highway Access Permit-A State Highway Access Permit is required when vehicular access is needed to construct, relocate, and modify any facilities associated with stormwater that are within highway right-of-way.

CDOT Utility Permit -Utility Permits are needed to perform utility accommodation work in the CDOT right-of-way, including installation, adjustment, relocation, removal or maintenance of facilities not owned by CDOT. These permits are issued to the owner of the utility. The connection of another entity's stormwater drainage system to the State highway drainage system will require a Utility Permit.

CDOT Special Use Permit -Similar to a Utility Permit, a CDOT Special Use Permit is required for other types of work that is done within the State highway right-of-way. This would include landscaping, surveying, or connection of any type of drain line (other than a stormwater drain) to a CDOT storm sewer – such as a dewatering discharge from a construction site located either within or next to the State highway right-of-way.

Stormwater Management Plan

To ensure that the water quality of receiving waters is protected during construction, the development and implementation of a Stormwater Management Plan (SWMP) is required for all construction projects.

The SWMP serves to improve water quality by reducing pollutants in stormwater discharges. The SWMP achieves this by including BMPs necessary to provide for erosion, sediment, and general pollution prevention controls. The requirements of the SWMP and guidance for the development of SWMPs are included in Chapter 4.

Inspection and Maintenance Program

CDOT has adopted an Inspection and Maintenance Program to ensure proper implementation and maintenance of the SWMP. The frequency of inspections is a function of the phase of construction. Required inspection frequencies for active and completed construction sites are described below.

Active Sites. For sites where construction has not been completed, thorough inspections of the stormwater management BMPs shall occur at a minimum of every 14 days and after any precipitation or snowmelt event that causes surface runoff.

Completed Sites. For sites where construction has been completed, but final stabilization has not been achieved due to lack of vegetative cover, thorough inspections of the stormwater management BMPs shall occur at a minimum of every 30 days.

A CDOT Stormwater Management Plan Field Inspection Form shall be used for documentation of the inspections. A sample of the inspection form is included in Appendix B. The latest revision of the inspection form can be obtained from the CDOT Water Quality Program Manager.

CHAPTER 3

Pollutant Types and Effects on Receiving Waters

3.1 Erosion and Sedimentation

Erosion and sedimentation are natural processes whereby soil materials are detached, transported, and then deposited from one location to another due to the action of water, wind, ice, or gravity.

These natural processes are accelerated by land disturbance activities, including highway construction projects. Accelerated erosion and sedimentation can result in significant adverse impacts on receiving waters, therefore affecting recreational uses, aquatic life, water stability, safety, roadway structures, aesthetics, and maintenance. Areas where rapid development has occurred will show an increase in channel degradation, usually accompanied by bank erosion.

3.1.1 Types of Erosion

Common types of erosion include the following:

- **Sheet Erosion –** Transporting of small soil particles loosened by impacts of raindrops on soils by runoff flowing in a thing layer over the ground surface.
- **Rill Erosion –** Formation of numerous small channels several inches deep.
- **Gully Erosion –** Accumulation of water in narrow channels, increasing their depth.
- **Channel Erosion –** Scouring action in channel banks and bottom.

3.1.2 Factors Affecting Erosion

The erosion potential of any area is determined by four interrelated factors, as described below.

Soil Characteristics. The soil characteristics that influence erosion by rainfall and runoff are the infiltration capacity of the soil and the resistance of the soil to detachment and being carried away by falling or flowing water. Granular soils containing high percentages of fine sands and silt are normally the most erodible. Cohesive soils with a higher content of clay and organic matter are less erodible. Clays act as a binder to soil particles, thus reducing erodibility. However, while clays have a tendency to resist erosion, once eroded they are easily transported by water. Soils high in organic matter have a more stable structure that improves their permeability. Such soils resist raindrop detachment and allow more rainwater infiltration. Clear, well-drained, and well-graded gravels and gravel-sand mixtures are usually the least erodible soils. Soils with high infiltration rates and permeabilities reduce the amount of runoff.

Vegetative Cover. Vegetative cover plays an important role in controlling erosion by shielding the soil surface from the impact of falling rain, holding soil particles in place,

maintaining the soil's capacity to absorb water, slowing the velocity of runoff, and removing subsurface water between rainfalls through the process of evapotranspiration.

Topography. The size, shape, and slope characteristics of a watershed influence the amount and rate of runoff. As both slope length and gradient increase, the potential for erosion is magnified.

Climate. The frequency, intensity, and duration of rainfall are fundamental factors in determining the amount of runoff produced from a given area. As both the volume and velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in temperature, as well as variations in rainfall, help to define the high erosion risk period for the year. When precipitation falls as snow, erosion will take place. However, in the spring, the melting snow produces runoff that increases erosion hazards. If the ground is still partially frozen, its absorptive capacity is reduced. Frozen soils are relatively erosion-resistant. However, soils with high moisture content are subject to uplift by freezing action and are usually easily eroded upon thawing.

3.2 Pollutant Types and Sources

The main pollutant resulting from erosion is sediment. Sediments are typically present in inorganic form as silt, clay, or sand particles, and in organic form as fine particulates. Less common pollutants are metals, or nutrients such as nitrogen or phosphorus, associated with minerals exposed by erosion or excavated during construction activities.

Other potential pollutants, not associated with erosion, are chemicals that are used and stored at construction sites. Table 3-1 lists pollutants that may be present during highway construction activities.

TABLE 3-1
Construction Site Pollutants

Source	Pollutants
Adhesives	Phenols, Formaldehydes, Asbestos, Benzene, Naphthalene
Cleaners	Metals, Acidity, Alkalinity, Chromium
Plumbing	Lead, Copper, Zinc, Tin
Painting	VOCs, Metals, Phenolics, Mineral Spirits
Woods	BOD, Formaldehyde, Copper, Creosote
Masonry/Concrete	Acidity, Sediments, Metals, Asbestos
Demolition	Asbestos, Aluminum, Zinc, Dusts
Yard O & M	Oils, Grease, Coolants, Benzene and derivatives, Vinyl Chloride, Metals, BOD, Sediments, Disinfectants, Sodium Arsenite, Dinitro compounds, Rodenticides, Insecticides
Landscaping and Earthmoving	Pesticides, Herbicides, Fertilizers, Nutrients, BOD, Acidity, Alkalinity, Metals, Sulfur, Aluminum Sulfate
Materials Storage	Spills, Leaks, Dusts, Sediments

Source: Adapted from *California Storm Water Best Management Practice Construction Handbook* (30).

3.3 Effects of Receiving Waters

A direct effect of sediments discharged into receiving waters is the increase in turbidity due to the increase in concentration of suspended solids. Increase in turbidity will result in higher costs for water treatment and will affect aquatic biota by reducing the photosynthetic activity. An increase in suspended solids can damage water supplies and will affect feeding and nesting habits of creatures in the receiving waters.

An indirect effect of erosion is the deposition of sediments in a stream's channel bottom, which will lower the survival of fish eggs, damage bottom organisms, and destroy aquatic plants. Sediments reduce the oxygen in the water, deteriorate the health of fish and other aquatic creatures, and endanger survival of aquatic organisms. Excess sediments will accumulate in reservoirs and ponds, reducing their storage volume and potentially causing flood damages.

3.4 Highway Runoff

Operation of the highway system produces pollutants that are transported by runoff and cause adverse impacts to receiving waters. The Federal Highway Administration (FHWA) has sponsored significant research to determine highway runoff pollutant types and sources, impacts to receiving waters, and methods to estimate those impacts. Some of the findings of FHWA's research are summarized in this section.

3.4.1 Factors Affecting Pollutant Types and Concentrations

The types and concentration of pollutants present in highway runoff are affected by many factors, including the following:

- Traffic characteristics
- Climatic conditions
- Maintenance practices
- Surrounding land use
- Pavement characteristics
- Vegetation types on the right of way
- Institutional characteristics (i.e., litter laws, speed limit enforcement, and car emission regulations)

The FHWA has assigned levels of importance (low, medium, high) to various factors that affect the characteristics of highway runoff, as listed in Table 3-2.

TABLE 3-2
Factors Affecting Highway Runoff Characteristics

Factor	High	Medium	Low
Climatic conditions	X		
Pavement Quantity	X		
Right-of-Way Vegetation	X		
Average Daily Traffic (ADT)	X		
Surrounding Land Use	X		
Highway Drainage Features	X		
Atmospheric Deposition		X	
Highway Configuration		X	
Pavement Composition/Condition		X	
Vehicular Inputs		X	
Maintenance Practices		X	
Highway Design			X
Institutional Characteristics			X

Traffic density has been suggested as one of the main factors affecting highway runoff. However, studies have not shown a direct correlation between Average Daily Traffic (ADT) and pollutant concentrations. ADT is certainly a very important factor, but it does not seem to dominate over the combined effects of the other factors.

One factor that has a major influence on highway runoff characteristics is the surrounding land use. Major differences occur between highways in urban areas versus highways in rural areas. An ADT of 30,000 vehicles per day is used to distinguish between urban, rural urban, and rural highways. Highway runoff characteristics are similar to those of urban runoff. Common pollutants found in highway runoff, as well as their sources, are listed in Table 3-3.

TABLE 3-3
Sources of Common Highway Pollutants

Pollutants	Source
Particulate	Pavement wear, vehicles, atmosphere, maintenance
Nitrogen, Phosphorus	Atmosphere, roadside fertilizer application
Lead	Leaded gasoline, tire wear, oil and grease, bearing wear
Zinc	Tire wear, motor oil, grease
Iron	Autobody rust, steel highway structures, engine parts
Copper	Metal plating, bearing and bushing wear, moving engine parts, brake lining wear, fungicides, insecticides
Cadmium	Tire wear, insecticide application

TABLE 3-3
Sources of Common Highway Pollutants

Pollutants	Source
Chromium	Metal plating, moving engine parts, brake lining wear
Nickel	Fuels, oils, metal plating, bushing wear, brake lining wear, asphalt paving
Manganese	Moving engine parts
Bromide	Exhaust
Cyanide	Anticake compound used to keep deicing salt granular
Sodium, Calcium	Deicing salts, grease
Petroleum	Spills, leaks, oils, antifreeze and hydraulic fluids, asphalt surface leachate
Polychlorinated-biphenyl, pesticides	Spraying of highway ROW, background atmospheric deposition, PCB catalyst in synthetic tires
Pathogenic bacteria	Soil, litter, bird droppings, trucks hauling livestock and stockyard waste
Rubber	Tire wear
Asbestos	Clutch and brake lining wear

Source: *Sources and Migration of Highway Runoff Pollutants* (3).

As part of the FHWA research, highway runoff from 31 sites (including one site in Denver on I-25) and from 993 storm events was evaluated. Event Mean Concentrations (EMCs) were determined for common and significant highway pollutants in both urban (ADT>30,000) and rural (ADT<30,000) areas. Median EMC concentrations, designated as the site median, are shown in Table 3-4. The median site (50th percentile) provides the most probable value for the site median concentration.

TABLE 3-4
Median EMC Concentrations (mg/l)

Pollutant	ADT<30,000	ADT>30,000
Total Suspended Solids	41	142
Volatile Suspended Solids	12	39
Total Organic Carbon	8	25
Chemical Oxygen Demand	49	114
Nitrate plus Nitrite	0.46	0.76
Total Kjeldahl Nitrogen	0.87	1.83
Total Phosphorus	0.16	0.40
Copper	0.022	0.054
Lead	0.080	0.400
Zinc	0.080	0.329

Source: *Pollutant Loadings and Impacts from Highway Stormwater Runoff* (5).

3.4.2 Effects of Highway Runoff on Receiving Waters

Three sites were selected during the FHWA research to determine impacts of highway runoff on receiving waters. Two of the sites represented highway discharges into streams, while the third site represented discharges into a lake. All sites represented highway systems with low to medium traffic volume (ADT<30,000) and no curb and gutter drainage design. This type of highway system is typical of the majority of CDOT highways. The study at each site included highway runoff flow measures, wet weather monitoring, sediment and vegetation sampling, and biological assessment.

The study concluded that highway runoff from "low to medium traffic volume (ADT<30,000) rural highways exert minimal to no impact on the aquatic components of most receiving waters." Specific conclusions applicable to the studied sites are as follows:

- Annual pollutant loads from highways were low compared to loads from entire watersheds.
- There were no significant violations of state water quality standards or EPA acute criteria at any of the sites during discrete storm events.
- No discernible trends or consistently elevated accumulations of pollutants in sediments were observed at the two stream sites.
- At the lake site, direct discharge of highway runoff from the bridge deck scupper drains caused a localized increase in metals and salts in near shore (i.e., near the bridge) sediments and cattails. It can be inferred from the quarterly benthos sampling and in-situ flow-through bioassays at this site that the impact is minimal.
- Of five species (mayfly, isopod, water flea, gammarid, and fathead minnow) used in the acute laboratory bioassays, only the gammiarid exhibited a toxic response to undiluted highway runoff. Two week (chronic) algal assays did demonstrate reduced growth for Selenastrum exposed to undiluted runoff compared to controls. Dilution effects were not determined in the laboratory bioassays. Flow-through in-situ bioassays at the lake site, where dilution occurred naturally, did not indicate an impact for six species.

3.4.3 Procedures to Estimate Impacts on Receiving Waters

The NPDES stormwater regulation does not require at this time that stormwater discharges meet a certain numeric water quality standard. Therefore, a quantitative water quality analysis will be necessary on very few CDOT projects, and should only be completed when required by a regulatory agency or when deemed necessary by the designer.

FHWA developed a procedure to perform quantitative water quality analyses. This procedure is described in FHWA's publication *Pollutant Loadings and Impacts from Highway Stormwater Runoff* (5). To apply the procedure, the following site and highway characteristics data are needed:

- Drainage area
- Rainfall
- Average Daily Traffic (ADT)
- Dissolved pollutant concentration

- Target receiving water concentration
- Stream flow

Application of the predictive procedure, whether the discharge is into a stream or a lake, is not complicated. Site and highway characteristic data are gathered, highway runoff water quantity and quality calculations are performed, and impacts to the receiving water are estimated. The procedure allows for computation of the following:

- Average number of storms per year
- Highway runoff rate and volume
- Ratio of highway runoff to stream runoff
- Pollutant mean event concentration
- Pollutant mass loads
- Once in three year stream pollutant concentration
- Average lake phosphorus concentration

The procedure estimates the once in three year stream pollutant concentration, which is then compared with EPA's acute criteria and National Urban Runoff Program threshold effect level. If the ratio of the predicted pollutant concentration to EPA's acute criteria is less than 0.75, it is unlikely that a toxicity problem exists. If the ratio is greater than 5, then interception of the pollutant will be required and BMPs should be considered.

For lake impact analysis, if the predicted phosphorus load from the highway is less than 0.01 mg/l, it is unlikely that any adverse impacts will be experienced. If the predicted phosphorus concentration is greater than 0.02 mg/l, BMPs should be considered.

BMPs used to improve highway runoff quality are described in section 5.3 of this guide.

3.5 Highway Maintenance Practices

Highway maintenance practices have the potential for resulting in adverse impacts to receiving waters. Highway maintenance practices need to be identified, and their effects determined, so that appropriate BMPs can be established and impacts to receiving waters can be minimized. FHWA has performed research in this area. This section summarizes FHWA's findings.

Highway maintenance practices can be classified according to their potential to impact water quality. Type I refers to practices that will have a probable impact on receiving waters, Type II are practices that have a possible impact, and Type III are practices that have no probable impact. Typical highway maintenance practices, as they relate to each of the three types described above, are listed in Table 3-5.

TABLE 3-5
Highway Maintenance Practices

Type I – Probable Impact
Repairing slopes and slides
Cleaning or repairing hydraulic structures
Painting bridges
Substructure repair
Chemical vegetation control
Type II – Possible Impact
Pavement repairs, cleaning, marking
Highway surface treatments
Blading and restoring unpaved berms and/or shoulders
Repairing curbs, gutters, and paved ditches
Bridge surface cleaning and deck repairs
Mowing
Planting or care of shrubs, plants, and trees
Seeding, sodding, fertilizing
Care of rest areas
Washing and cleaning maintenance equipment
Storage of non-fuel materials and fuels, and disposal of used oils
Blading unpaved surfaces
Snow plowing
Sanding
Deicing
Type III – No Probable Impact
Pothole patching and surface repairs
Filling and sealing joints and cracks
Pavement jacking
Planing pavements
Bridge joint repair
Superstructure repair
Guardrail and crash attenuator repair
Snow fence installation and removal
Highway lighting
Sign maintenance
Control and proper disposal of roadside litter

Source: *A Reference Manual for Assessing Water Quality Impacts from Highway Maintenance Practices* (24).

CHAPTER 4

Stormwater Management Plan Procedures

4.1 Overview

The CDPHE states in the "General Permit for Stormwater Discharges Associated with Construction Activity" rationale that under the framework of the NPDES and CDPS stormwater regulations, construction activities must obtain a discharge permit. In the past, this permit has been called a NPDES permit. A Stormwater Management Plan (SWMP) is required by the CDPS program. The SWMP must contain information and BMPs necessary to:

1. Minimize the amount of disturbed soil.
2. Control and minimize erosion and sedimentation during and after the construction phase of a project.
3. Prevent runoff from offsite areas from flowing across the site.
4. Slow down the runoff.
5. Reduce pollutants in stormwater runoff (i.e., stormwater quality management).

All projects involving an earth disturbance require a SWMP. The SWMP is prepared during the design phase of projects and must be part of the project's bid documents. Projects with 1 acre or more of earth disturbance (Phase II) require a CDPS permit, which involves the completion and submittal of a "General Permit for Stormwater Discharges Associated with Construction Activity" (the application can be obtained from www.cdphe.state.co.us).

The SWMP, in combination with the required Contractor project reviews, project plans, and specifications, must define project limits and area of disturbance, sequence of construction activity, BMPs for stormwater pollution prevention, method of material handling and spill prevention, method of waste disposal, and final stabilization methods. If these requirements are not included in the SWMP, then their location should be referenced in the SWMP title sheet. BMPs should constitute compliance with "Best Available Technology (BAT) and Best Conventional Technology (BCT) as required by the Federal Clean Water Act" (31).

In general, CDOT or CDOT's representative obtains permit certification for most CDOT projects with the exception of design-build projects. Designers begin the permit application process by providing the required one-page Notice of Intent. The "General Permit for Stormwater Discharges Associated with Construction Activity" is submitted to the CDPHE at least 10 days prior to the start of construction.

Various erosion control and pollution prevention requirements must be addressed when developing a SWMP. The main objective of any SWMP is to prevent sediment from reaching receiving waters. The SWMP accomplishes this by specifying BMPs for stabilizing earth disturbances and by including directions for preventing or minimizing erosion associated

with construction activity. Construction operations must implement the provisions of the SWMP to maintain permit compliance and avoid incurring regulation penalties.

Although the main objective of the SWMP is to focus on temporary BMPs used during construction, the SWMP also should incorporate or reference the permanent water quality measures included in the project. Permanent BMPs are included in the drainage design of the project; the design process involves coordination with CDOT environmental specialists, design, construction, and maintenance personnel. (Refer to Chapter 2 for MS4 permit guidance and CDOT Planning Procedure document for incorporating permanent BMPs into CDOT projects.)

The SWMP must be specific to each project and must consider all measures stated in the CDOT Water Quality Specification 107.25 and Erosion Control Specification 208 (*CDOT Standard Specifications*, Current Edition). The SWMP's length and complexity will vary with the size of the project, severity of site conditions, and proximity to state waters and sensitive environments.

4.2 SWMP Procedures

The following SWMP site information is required for all projects:

1. Location map
2. Discharge locations (applies to projects with drainage plans)
3. Soil classification
4. Presence of fisheries, spawning areas, and wetlands
5. Presence of threatened and endangered species
6. Area of disturbance
7. Stream crossings (names of receiving waters)
8. Unique landscape and cultural values to protect
9. Identification of existing vegetation
10. Compliance with 107.25 CDOT Water Quality Specification

Key design elements required of all SWMPs are as follows:

1. Seeding plan to include seeding, mulching, and fertilizing application and requirements
2. Requirements to protect existing vegetation
3. Tabulation and location of erosion and sedimentation control items
4. Force account erosion control plan to compensate for unforeseen conditions caused by erosion and sedimentation
5. Mapping of existing wetlands and wetland mitigation sites
6. Reference to standard and project specifications pertinent to the SWMP
7. Reference to drainage features not included in the SWMP
8. Notes defining methods of implementation of BMPs and plan

9. Notes defining methods of incremental stabilization (phased seeding and mulching)
10. Design details not included in M&S Standard Plans

The seeding and mulching plan must be prepared or reviewed by a CDOT Landscape Architect. The plan should always be included in the SWMP, and specifications should be included and referenced in the specification document. In addition, all projects must provide requirements to protect existing vegetation, wetlands, and other sensitive environments and cultural sites. On minor projects where erosion control items are determined by the designer to be minimal (i.e., < 0.5 acre), protection BMPs and seeding requirements can be included in the price of the work. However, it is recommended that all items be paid for in accordance with CDOT's specifications.

A CDPS construction activity permit is required for earth disturbances of 1 acre or greater for CDPS Phase II and areas 5 acres or greater for CDPS Phase I. If the project is part of a larger common plan, the sum of all phases is used to determine the total disturbance area. Pavement surface is included in the area measurement if that surface is to be removed to exposed earth.

Projects that require a CDPS permit must include the following **additional information**.

1. Runoff coefficient: pre-construction and post construction
2. Existing soil data: description and quality of discharge, soil type
3. Existing vegetation: general description of plant classifications, e.g., alpine grasses and forests of the higher mountains
4. Reference to other water quality measures not included in the SWMP, e.g., riprap, culvert end sections, or permanent sediment basins

4.3 Creating a Successful Stormwater Management Plan

Analysis of site conditions is essential for proper stormwater management. The author of the SWMP must inspect the future construction site and the construction plans. In addition to the SWMP site information required for all projects, the SWMP should address the following factors:

1. Unstable stream reaches and flood mark
2. Watershed areas
3. Stream crossings
4. Access routes for construction
5. Access for maintenance of temporary and permanent erosion controls
6. Borrow and waste (unclassified excavation) disposal areas
7. Critical natural and constructed slopes, soil types, eroding areas, rock outcroppings, and seepage zones

8. Requirements imposed by adjacent landowners or stewards
9. Construction dewatering methods and locations
10. Detours
11. Concrete washout methods and locations
12. Fuel storage areas
13. Methods of limiting off-site soil tracking

Furthermore, specification 107.25 (*CDOT Standard Specifications*, Current Edition) defines requirements for protecting water. Projects can involve working in highly sensitive environments such as wetlands and threatened and endangered species habitat. During the disposal of construction borrow materials, it is the Contractor's responsibility to not impact the environment and it is CDOT's liability to ensure proper disposal of materials. The CDOT Regional Environmental Representative should review these issues with the designer for inclusion in the SWMP.

The CDOT 107.25 Water Quality Specification defines the factors of concern to the designer; the 208 Erosion Control Specification defines BMPs and the implementation process. Both specifications are good guidelines for the designer and construction personnel when creating and implementing the SWMP. In addition to the specifications, the designer should refer to Permanent Structure BMPs for technical guidance on how to design and construct BMPs for construction projects. The CDOT M&S Standard Plans contain detailed drawings of BMPs, and the *CDOT Item Book* (Current Edition) describes the various pay items used in the SWMP.

4.4 Levels of SWMP Development

There are several phases in the development of a SWMP. These phases are outlined below.

4.4.1 Project Scope

This stage of project development involves addressing the environmental issues. The project team needs to discuss and define how to incorporate the concerns listed in the project's NEPA document or environmental regulations relevant to the project. This process involves communication between the environmental specialists, designers, construction, and maintenance personnel. When working on public lands and sites adjacent to sensitive environments, the inclusion of other State and Federal agencies is beneficial. Including their water quality ideas and the concerns of relevant stakeholders in the SWMP may lessen or eliminate potential project opposition. Proper coordination and assessment will better define the project's drainage requirements and potential impacts on drainage, water quality, or water resources.

Defining who will be completing the SWMP is also critical during the scoping process. Ultimately, the SWMP designer, working with the environmental specialists and project engineer, is responsible for including the objectives of the stakeholders and water quality assessment in the plan. The SWMP must address environmental protection, avoidance, and

minimization; erosion control; stabilization implementation and seeding; and scheduling of the plan.

4.4.2 Field Inspection Review (FIR)

At this stage, the SWMP should include the seeding plan and a list of the BMPs that will be included in the project's pay items. The seed plan includes type and amount of seed, planting method, fertilizer requirements, mulching type, and mulch application. Notes and specifications on when to seed and phased seeding requirements also must be defined in the SWMP. On major projects (i.e., new alignments, major widening, or where deemed necessary), the designer should display the location of BMPs, existing wetlands, and other sensitive environments on project plan sheets. Scaled CAD drawings showing the layout of the project and BMPs are beneficial when outside parties will be reviewing the plan. It is also beneficial to the Contractor reviewing and building the plans to display the BMP locations on the drawings. It is up to the team to decide how they will display the BMP locations of the water quality plan, a decision that is driven by project location, environmental issues, and stakeholder concerns. For example, a bridge replacement project located over a mountain stream and wetlands may require a complex contour drawing showing BMP locations, while a concrete overlay in eastern Colorado will include notes on stabilization and a tabulation of BMP locations. On minor projects such as overlays, minor widenings, or intersection improvements, a seed plan and tabulation of BMP locations maybe be sufficient. If there is an earth disturbance, a seed plan is always required.

During the FIR process or before the Final Office Review (FOR), the SWMP designer must address the following with the Hydraulic Engineer: corridor (roadway ditch) stabilization, embankment protection, channel impacts, temporary stream crossings, dewatering, temporary sediment basins, and other hydraulic issues that will affect water quality. The CDPS regulation does not require the SWMP designer to be a registered engineer, and often the designer may be a Landscape Architect or Hydraulic Engineer. Drainage design is critical, and a successful SWMP must address drainage issues during and after construction.

The engineer should assist the SWMP designer by coordinating the use of permanent water quality features such as riprap placement and sediment basin construction. Proper phasing and scheduling of the SWMP is essential. It is always beneficial to place permanent water quality BMPs at the beginning of a construction project whenever feasible.

To facilitate the implementation of the SWMP, the following items should be listed as salient features in the specification document:

1. Topsoil
2. Seeding and mulching
3. Temporary erosion control items
4. Channel work such as riprap placement or channel stabilization
5. Permanent structural BMPs (i.e., sediment basins)

4.4.3 Final Office Review (FOR)

At this stage of project development, the SWMP should be complete and included in the plan set. The title sheet of the SWMP should include the following:

1. Seeding Plan
    - Plant common name and scientific name
    - Seed rate (pounds of pure live seed per acre/species-itemized and total)
    - Seeding application method
    - Mulching application method
    - Fertilizer requirements
    - Notes defining incremental stabilization and scheduling
2. Additional information defined in permitted projects section
3. Tabulation – pay item description and totals
4. Reference to specifications – standard and project provisions
5. Notes - Define project SWMP requirements and provide references to other environmental designs, e.g., wetlands and threatened and endangered species mitigation plans.

On CDPS permitted projects or major projects involving NEPA documents or environmental issues, the project should include a pay item for an erosion control supervisor. Equipment hours for sediment removal and disposal and erosion control also should be included. Method of payment for sediment removal and disposal is at the discretion of the construction project engineer. The project engineer also should review SWMP pay items and contents prior to the FOR. SWMP pay item quantities such as erosion bales, seeding, mulch tackifier, and mulch (weed free) must be increased to account for replacement, as directed work and incremental installations of seeding and mulching.

After the SWMP is reviewed and finalized, the Regional Environmental Representative or CDOT's consultant must complete the construction activity permit application and submit the application to the CDPHE. A copy of the SWMP is not required in the submittal. However, the project manager should consult the regional environmental section for additional internal plan documentation.

4.5 Construction

After the project is awarded to the Contractor, implementation of the SWMP begins. The first step is the Pre-Construction Conference. During this project review, or at least 10 days prior to the start of construction, the Contractor is required to identify the locations of potential pollution sources, areas used for storage of materials, dedicated asphalt, or concrete batch plants. A spill contingency plan for pollutants also is required at this time.

Furthermore, at least 10 days prior to the start of construction, the Contractor must submit a schedule outlining the implementation of erosion and sediment control measures (BMPs). The schedule must include erosion and sediment control work for all areas within project boundaries, including haul roads, storage areas, borrow pits, and batch plants. Updates to the schedule must be maintained and submitted to the engineer for approval.

Prior to construction disturbance, baseline vegetation conditions should be determined to quantitatively assess plant density and cover. This information is needed to de-activate the

CDPS stormwater permit. The CDOT Landscape Architect should be contacted if technical support is needed.

When required, an Erosion Control Supervisor (Contractor representative) must be available to manage the project erosion control and water quality plan. This person's responsibilities include, but are not limited to, the oversight of BMP installation, water quality permit compliance, adjustments for unforeseen conditions affecting water quality, and inspection of the SWMP features.

The inspection of the project occurs at 14-day intervals and after each storm event during active construction. The Erosion Control Supervisor must have the ability to make requested modifications to control measures within 7 days after the inspection. During project suspension and until the project is accepted and the vegetative cover is equal to 70 percent of the pre-existing cover, the reports take place every 30 days. When the ground is frozen or covered in snow, inspections are suspended. A report is created from the inspection and becomes part of CDOT's project records.[1]

If, during construction, the Contractor proposes changes that would affect the SWMP, the Contractor must obtain approval in writing. Proposed changes to the plan and acceptance by the engineer must be documented and become part of the project records.

In addition to internal project inspections, a CDOT Regional or Headquarter Erosion Control Advisory Team (RECAT) will review a sampling of projects from each region. The purpose of these inspections is to provide support in erosion control and water quality to construction personnel at the regional level, improve consistency in CDOT's erosion control program on a statewide basis, identify any deficiencies in CDOT's erosion control program, and develop strategies to correct the deficiencies. Each project visited will receive a report summarizing the review and rating of the project.[2]

The CDOT Project Engineer who is responsible for the construction phase of the project will handle implementation of the SWMP or ensure that the plan is implemented during construction.

4.6 Post-Construction Site Evaluation and Report

The Project Engineer and representatives from the Regional Environmental Office, with technical support from the CDOT Landscape Architect, should perform a post-construction site evaluation focusing on the vegetative stabilization of cut and fill slopes and other areas of previous ground disturbance. This evaluation may be performed 6-18 months after project completion depending on the level of plant establishment. The CDPS permit requires: (1) establishment of 70 percent plant density relative to pre-construction conditions; (2) absence of evidence of significant erosion; and (3) removal of temporary BMPs. The Regional Environmental Office representative should evaluate and document the 70 percent plant density requirement using the same methods to determine plant density and cover as were employed prior to construction. (See Section 4.11, Method of Measurement for Vegetative Cover).

[1] Refer to the Appendix of CDOT Form 1176a, *Erosion and Sediment Control Field Inspection Report*.

[2] RECAT Questionnaire and RECAT Project Rating Form.

Based upon this post-construction site evaluation, additional seeding or other types of BMPs may be required or recommended in order to legally inactivate the permit. A checklist is provided below (See Section 4.8, Record Keeping) to aid in this evaluation. Copies of the checklist should be sent to the Regional Planning and Environmental Manager.

4.7 CDPS Permit Deactivation Notification

Based upon the results of the post-construction site evaluation checklist, the responsible Regional Environmental Representative shall fill out and sign the Inactivation Notice for Construction Stormwater Discharge General Permit Certification and send it to the Water Quality Control Division (WQCD) for inactivation. The person signing off on this notice certifies, under penalty of law, that final stabilization has been attained (70 percent of pre-disturbance vegetative cover as defined in Section 4.11) and measures to control pollutants in stormwater discharges have been completed.

4.8 Record Keeping

Complete files containing all relevant stormwater information through the life of the construction project should be kept by the Regional Environmental Office.

Table 4-1 provides a summary of key documents.

TABLE 4-1
Report/Memorandum Documentation Codes

Report/Memorandum Name	Documentation Code
Watershed Impact Memorandum	WIM-Project Number
NEPA Document or Water Quality Assessment	EA, EIS or Drainage Report
Stormwater Discharge Associated with Construction Activity	SDACA-Permit No. COR-030000
Field Inspection Review (FIR) Meeting Summary	FIR-Project Number
Final Office Review (FOR) Meeting Summary	FOR-Project Number
Contractor Pre-Construction Conference Meeting Summary	PRECON-Project Number
On-Site Review by Regional Environmental (Technical Memorandum)	CONREV-Project Number
RECAT Site Report	RECAT-Project Number
Post Construction Site Evaluation and Report	POST-Project Number
CDPS Permit Deactivation Notification	DEACT-Project Number

4.8.1 Site Evaluation Procedure

The post-construction evaluation checklist consists of the following items:

- Date/Time
- Location/Project

- Reviewer/Region
- Weather Conditions

__Coordinate site visit with project manager and landscaping representatives

__Visit the construction site (all phases)

__Review seeding of cut and fill slopes

__Observe existence of rills or gullies due to highway drainage or operations

__Review any potential sediment/pollution source areas from CDOT operations

__Ensure all temporary BMPs (hay bales, silt fences, sedimentation pond) are removed

__Measure/evaluate 70 percent vegetative density of pre-disturbance levels

__Provide recommendation: (1) further stabilization/corrective action or (2) deactivation

4.9 SWMP Title Sheet Requirements

Refer to Appendix A for a sample SWMP Title Sheet.

1. Additional Information:
   a. Pre-Construction and Post-Construction Runoff Coefficient
   b. Soil Classification - existing soil description
   c. Description of Existing Vegetation
   d. Reference to Schedules
   e. Reference to 100-year flood plan boundaries
   f. Reference to CDOT project Title Sheet
   g. Reference to Plan and Profile Sheets and Cross Sections
   h. Reference to Surface Waters
   i. Reference to Specification 107.25 - Water Quality
   j. Inspection and Maintenance procedures 107.25 and 208 specifications
   k. Reference to other SWMP information not included in the SWMP
2. Seeding Plan: (Refer to Chapter 5 for BMP definitions)
   a. Area of Disturbance
   b. Seed Plan displaying common name, botanical name, and pounds of pure live seed per acre
   c. Seeding Application
   d. Mulching Application
   e. Fertilizer Requirements
   f. Special Requirements - soil preparation
   g. Stabilization Requirements
3. SWMP Notes: general notes not included in the plan and specifications document
4. SWMP Project Totals:
   a. Pay item tabulation - unit number, description, unit, quantity and specification reference.

4.10 Resources

The following are helpful resources in creating a SWMP:

- *CDOT Standard Specifications* (Current Edition)
- *National Stormwater Best Management Practices Database (EPA/ASCE, Version 1.0, 6/99)*
- *Urban Drainage and Flood Control District (UDFCD) Drainage Criteria Manual (V.3)*
- Colorado Department of Health and Environment (CDPHE)
  Water Quality Control Division (WQCD)
  Stormwater Program-www.cdphe.state.co.us
  (303) 692-3500
- *CDOT Drainage Manual* (Current Edition)
- *CDOT Item Book* (Current Edition)

4.11 Method of Measurement for Vegetative Cover

This section describes the basis for determining final stabilization as required for terminating coverage under the "General Permit for Stormwater Discharges Associated with Construction Activity."

4.11.1 Vegetative Cover

The restoration for final stabilization shall form an effective and permanent vegetative cover that prevents soil movements prior to termination under the CDPS permit. The minimum vegetative cover requirement shall be the amount of cover sufficient to prevent accelerated erosion. Accelerated erosion shall be defined as rills of 2 inches deep or more, earth slides, mud flows, sediment deposition, or evidence of concentrated flows of water over bare soils.

The CDOT staff shall take into consideration final stabilization in relation to the level of vegetation cover at the site prior to disturbance.

4.11.2 Documentation

Documentation supporting that the site has been adequately stabilized to 70 percent of pre-disturbance cover and does not show signs of accelerated erosion shall be submitted. The documentation required shall include the following:

1. Pictures of the desirable plant growth (State and County noxious weeds excluded) at the construction project site shall be required prior to construction disturbance and when determining that final stabilization is adequate. Pictures of the location where each transect (see below) was conducted shall be required. Low-level photography shall occur at approximately 90 degrees to the surface in order to properly assess ground cover.
2. A minimum of at least one 50-foot transect of pre-construction and post-construction cover shall be conducted for every 5 acres that is cleared, graded, or excavated. The

environmental specialists shall determine the number of transects required for large construction projects (>20 acres).

Transects shall be located in an area(s) that is representative of the revegetation for the whole construction project. Transects shall be conducted by laying out a 50-foot tape. At every footmark, it must be noted whether vegetation or bare soil is encountered. (Vegetation consists of viable grasses, shrubs, trees, or forbs.) Results are to be expressed as a percent cover.

For example: One transect of 50 points in which 28 points exhibit cover is (28/50) = 0.56 = 56 percent cover.

For example: Combined transects of 50 points each in which 28 points exhibit cover in one transect and 41 points exhibit cover in the other transect is (28+41)/100 = 69/100 = 0.69 = 69 percent cover.

3. In areas in which final stabilization may be less than satisfactory (less than 70 percent of pre-construction cover) due to poor soil or other natural site conditions, the CDOT representative shall document the percent cover of the indigenous vegetation with pictures and a transect(s).

4.12 Termination of General Permit for Stormwater Discharges Associated with Construction Activity

Termination of coverage under the general permit will be at the discretion of the CDOT representative staff based on an analysis of erosion potential as described above. In some cases, the project may be stable with the exception of certain confined areas. In this instance, the project can be deactivated contingent upon repairing the potential erosion problem. CDOT is responsible for permit coverage and final stabilization. An inactivation form is supplied with the permit certification or can be obtained at the CDPHE Website: www.cdphe.state.co.us.

CHAPTER 5

Construction Best Management Practices

5.1 Introduction

BMPs are "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States" (40 CFR 122.2). BMPs include, but are not limited to, "treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage" (40 CFR 122.2). BMPs also include measures for the control of erosion and sedimentation, and for the treatment of stormwater runoff (including highway runoff).

Implementation of BMPs for erosion and sediment control, and stormwater treatment is required by the CPDS stormwater regulations, and other regulatory guidance (see Section 2). BMPs are to be included in the SWMPs prepared for construction projects (see Section 4).

5.2 Planning

Planning for the inclusion of appropriate BMPs should occur early in the site development process, and can be divided into four separate steps:

1. Site Assessment – Collect the information from the site regarding topography, soils, drainage, vegetation, and other predominant features. Also make note of any existing erosion that is present. Analyze the information to anticipate erosion and sedimentation problems.

2. Avoidance and Minimization – Avoiding or minimizing disturbances on construction sites are the best protection measures against erosion and sedimentation problems. Inclusion of these measures will also decrease the amount of BMPs required during construction.

3. Construction Scheduling and Phasing – Develop a construction schedule and phasing plan that minimizes the amount of area exposed thus minimizing erosion and impacts to the area from development.

4. SWMP – Develop and implement a SWMP that specifies effective BMPs, taking into consideration the information generated from the site assessment and the construction schedule and phasing.

5. Inspections and Maintenance – Inspection and maintenance of BMPs are required by the SWMP. Evaluate the BMPs that will be implemented and allocate the necessary resources to provide for timely and thorough inspections and maintenance.

5.2.1 Site Assessment

Topography is the primary factor to be considered in determining the BMPs to be used at the site. Soils, vegetation, and hydrologic features must also be taken into account.

Grading will determine the slope gradient and slope length. After grading is completed, areas that remain exposed to precipitation and runoff will require the inclusion of additional BMPs. The appropriate BMPs will be a function of the duration of exposure and whether grading is interim or final.

Soil conditions should be assessed for erosion potential and suitability for revegetation. However, a detailed analysis of soil-erosion potential is not necessary, because all soils will be subject to erosion and can be generalized as equivalent for the design of BMPs.

Most vegetation will be removed from a construction site during clearing and grading operations. An assessment of existing onsite vegetation is of limited use when post-development landscaping and irrigation are planned, but can be useful in selecting grasses when non-irrigated revegetation is intended. Analysis of soil is useful to determine fertilizer requirements for vegetation establishment.

Analysis of streams and other hydrologic features of a site are important in the design of BMPs. The drainage basins upslope and within the site should be assessed. The configuration of hillslope areas and drainageways, in the context of planned roads and buildings, will determine the necessary erosion and sediment controls. The location of permanent drainage channels and other elements of the drainage system should be defined as part of the plan.

5.2.2 Avoidance and Minimization

Vegetation is the most effective way to control erosion, and disturbing soil removes this natural protective measure. Avoiding disturbance is the optimal measure to control erosion and sedimentation. Only clear and grub portions of the site that are necessary for construction, and preserve as much of the existing vegetation as possible. Preserve trees, bushes, and strips of natural vegetation in the area of construction. These natural elements serve to help hold soil particles in place, absorb the impact of rainfall, encourage infiltration, and slow the velocity of runoff.

Measures to avoid or minimize soil disturbances should be incorporated as early as the design phase of the project. Avoidance and minimization reduces the need for structural BMPs. Examples of avoidance and minimization measures include:

- Provide a clear span bridge over a receiving water.
- Install retaining walls adjacent to sensitive areas to avoid impact.
- Provide designated entries and exits as part of work access plan to the extent of land disturbance.
- Divert offsite runoff away from construction areas.
- Define areas of existing vegetation for protection on the plans.
- Design roadway alignments to minimize impacts to sensitive areas.

- Prohibit staging and stockpiling material in wetlands and threaten and endangered habitats.

5.2.3 Construction Scheduling and Phasing

This involves developing a construction schedule and phasing plan that minimizes the amount of erosion created by the development. Limiting the amount of soil exposed will result in the least impact to the area.

A construction schedule should be developed that takes into consideration the seasons and periods of heaviest precipitation. The schedule should also consider the available planting season to avoid having significant amount of exposed areas prior to the winter season when planting opportunities are limited.

In addition to scheduling, consideration must be given to phasing the project. CDOT Standard Specifications limit disturbed areas to 34 acres, including 17 acres for earthwork operations and 17 acres for clearing and grubbing. The phase the construction project should be phased conform to this requirement as well as to minimize the amount of exposed areas. This includes providing permanent stabilization for disturbed areas prior to progressing to the next stage of construction.

5.2.4 Stormwater Management Plan

The next step in the process is to develop and implement the SWMP for the construction site. The SWMP is typically prepared during the design phase of the project, and guidelines are included in Chapter 4. The SWMP should be modified by the contractor as necessary to reflect actual site conditions. Implementation of the SWMP will only be successful if the appropriate BMPs are utilized and their effectiveness is monitored. Therefore, SWMPs must be modified to conform to the construction site conditions.

5.2.5 Inspection and Maintenance

Inspection and maintenance are as important to pollution prevention as proper planning and design. The inspections will be used to determine whether the appropriate BMPs have been implemented, and whether maintenance or repair is required. The frequency and types of inspections are outlined in Chapters 2 and 4.

5.3 Elements of Best Management Practices

The objective of erosion control is to limit the amount of erosion occurring on disturbed areas until the site is stabilized. The objective of sediment control is to capture the soil that has been eroded before it leaves the construction site. Despite the use of both erosion and sediment control measures, it is recognized that some amount of sediment could remain in runoff leaving the construction site. This should be minimized.

The BMPs for a site are usually comprised of five major elements:

- Erosion Control
- Sediment Control
- Materials Handling and Spill Prevention

- Waste Management
- General Pollution Prevention Measures

Erosion controls are surface treatments that stabilize soil exposed by excavation or grading. Erosion control measures are referred to as source controls.

Sediment controls capture soil that has been eroded. Soil particles suspended in runoff can be filtered through a porous media or deposited by slowing the flow and allowing the natural process of sedimentation to occur. Sediment controls are measures implemented when erosion has occurred.

Materials Handling and Spill Prevention are measures implemented to minimize or prevent contamination of the natural resources present from materials stored on construction sites.

Waste Management are measures implemented to minimize or prevent contamination of the natural resources present from waste materials.

General Pollution Prevention BMPs are implemented to minimize or prevent general contamination of the construction site and natural resources present.

Table 5.1 provides a summary of the stormwater quality management BMPs to consider and included in this Guide.

TABLE 5.1
Stormwater Quality Management BMPs

BMP Name	BMP Number, Page
Erosion Control BMPs (EC)	
Seeding	EC 1, Page 5-8
Mulching	EC 2, Page 5-10
Mulch Tackifier	EC 3, Page 5-12
Soil Binder	EC 4, Page 5-13
Erosion Control Blankets	EC 5, Page 5-14
Turf Reinforcement Mats	EC 6, Page 5-19
Embankment Protector	EC 7, Page 5-22
Berm/Diversion	EC 8, Page 5-26
Check Dams	EC 9, Page 5-29
Outlet Protection	EC 10, Page 5-34
Temporary Drainage Swale	EC 11, Page 5-36
Grading Techniques	EC 12, Page 5-37
Sediment Control BMPs (SC)	
Erosion Bale	SC 1, Page 5-41
Erosion Logs	SC 2, Page 5-44

5.4 Selection of Controls

Implementation of BMPs will be successful if used appropriately, taking into account a number of factors. The following are guidelines recommended in determining the appropriate BMPs for the site:

1. Determine the limits of clearing and grubbing. If the entire site will not undergo excavation and grading, the boundaries of cut-and-fill operations should be defined. Buffer strips of natural vegetation may be utilized as a control measure.
2. Define the layout of buildings and roads. - This will have been decided previously as part of the general development plan. If building layout is not final, the road areas stabilized with pavement and the drainage features related to roads should be defined as they relate to the plan.
3. Determine permanent drainage features. - The location of permanent channels, storm sewers, roadside swales, and stormwater quality controls such as ponds, wetlands, grassed-lined swales, buffer strips, and areas of porous pavement, if known, should be defined.
4. Determine extent of temporary channel diversions. - If permanent channel improvements are a part of the plan, the route, sizing, and lining needed for temporary channel diversions should be determined. Location and type of temporary channel crossings can be assessed.
5. Determine the boundaries of watersheds. - The size of drainage basins will determine the types of sediment controls to be used. Areas located offsite that contribute overland flow runoff must be assessed. Measures to limit the size of upland overland flow areas, such as diversion dikes, may be initially considered at this stage.
6. Select erosion controls. - All areas exposed will require a control measure be defined dependent on the duration of exposure. These can be selected based on the schedule of construction.
7. Select sediment controls. - Areas greater than 5 acres will require the installation of sediment basins. Consideration can be given to dividing large drainage basins into subareas, each served by a sediment basin.
8. Determine staging areas. - The schedule of construction will determine what areas must be disturbed at various stages throughout the development plan. The opportunity for staging cut-and-fill operations to minimize the period of exposure of soils can be assessed. The sequence for installing sediment controls and erosion controls can also be determined at this time.
9. Identify locations of topsoil and other stockpiles.
10. Identify location of construction roads, access points, and material storage areas.

5.5 Erosion Control

Erosion Control BMPs

- ❑ Seeding
- ❑ Mulching
- ❑ Mulch tackifier
- ❑ Soil Binders
- ❑ Erosion Control Blankets
- ❑ Turf Reinforcement Mats
- ❑ Embankment Protector
- ❑ Berm/Diversion
- ❑ Check Dams
- ❑ Outlet Protection
- ❑ Temporary Drainage Swales
- ❑ Grading Techniques

Erosion and sedimentation processes during and after construction or maintenance activities (including highway construction and maintenance) can result in adverse impacts to the environment. These adverse impacts can be minimized through proper application of BMPs.

The first line of defense is to prevent erosion, which is accomplished by protecting the soil surface from raindrop impact and overland flow of runoff. Soil stabilization is a common and effective practice used to minimize erosion. Common practices include establishing new vegetation, maintaining and protecting existing vegetative cover over soils, and techniques to minimize erosion over disturbed soils where establishing a cover is not practical or possible.

Soil stabilization practices reduce the potential for erosion by:

- Absorbing the kinetic energy of raindrops
- Intercepting water so it can infiltrate into the ground
- Slowing the velocity of runoff
- Binding the sediments in the root layer

Soil stabilization practices are key practices, since the most cost-effective measure for erosion and sediment control is the prevention of erosion. This section discusses the most common erosion control BMPs.

EC 1: Seeding

Description

Grass and forb species planted for temporary or permanent cover on disturbed surfaces.

Applications

- Used for temporary cover when a disturbed area (i.e., detour slopes) will be left in place for more than 3 months.
- Used as permanent cover on disturbed soils.
- Used to improve wildlife habitat and aesthetics.

Limitations

- Seeding should not be applied when the ground is frozen or during the summer when moisture is not available to the seed.

Design Guidelines

- Appropriate native seed mix must be selected by determining soil type, precipitation, elevation, and aspect of site. If possible, identify native plant material that currently exists on site. CDOT landscape architect should be consulted for seed mix or for seed mix approvals.
- Provide a mix with a minimum of 6 native cool and warm season, bunch and sod forming grasses. Provide 80 to 100 pure live seed per square foot when evenly applied by a drill seeder.

- Jobs with landscaping and federal financial participation shall include wildflowers in the mix.
- Non-native species (i.e., oats, millet, winter wheat) may be used for a temporary nurse crop. Non-native species may be used for irrigated lawn areas.
- Provide for multiple mobilizations for seeding.

Installation

- Weights, seed species, and percentage of purity and germination must be checked prior to seeding.

TABLE EC 1.1
Seeding Season

Zone	Spring Seeding	Fall Seeding
Below 6000'	Spring thaw to June 1st	September 1st until consistent ground freeze
6000' to 7000'	Spring thaw to June 15th	August 15th until consistent ground freeze
7000' to 8000'	Spring thaw to July 1st	August 1st until consistent ground freeze
Above 8000'	Spring thaw to consistent ground freeze	Spring thaw to consistent ground freeze

- Seeding in areas that are not irrigated should be restricted to the seasons described in Table EC 1.1. If seeding cannot be accomplished due to seasonal constraints, apply mulch and mulch tackifier to the slopes for temporary erosion control. Maintain temporary mulch until permanent seeding is allowed.
- Prior to permanent seeding prepare soil and, if required, incorporate topsoil, amendments and fertilizer.
- Drill seed disturbed areas flatter than 2:1.
- Broadcast seed and rake into the soil on slopes 2:1 or steeper, double to triple drill seeding rates.
- Hydroseed only where 20 inches per year or more of precipitation occur and when slopes are 2:1 or steeper. Double to triple the hydroseeding rates.
- Permanent and temporary seeding shall occur throughout construction.

Maintenance and Inspection

- Inspect seeded areas frequently. If the seeded areas fail to establish, provide adequate ground coverage or is disturbed, the area should be re-seeded.

EC 2: Mulching

Description

Application of plant residues to the soil surface. Typically mulching material includes certified weed free hay or straw, certified under the Colorado Department of Agriculture Weed Free Forage Certification Program and inspected as regulated by the Weed Free Forage Act, Title 35, Article 27.5, CRS and wood cellulose fiber.

Applications

- Used in combination with mulch tackifier for temporary erosion control (i.e., incomplete slopes, detour slopes, stockpiles).
- Used in combination with mulch tackifier for temporary erosion control on slopes when seeding is not allowed due to seasonal constraints.
- Used to cover permanent or temporary seed areas.

Limitations

- Hay may have limited availability in the spring. When approved, straw may be substituted at 2 tons per acre.
- Hydromulch with wood cellulose fibers shall be limited to operations where precipitation is over 20 inches.
- Over spraying of hydromulch may result in erosion.
- Hydromulch shall not be done in the presence of free surface water.

Installation

- Mulch shall be applied at a rate of 1 ½ to 2 tons per acre.
- At a minimum, 50% of the mulch, by weight, should be 10 inches or more in length.
- Depth of the applied mulch should not be less than 1 inch and mot more than 2 inches.
- Applied mulch should be uniformly distributed so that no more than 10% of the soil surface is exposed.
- Applied mulch should be anchored to the soil surface by using tackifier and mechanically crimping immediately after mulching or at least within 4 hours.
- Apply hydromulch immediately after seeding. Hydromulch mixture shall be applied at 2000 pounds per acre wood cellulose fiber mulch; 100 pounds per acre tackifier.

Maintenance and Inspection

- Inspect frequently and reapply mulching in areas where the mulching has been loosened or removed. Mulch tackifier must be applied with additional applications of mulching.

EC 3: Mulch Tackifier

Description

An organic soluble powder adhesive used in the form of a water slurry to adhere native hay, straw, hydromulch, or seed to a surface and together. Derivative of plant material phyllium or Guar.

Applications

- Used in combination with a native forage material for mulching applications.
- Used in combination with seed to adhere seed to soil.
- Used to adhere wood cellulose material (hydro mulch) to surface.
- Used to cover disturbances as temporary cover for wind erosion.

Limitations

- Temporary measure to hold mulch material until native seeding is established.
- Product is water-soluble and must be reapplied 6-12 months after initial application if plants have not stabilized soils.
- Do not apply during precipitation event or over snow.
- Do not apply where in areas of concentrated flow.

Design Guidelines

Design mixture as shown or as recommended by the manufacturer:

- 150-200 lbs of organic mulch tackifier per acre.
- 1,000 gallons of water per acre.
- 350 lbs of wood cellulose material per acre.

Installation

- Apply within 4 hours of mulch application.
- Always apply in a liquid state.
- Can be applied in combination with organic fertilizers and humates.

Maintenance and Inspection

- Mulch movement indicates poor application and product mixture.
- Proper application will bond mulch material together and to soil.
- Inspect by touching mulch surface to determine if adhesion has occurred.

EC 4: Soil Binder

Description A polyacrlimide (PAM) soil conditioner applied to soil to reduce soil erosion.

Applications

- Used as temporary soil stabilizer on disturbed areas.
- Used in conjunction with seeding, mulching and mulch tackifier to reduce soil loss and encourage vegetation establishment.

Limitations

- Temporary measure to reduce soil loss.
- Product must be reapplied 6-12 months after initial application. If used in conjunction with seeding, reapply every 6-12 months until vegetation is established.
- Do not use as a mulch tackifier.
- PAM products must have enough soil penetration to be an effective adhesive material.

Design Guidelines

Mixture Application rate:

- 10-20 lbs per acre
- Mix with water and agitate.

Materials

- Minimum 12-15 mg/mol and charge density of 8-35%.
- Use anionic PAM.
- Use emulsion formulas for applications with water trucks

Installation

- Mix in water truck or hydroseeder and apply in a liquid state.
- Apply over roughened soil surface.
- Can be applied in combination with organic fertilizers and humates.

Maintenance and Inspection

- Rill erosion indicates poor product mixture and/or application. Reapply if rill erosion is present.
- Reapply atleast every 6 to12 months or when the surface has been disturbed.

EC 5: Erosion Control Blankets

Description

Organic or synthetic blankets installed on steep lopes or channels to prevent erosion until final vegetation is established.

Applications

- Used to control erosion and promote the establishment of vegetation.
- Used to protect channels against erosion from concentrated runoff. Also refer to EC 6, Turf Reinforcement Mats, for additional types of erosion protection for areas with concentrated runoff.
- Used as a temporary feature.

Limitations

- Blankets used on slopes should be biodegradable, or photodegradable, non-toxic to vegetation or germination of seed, and non-toxic or injurious to humans.
- Do not use on slopes where vegetation is already established.
- Use on slopes 2:1 or steeper. Also use in locations with 3:1 slopes facing south or west. Product must be reapplied 6-12 months after initial application. If used in conjunction with seeding, reapply every 6-12 months until vegetation is established.

Design Guidelines

- For slope applications, selection of the appropriate material will depend on the amount of runoff, steepness of the slope, flow velocities, cost, ease of installation, type of soils, shear stress, and past experience.
- For channel applications, selection will be based mainly on shear stress. Refer to EC 6 for additional selections.
- Table EC 5.1 indicates dome recommended criteria for the selection of erosion control blankets.

TABLE EC 5.1
Seeding Season

Condition	Blanket Type
Slopes 2:1 or Steeper	Straw Blanket Straw/coconut blanket Synthetic Blanket Wood Fiber Blanket (excelsior)
Erosive soil (sand) or slopes receiving sheet flow from roadway surface runoff	Straw Blanket Straw/coconut blanket Synthetic blanket

Materials

- Combination Blankets: Consists of a photodegradable plastic netting which covers, and is entwined, in a natural organic or man-made mulching material. The mulching material can be wood-fiber, excelsior, straw, coconut fiber, manmade fiber, or a combination of the same. Some existing combinations are 100% coconut fiber, or 70% agricultural straw and 30% coconut fiber, or 100% agricultural straw.
- Jute mesh: Consists of a mat lining woven of undyed and unbleached jute yarn. Varies from 1/8" to ¼" in diameter. The mat weighs approximately 0.80 lbs per square yard, with openings about 3/8" by ¾". It can be used with or without straw underlay.
- Soil reinforcement mats: Formed by three-dimensional structures of entangled nylon monofilaments, melt-bonded at their intersections. These mats must be capable of maintaining its shape, and are generally highly resistant to environmental and ultraviolet degradation.

Installation

- Areas where the blanket is to be used shall be properly prepared, fertilized, and seeded before the blanket is placed.
- Installation of the blankets shall be in accordance with the manufacturer's recommendations.
- The blanket shall be placed smoothly but loosely on the soil surface without stretching.
- Pins and staples shall be made of wire 0.162 inch or larger in diameter. "U" shaped staples shall have legs 8" long, and a 1" crown. "T" shaped pins shall have a minimum length of 8". The bar of the "T" shall be at least 4" long. Triangular survey stakes can also be used (see Figure 5.1).
- Staples shall be inserted in a pattern according to the manufacturer's recommendation.
- The upslope end of the blanket shall be buried in a trench 6" by 6" deep beyond the crest of the slope to avoid undercutting (see Figure EC 5.2).
- For slope applications, there shall be at least a 6" overlap wherever one roll of blanket ends and another begins, with the uphill blanket placed on top of the downhill blanket (see Figure EC 5.2).
- There shall be at least a 4" overlap wherever two widths of blanket are applied side by side (see Figure EC 5.2).
- In channels, the blanket shall be buried at terminal ends and every 35' in a trench 6" deep by 6" wide. Before backfilling, staples shall be placed across the width of the trench spaced at 6" on center in a zigzag pattern. The trench shall then be backfilled to grade and compacted by foot tamping.

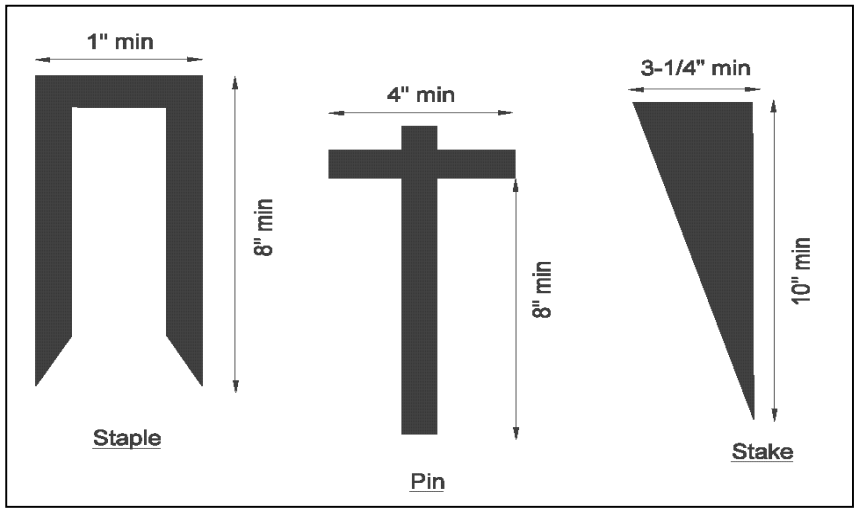


FIGURE EC 5.1
Erosion Control Blanket Anchors

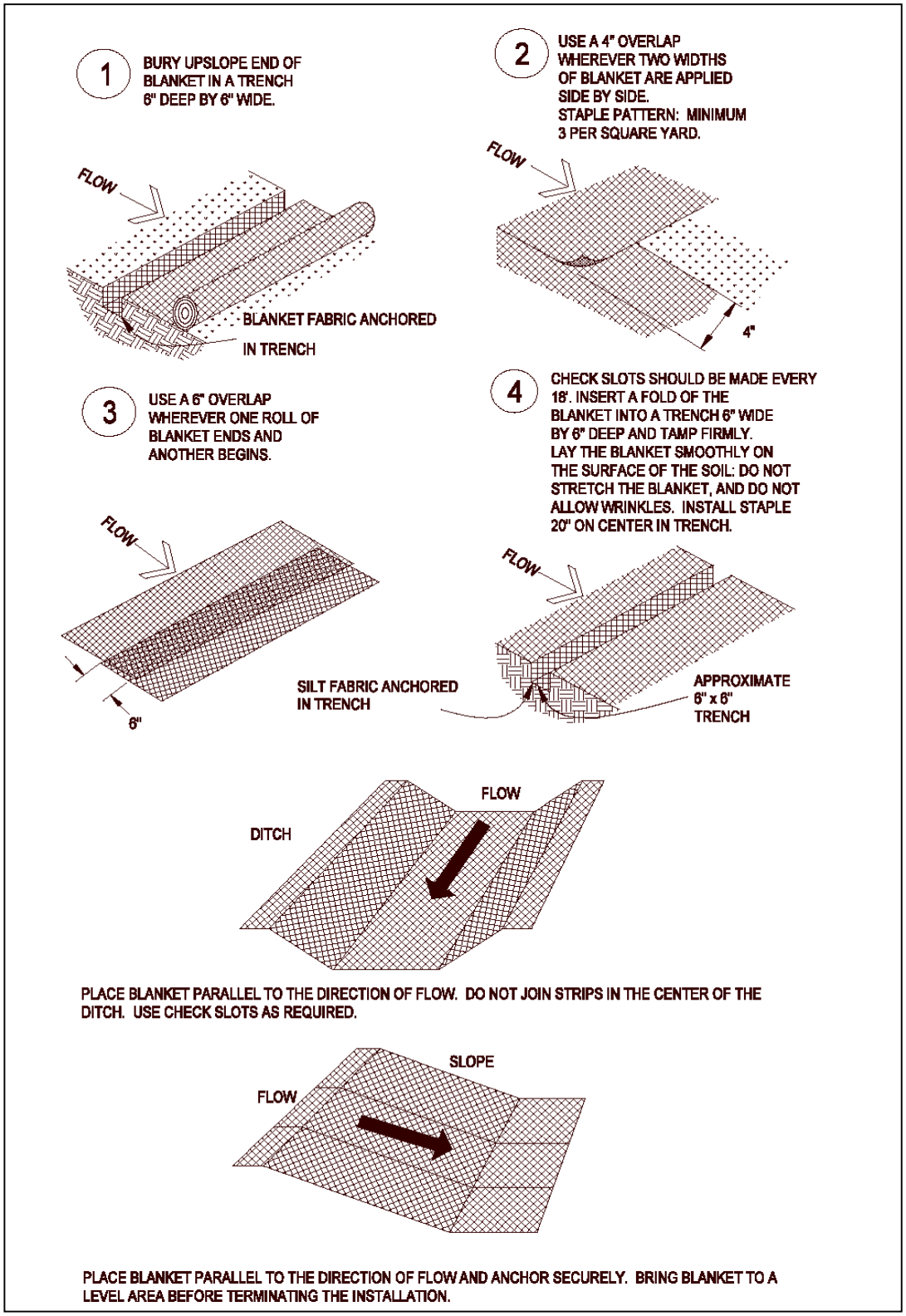


FIGURE EC 5.2
Erosion Control Blanket Installation

Maintenance and Inspection

- Re-anchor loosened matting and replace missing matting and staples as required.
- Inspection shall be performed periodically especially after a storm event that results in runoff, and any required repairs or maintenance shall be executed immediately.

EC 6: Turf Reinforcement Mats (TRM)

Description

A rolled permanent erosion control product composed of UV-stabilized, non-degradable, synthetic materials (which may include an organic, biodegradable fiber component) processed into a three-dimensional matrix.

Applications

- Used in ditches, swales, channels, and slopes where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation to prevent erosion.
- Used in transition areas before and after hard armor (i.e., riprap, concrete, asphalt etc.) to provide for stable and non-erosive transition.

Limitations

- In an unvegetated state, velocities should not exceed 14 ft/sec maximum or the limitations provided by the manufacturer.
- In a vegetated state, velocities should not exceed 25 ft/sec maximum or the limitations provided by the manufacturer.
- Maximum slope is dictated by the soil stability and above referenced limited velocity and shear stress limitations.
- Soils must be conducive to the establishment of vegetation.

Design Guidelines

- TRM may be installed as either an on-the-surface or soil-loaded system (for surface, see Figure EC 5.1; for soil-loaded, see Figure EC 5.2).
- TRM shall be unrolled in direction of flow with edges overlapped a minimum of 4 inches and end of rolls overlapped a minimum of 6 inches.
- Anchors for the TRM should be per manufacturer's recommendations for the particular TRM application and no less than two per square yard.

- TRM shall extend 2 feet minimum above the design maximum flow line in ditches, swales, and channels.
- Unless the TRM is anchored by a hard armor application, the leading edge of the TRM shall be buried and anchored per Figure EC 5.3.
- Soil-loaded system shall have no more than 1.5 to 2 inches of soil applied on the TRM.

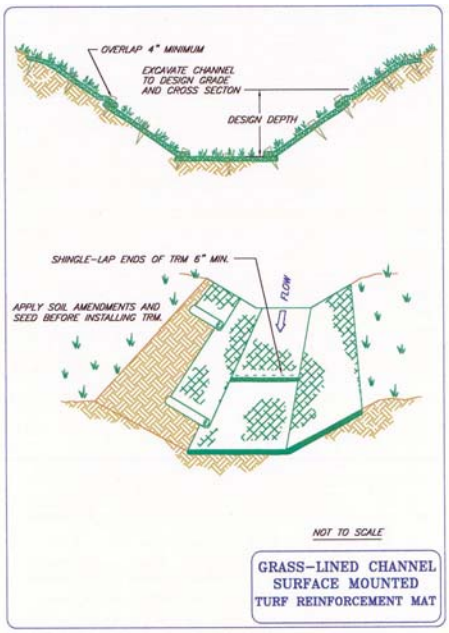


FIGURE EC 6.1
TRM in Ditch Application (CDOT[18])

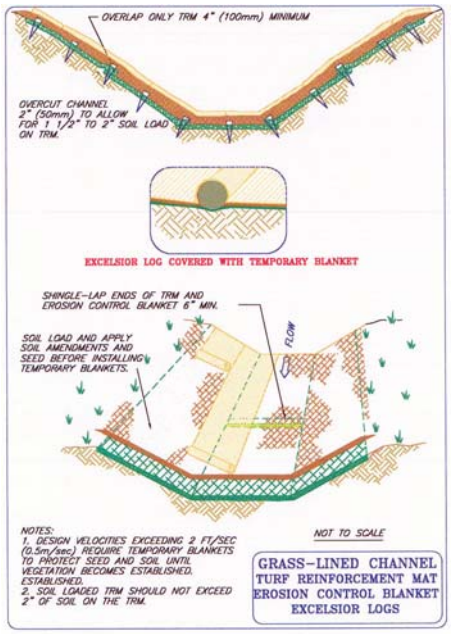


FIGURE EC 6.2
TRM in Ditch Application with Mesh/Burlap Socks (CDOT[18])

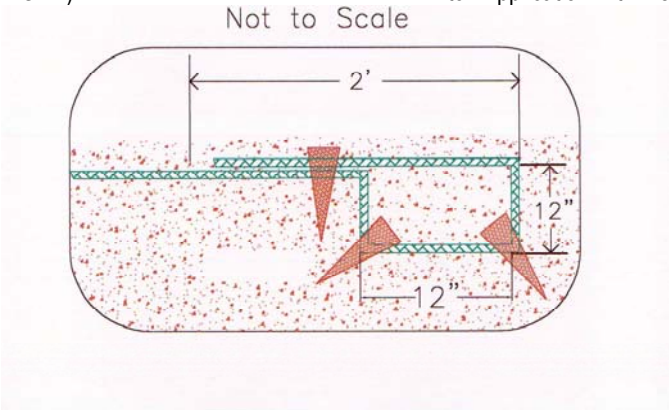


FIGURE EC 6.3
Trenching of TRM (CDOT[18])

Installation

- All vegetation, roots, rocks, and other objectionable material shall be removed and disposed of so as not to create loss of soil contact by the TRM when installed.
- If TRM is not soil loaded, apply seed, soil amendments, etc. before installing TRM.
- If the TRM is soil loaded, follow installation of the TRM with seed and soil amendments. After soil loading the TRM, install an erosion control blanket as shown in Figure EC 6.2. Install the erosion control blankets in accordance with the manufacturers recommendation. General guidelines are included in BMP EC 11: Erosion Control Blanket.
- If mesh/burlap socks are used in conjunction with the soil-loaded system, they should be placed before the erosion control blanket and after soil loading. The erosion control blankets should be unrolled and closely stapled to the upper edge of the mesh/burlap sock; unrolled tightly over the mesh/burlap sock and stapled closely at the lower edge; and then continuously unrolled (see Figure EC 6.3).

Maintenance and Inspection

- Re-anchor loosened matting and replace missing matting and staples as required.
- Inspection shall be performed periodically especially after a storm event that results in runoff, and any required repairs or maintenance shall be executed immediately.

EC 7: Embankment Protector

Description

A conduit or chute used for drainage conveyance down slopes.

Applications

- Used to convey concentrated runoff from the top to bottom of slopes.
- Used as a temporary measure.

Limitations

- Embankment protectors used along unstabilized slopes will be limited to tributary drainage areas of 2 acres or less. Tributary areas between 2 and 5 acres are feasible provided the slopes are stabilized.
- Open-chute drains shall be used only on straight alignment.
- Embankment Protectors shall be placed only on well compacted stable slopes.

Design Guidelines

- Open-chute embankment protectors must be designed by an engineer. The design should provide for adequate protection of the slopes and upstream and downstream areas. The selection of a design frequency should be relative to the life of the BMP, upstream and downstream conditions, and the hazards involved.
- Design criteria are provided for pipe embankment protectors in Table EC 7.1 for various contributing areas. For contributing areas not specified in Table EC 7.1, an engineering design is required.

TABLE EC 7.1
Pipe Embankment Protectors Design Criteria

Maximum Drainage area (acres)	Pipe Diameter (inches)
< 1.5	12
< 5	18
< 10	24

Materials

- The embankment protectors shall consist of heavy-duty material designed and suitable for the purpose. Figure EC 7.1 shows some examples.

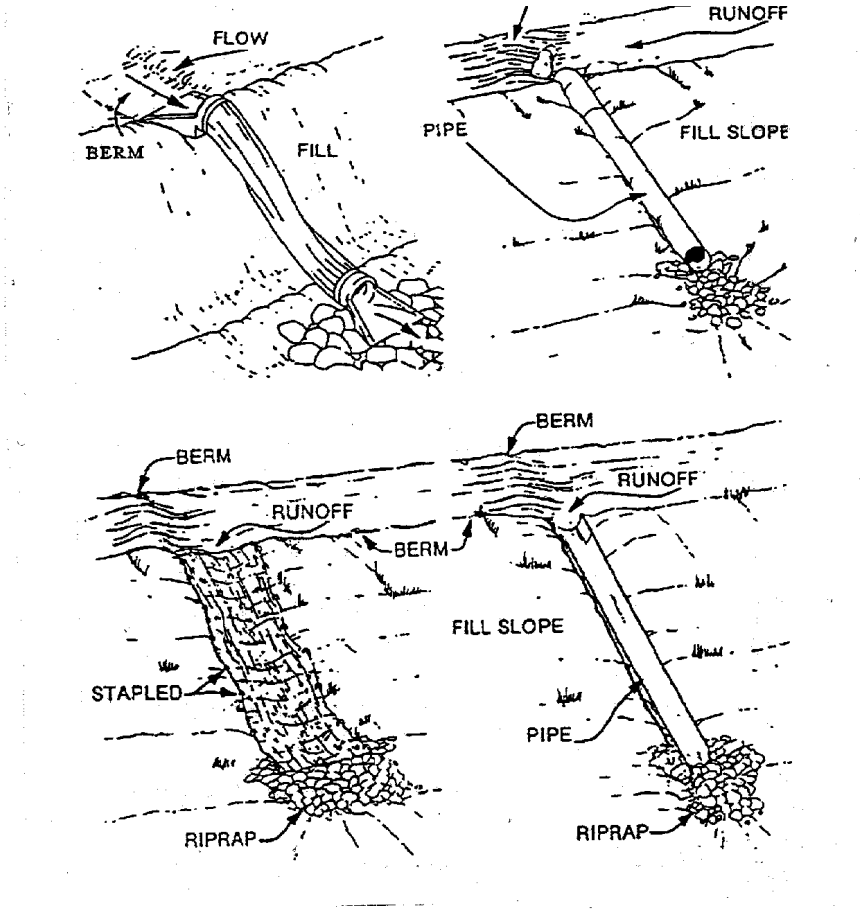


FIGURE EC 7.1
Slope Drains (CDOT[18])

Installation

- The inlet of the embankment protectors shall be protected to prevent erosion. For pipe embankment protectors, an end section with a short

section of pipe through a berm creates the most satisfactory inlet. Height of berm at the inlet of the pipe shall be at least two pipe diameters as measured from the invert from the pipe (see Figure EC 7.2).

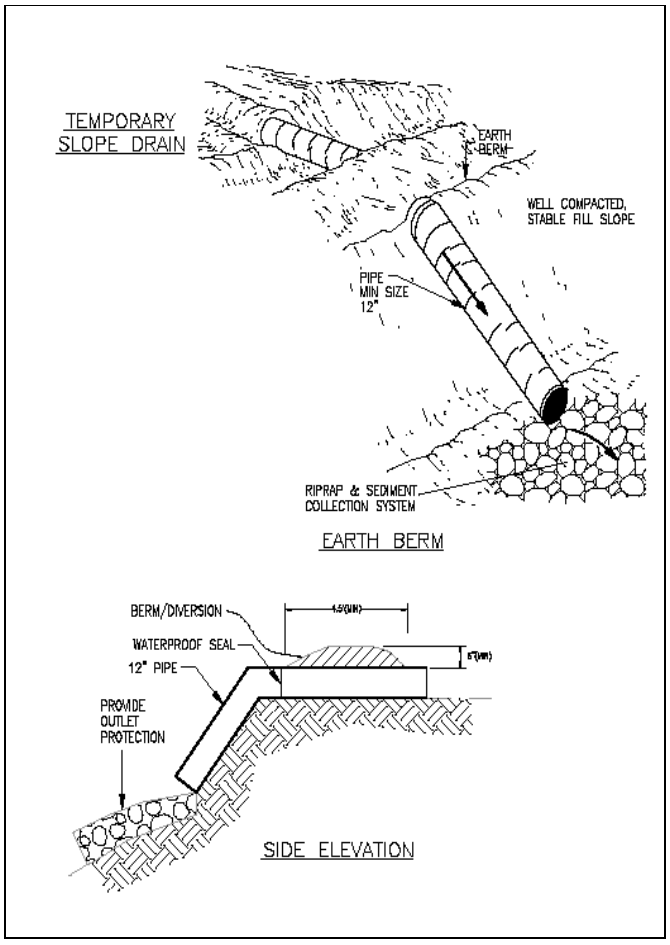


FIGURE EC 7.2
Pipe Slope Drain (CDOT[18])

For chutes as shown in Figure EC 7.1, a channeled section should be provided at the inlet. Minimum freeboard of 6 inches must be provided.

The berm or channeled section of the embankment protector should be lined with rock. Placement of a geotextile under the rock may be considered to minimize migration of fines. The geotextile shall extend 5 feet in front of the inlet and be keyed in 6 inches on all sides. The earthen berm and soil under the entrance section shall be compacted in 8-inch lifts to prevent seepage and failure.

- Pipe embankment protectors shall be securely fastened together and have water-tight fittings. The pipe sections shall be securely anchored to the slope. Minimum pipe size shall be 12 inches nominal.

- Adequate outlet protection must be provide to ensure discharges from the embankment protector does not cause erosion. Rock outlet protection (BMP EC 10) should be considered.

Maintenance and Inspection

- After each significant rainfall, embankment protectors should be inspected for erosion and accumulation of debris at the inlet and outlet. Debris should be removed and areas with erosion should be stabilized immediately.
- Embankment protectors composed of pipes should be inspected for breaks or clogs in the pipe. Open chute protectors should be inspected for undercutting. Required repairs should be provided immediately
- Embankment protectors should be removed when their useful life has been completed. The area beneath and adjacent to the embankment protectors should be seeded and mulched immediately after removal.

EC 8: Berm/Diversion

Description

A temporary berm or ridge made of soil (or coarse aggregate), with or without a diversion channel.

Applications

- Used to intercept and divert runoff to desired location such as towards a sediment trap or a slope drain.
- Used to divert runoff from areas where it might damage property, cause erosion, or interfere with the establishment of vegetation.
- Used along the top edges of cuts and fills to protect the embankment.
- Used as a temporary feature.

Limitations

- Berms to intercept and divert runoff should not be used where the drainage area exceeds 10 acres.
- Should not be used in areas with slopes steeper than 10 percent.

Design Guidelines

Location

- Appropriate location should be determined by considering outlet conditions, topography, land use, soil type, length of slope, and areas where seepage might be a problem.

Berm

- Berms shall have a minimum height of 18 inches, side slopes of 2:1 or flatter, and a minimum base width of 4.5 feet (see Figure EC 8.1).

Diversion channel

- The diversion channel shall have a minimum capacity to convey the runoff expected from a 2-year frequency storm. Diversions to protect homes, schools, industrial buildings, roads, parking lots, and comparable high risk areas, as well as those intended to function in connection with other structures, shall have sufficient capacity to carry peak runoff expected from a storm frequency consistent with the hazard involved.
- Design channel in accordance with the CDOT *Drainage Design Manual*.
- The minimum freeboard shall be 6 inches.
- The geometry may be parabolic, trapezoidal, or V-shaped (see Figure EC 8.1).

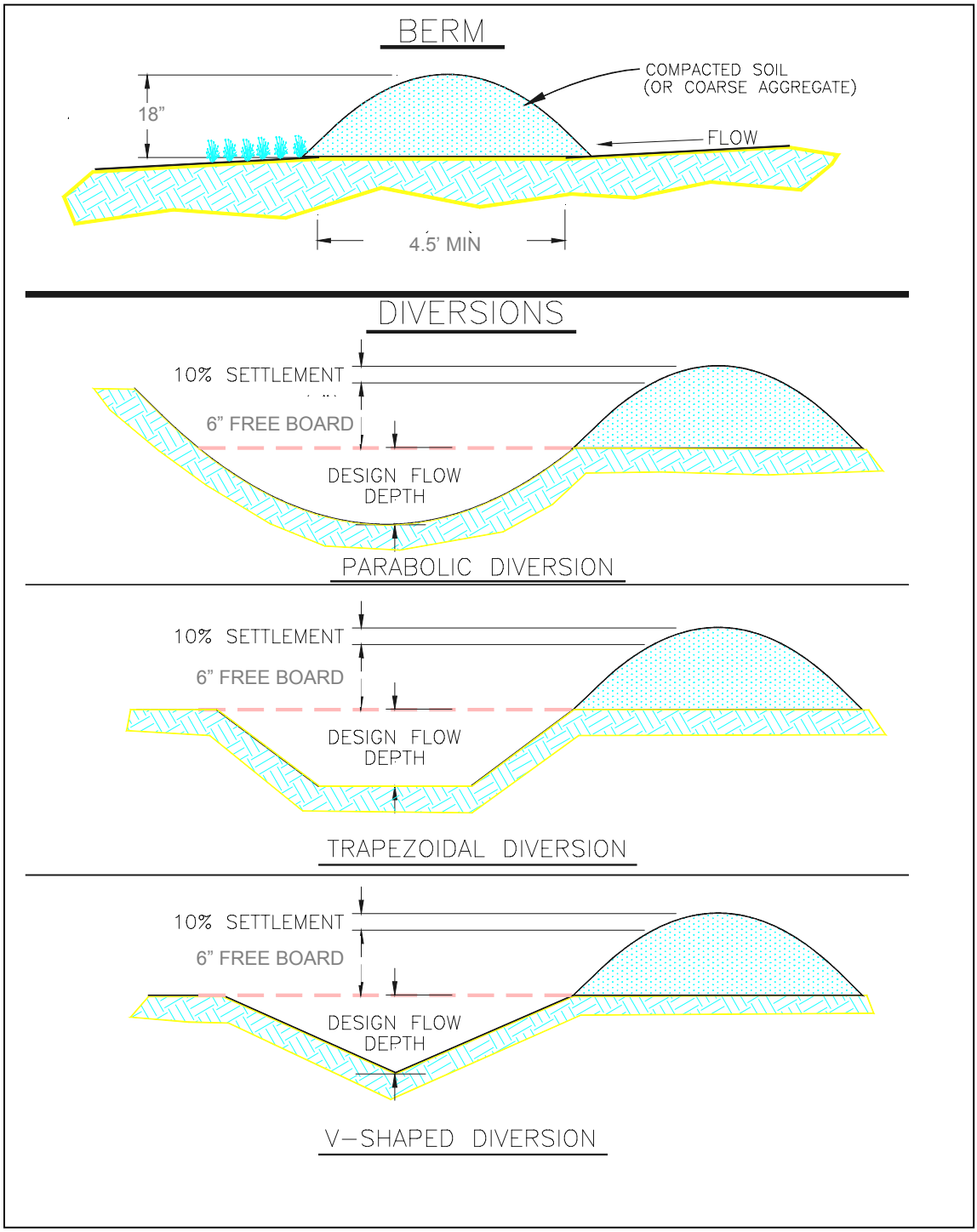


FIGURE EC 8.1
Berm/Diversion Geometry (Adapted from VEaSCH[28])

Materials

- Berms and diversions should be constructed of compacted soil or coarse aggregate.

Installation

- All berms shall have an uninterrupted positive grade to a stabilized outlet. The outlet should be capable of conveying concentrated runoff into an undisturbed, stabilized area at a non-erosive velocity.
- Berms shall be compacted as needed to prevent unequal settlement.
- Diversion channels shall be excavated or shaped to line, grade, and cross-section as indicated in the plans and as required to meet the criteria as specified.
- All trees, brush, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the diversion.
- Berms and diversion channels should be stabilized with riprap, turf reinforcement or appropriate measure for protection against erosion and failure.

Maintenance and Inspection

- Inspection and maintenance must be provided periodically and after each rain or snowfall event that causes runoff.
- Sediments accumulated against the berm should be removed periodically and properly disposed of.
- Erosion along the berm should be repaired with the stabilization measure re-established.

EC 9: Check Dams

Description

Small dams constructed across a swale or drainage ditch.

Applications

- Used for the purpose of reducing the velocity of concentrated stormwater flows to non-erosive velocities, thereby reducing erosion in swales or ditches.
- Used on temporary or permanent ditches or swales to reduce erosion.
- Used in borrow ditches until vegetative cover is established.
- Used as a temporary feature.

Limitations

- Use only in small open channels which drain 10 acres or less.
- Do not use in continuous flow streams.
- Should not be used as a primary sediment trapping device.

Design Guidelines

Location

- The check dam should be placed in reasonably straight ditch sections to minimize the potential for erosion in the channel bend.
- In locating the check dam, consideration should be given to the effects and reach of the impounded water and sediment.

General criteria

- Standard check dams are 2 feet high with 2:1 side slopes and a weir section at the center of the dam at least 6 inches lower than the existing ground at the outer edges of the check dams. These dimensions may be modified based on individual needs (see Figure EC 9.1).

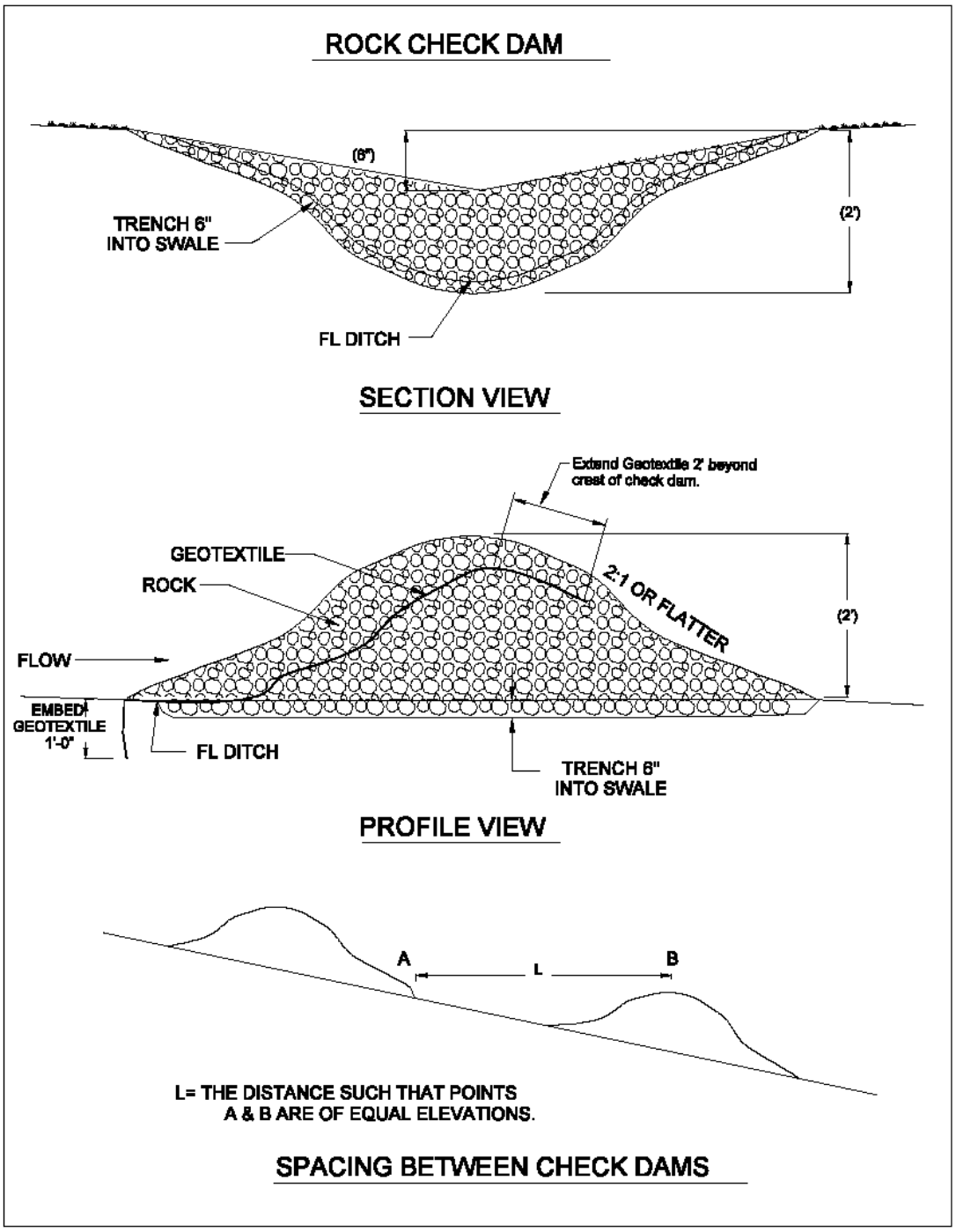


FIGURE EC 9.1
Rock Check Dam (CDOT[18])

- A 2-year or larger storm should safely flow over the check dam without an increase in upstream flooding or destruction of the check dam.
- The maximum height of the check dam at the center should not exceed 2 feet or one-half the depth of the ditch or swale. The check dam shall be wide enough to reach from bank to bank of the ditch or swale.

- As a general rule, the maximum spacing between dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam (see Figure EC 9.1). Based on this criteria alone, recommended spacing for a 2 feet high check dam given various channel slopes are included in Table 5.5 below.

TABLE EC 9.1
Check Dam Spacing

Slope	2 percent	3 percent	4 percent	5 percent	6 percent
Spacing (ft)	100	67	50	40	33

- If using the above criteria results in the check dams being too close together, a second criteria can be used. This criteria involves calculating the adjusted slope required to reduce the flow velocity to non-erosive rates. The adjusted slope can be calculated using a form of Manning's equation:

$$S_a = \left(\frac{V_e \times n}{1.49 \times R^{2/3}} \right)^2 \text{ (English Units)}$$

where:

S_a = Adjusted channel slope, ft/ft

V_e = Permissible velocity for native grass, 4 ft/s.

n = Manning's roughness coefficient

R = Hydraulic radius, ft = Cross section flow area/wetted perimeter

Note: Applies to Froude number < 0.5.

The required spacing will the be determined as:

$$X = \frac{Y}{S - S_a}$$

where:

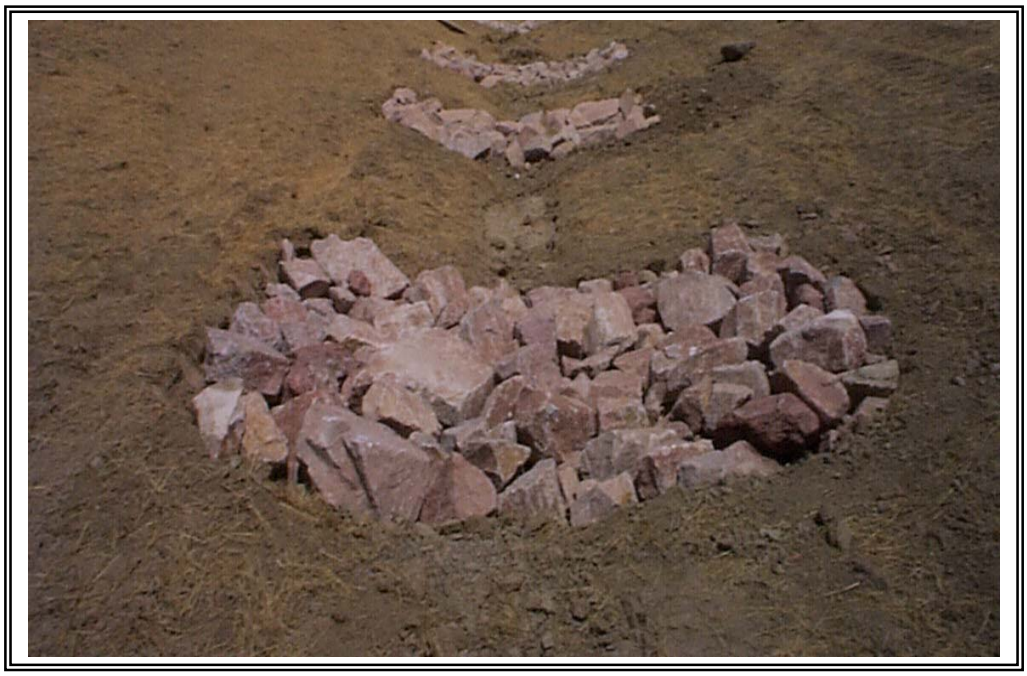
X = Check dam spacing, ft

Y = Check dam height, ft

S = Natural channel slope, ft/ft

Materials

- Check dams should be constructed of 4- to 6-inch stone. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to insure that the center of the dam is lower than the edges.



- Erosion bales and other types of materials can be considered for check dams. Erosion bale check dams will be used only as temporary erosion control measures.

Installation

- A weir section shall be located at the center of the dam. This weir shall be at least 6 inches lower than the outer edges as shown in Figure EC 9.2.
- Check dams should be keyed into the sides and bottom of the channel, minimum of 4- to 6-inches.
- Erosion bales used as check dams must be placed in rows, lengthwise, oriented perpendicular to the contour, with ends of adjacent bales tightly abutting one another as shown in Figure EC 9.2.
- The maximum spacing between barriers should be such that the toe of the upstream barrier is at the same elevation as the top of the downstream barrier (see Figure EC 9.2).

Maintenance and Inspection

- While this practice is not intended to be used primarily for sediment trapping, some sediment will accumulate behind the check dams. After each significant rainfall, check dams should be inspected for sediment and debris. Sediment should be removed from behind the check dams when it has accumulated to one-half of the original height of the dam and properly disposed of.
- Inspect for erosion along the edges of the check dams and repair as required immediately.

- Check dams should be removed when their useful life has been completed. In temporary ditches and swales, check dams should be removed and the ditch filled in when it is no longer needed. In the case of grass-lined ditches, check dams should be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams should be seeded and mulched immediately after the check dams are removed.

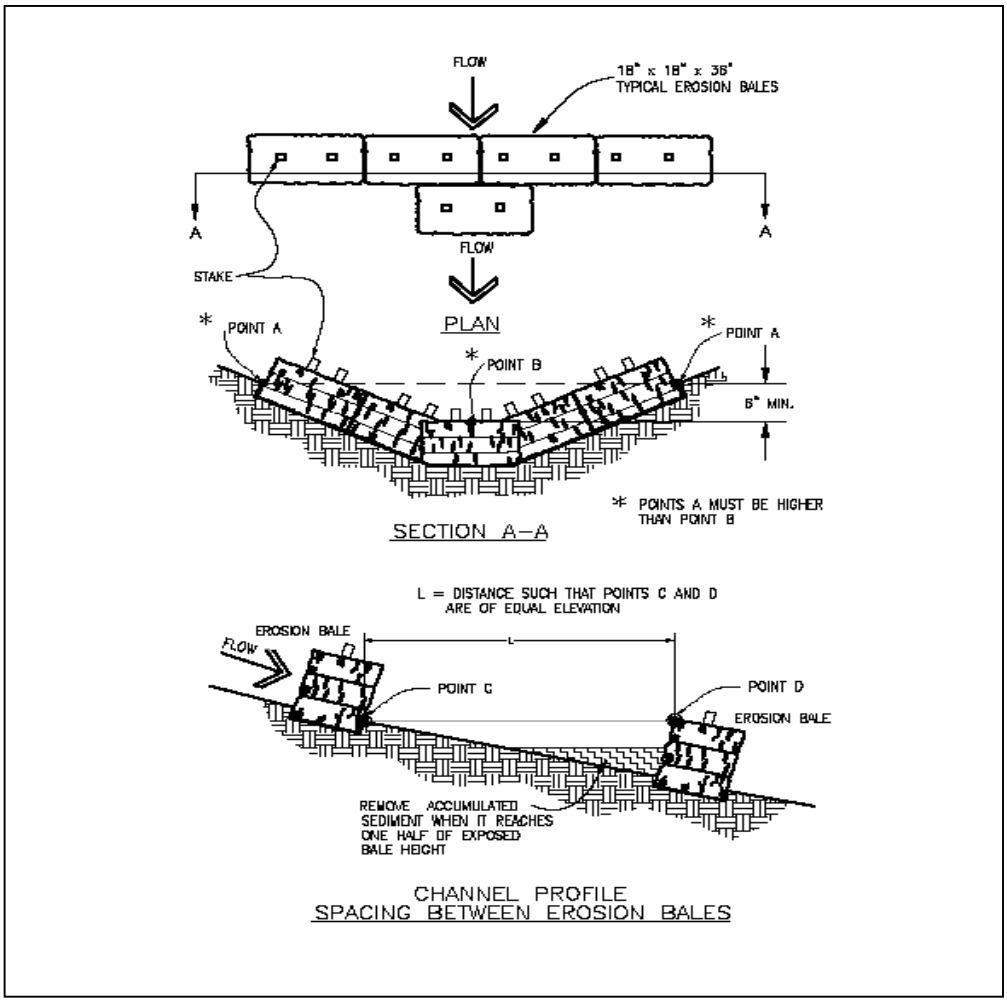


FIGURE EC 9.2
Erosion Bale Check Dams (CDOT[18])

EC 10: Outlet Protection

Description

A structurally lined apron (generally with riprap, grouted riprap, or concrete) placed at the outlet of pipes or paved channel sections.

Applications

- Used as an energy-dissipation device to prevent scour and erosion at the outlet by reducing the velocity and energy of concentrated flow.
- Used as a temporary feature.

Limitations

- Do not use where the flow is excessive for the economical use of an apron. Excavated stilling basins may be used as an option. Criteria for the design of stilling basins is available from the Bureau of Reclamation[34].

Design Guidelines

- Outlet flow velocity must not exceed the permissible velocity of the receiving channel. Outlet protection is required when the permissible velocity of the receiving channel is exceeded.
- Grade of the apron shall be 0.0 percent. The apron length will be determined based on the outlet flow rate and the tailwater level. The apron width will be determined based on the tailwater condition and whether the discharge is into a well-defined channel or onto a flat area with no defined channel. The apron shall be located so as to avoid bends in the horizontal alignment. The outlet protection shall be installed immediately upon construction of the pipes or channel sections.
- The apron may be lined with riprap, grouted riprap or concrete. Riprap size will be a function of the outlet flow rate, flow velocity, and the tailwater level.
- Specific design guidelines for outlet protection can be found in the Energy Dissipation Chapter of CDOT's *Drainage Design Manual* or in:
  - Hydraulic Design of Energy Dissipaters for Culverts and Channels, *Hydraulic Engineering Circular No. 14*, U.S. Department of Transportation, Federal Highway Administration.
  - Hydraulic Design of Stilling Basins and Energy Dissipaters, *Engineering Monograph No. 25*, U.S. Department of the Interior, Bureau of Reclamation.

Installation

- Gradation, quality, and placement of riprap shall conform to Section 506 of CDOT's Standard Specifications for Road and Bridge Construction.
- Stone shall be placed homogeneously and to the full-course thickness in one operation; displacement of underlying materials shall be avoided.
- A geotextile, or a granular filter, should always be included and placed between the riprap and the underlying soil. The geotextile is used to prevent soil movement into and through the riprap. The geotextile material to be used shall conform to Section 420 of CDOT's Standard Specifications for Road and Bridge Construction.
- The geotextile shall be protected from punching, cutting, or tearing. Overlaps between two pieces of geotextile shall be 1 foot minimum.

Maintenance and Inspection

- Inspection shall be performed after high flows for scour and dislodged stones. Repairs shall be made immediately.

EC 11: Temporary Drainage Swale

Description

Temporary drainage swales are implemented to intercept, divert, collect surface runoff, and convey the accumulated runoff to acceptable outlet points in order to prevent sediment from entering the storm drainage system.

Applications

- Along the bottom or mid-slope of steep grades to intercept sheet flow and direct the concentrated runoff towards an acceptable outlet point.
- At the top of slopes to divert and direct offsite runoff from adjacent slopes.
- Along roads to intercept and convey runoff.
- Can be used as an alternative to silt fences.

Limitations

- May be necessary to implement other sediment control measures along with swales to control erosion.
- Swales are not effective sediment trapping measures.

Standards and Specifications

- Drainage swales shall be sized according to design procedures outlined in the CDOT *Design Drainage Manual*.
- At a minimum, the swale should conform to predevelopment drainage patterns.
- Provide stabilized drainage channels and outlets.
- Permanent dikes and swales should be installed where possible.
- Do not use to divert runoff from highway right-of-way onto adjacent properties.

Maintenance and Inspection

- Inspect temporary swales weekly and after rainfall and snowfall events for washouts, lost riprap, damaged lining, erosion, and accumulation of debris and sediment in the swale. Repair damaged sediment control measures and remove accumulated sediment as soon as possible.
- Remove temporary sediment control measures once the project areas has been stabilized.

EC 12: Grading Techniques

Description Soil surface roughening, terracing and rounding at tops of cuts, transitions, and roadway ditches to facilitate plant establishment and minimize soil erosion.

Applications

- Used to temporarily stabilize disturbed areas and protect from wind and water erosion.
- Used as a temporary practice during construction.

Installation

- Round channel bottoms to avoid V-shaped ditches and top of cut of cut slopes.
- Avoid angles in cut-and-fill transition areas by rounding transition line.
- Roughen, terrace, scarify or disc parallel to the contours. Scarify or disc to maintain 1- to 3-inch minimum variation in soil surface.

- Grading techniques are BMPs that must be implemented in conjunction with other BMPs such as mulching or soil binders. Use of only grading techniques are not adequate erosion control BMPs.

Maintenance and Inspection

- Inspection and maintenance must be provided periodically and after each rain or snowfall event that causes runoff to ensure roughed state is maintained.
- Rills developed should be filled and the area re-graded immediately .

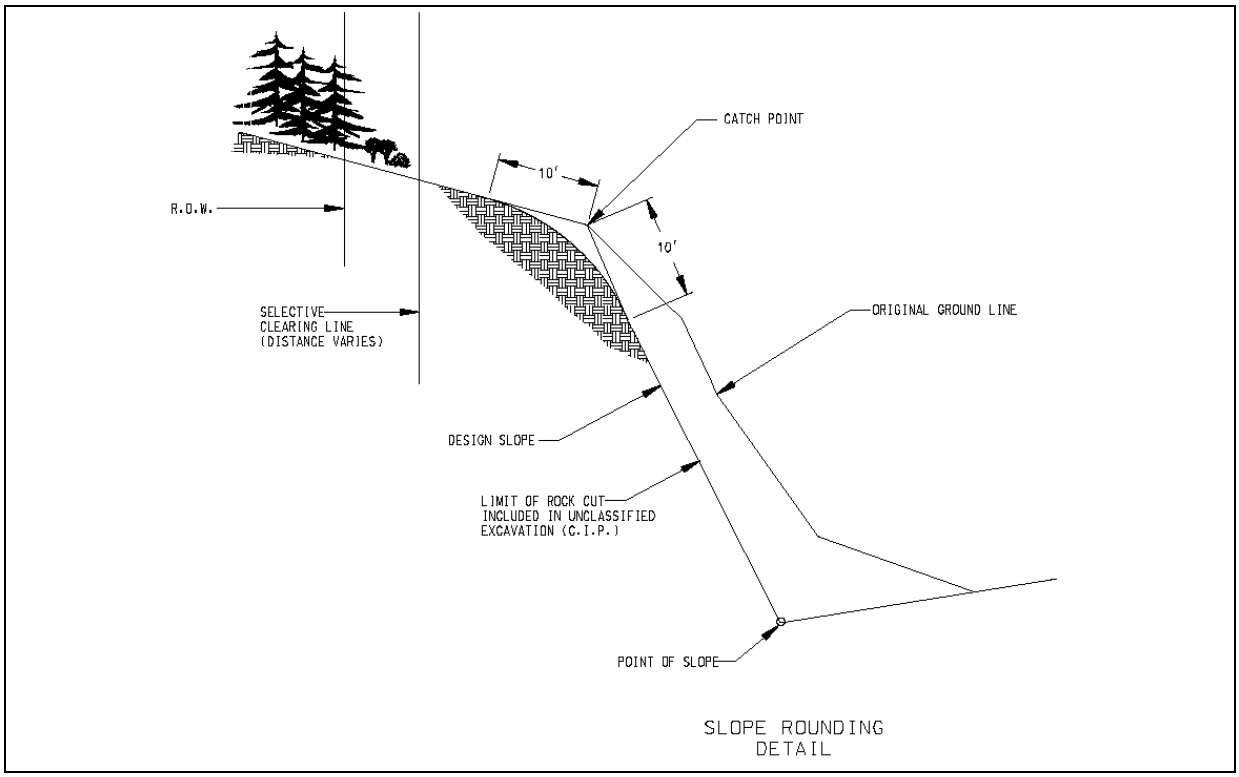


FIGURE EC 12.1
Slope Rounding Flatter than 2:1(CDOT[18])

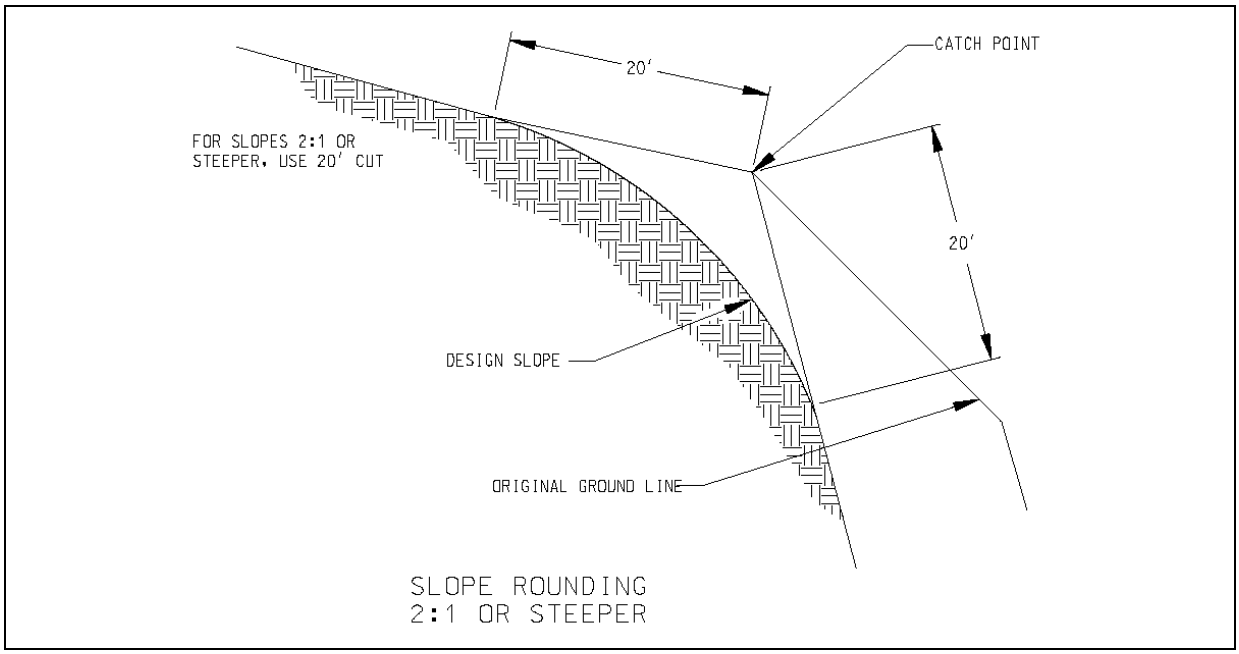


FIGURE EC 12.2
Slope Rounding 2:1 or Steeper (CDOT[18])

5.6 Sediment Control

Sediment Control BMPs

- ❑ Erosion Bale
- ❑ Erosion Logs
- ❑ Silt Fence
- ❑ Storm Drain Inlet Protection
- ❑ Sediment Trap
- ❑ Sediment Basin
- ❑ Dewatering Structure
- ❑ Stabilized Construction Entrance
- ❑ Brush Barrier
- ❑ Gravel Barrier
- ❑ Silt Barrier

Sites exposed to wind, rain, and snow can be susceptible to soil erosion and subsequent sedimentation. Sedimentation results when soil particles are suspended in surface runoff or wind and are deposited in streams and other water bodies.

Erosion can be accelerated by vegetation removal, earthwork activities, changing natural drainage patterns, and by covering the ground with impermeable surfaces. It is important to recognize that the optimal BMP is to prevent or minimize erosion by proper planning and the use of the erosion control practices identified in Section 5.5. However, erosion is inevitable to some extent on construction sites. Therefore, anticipating sedimentation and providing for a secondary line of defense by implementing sediment control BMPs is good planning. Sediment control BMPs are intended to intercept, slow, or detain the flow of storm water to allow sediment to settle and be trapped.

Following are some of the most common sediment control BMPs.

SC 1: Erosion Bale

Description

A temporary sediment barrier consisting of a row of entrenched and anchored straw, or hay bales.

Applications

- Used as temporary sediment barriers and filters along the toe of fills or around inlets.

Limitations

- Do not use along toe of fills where the size of the drainage area is greater than one-quarter acre per 100 feet of barrier length; maximum slope length and gradient behind the barrier is 100 feet and 50 percent (2:1), respectively.
- Do not use where effectiveness is required for more than 3 months. Useful life of erosion bale is approximately 1 year; the bales may have to be replaced one or more times during construction.
- Under no circumstances should erosion bale be constructed in flowing streams or in swales where flows are likely to exceed 1 cfs, and where the contributing drainage area is greater than 1 acre.
- Not to be used where the control of sediment is critical; in high-risk areas; in areas where they cannot be entrenched as required and firmly anchored; and areas where ponded water could flow onto the roadway.

Installation

- The erosion bale must be entrenched and backfilled. A trench should be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. After the bales are staked, the excavated soil must be backfilled against the barrier. Backfill soil should conform to the ground level on the downhill side and should be built up to 4 inches against the uphill side of the barrier.
- Each bale must be securely anchored by at least two wooden stakes driven toward the previously laid bale to force the bales together. Stakes should be driven into the ground a minimum of 1 foot to securely anchor

the bales. Stakes should have a minimum diameter or cross section of 2 inches. Reinforcing bars shall not be used in place of the wooden stake.

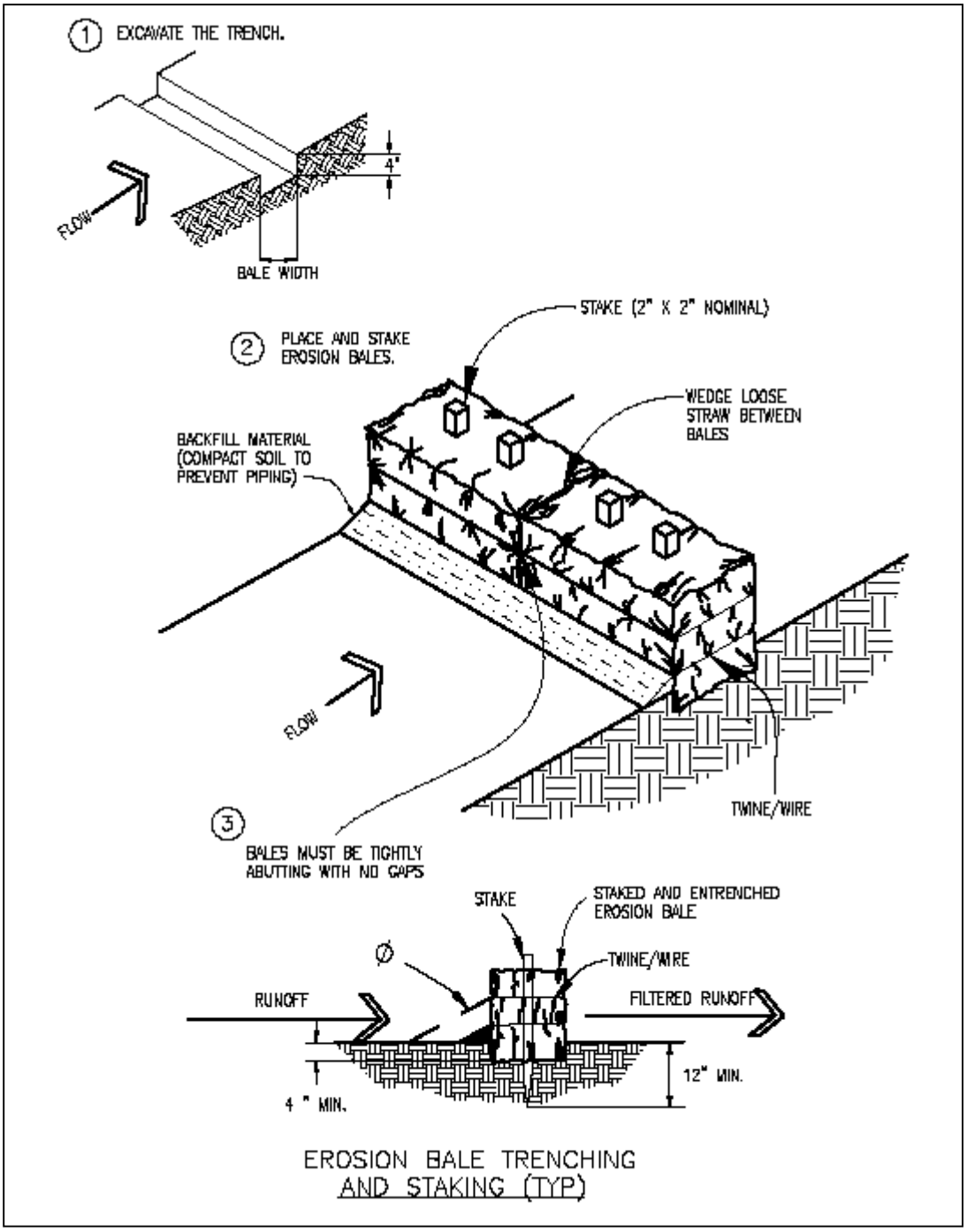


FIGURE SC 1.1
Erosion Bale Installation (CDOT[18])

- All bales must be either wire-bound or string-tied, and they should be installed so that bindings are oriented around the sides rather than along

the tops and bottoms of the bales (in order to prevent deterioration of bindings).

- The gaps between bales should be filled by wedging with straw to prevent water from escaping between the bales. The main consideration is to obtain tight joints. Erosion bales will not filter sediment or pond water if the water is allowed to flow between, around, or under the bales. Loose straw or hay scattered over the area immediately uphill from an erosion bale barrier tends to increase barrier efficiency.
- Along toe of fills, install the erosion bales along a level contour and leave enough area behind the barrier for runoff to pond and sediment to settle. A minimum distance of 5 feet from toe of the fill is recommended.

Maintenance and Inspection

- Erosion bales deteriorate quickly and, therefore, inspections during construction should be frequent. Repair or replacement should be made promptly as needed.
- Erosion bales must be removed when they have served their usefulness.
- Trenches where erosion bales were located should be graded and stabilized.
- Sediment accumulation against the erosion bale barrier shall be removed when it reaches half the exposed bale height. Sediments removed must be properly disposed.
- Replace erosion bales as necessary but at a minimum of once each year.

SC 2: Erosion Logs

Description

Erosion logs filled with rock or other filter material used for erosion and sediment control.

Applications

- Used upstream of curb inlets to filter sediment laden runoff. Logs of various length can be accommodated with multiple logs installed in series. Typical placement of a log is upstream of an inlet, in the gutter flow line, and also at the entrance of an inlet.
- Used as check dams in ditches and swales for erosion control until vegetative cover is established.
- Used as a temporary feature.

Limitations

- Logs are manufactured BMPs. Refer to the manufacturer for guidelines on limitations.
- Do not use in ditches and swales with continuous flow.

Material

- Several types of logs exist. A "gravel" log is typically a cylindrical shaped filter with ¼ inch mesh or burlap filter cover filled with ¾ inch gravel. Refer to the manufacturer for specific material specifications.

Installation

General installation guidelines are provided, however, refer to the manufacturer for specific installation requirements.

Installation for Check Dam Applications

- When using as a check dam, it should be placed in straight sections to minimize the potential for erosion in the channel bend.

Installation for Curb Inlet Protection (Upstream of inlet)

- Logs will be used upgradient of inlet perpendicular to and flush with the curb.
- The maximum height of the curb log should be less than the top of the curb opening. This is to allow overflows to occur during large rainfall events even though sediment-laden runoff will enter the storm drainage system.
- No less than two 10-inch diameter logs must be used in sequence, spaced no more than five feet apart, upgradient of inlet. No less than six logs shall be used if the 4–inch log is chosen.
- Incline at 30 degrees from perpendicular, opposite the direction of flow.

Installation for Curb Inlet Protection (Entrance of inlet)

- Identify curb opening dimensions to determine how many logs are required.
- Place the log(s) end-to-end along the curb inlet opening.
- Angle the ends of the log(s) towards the curb inlet opening.

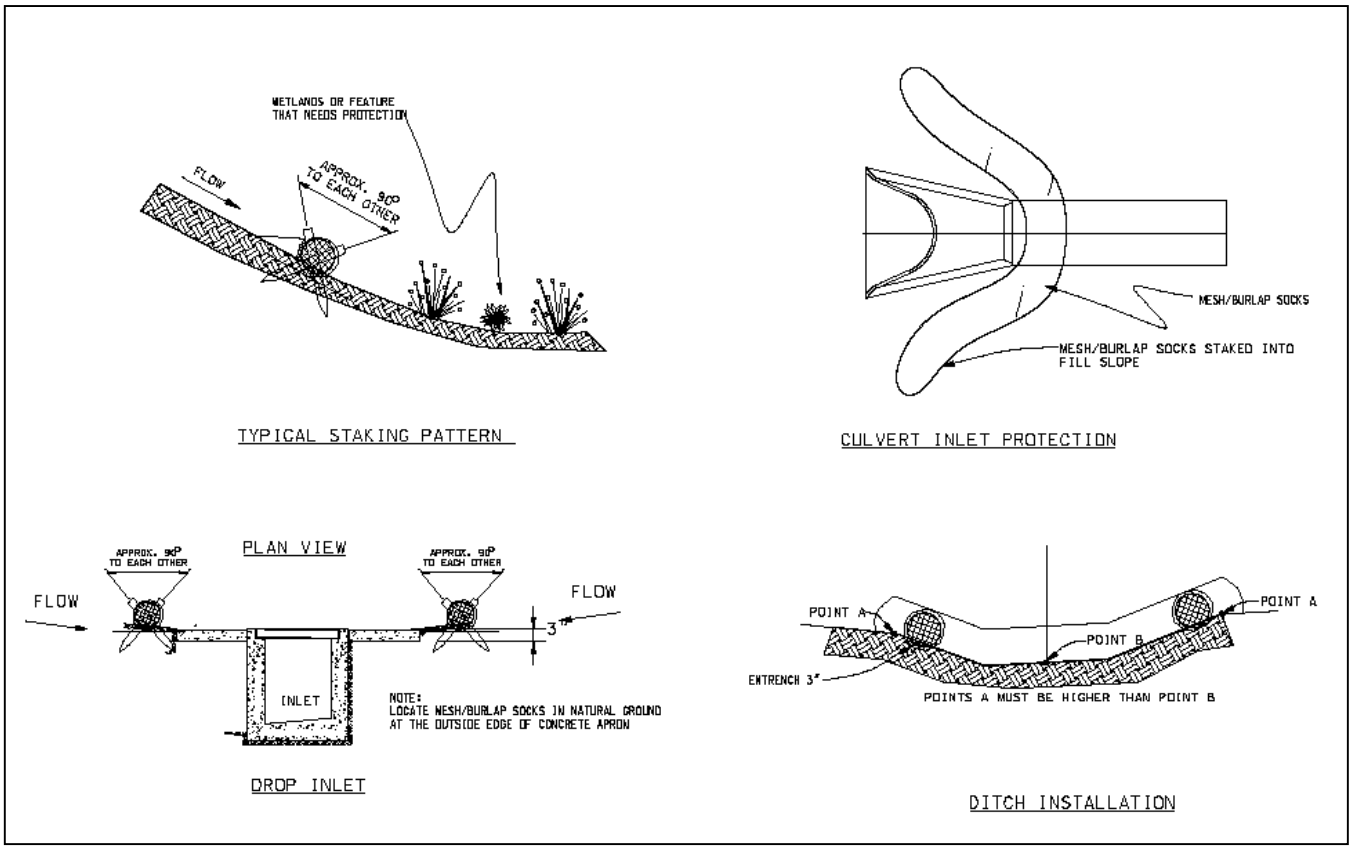


FIGURE SC 2.1
Applications for Erosion Logs (CDOT[18])

Maintenance and Inspection

- Inspect logs daily for cuts, abrasions, and proper installation, replace or reposition daily. Remove sediment and dispose in a proper manner.
- Discontinue use if logs create a traffic hazard.

SC 3: Silt Fence

Description

A temporary vertical barrier of filter fabric attached to and supported by posts and entrenched into the ground.

Applications

- Used to intercept sediment from disturbed areas during construction operations.
- Used to filter sheet flow.
- Typically used along the toe of fills, in transition areas between cut and fills, and adjacent to streams.
- Also used around drop inlets as applicable (see BMP SC 4).
- Used as a temporary feature.

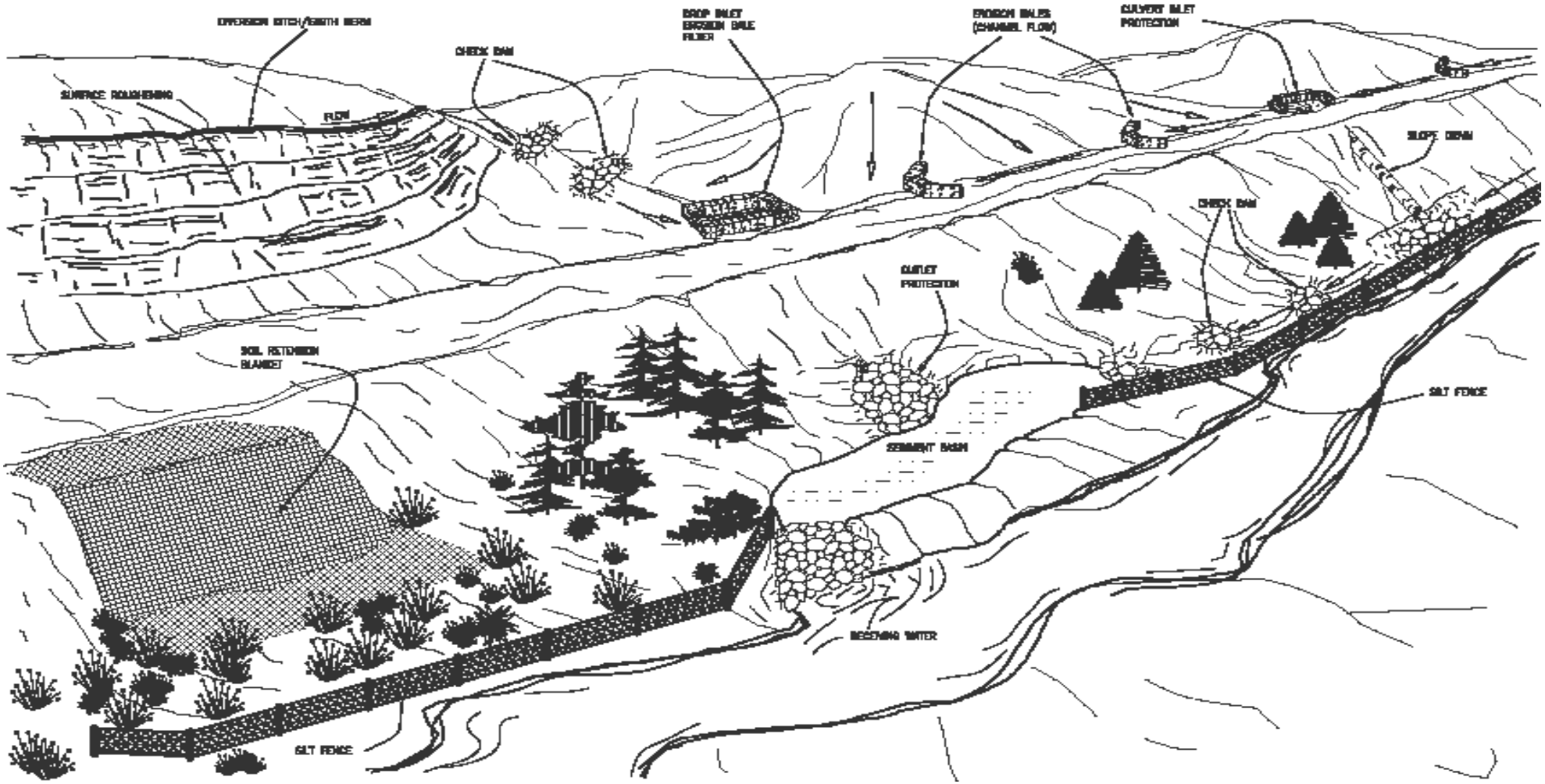


FIGURE SC 3.1
Silt Fence Applications (CDOT[18])

Limitations

- Maximum drainage area is one-quarter acre per 100 feet of silt fence length; the maximum slope length behind the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2:1).
- Under no circumstances should silt fences be constructed in live streams, swales, or ditches.
- On steep slopes, care should be given to placing the fence perpendicular to the general direction of the flow.
- Silt fences should not be used in areas where rocky soils will prevent keying in the filter fabric.

Materials

- The filter fabric shall conform to the requirements described in Section 420 of CDOT's Standard Specifications for Road and Bridge Construction. Minimum height of the filter fabric shall be 36 inches.
- The use of joints should be minimized to improve the strength and efficiency of the barrier.
- Posts for silt fences shall be metal or hard wood with a minimum length of 42 inches. Wooden posts shall have a minimum diameter or cross section of 1-¼ inches. Metal posts shall be "studded tee" or "U" type with a minimum weight of 1.33 lbs/ft, and they shall be protected against corrosion. Metal posts shall have projections for fastening wire.
- When used, wire fence reinforcement for the filter fabric should be a minimum of 36 inches in height and a minimum of 14 gauge, with a maximum mesh spacing of 6 inches.

Installation

- Drive posts vertically into the ground to a minimum depth of 18 inches, and excavate a trench approximately 6 inches wide and 6 inches deep along the line of posts and upslope from the barrier (see Figure SC 3.2). Not less than the bottom 1 foot of the filter fabric shall be buried into this trench. The trench shall be backfilled and the soil compacted.
- When joints are necessary, filter cloth shall be spliced together only at a support post and securely sealed (see Figure SC 3.3).
- The filter materials shall be fastened securely to metal or wooden posts using wire ties, or to the wood posts with ¾-inch long #9 heavy-duty staples. The filter fabric shall not be stapled to existing trees.
- Posts shall be spaced a maximum of 10 feet apart. For channel flow applications, the posts shall be spaced a maximum of 3 feet apart.

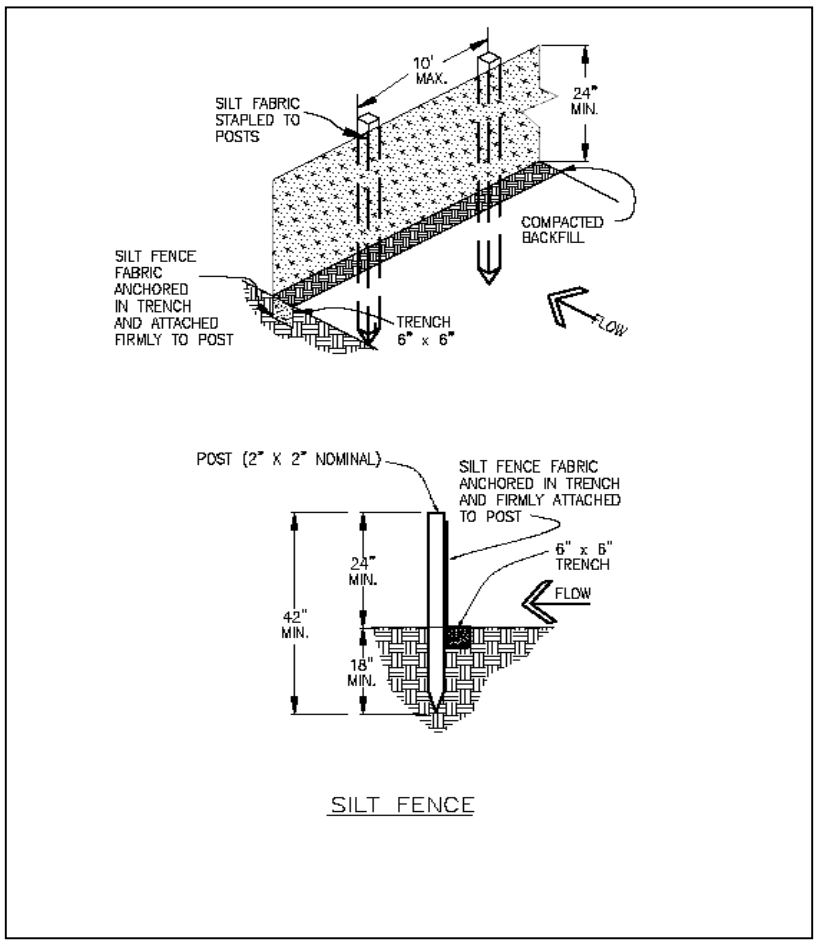


FIGURE SC 3.2
Silt Fence Installation (CDOT[18])

- When used, the wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 3/4 inches long, tie wires, or hog rings. The wire shall extend into the trench a minimum of 2 inches and shall not extend more than 36 inches above the original ground surface.
- Along the toe of fills, install the silt fence along a level contour and provide an area behind the fence for runoff to pond and sediment to settle. A minimum distance of 5 feet from the toe of the fill is recommended.
- The height of the silt fence from the ground surface shall be minimum of 24 inches and shall not exceed 36 inches; higher fences may impound volumes of water sufficient to cause failure of the structure.

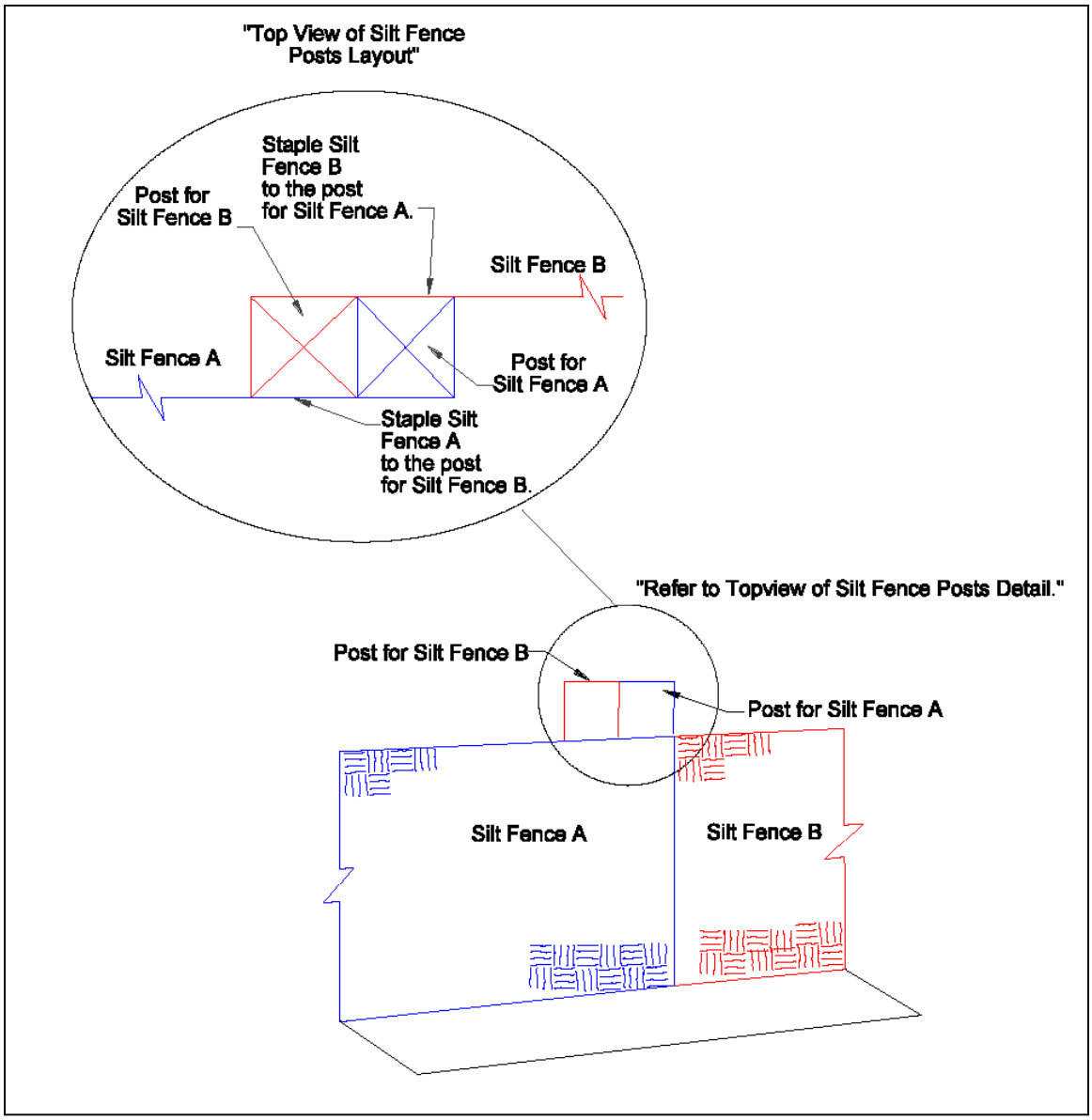


FIGURE SC 3.3
Silt Fence Joints(CDOT[18])

Maintenance and Inspection

- Silt fences shall be periodically maintained to prevent sediment from passing over or under the fence. Sediment shall be removed from behind the silt fence when it accumulates to one-half the exposed fabric height. Sediments removed must be properly disposed.
- Silt fence damaged by wind or other factors should be promptly repaired.
- Silt fences shall be removed when they have served their useful purpose. The area with the silt fences shall be stabilized after removal of the fence.

SC 4: Storm Drain Inlet Protection

Description

A barrier across or around a storm drain drop inlet, a curb inlet, or a culvert inlet.

Applications

- Used to intercept and filter sediment-laden runoff and prevent it from entering storm drainage systems.
- Used as a temporary feature.

Limitations

- Not to be used in place of a sediment-trapping device; used as a secondary control device.
- Do not use where ponded water might flow onto the roadway.
- Blocking of the inlet should not be watertight.

Installation

Drop Inlet Erosion Bale Filter

- Construct a barrier around the storm drain inlet using erosion bales (see Figure SC 4.1); see BMP SC 1 for guidelines on erosion bale installation. Using silt fence in lieu of erosion bales is an alternative to this type of inlet protection. See BMP SC 3 for guidelines on silt fence installation.

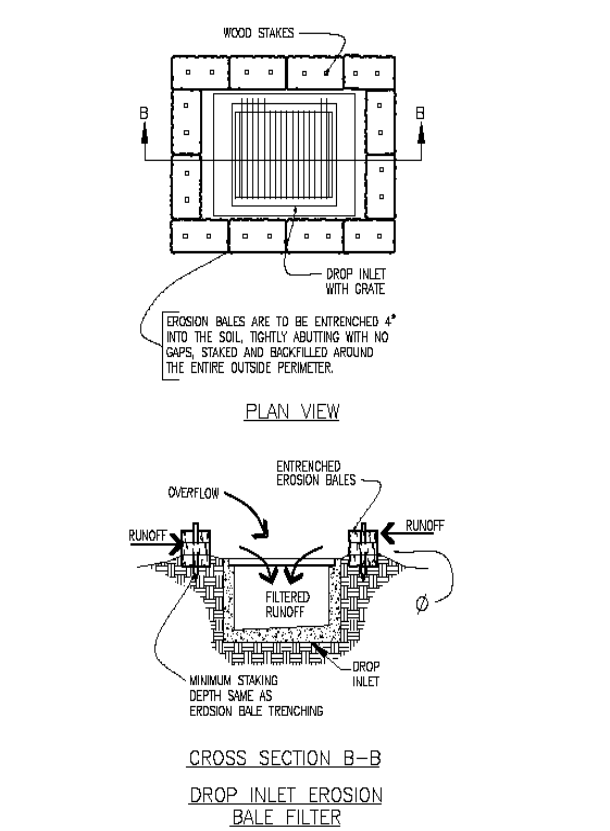


FIGURE SC 4.1 Drop Inlet Erosion Bale Filter(CDOT[18])

- Use only if the area adjacent to the inlet consists of soil. Do not install on top of pavement.
- Maximum allowable drainage area is 1 acre.
- Sediment accumulated against the erosion bales shall be removed when it has reached half the height of the exposed erosion bale.
- Applicable where the inlet drains a relatively flat area.

Drop Inlet Block and Gravel Filter

- Maximum drainage area is 1 acre.
- Construct according to Figure SC 4.2 using concrete blocks, ½-inch wire screen, and 1.5-inch maximum size gravel.
- Sediments shall be removed when material is within 4 inches of the top of the concrete blocks.

Drop Inlet Gravel and Wire Mesh Filter

- Construct similar to the drop inlet block and gravel filter using ½-inch wire screen and 1.5-inch maximum-size clean gravel.

Curb Inlet Block and Gravel Filter

- Use on pavement or

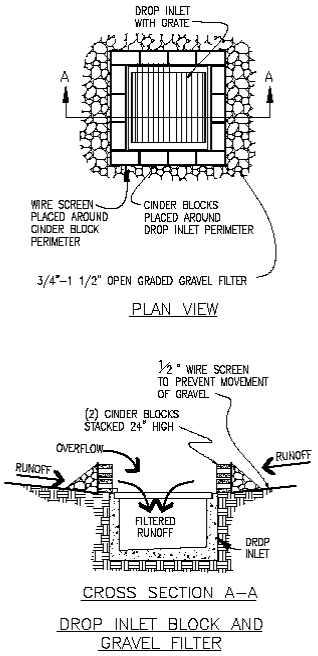


FIGURE SC 4.2 Drop Inlet Block and Gravel Filter(CDOT[18])

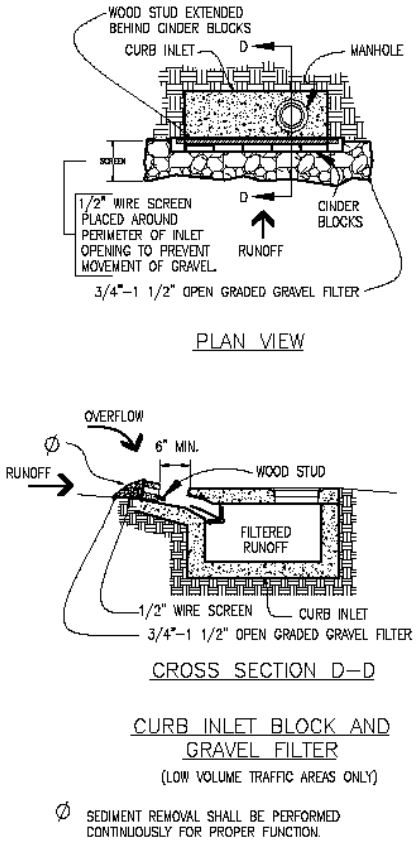


FIGURE SC 4.3 Curb Inlet Block and Gravel Filter(CDOT[18])

bare ground.

- Construct according to Figure SC 4.3 using concrete blocks and a 2 x 4-inch wood stud for support, ½-inch wire screen, and 1.5-inch maximum-size gravel.
- Sediment shall be removed when material is within 3 inches of the top of the concrete blocks.
- Use when overflow capability is necessary to prevent excessive ponding.

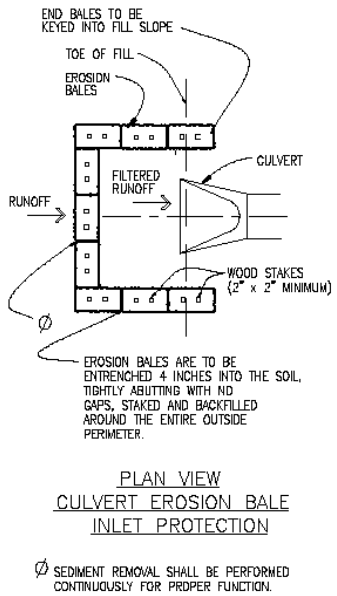


FIGURE SC 4.4 Culvert Erosion Bale Inlet Protection(CDOT[18])

Culvert Erosion Bale Inlet Protection

- Maximum drainage area shall be 1 acre
- Install erosion bales in accordance with guidelines given in BMP SC 1.
- Construct according to Figure SC 4.4.

Rigid Inlet Protection Device

- A Rigid Inlet Protection Device is a manufactured inlet protection BMP. The BMP consist of a frame and filter cover placed over an area inlet to filter sediment laden runoff.
- The BMP can be used for various types and sizes of storm drain inlets with round or square bases with 60″ O.D. or smaller precast risers. Refer to an approved manufacturer for guidance on BMP selection and installation.

FIGURE SC 4.5
Rigid Inlet Protection Device

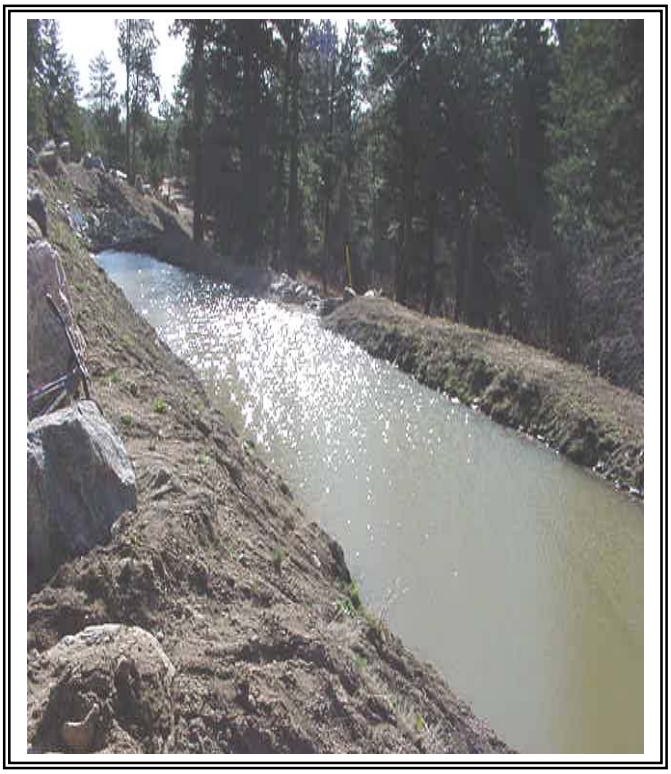
Maintenance and Inspection

- Storm drain inlet protection shall be inspected periodically and after each rain or snowfall event, and repaired when necessary. Accumulated sediment shall be removed and properly disposed of.
- Storm drain inlet protection shall be removed after it has served its useful purpose.

SC 5: Sediment Trap

Description

A small temporary ponding area formed by excavating below grade and/or by constructing an earthen embankment with a hard-lined spillway.



Applications

- Used to detain sediment-laden runoff from small disturbed areas to allow sediments to settle out.

Limitations

- Use only if the contributing drainage area to the trap is 5 acres or less. If the contributing drainage area is greater than 5 acres, then a sediment basin should be considered (see BMP SC 6).
- Use only for treatment of onsite runoff.
- Never construct a sediment trap on a flowing stream or in wetlands.

Design Guidelines

Location

- Traps should be located at points of discharge from disturbed areas.
- The location will be determined by the natural terrain, drainage pattern of the runoff, and the accessibility for maintenance.
- Traps should not be located closer than 20 feet from a proposed building foundation or highway edge of road.

Capacity

- Sediment traps shall have a storage volume of 3,600 ft^3/acre of contributing drainage area.

- Half of this volume shall be in the form of wet storage or a permanent pool. The other half shall be in the form of dry storage. When possible, the wet storage volume should be contained within the excavated portion of the trap.
- The wet volume is measured from the low point in the trap to the base of the embankment.
- The dry volume should be measured from the base of the embankment to the crest of the spillway.
- The depth within the wet storage area should be a maximum of 4 feet, although 2 feet is preferred.

Shape

- A rectangular and shallow trap, with a length-to-width ratio of 2:1 or greater is recommended.

Embankment

- Maximum embankment height shall be 5 feet measured on the downstream side. The minimum top embankment width shall be 4 feet. Side slopes for the embankment and the excavated areas shall be 2:1 or flatter.
- Fill material for the embankment shall be free of roots or other vegetation, organic material, large stones, and other objectionable material.

Spillway

- The spillway shall consist of a stone section in the embankment formed by a combination coarse aggregate/riprap to provide for filtering/detention capability. Riprap shall be 4- to 8-inch rock, while the coarse aggregate shall be 1/2 to 3/4 inches. The spillway crest shall be at least 1 foot below the top of the embankment.

Installation

- Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.
- The area under the embankment shall be cleared and stripped of any vegetation and roots.
- A geotextile should be placed at the stone-soil interface to act as a separator.

Maintenance and Inspection

- Sediment shall be removed from the trap when the wet storage volume is reduced by half. Sediments removed must be properly disposed.

- Spillway should be regularly inspected; rocks clogged with sediment shall be cleaned or replaced.

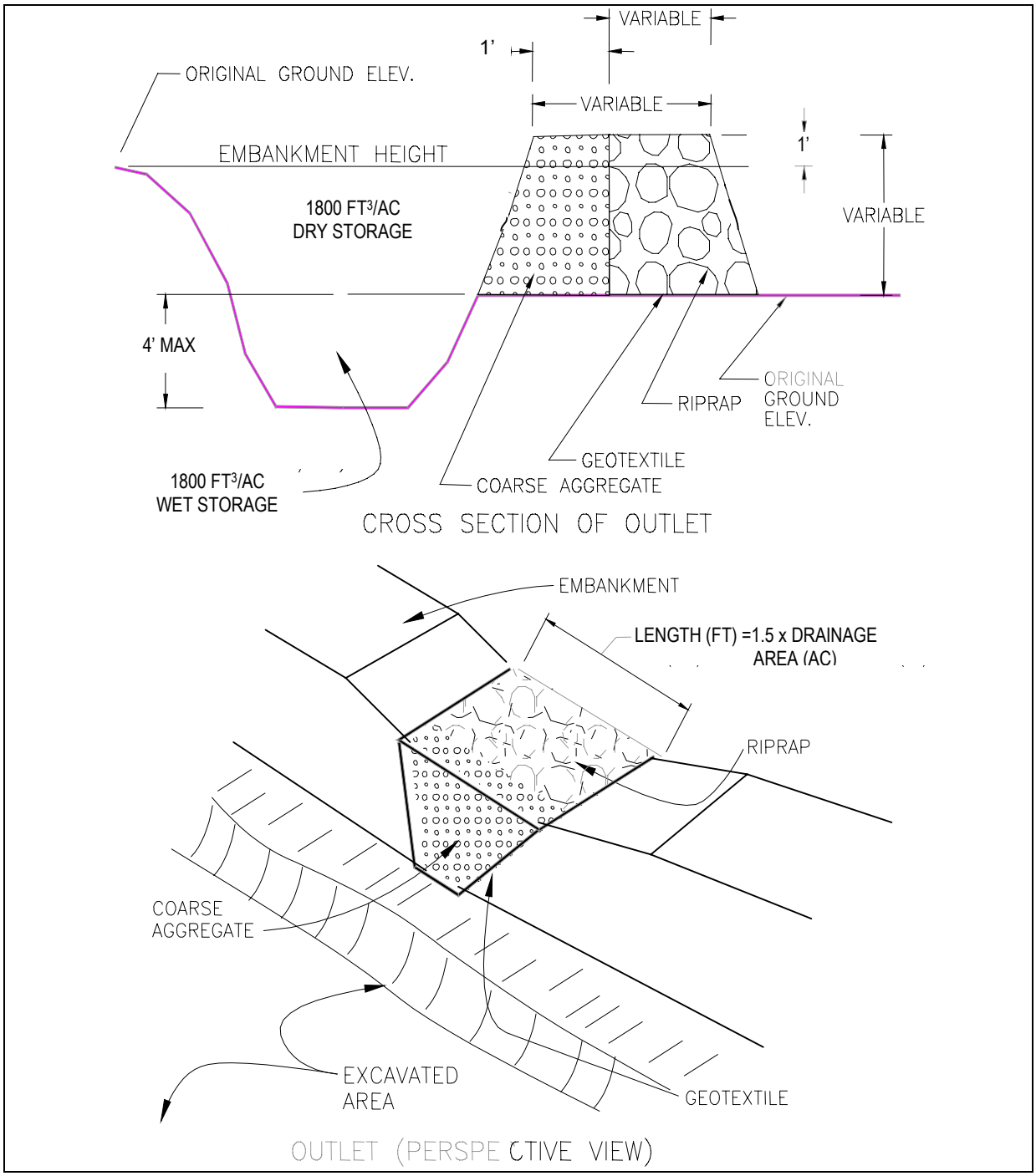


FIGURE SC 5.1
Sediment Trap (Adapted from VEaSCH[28])

SC 6: Sediment Basin

Description A temporary basin with a controlled outlet. Differs from a sediment trap in that it is designed for larger drainage areas and has a controlled release structure. This basin can also be constructed as a combination of embankment and excavation.

Applications

- Used to detain sediment-laden runoff from disturbed areas long enough for sediment to settle out.
- May be designed to be upgraded to a permanent structure after construction is completed.

Limitations

- Use for contributing drainage areas greater than 5 acres.
- Do not use on sites where failure of the structure or embankment would result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities.
- Sediment basins should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, etc. to reduce the amount of sediment flowing into the basin.
- Never construct a sediment basin on a flowing stream.
- Use for treatment of onsite runoff only.

Design Guidelines

Location

- Location should be such that the basin intercepts the largest possible amount of runoff from the disturbed area. Appropriate locations are generally low areas and natural drainageways below disturbed areas.
- Location shall be such as to minimize interference with construction activities.
- Ease of maintenance access for cleanout should be considered when selecting a location.

Capacity

- Total basin capacity shall be 3,600 ft^3/acre of contributing drainage area. Half of this volume shall be in the form of a permanent pool or wet storage. The other half of this volume shall be in the form of dry storage available for runoff storage (see Figure SC 6.1).

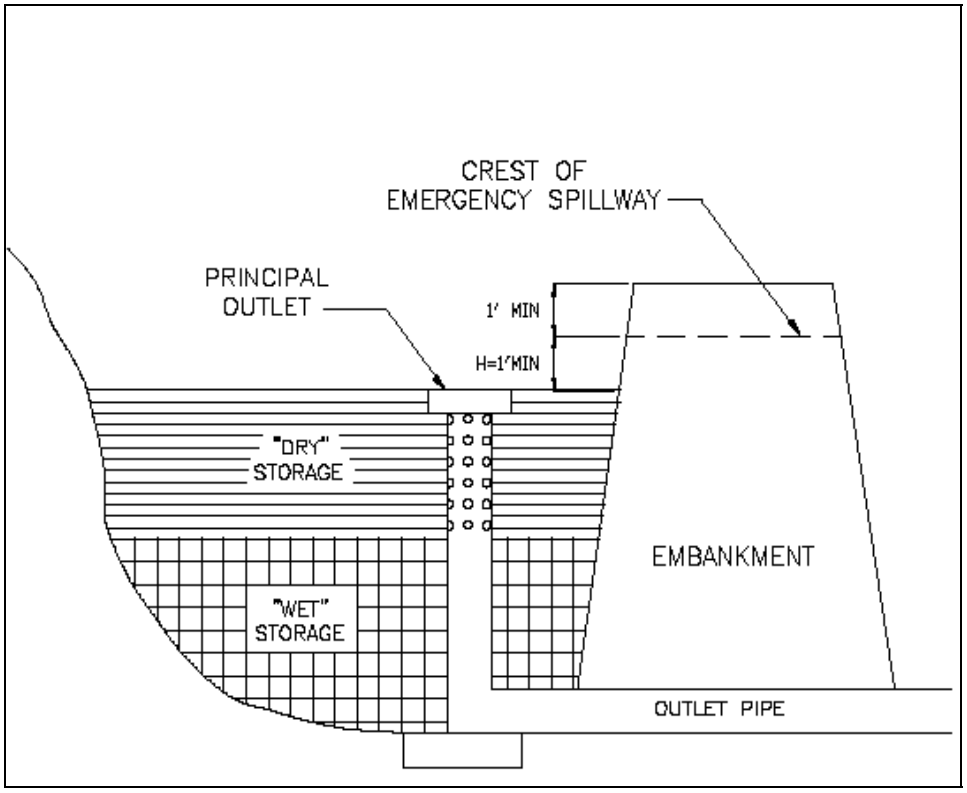


FIGURE SC 6.1
Sediment Basin (Adapted from VEaSCH[28])

Shape

- The basin shall be long and narrow, with a length-to-width ratio of 2:1 or greater. Appropriate basin shape may be attained by properly selecting the site of the basin, by excavation, or by the use of baffles.
- If the 2:1 ratio cannot be achieved, baffles should be placed halfway between the inflow point and the outflow. Figure SC 6.2 shows recommended baffle locations to attain length-to-width ratios of 2:1 or greater.
- A plywood (or equivalent) fence can be used for the baffle. Posts for this fence should be buried at least 3 feet into the ground. The fence should be at least 4 feet high. In large basins, CDOT Type IV concrete barriers can be used as baffles.

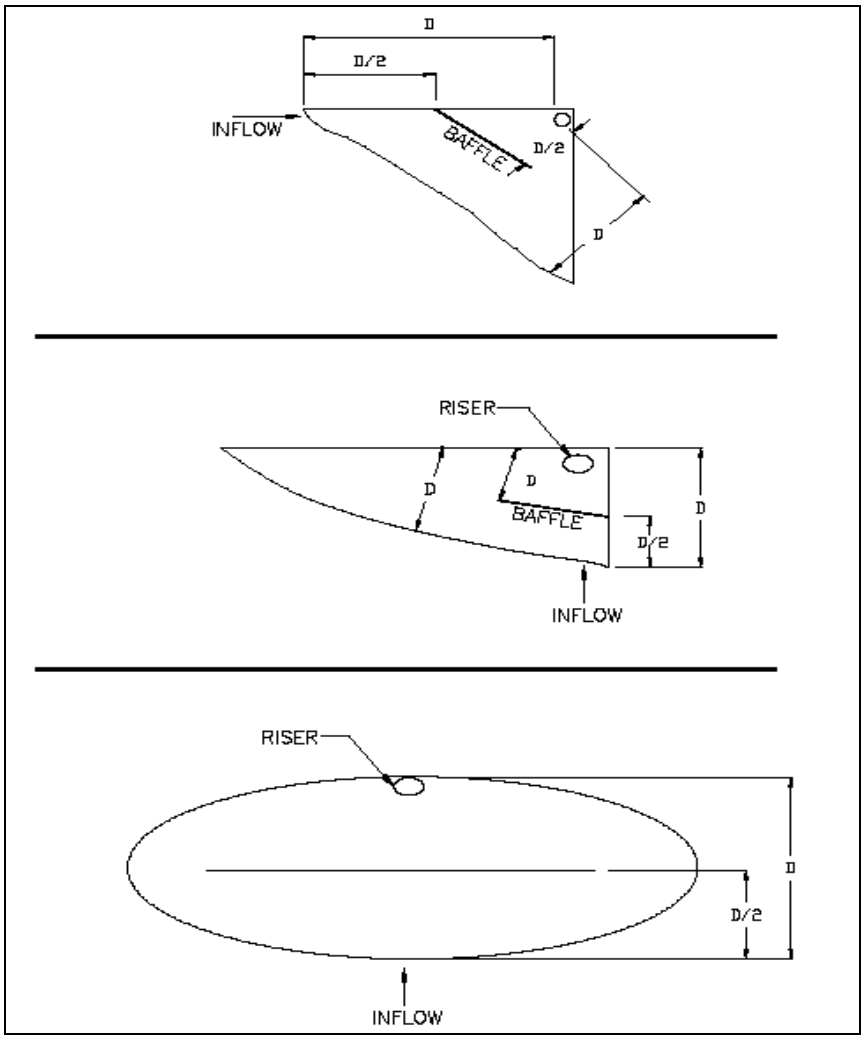


FIGURE SC 6.2
Sediment Basin Baffle Location (Adapted from UDFCD[16])

Embankment

- Maximum embankment height shall be 9 feet. Measures should be incorporated in the embankment to protect against failure due to seepage. A geotechnical engineer should be consulted for specific design considerations.

Outlet

- The basin outlet shall consist of a principal outlet (perforated vertical pipe) and an emergency spillway (see Figure SC 6.1).

Principal Outlet

- The principal outlet shall consist of a perforated vertical pipe joined by a watertight connection to a horizontal outlet pipe extending though the embankment and outletting beyond the downstream toe of the fill (see Figure SC 6.1).
- The outlet pipe shall be designed to pass the peak flow expected from a 2-year storm. The outlet pipe diameter can be determined using Table SC 6.1 below. For the purposes of the table, Q (cfs) is the flow for the 2-year storm; H (ft) is the difference in elevation between the crest of the principal outlet and the crest of the emergency spillway (see Figure SC 6.1); and D (inches) is the pipe diameter.

TABLE SC 6.1
Outlet Pipe Diameter (inches)

H	$D = 6.171(Q/H)^{1/2}$	$D = 1.232(QH)^{-1.5}$
1.0	Q < 24 cfs	Q > 24 cfs
1.5	Q < 75 cfs	Q > 75 cfs
2.0	Q < 135 cfs	Q > 135 cfs
2.5	Q < 250 cfs	Q > 250 cfs
3.0	Q < 400 cfs	Q > 400 cfs

- The principal outlet shall be designed to drain the dry storage volume in a period of no less than the required drain time. Refer to Chapter 6 for design guidance of the perforations and drain time.
- The top of the principal outlet shall be set at an elevation at least (1 foot) below the crest of the emergency spillway.
- A trash rack and an anti-vortex device should be attached to the top of the principal outlet to prevent floating debris from being carried out of the basin and to improve the hydraulic performance at the entrance to the principal outlet.

- The base of the principal outlet shall be firmly anchored to prevent flotation. As a minimum, a safety factor of 1.25 shall be used (downward forces = 1.25 x upward forces). Anchoring can be done through a concrete base or square steel plate covered with stone, gravel, or compacted soil.
- The outlet pipe, which extends through the embankment, shall be designed to carry the flow provided by the principal outlet with the water level at the crest of the emergency spillway. The connection between the principal outlet pipe (perforated vertical pipe) and the outlet pipe shall be watertight.

Emergency Spillway

- The emergency spillway shall consist of an open channel constructed in the embankment over undisturbed material (not fill). If conditions do not allow for the construction of the spillway over undisturbed material, the spillway may be constructed of non-erodible material such as riprap.
- The emergency spillway shall be designed to carry the peak rate of runoff expected from a 10-year storm, less the flow conveyed through the principal outlet.
- A geotech engineer shall be consulted regarding spillway stability.
- The design high-water elevation through the emergency spillway shall be at least 1 foot below the top of the embankment.
- The crest of the emergency spillway channel shall be at least 1 foot above the crest of the principal outlet.

Installation

- Areas under the embankment and any structural works shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other objectionable material.
- To facilitate cleanout and restoration, the pool area (measured at the top of the principal outlet) shall be cleared of all brush and trees.
- Design elevations, widths, and entrance and exit channel slopes are critical to the successful operation of the spillway and must be constructed within a tolerance of +/- 2.4 inches.
- The embankment shall be constructed on undisturbed ground.
- For earthen-fill embankments, a cutoff trench shall be excavated along the centerline of the embankment. The cutoff trench shall extend up both abutments to the top of the perforated vertical pipe.
- The riser and barrel of the principal outlet shall be placed on a firmly compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent flotation.

- Pervious material such as sand, gravel, or crushed stone shall not be used as backfill around the outlet pipe.

Maintenance and Inspection

- Sediment shall be removed from the basin when the wet storage volume has been reduced by half. The elevation of the sediment cleanout level shall be calculated and clearly marked on the riser. Sediments removed must be properly disposed.
- Inspection of the basin shall take place at the end of each working day, and damages shall be repaired immediately.

SC 7: Dewatering Structure

Description

A settling device to treat water from dewatering activities.

Applications

- Used to remove sediments from dewatering activities.
- Used as a temporary feature.

Limitations

- May not be needed if the water is discharged to a well-stabilized vegetated area. The stabilized area should be capable of filtering sediment while at the same time withstanding the velocity of the discharged water without eroding. A minimum filtering length of 75 feet is recommended for the stabilized area.
- Dewatering operation will require and must comply with all applicable permits.
- Never construct in wetlands.

Design Guidelines

- Recommended structure consists of an excavated basin surrounded by a perimeter control such as erosion bales (see Figure SC 7.1) or a berm. The excavated area should be at least 3 feet deep. The excavated portion will serve for wet storage, and the remainder will provide dry storage.
- The structure's storage volume (measured from the bottom of the excavation to the crest of the riprap weir) can be calculated as follows:

  Storage volume (ft^3) = Pump discharge (gal/min) x *0.24*

  The above rate allows for a continuous pumping time of 3 hours. When water reaches the outlet crest, pumping must stop until the water drains down and additional capacity is made available.
- The wet storage area may be dewatered into a well-vegetated area, but only after a minimum detention time of 6 hours.

Installation

- Construct as shown in Figure SC 7.1. Install erosion bales or a berm, as described in Sections SC 1 and EC 8.
- The excavated basin should be lined with a filter fabric to reduce scour and prevent the inclusion of soil from within the structure. The entire inside face of the erosion bales shall be covered with an impermeable geotextile.
- The riprap weir shall have a minimum width of 3 feet, and shall be minimum 6 inches below the top of the embankment.

Maintenance and Inspection

- Sediments should be removed once they have accumulated to one-half of the excavated depth and properly disposed of.

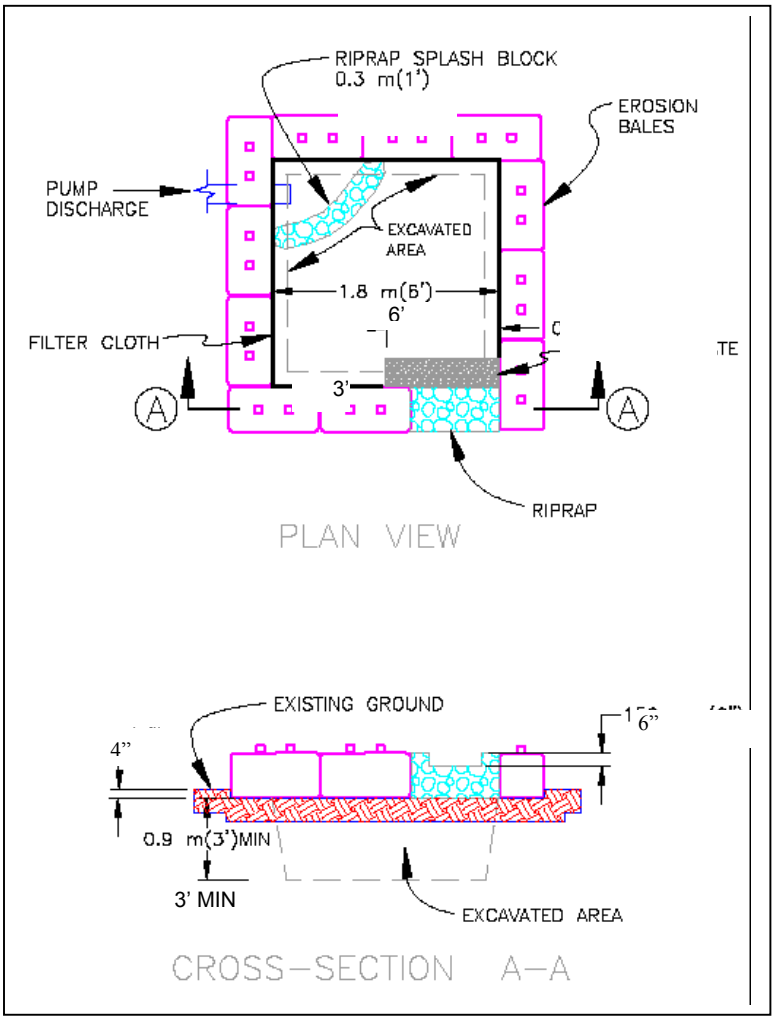


FIGURE SC 7.1
Dewatering Structure (Adapted from VEaSCH[28])

SC 8: Stabilized Construction Entrance

Description

A stabilized layer of aggregate underlined with a geotextile and located where traffic enters or exits the construction site.

Applications

- Used to reduce the amount of mud tracked onto paved public roads by vehicles or runoff leaving the construction site.
- Used as a temporary feature.

Installation

- The entrance must extend the full width of the ingress/egress area and have a minimum width of 12 feet and a minimum length of 70 feet (see Figure SC 8.1).
- Area of the entrance must be excavated a minimum of 12 inches. The geotextile will then be placed and covered with a minimum 12-inch layer of aggregate. The aggregate shall be equal to or greater than 3 inches (see Figure SC 8.1).

Maintenance and Inspection

- The structure shall be maintained daily.
- Stone shall be added and repairs performed as conditions require.
- Any mud or dirt tracked onto paved surfaces should be cleaned up within 24 hours.
- Damaged curb, gutter or sidewalk should be replaced.

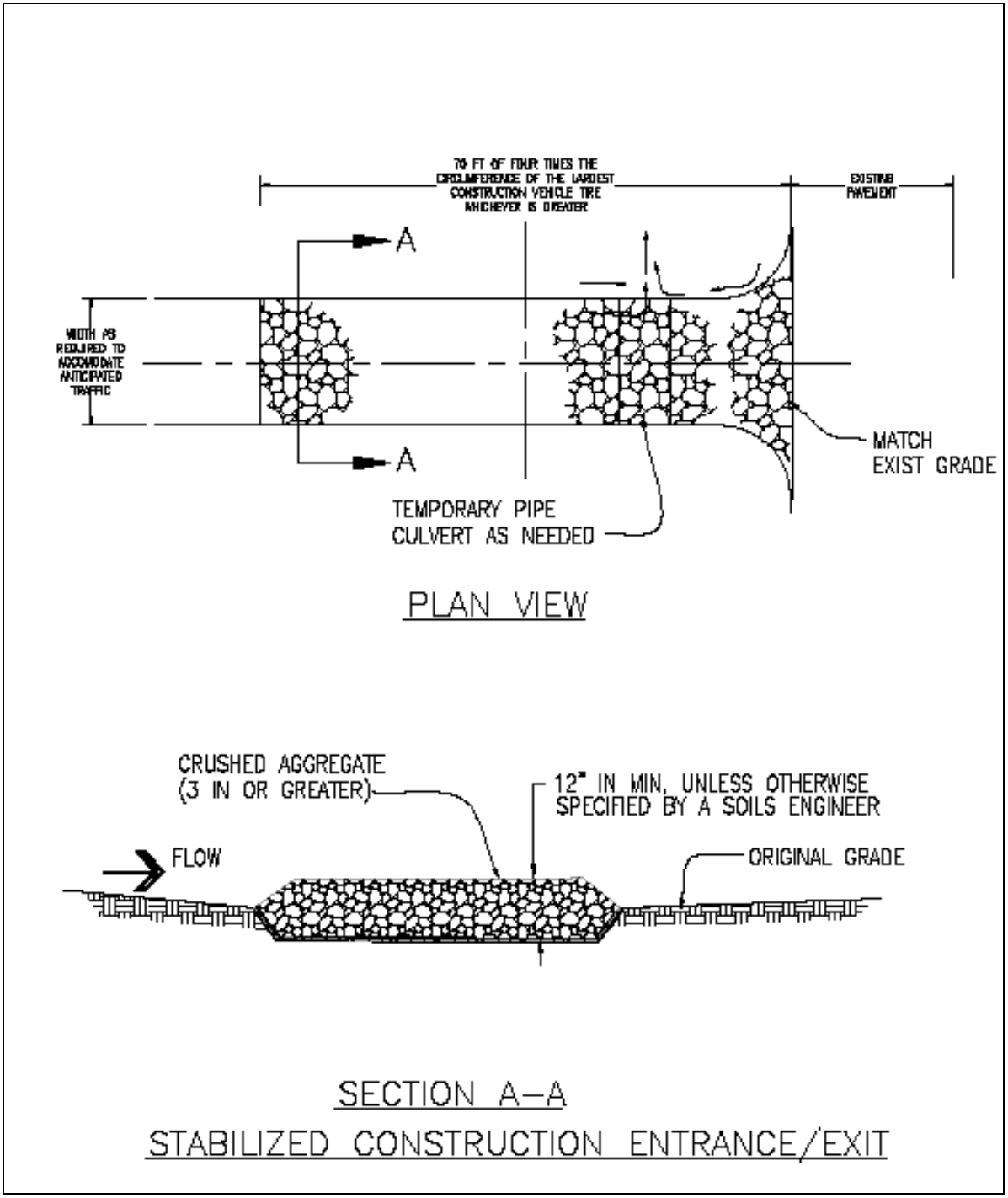


FIGURE SC 8.1
Stabilized Construction Entrance(CDOT[18])

SC 9: Brush Barrier

Description A temporary sediment barrier constructed at the perimeter of a disturbed area from the residue materials available from clearing and grubbing the site, and generally covered with filter fabric.

Applications

- Used for the purpose of intercepting and retaining sediment from disturbed areas of limited extent.
- Used to prevent sediment from leaving the site.
- Used as a temporary feature.

Limitations

- Should be used only in areas of sheet or very low flow.
- Should not be used in a developed area where they could be a visual problem.

Materials

- Brush barriers are constructed at the time of clearing and grubbing, and consist of brush, limbs, root mat, weeds, vines, soil, rock, and unmerchantable timber.

Installation

- Height of a brush barrier shall be 3 feet minimum.
- The width of a brush barrier shall be a minimum of 5 feet at its base. The sizes of brush barriers may vary considerably based upon the amount of material available and the judgment of the designer.
- The barrier shall be constructed according to Figure SC 9.1 by piling brush, stone, root mat, and other material from the clearing process into a mounded row on the contour.
- The filter fabric shall be cut into lengths sufficient to lay across the barrier from its upslope base to just beyond its peak. Where joints are necessary, the fabric shall be spliced together with a minimum 6 inches overlap and securely sealed.

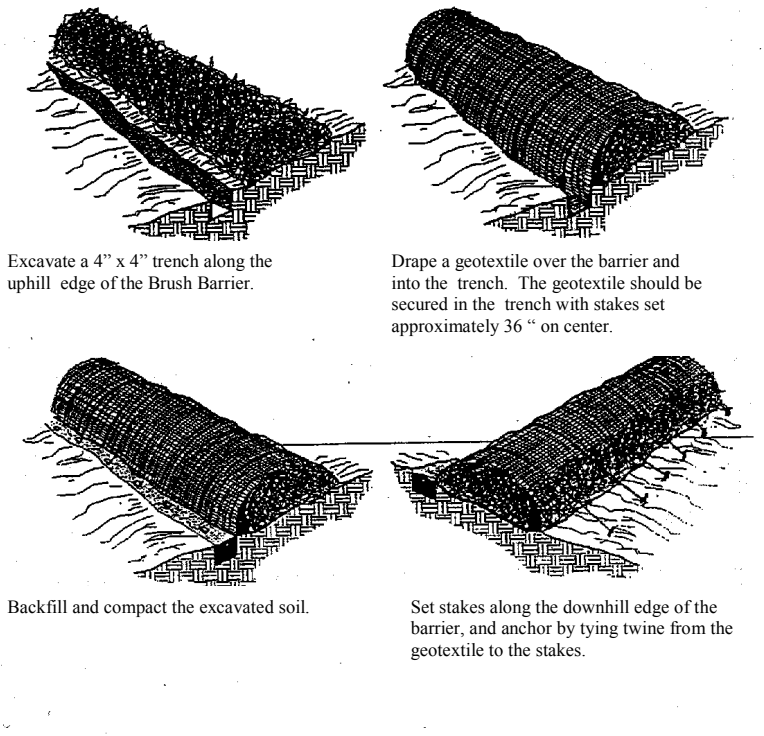


FIGURE SC 9.1
Brush Barrier (Adapted from VEaSCH[28])

Maintenance and Inspection

- Inspect frequently during construction, and repair or replace promptly as needed.
- Remove when they have served their usefulness, but not before the upslope areas have been permanently stabilized.
- Sediment accumulated behind the barrier shall be removed when it reaches half the exposed brush barrier height and disposed of properly.

SC 10: Gravel Barrier

Description Flexible building blocks made of bags filled with soil or rock material.

Applications

- Used to divert stream channels, as barrier walls in sediment basins, and as retaining walls between fill slopes and watercourses during construction.
- Used as a temporary feature.

Limitations

- Maximum drainage area is 5 acres.

Installation

- When building a barrier wall, stack the gravel bags using an alternately layered method.
- Cover gravel bags with a plastic lining when waterproofing is desired.
- The base of the barrier should be at least 48 inches wide and the height a minimum of 18 inches.

Maintenance and Inspection

- Gravel bag barriers shall be periodically maintained, and any breaks in the barrier shall be promptly repaired.
- Remove sediments behind the barrier when they accumulate to a height of 6 inches and dispose of properly.

SC 11: Silt Barrier

Description

A silt barrier is a sediment control device made of foam sewn into a woven geo-synthetic fabric. Triangular in shape, it is 10 to 14 inches high in center, with a 20- to 28-inch base. An apron extends beyond both sides of the triangle along its standard section of 7 feet. A sleeve at one end allows attachment of additional sections as needed. This BMP can be used to provide settling and/or reduction in water velocity/erosive forces, and it can be used as an alternative to straw bales, silt fence, and rock check dams for containing erosive soils at constructions sites. See Figure SC 11.1.

Applications

- May be used in the following applications:
  - Ditch Check Dam: can be installed in roadway ditches and drainage ditches.
  - Diversion Dam: can be installed as diversion dams or dikes.
  - Continuous Barrier: can be attached end to end to form a continuous barrier in rough terrain.
  - Ponds and Streams: can be used as a positive barrier around streams, ponds, and wetlands.
  - Drop Inlet Protection: can be installed for protecting drop inlets.
  - Temporary Lined Ditch: can be used as a temporary lined ditch.
- This BMP may be used for perimeter protection and in combination with other barriers.
- Used downstream of disturbed areas subject to sheet and rill erosion where drainage area is not greater than 0.25 acre per 100 linear feet of barrier and the slope behind the barrier should be no steeper than 2:1. On relatively flat slopes, the maximum disturbed slope distance should not

exceed 100 feet. The allowable disturbed slope distance decreases as the slope gets steeper.

Limitations

- This BMP should not be used:
  - Where flow volume or velocity inhibit BMP function.
  - As a filter.

Installation

- Install with the long flap upstream.
- Install to prevent water from going around or under the BMP.
- Install along the contour.
- Anchor with adhesive on asphalt or other hard surfaces, or with staples or stakes on soil or soft surfaces.

Maintenance and Inspection

- During construction, inspect daily and during storm events. Make any required repairs.
- Sediment should be removed when the deposits reach half the height of the silt barrier and properly disposed of.
- Prior to removal, evaluate the site to determine if the silt barrier is no longer needed (the area has stabilized and potential of sediment-laden water exiting the area has passed) and remove sediment buildup in front of the silt barrier. Depending upon placement, revegetation of site may be necessary.

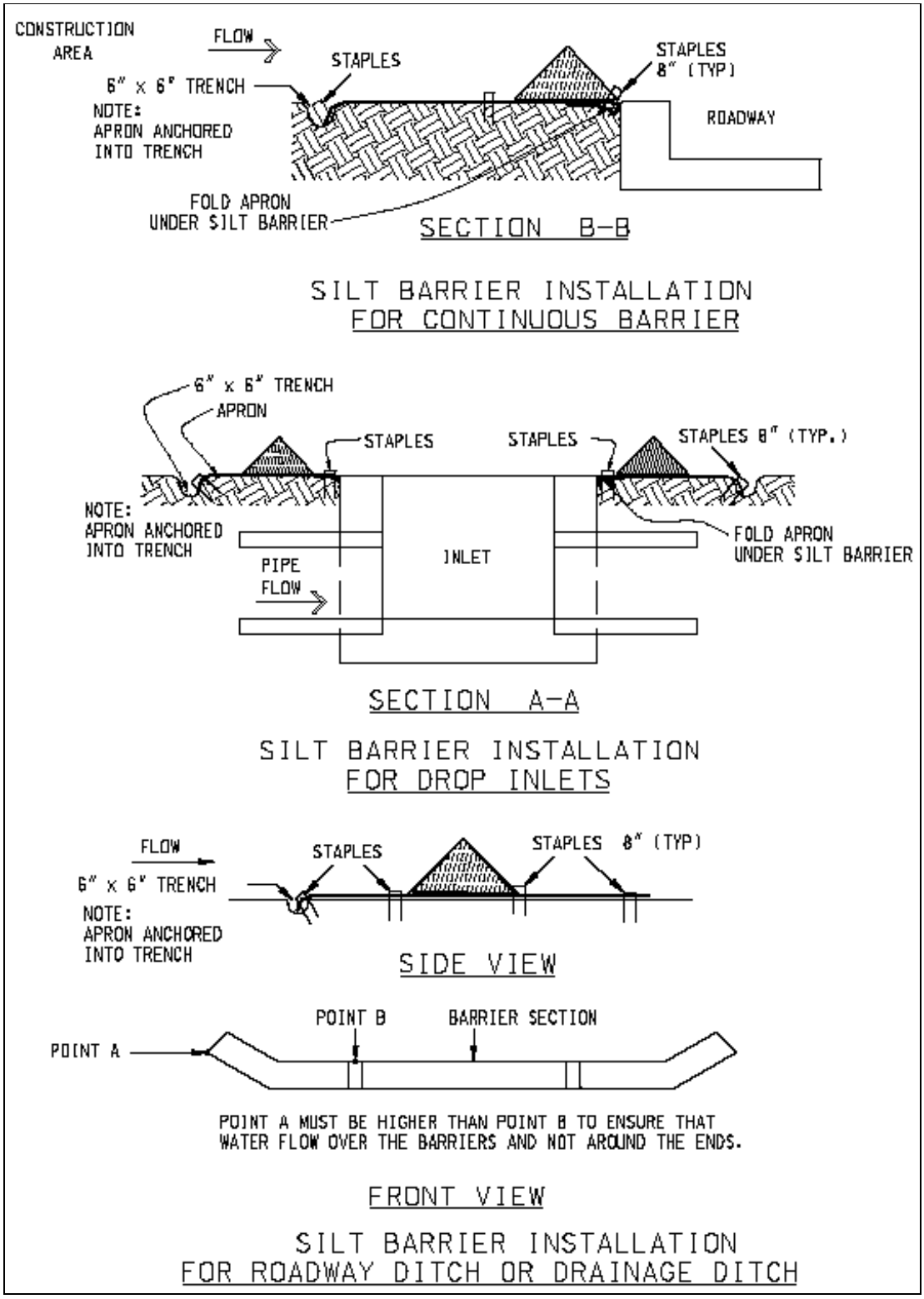


FIGURE SC 11.1
Silt Barrier Installation (CDOT[18])

5.7 Materials Handling and Spill Prevention

Materials Handling and Spill Prevention BMPs

- Stockpile Management
- Material Management
- Material Use
- Spill Prevention and Control

Material management is important, because the optimal approach to reduce pollution potential is to prevent it at the source. Material storage areas are a major source of risk due to possible mishandling of materials and accidental spills. Developing protocols for materials storage and handling, and response procedures for handling spills, are necessary measures to minimize the contamination impact to stormwater runoff. Developing and incorporating these measures will increase awareness and minimize the opportunities for mishandling and spills.

The following BMPs provide guidance on material management and spill prevention and control.

MH 1: Stockpile Management

Description These practices are implemented to reduce associated stormwater pollutants from entering storm drains and watercourses from typical soil, concrete, asphalt, or aggregate stockpiles found at construction sites.

Applications Areas where active and non-active stockpiles of construction materials are stored.

Standards and Specifications

- Stockpiles must be protected continuously and located away from areas where concentrated stormwater flow is anticipated, major drainage ways, and stormwater inlets. Stockpiles shall be covered and/or protected with a temporary perimeter sediment barrier. Stockpiles of "cold mix" asphalt stockpiles shall be placed on and covered with durable plastic or comparable material at all times when not in use.
- Temporary perimeter sediment barrier such as berms, dikes, silt fences, or sandbags must be constructed to protect stockpiles from runoff.
- Implement wind erosion control practices as appropriate on all stockpiles (BMP GP 5).
- Waste stockpiles of concrete, solid, sanitary/septic materials, liquids, hazardous materials, and contaminated soils shall be in accordance to Section 5.8, Waste Management BMPs.

Maintenance and Inspection

- Routinely spot-check stockpile areas for compliance.
- Identify spills or leaks from stockpiles into the storm drain at or near CDOT work areas and report to the CDOT illicit discharge hotline.
- Containment structures or other perimeter controls shall be inspected routinely and repaired when signs of degradation are visible.

MH 2: Material Management

Description These practices are to be implemented for proper handling and storage of materials in order to prevent spills or leaks into the storm drains or watercourses.

Applications These practices are implemented at all construction sites where delivery and storage of materials may be detrimental to the environment. Materials of concern are not limited to soil, pesticides, herbicides, fertilizers, petroleum products, asphalt and concrete components, and hazardous chemicals such as acids, paints, solvents, adhesives, and curing compounds.

Standards and Specifications

Storage and Material Handling Areas

- Designated storage sheds must meet building and fire code regulations.
- Material safety data sheets (MSDS) shall be made available for all materials.
- Training for proper material handing and storage techniques shall be required.
- Provide sufficient separation between storage containers to allow cleanup and emergency response.
- Provide storage for materials indoor away from rainfall and offsite flows, whenever possible.
- Chemically incompatible materials should not be stored together or in the same storage facility.
- Label all materials properly and maintain current legible labels; also maintain a current inventory of all material delivered and stored.
- Hazardous materials must comply with federal, state, local, and CDOT HazMat requirements.
- Provide above ground secondary containment for all hazardous chemical materials.
- Immediately contain and cleanup any spills.

Loading and Unloading Areas

- Cover loading and unloading areas to reduce exposure of materials to rainfall.
- Routinely check vehicles and equipment such as valves, pumps, flanges, and connections for leaks.

- Direct offsite stormwater flows away by grading, berming, or curbing the area around the loading/unloading area.

Maintenance and Inspection

- In general, areas shall be inspected on a regular basis (once per week).
- Inspect equipment and vehicles routinely for leaks.
- Maintain an ample supply of cleanup materials at all designated storage and handling areas where leaks and spills are likely to occur.
- Spot-check material storage and handling areas for compliance.
- Material storage areas shall be routinely checked for accumulation of non-labeled materials and spills.
- Identify spills or leaks into the storm drain at or near CDOT work areas and report to the CDOT illicit discharge hotline.
- Containment structures or other perimeter controls shall be inspected routinely and repaired when signs of degradation are visible.

MH 3: Material Use

Description

These practices are implemented to ensure minimal water quality impacts from the use of construction materials.

Applications

These practices shall be implemented at all construction sites. The contractor is responsible for identifying proper material use measures for all materials used at constructions site projects. The following represent some of the materials of concern where this BMP will be implemented.

- Pesticides, herbicides, and fertilizers
- Detergents and cleaners
- Petroleum products such as fuel, oil, and grease
- Asphalt and concrete compounds
- Hazardous chemicals
- Other materials that may have negative impacts if released into the environment

Design Guidelines

- MSDS shall be made available for all materials.
- Do not remove original labels; re-label all materials properly and maintain current legible labels with proper safety and disposal information.
- Use less hazardous, recycled, or non-toxic materials when possible.
- Leftover materials should be recycled and properly disposed of.
- Use materials only where and when necessary to complete the construction activity; avoid excess application of materials.
- Never clean paintbrushes or paint containers into a street, gutter, storm drain, or watercourse. Dispose of used materials properly.
- Herbicides shall be applied by a licensed applicator; fertilizers and herbicides shall not be over-applied. Only the amounts needed should be prepared.

Maintenance and Inspection

- In general, areas shall be inspected on a regular basis (once per week).
- Maintain an ample supply of cleanup materials at all designated maintenance areas where leaks and spills are likely to occur.

- Spot-check material use areas for compliance and to ensure appropriate practices are being employed by employees and contractors.
- Material use areas shall be routinely checked for accumulation of non-labeled materials and spills.
- Identify spills or leaks into the storm drain at or near CDOT work areas and report to the CDOT illicit discharge hotline.
- Containment structures or other perimeter controls shall be inspected routinely and repaired when signs of degradation are visible.

MH 4: Spill Prevention and Control

Description These practices are implemented to prevent and control spills to ensure that spills and leaks do not result in water quality impacts.

Applications This BMP applies to all construction activities. Spill prevention and control measures shall be implemented any time chemicals or hazardous substances are used, stored, or handled.

Design Guidelines

The following general design guidelines can be implemented for spill prevention and control measures for various activities and areas:

- Identify materials delivered, handled, stored, and used at a project site.
- Identify project areas and activities potentially susceptible to spills. Areas and activities that are most vulnerable to spills include: transportation facilities, loading and unloading areas, fuel and chemical storage areas, process activities, dust or particulate generating processes, and waste disposal activities.
- Develop spill response procedures.

Limitations This BMP only applies to spills caused by the contractor. The measures described in the BMP are general. The contractor is responsible for identifying practices for specific materials used, stored, or handled on a project site.

Standards and Specifications

- Spills shall be contained and cleaned up as soon as possible.
- If complete cleanup is not immediately possible, then spills shall be fully covered and not exposed to rainfall.
- Spills shall not be washed down into the storm drain or buried.
- Residuals left over from the cleanup activity such as absorbent pads or containers of spill material shall be disposed of properly.

- Proper spill and illicit discharge reporting procedures shall be followed for both hazardous and non-hazardous materials.
- An area where a spill has occurred shall be inspected to verify that spill residuals are not present after the initial cleaning and that the area does not need to be re-cleaned.

Spill Prevention and Control Plan

A Spill Prevention and Control Plan may need to be developed and implemented for certain products that are stored, processed, and refined. A Spill Prevention and Control Plan identifies areas where spills can occur onsite, specifies material handling procedures and storage requirements, and identifies spill cleanup procedures. The purpose of this plan is to establish standard operating procedures and the necessary employee training to minimize the likelihood of accidental releases of pollutants that can contaminate stormwater runoff. Spill prevention is prudent both environmentally and economically, since spills increase operating costs and lower productivity.

Stormwater contamination assessment, flow diversion, recordkeeping, internal reporting, employee training, and preventative maintenance are associated BMPs that should be incorporated into a comprehensive Spill Prevention and Control Plan.

A Spill Prevention and Control Plan is applicable to facilities that transport, transfer, and store hazardous materials, petroleum products, fertilizers, or any other material that can contaminate stormwater runoff. An important factor of an effective Spill Prevention and Control Plan is quick notification of the appropriate emergency response team.

Emergency spill cleanup plans should include the following information:

- A description of the facility including the nature of the facility activity and general types and quantities of chemicals stored at the facility.
- A site plan showing the location of storage areas for chemicals, location of storm drains, site drainage patterns, fire-fighting equipment and water source locations, and the location and description of any devices used to contain spills such as positive control valves.
- Notification procedures to be implemented in the event of a spill, such as, posting phone numbers of key personnel and appropriate regulatory agencies.
- Instructions regarding cleanup procedures.
- Designating personnel with overall spill response cleanup responsibility.

A summary of the plan should be written and posted at appropriate points in the building (i.e., project trailer and areas with a high spill potential), and

shall identify the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to be contacted in the event of a spill.

Cleanup of spills should begin immediately. No emulsifier or dispersant should be used. In fueling areas, absorbent materials should be packaged in small bags for easy use, and small drums should be available for storage of absorbent and/or used absorbent. Absorbent materials shall not be washed into the floor drain or storm sewer.

Cleanup Response Procedures

Response guidelines have been identified below for contractors responding to spills that may potentially result in an illicit discharge. It is the contractor's responsibility to have all emergency phone numbers available at the construction site as well to notify the proper response agencies in a timely manner. It is also the contractor's responsibility to ensure timely and proper cleanup of any spill.

For **non–hazardous materials** such as gasoline, paint, or oil that may be spilled in **small quantities** which do not enter state waters or pose a potential to do so, the following measures shall be implemented:

- Use absorbent materials to contain spills and clean the area of residuals
- Do not hose down spill area with water
- Dispose of the absorbent material properly

For **non-hazardous materials** that qualify as a **significant spill** or spills of any size that enter state waters or have the potential to do so, the following measures shall be implemented:

- Contact the CDPHE Environmental Emergency Spill Reporting Line (1-877-518-5608) within 24 hours of the spill event. A written notification to the CDPHE-EMP is necessary within 5 days.
- Contact the Colorado State Patrol 24-hour hotline (1-303-239-4501) if the spill is on a state highway.
- Report spill to project foreman and CDOT maintenance personnel on patrol.
- Call the CDOT illicit discharge hotline if spilled material spreads to a CDOT storm drain or a waterway adjacent to CDOT right-of-way.
- Cleanup spill immediately. Use absorbent materials if the material is on an impermeable surface. Construct an earthen dike to contain a spill on dirt areas. If rainfall is present at the time of the spill, cover the spill with a tarp to prevent contaminating runoff.

For spills involving **hazardous materials**, the following measures shall be implemented:

- Contact the local emergency response team by dialing 911.

- Contact the CDPHE-EMP 24 Environmental Emergency Spill Reporting Line (1-877-518-5608) within 24 hours of the spill event. A written notification to the CDPHE-EMP is necessary within 30 days.
- Contact the Colorado State Patrol 24-hour hotline (1-303-239-4501) if the spill is on a state highway.
- Report spills to project foreman and CDOT maintenance personnel on patrol.
- Call the CDOT illicit discharge hotline if spilled material spreads to CDOT storm drain or waterway adjacent to CDOT right-of-way.
- Construction personnel shall not try to clean up the spill.
- Cleanup spill immediately; a licensed contractor or HazMat team shall be used to properly clean up spills.

Maintenance and Inspection

- In general, areas shall be inspected on a regular basis of at least every 14 days and after a storm event.
- Inspect equipment and vehicles routinely for leaks.
- Maintain an ample supply of cleanup materials at all designated maintenance areas where leaks and spill are likely to occur.
- Spot-check material storage and handling areas for compliance.
- Material storage and use areas shall be routinely checked for accumulation of non-labeled materials and spills.
- Identify spills or leaks into to the storm drain at or near CDOT work areas and report to the CDOT illicit discharge hotline.
- Containment structures or other perimeter controls shall be inspected routinely and repaired when signs of degradation are visible.

5.8 Waste Management

Waste Management BMPs

- Concrete Waste
- Solid Waste
- Sanitary and Septic Waste
- Liquid Waste
- Hazardous Waste
- Contaminated Waste

Stormwater runoff from areas where construction wastes are stored or disposed of can be polluted. Wastes leached or spilled from management areas may build up in soils or on other surfaces and be carried by stormwater runoff. There is also the potential for liquid wastes from lagoons or surface impoundments to overflow, soak the surrounding area, or be washed to receiving waters. Solid wastes improperly stored can contaminate stormwater runoff and contribute pollutants. Possible contaminants include toxic compounds, oil and grease, oxygen-demanding organics, paints and solvents, heavy metals, and high levels of suspended solids.

The optimal approach to reduce the potential for stormwater contamination from wastes is to reduce the amount generated and, consequently, the amount stored onsite. Several BMPs included in the following section will provide guidance on dealing with the management of wastes.

WM 1: Concrete Waste Management

Description

Practices to be used in order to minimize and prevent concrete waste associated with construction activities from entering storm drains and watercourses.

Applications

Facilities or designated construction work areas where concrete waste is generated from demolition activities; where concrete is used as a construction material; where concrete trucks or concrete-coated equipment are washed on site as permitted by the engineer; where slurries containing Portland cement concrete (PCC) or asphalt concrete are generated; and where mortar-mixing areas exist.

Standards and Specifications

Collection, Storage, and Disposal Guidelines

- Waste generated from concrete activities shall not be allowed to flow into drainage ways, inlets, receiving waters, or in the CDOT highway right-of-way. Concrete waste shall be placed in a temporary concrete washout facility.
- Concrete washout facilities will be comprised of an excavation with erosion bales and construction fences along the perimeter (see Figure WM1.1). The bottom of the excavation must be proven to be atleast 5 vertical feet above groundwater or, alternatively, the excavation must be lined with either a clay or synthetic liner that is designed to control seepage to a maximum rate defined in CDOT Standard Specifications Section 208. The facilities shall be maintained in good condition to contain all liquid and concrete waste generated by operations at a project site.
- Proper signage such as "Concrete Washout" or "Concrete Saw Water Disposal" shall be placed near concrete washout facilities to inform construction personnel of the location of designated concrete washout facilities.

- Temporary concrete washout facilities shall be located 50 horizontal feet from drainageways, inlets, and receiving waters unless otherwise approved by the engineer.
- Adding solvents, flocculents, or acid to washwater is prohibited.
- Whenever a concrete washout area is within 300 feet of the access to a road or highway, a stabilized construction entrance must be built as part of the washout, or at the entrance to the road or highway.
- Hardened concrete waste shall be properly disposed of following solid waste management procedures (BMP WM 2).
- Removal of temporary facilities, including the solid concrete waste and the material used to construct the facilities, shall be the responsibility of the contractor, who shall remove the waste from the project site and dispose of it properly following guidelines outlined in solid, liquid waste management (BMP WM 2 and WM 4) and any applicable regulations.

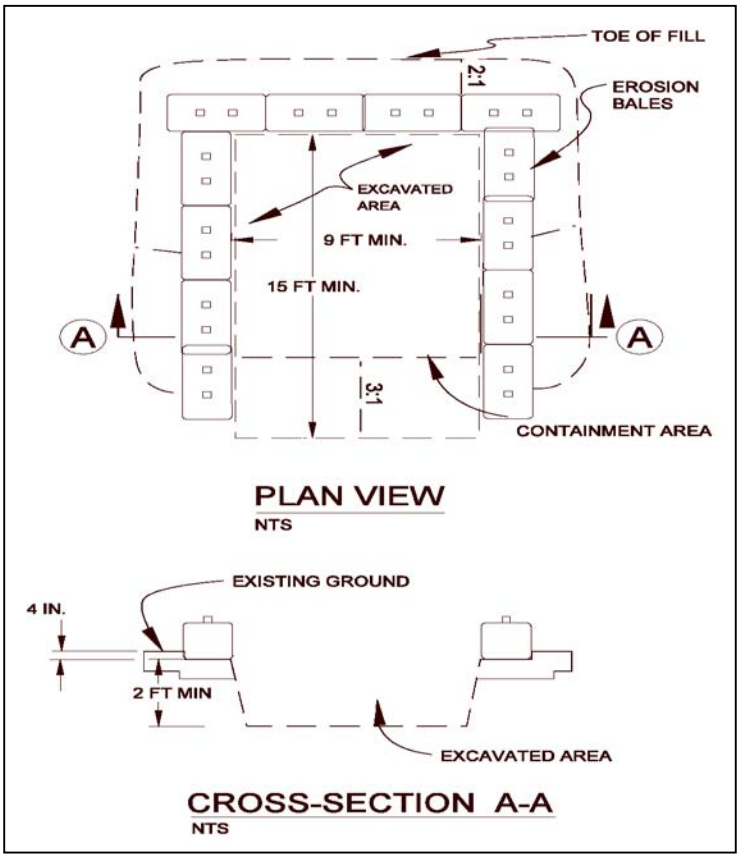


FIGURE WM1.1
Concrete Waste Management Detail

Maintenance and Inspection

- The contractor shall monitor concrete activities working tasks weekly to ensure proper waste management techniques are being utilized.
- Regular maintenance of temporary concrete washout facilities shall include removing hardened concrete and proper disposal. It is recommended that facilities be cleaned out once they are 75 percent full, or new facilities shall be constructed to provide additional concrete waste storage.

WM 2: Solid Waste Management

Description Practices to be used in order to minimize and prevent solid waste associated with construction activities from entering storm drains and watercourses.

Applications Facilities or designated construction work areas where solid waste is generated. Solid waste can be classified as non-hazardous solid material including: concrete, rock, debris, soil, wood, plastic, fabrics, mortar, metal scraps, styrofoam, and general litter created by the public, such as but not limited to beverage containers and plastic wrappers.

Limitations During the non-rainy season or in arid portions of the state, temporary stockpiling of non-hazardous solid waste may not require stringent drainage control measures. The engineer for the project shall determine if drainage control measures are warranted for a specific construction site where non-hazardous solid waste is being stockpiled.

Standards and Specifications

Collection, Storage, and Disposal Guidelines

- Litter shall be minimized at all construction sites and collected on a weekly basis into water-tight dumpsters. Trash receptacles shall be provided in various locations within the construction site boundaries. Collected trash shall not be placed near drainage inlets or watercourses. A trash hauling contractor shall be used to properly dispose of the collected waste in a timely manner. Dumpster washout at the construction site is not permissible.
- Priority shall be given to remove waste and debris from drainage inlets, trash racks, and ditches in order to prevent clogging of the stormwater system.
- Waste storage areas shall be pre-approved by the engineer.
- Storage areas for solid waste shall be located at least 50 feet from drainageways and watercourses, and shall not be located in areas susceptible to frequent flooding. Sediment barriers such as berms, dikes, or other temporary diversion structures shall be used to prevent stormwater runoff from contacting stored solid waste at the project site.
- Solid waste shall be segregated properly into various categories for recycling or disposal. Proper disposal is required for each waste category. The contractor shall make every attempt to recycle useful vegetation, packaging material, and surplus construction materials when practical. Most construction materials can be recycled at recycling facilities.

- Additional disposal guidelines for hazardous materials and liquid waste are included in Sections WM 5 and WM 4, respectively.

Maintenance and Inspection

- The contractor shall provide regular inspections every 14 days and after each storm event to ensure proper solid waste management measures are being followed.

WM 3: Sanitary and Septic Waste Management

Description Practices to be used in order to minimize and prevent sanitary and septic waste associated with construction activities from entering storm drains and watercourses.

Applications Facilities or designated construction work areas that use temporary or portable sanitary and septic waste systems.

Standards and Specifications

- Temporary sanitary facilities shall be located away from drainage ways, inlets, receiving waters, areas of high traffic, and areas susceptible to flooding or damage by construction equipment.
- Temporary sanitary facilities shall be properly connected into a sanitary sewer system where permissible to prevent illicit discharges. Authorized sanitary sewer system connections shall comply with local health agency, county, and sanitary sewer district requirements.
- Wastewater generated from sanitary facilities shall not be allowed to flow into drainageways, inlets, receiving waters, or into the CDOT highway right-of-way.
- Only licensed sanitary/septic waste haulers shall be used to properly dispose of waste from temporary sanitary facilities.
- In project areas susceptible to strong winds, temporary sanitary facilities shall be secured to prevent overturning.

Maintenance and Inspection

- The contractor shall provide regular inspections every 14 days and after each storm event to ensure proper sanitary and septic waste management measures are being followed, and that sanitary facilities are being properly maintained and cleaned.

WM 4: Liquid Waste Management

Description Practices to be used in order to minimize and prevent liquid waste associated with construction activities from entering storm drains and watercourses.

Applications Facilities or designated construction work areas where liquid waste is generated.

Limitations

- Does not apply to solid waste management (BMP WM 2), hazardous wastes (BMP WM 5), concrete slurries/wastes (BMP WM 1), dewatering operations (BMP GP 1), and sanitary/septic wastes (BMP WM 3).
- Does not apply to non-stormwater discharges permitted by the CDPS permit held by CDOT. The following group of non-stormwater discharges are not considered to be illicit or illegal unless the discharges are identified by CDOT as sources of pollutants to state waters: landscape irrigation, diverted stream flows, rising groundwater, uncontaminated groundwater infiltration to separate storm sewers, uncontaminated pumped groundwater, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, and flows from riparian habitats and wetlands.
- Disposal of some liquid wastes may be subject to regulations or requirements of other CDPS permits secured for the construction site.

Standards and Specifications

- The contractor shall oversee and enforce all liquid waste measures and will instruct all employees and subcontractors on the identification of hazardous and non-hazardous liquid waste, and non-hazardous handling, storage, and proper disposal.
- The contractor shall hold regular safety meetings to ensure proper liquid waste measures are being adhered to and efforts are being made to minimize the amount of liquid waste produced.
- The contractor shall ensure compliance with all liquid waste management procedures and practices.

Containment and Disposal Guidelines

- Liquid wastes generated from operational procedures such as drilling residue and fluids shall not be allowed to flow into drainageways, inlets, receiving waters, or into the CDOT highway right-of-way.
- All liquid wastes shall be contained in designated areas such as sediment basins, holding pits, or portable tanks. Designated containment areas shall be located away from drainageways, inlets, receiving waters, areas of high traffic, and areas susceptible to flooding.
- Precautions shall be taken to ensure that proper spill prevention and control measures are being implemented (BMP MH 4) to avoid accidental spills.
- If a liquid waste is released or spilled, then capture the liquid with proper cleanup methods (BMP MH 4). Do not allow the liquid waste to flow uncontrolled or into drainageways, inlets, and receiving waters. Use diverting methods such as temporary dikes to control the spill and direct it to containment areas for capture.
- The contractor shall be responsible for adhering to all permit requirements, federal, state, and local regulations for properly disposing liquid waste.

Maintenance and Inspection

- The contractor shall provide regular inspections every 14 days and after each storm event to ensure proper liquid waste management measures are being followed.

WM 5: Hazardous Waste Management

Description Practices to be used in order to prevent hazardous waste associated with construction activities from entering storm drains and watercourses.

Applications Facilities or designated construction work areas where hazardous waste is discovered or generated by lead paint removal operations, and other operations encountering waste that are designated as hazardous by the Code of Federal Regulations or Colorado state laws.

Limitations This BMP provides general hazardous waste management guidelines, but does not relieve the contractor from full responsibility of complying with federal, state, local laws and CDOT Standard Specifications regarding storage, handling, transportation, and disposal of hazardous wastes. It is the contractor's full responsibility to identify all hazardous waste generated at the project site.

Standards and Specifications

These standards and specifications are general guidelines provided for planning the management of hazardous wastes. Specific requirements that must be adhered to are identified in CDOT Standard Specifications.

- Hazardous waste storage, transportation, and disposal shall comply with 49 CFR 172, 173, 178, 179, and 261-263, state regulations and CDOT Standard Specifications.
- Special materials and equipment may be required to manage wastes that are corrosive, combustible, flammable, oxidizer, poison, toxic, or reactive. Clearly label all waste containers with the appropriate description of the wastes being contained.
- Hazardous wastes shall be segregated, and incompatible or reactive wastes shall be disposed of properly in a manner to prevent fires and explosion. Always consult the health and safety officer, engineer, and/or CDOT environmental project manager prior to mixing hazardous wastes for disposal. Hazardous waste shall be segregated properly into various categories such as liquids, semi-liquids, and solids.
- Select the most appropriate disposal container to store the hazardous waste. Additionally, select a container that is compatible with the hazardous material being stored. For instance, use plastic or plastic-lined steel drums for storing corrosive materials. Corrosive materials will react with steel and cause the waste to be released from the drum. Always consult the engineer or CDOT environmental project manager to ensure that the container and waste are compatible.

- Waste containers shall be stored and managed in temporary containment facilities that shall meet the following requirements:
  - A spill containment volume 1.5 times the volume of all containers
  - Impervious to the materials contained for a minimum contact time of 72 hours
  - Free of accumulated rainwater or spills, with sufficient separation provided between stored containers to allow for spill cleanup
  - Incompatible, ignitable, and reactive materials shall not be stored in the same temporary containment facility
  - "Caution: Flammable Material" signs must be posted near containment areas to prevent fires or explosions
- The following management guidelines are recommended for containment facilities:
  - Keep containers closed at all times except when adding or removing waste from the container. Use a funnel or hose to transfer wastes to drums.
  - You must open, handle, and store containers to prevent ruptures or leaks. Make sure to open drums with a spark-proof wrench.
  - If the container begins to leak or you notice dents or bulges, transfer the waste to another container.
- Locate containment areas away from high-traffic areas, waterways, drainage inlets, sensitive habitats, and areas prone to flooding or ponding.
- Waste residuals from equipment or brushes shall be cleaned in designated containment areas and shall not be allowed to seep into soils causing soil contamination or to discharge into watercourses or drainageways.
- Secondary containment needs to be provided for all hazardous waste containers. In addition, containment berms shall be used in fueling and maintenance areas where the potential for spills is high.
- Hazardous waste containment areas shall be pre-approved by the engineer and/or CDOT environmental project manager.
- It is the contractor's responsibility to ensure that all hazardous waste discovered or generated at a project site is disposed of properly by a licensed hazardous material disposal contractor/facility utilizing properly completed Uniform Waste Manifest forms. The contractor is responsible for not exceeding hazardous waste storage requirements mandated by the state or other localities.

- Additional disposal guidelines for non-hazardous solid and liquid waste are included in Sections WM 2 and WM 4, respectively.

Maintenance and Inspection

- The contractor shall perform routine inspections at least every 14 days and after each storm event to ensure proper hazardous waste management measures are being followed.
- Containment structures, berms, covers, and liners shall be repaired or replaced as needed to function properly.

WM 6: Contaminated Waste Management

Description Practices to be used in order to minimize and prevent pollutants from contaminated soils from leaching into watercourses or drainage systems.

Applications Facilities or designated construction work areas where contaminated soils have been identified to be present.

Limitations The contractor is responsible for identifying pollutant-specific handling and disposal procedures for contaminated soils at the project site in accordance with the CDOT Standard Specifications.

Standards and Specifications

These standards and specifications are general guidelines provided for planning the management of contaminated soils. Specific requirements that must be adhered to are identified in CDOT Standard Specifications.

- The contractor is responsible for reviewing relevant environmental reports, appropriate plans, CDOT Standard Specifications, and project-special provisions for contaminated soils information. The contractor shall also take initiative to further inform the engineer of any potential or identified contaminated soils on the project site.
- Contractor and employees are responsible for meeting safety training requirements mandated by 29 CFR 1910.120 prior to performing any construction work or excavation at projects sites where contaminated soils have been classified as hazardous materials.
- The contractor is responsible for following all rules and regulations applicable to the excavation, handling, transport, and disposal of contaminated and hazardous materials. The applicable rules and regulations are not limited to the standards of Occupational Safety and Health Administration (OSHA), EPA, USDOT, CDPHE, CDOT, and local agencies.
- Contaminated soils or soils classified as hazardous should not be stockpiled. Hazardous materials should be managed in accordance with BMP WM 5.
- Surround the perimeter of the exclusion zone with a security fence for safety.
- Collect non-reusable protective equipment used at the project site and dispose of it properly. Additionally, treat and/or dispose of wastewater from decontamination procedures. Liquid waste management procedures are outlined in BMP WM 4.

- Contaminated soil shall be transported on vehicles registered for that purpose. Contact between the contaminated soil shall be limited to the excavation site from which the soil originated and to the registered transport vehicle.
- When an underground storage tank is discovered at a construction site, coordinate with the regional environmental project manager for guidance on handling and disposal procedures.
- Preventive measures, such as berms, freeze walls, cofferdams, and grout curtains, should be installed to prevent stormwater runoff or groundwater from mixing with hazardous materials or underground tank excavations. Water exposed to contaminated areas should be placed in water-tight holding tanks, tested, and properly disposed.

Maintenance and Inspection

- The contractor shall provide regular inspections atleast every 14 days and after each storm event to ensure proper contaminated soil management measures are being followed.
- The contractor shall be responsible for monitoring onsite contaminated storage and disposal procedures.

5.9 General Pollution Prevention

General Pollution Prevention BMPs

- ❑ Dewatering Operations
- ❑ Temporary Stream Crossing
- ❑ Clear Water Diversion
- ❑ Non-Stormwater Discharge Management
- ❑ Wind Erosion Control
- ❑ Paving Operations
- ❑ Street Sweeping and Vacuuming
- ❑ Vehicle and Equipment Management

This section describes specific common BMPs that minimize stormwater runoff pollution. The objective of General Pollution Prevention BMPs is to reduce the discharge of materials other than stormwater to drainage systems or receiving waters. The BMPs to consider are included in the following section.

GP 1: Dewatering Operations

Description Practices to remove and discharge excess water from construction sites. These practices manage the discharge of groundwater and accumulated precipitation in order to prevent potential pollutants from entering storm drains and watercourses.

Applications These dewatering practices are implemented to remove accumulated water and sediments from sediment traps, basins, and excavated areas. Sediment control from dewatering operations is required on all projects where excess water containing sediment-laden water is planned to be discharged.

Limitations These practices are limited to providing sediment control only allowing for minimal settling time for sediment particles. Other sediment control methods shall be used for better sediment removal when site conditions allow.

Standards and Specifications

- The contractor shall notify the engineer of all planned discharges. All dewatering operations must comply with applicable CDPS and local permits as well as regional and watershed-specific discharge requirements.
- Sediment control measures such as sediment traps (SC 5), sediment basins (SC 6), and dewatering structures (SC 7) shall be implemented to treat sediment-laden excess water from construction sites. Other sediment control measures such as filtration devices can be utilized only if approved by the engineer.
- All dewatering operations shall comply with CDOT Standard Specifications. The following are some of CDOT's guidelines for water quality control:
  - Water from dewatering operations shall not be directly discharged into any state waters including wetlands, irrigation ditches, canals, or storm sewers, unless allowed by the permit.
  - Discharge into sanitary sewers will not be allowed unless written permission is obtained from the owner or controlling authority and a copy of this approval submitted to the engineer.
  - Unless prohibited by law or otherwise specified in the contract, water from dewatering operations shall be contained in basins for dissipation by infiltration or evaporation; hauled away from the project for disposal in accordance with applicable laws and regulations; or shall be land applied to approved non-wetland

vegetation areas and allowed to soak into the soil. Depending upon the quality of the water, land application of water to vegetated areas may require a written concurrence of permit from the CDPHE. The contractor shall determine the quality of water based on the CDPHE guidelines, obtain applicable concurrences or permits, and furnish copies of the concurrences or permits to the engineer.

Maintenance and Inspection

- Sediment removal from dewatering devices shall be routinely performed and stabilized at the project site at locations designated by the engineer or shall be disposed of properly. Guidance for sediment disposal is provided in solid and contaminated waste management, WM 2 and WM 6, respectively.
- Perform routine spot-checks to ensure dewatering techniques are properly implemented.

GP 2: Temporary Stream Crossing

Description

A temporary stream crossing is a structure placed across a waterway to provide short-term access for construction purposes without entering the water. Temporary stream crossings are implemented to prevent construction equipment from damaging the waterway, blocking fish migration, and tracking sediment and other pollutants into the waterway.

Applications

Temporary stream crossings are installed at sites with the following conditions:

- Where construction vehicles and equipment need to cross a waterway and alternate access routes are not feasible or cause significant erosion.
- Where construction activities will only last 1 year.
- Where appropriate permits have been obtained.

Limitations

Temporary stream crossings are limited in operation for a maximum of 1 year and to waterways with drainage areas less than 1 square mile. Installation may require dewatering or diversion of the stream and cause disturbance of the waterway. Additionally, the temporary stream crossing may potentially become a constriction in the waterway obstructing flood flows.

Design Guidelines

Design

- Temporary bridges shall be of wood, metal, or other appropriate material. Pipes can be of reinforced concrete, corrugated metal, or plastic.
- Temporary crossings should be perpendicular to the stream.
- When pipes are used, aggregate should be used to form the crossing. Depth of the stone cover over the pipe shall be equal to half the pipe diameter, and in no case less than 12 inches.
- The pipe diameter shall be selected to convey the flow from a 2-year frequency storm. If the structure will stay in place for 30 days to a year, consider using the 5-year frequency storm. Minimum pipe size that may be used is 18 inches in diameter.
- Whenever possible, the slope of the pipe shall be at least 2 percent.
- If multiple pipes are used, they must be separated by a distance equal to half the diameter of the pipes. Minimum separation shall be 1 foot and maximum separation shall be 3 feet. Aggregate shall be placed between the pipes.

Construction (see Figure GP 2.1)

- Bridges shall be constructed to span the entire channel at or above bank elevation and shall be securely anchored using steel cable or chain.
- When using pipes, the invert elevation of the pipe shall be installed on the natural streambed grade. A geotextile should be placed on the streambed and streambanks prior to placing the pipe and aggregate. The geotextile should extend 12 inches beyond the end of the culvert.
- The pipe length shall not exceed 40 feet, and shall extend at least 1 foot beyond the upstream and downstream toe of the aggregate around the pipe.
- The construction of any specific crossing method shall not cause a significant water-level difference between upstream and downstream water surface elevations. Construction shall also not disturb or create a barrier in the stream channel during fish spawning and migration periods.

Removal

- Removal of a temporary stream crossing shall consists of removing the temporary structure from the stream channel, removal of all construction material, restoration of the original stream channel cross section, and protection of the stream banks from erosion. All removed materials shall be stored outside the waterway floodplain.
- All temporary crossings shall be removed within 14 calendar days after the structure is no longer needed. Unless prior approval is obtained from the engineer, all structures shall be removed within 1 year from the date of installation. Removal of the structure shall not take place during the spawning periods for the given stream.
- Removal of temporary stream crossings shall be performed without construction equipment working in the stream channel.
- All areas disturbed during culvert installation shall be stabilized within 14 days of the disturbance with standard practices in Section 5.5, Erosion Control of this Guide.

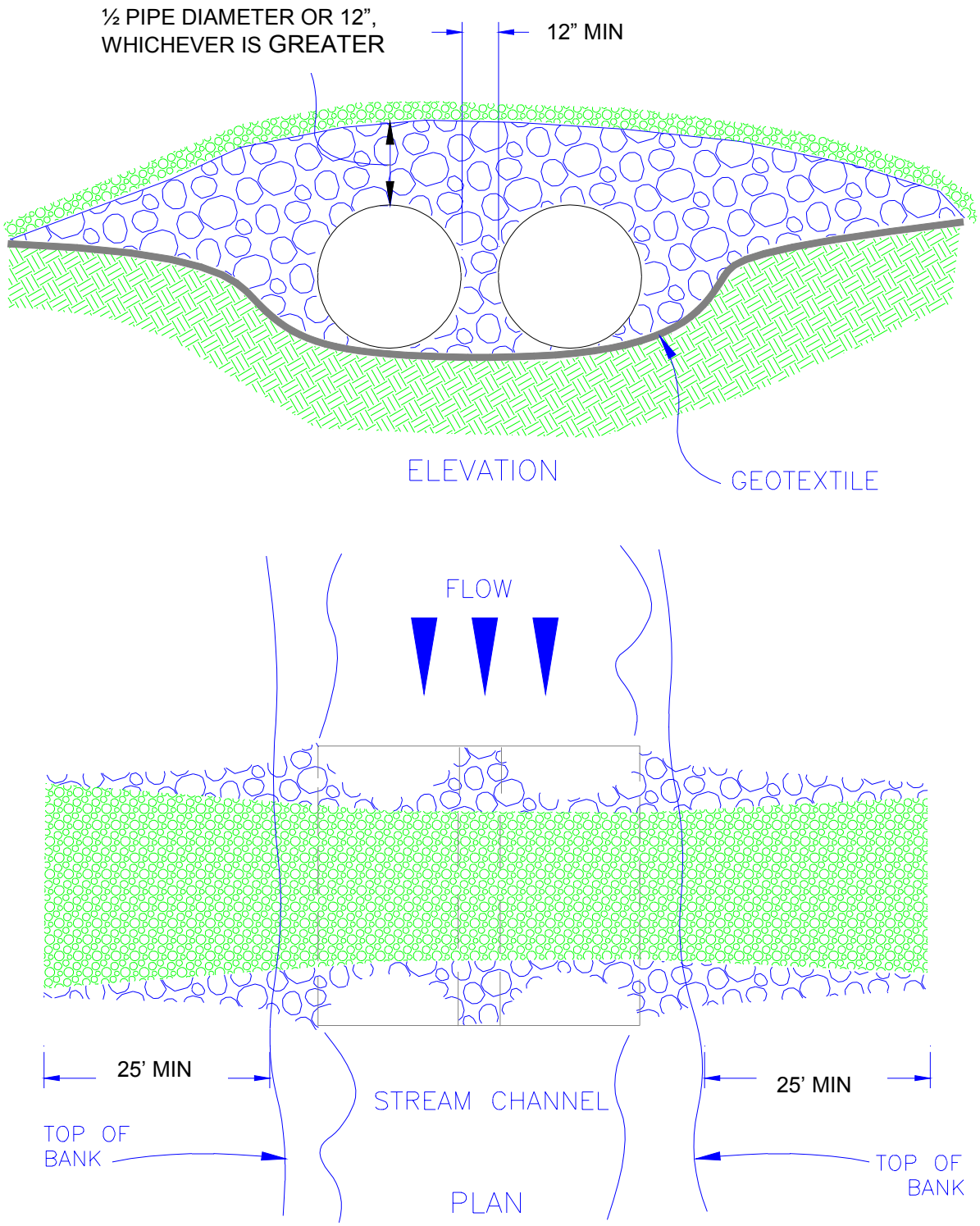


FIGURE GP 2.1
Temporary Stream Crossing

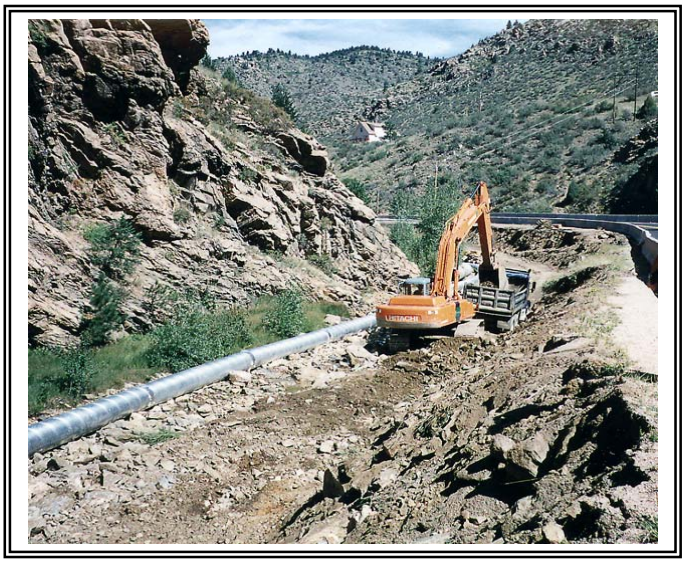
Maintenance and Inspection

- Weekly inspections shall be performed to ensure that the culverts, streambeds, and streambanks are not damaged, and that sediment is not entering the stream or blocking fish passage or migration. Inspections shall also be performed after each storm event and damages shall be repaired immediately. An assessment of the foundation shall be performed during the inspection and the lost aggregate shall be replaced.
- Trapped sediment or debris shall be routinely removed and disposed of properly outside the highway right-of-way.
- Perform routine spot-checks to ensure CDOT personnel or subcontractors are properly implementing temporary stream crossing techniques.

GP 3: Clear Water Diversion

Description

A temporary structure used to convey clear surface water runoff around a construction site and discharge it downstream of the project site with minimal water quality impacts. Common diversion structures used to intercept surface runoff are diversion ditches, berms, dikes, slope drains, drainage, and interceptor swales.



Applications

Temporary clear water diversion structures can be implemented where appropriate permits have been secured to perform work in a running stream or waterbody.

Limitations

- Clear water diversion activities may require special permit requirements or mitigation measures.
- Diversion activities will almost always disturb the waterway during installation and removal of diversion structure.

Design Guidelines

- Diversion structures shall be constructed with materials free of pollutants such as dirt or oil and grease. In addition, the construction materials shall be free of contaminants, non-toxic, non-hazardous, and neutral pH.
- Barriers adequate enough to prevent the flow of muddy water into streams shall be constructed and maintained between working areas and streams. These barriers or structures shall be constructed to accommodate fluctuations in water depth or flow volume due to tides, storms, or flash floods. The constructed diversion structures shall allow sufficient water to flow downstream to maintain aquatic life.
- Equipment used during construction of diversion structures shall be free of leaks, and shall be clean of petroleum residue. Equipment being used adjacent to a waterbody, but not within the waterbody, shall be placed over drip pans.

- When using an excavator , crane, or backhoe, the main body of the equipment shall not enter the waterbody, and only the bucket of the excavator shall be allowed to remove or place fill in the stream. In cases where a stream crossing is necessary to access the work site, the main body of the excavator can enter the water body beyond the stream banks with prior approval from the engineer.
- Vegetation shall only be disturbed where necessary. Care shall be taken not to damage vegetation beyond the necessary limits for constructing a diversion structure. Additional precaution shall be taken in order to prevent people or equipment from damaging additional vegetation. Riparian vegetation shall be cut off no lower than ground level to promote rapid regrowth. Clean river cobble shall be placed over riparian vegetation to prevent damage to underlying soil and roots while constructing work areas and roads.
- The construction impacts of diversion structures on streams shall be minimized by scheduling operations during low-flow periods and avoiding fish migration and spawning periods.
- Temporary diversion structures can be swales, dikes, and ditches. Slope stabilization and velocity dissipation shall be provided at transition points in the diversion.

Maintenance and Inspection

- Inspections of diversion structures shall be performed before and after each storm event, and damages shall be repaired immediately.
- Inspections shall be performed to ensure that linings, accumulated sediment, and slope protection are not damaged.

GP 4: Non-Stormwater Discharge Management

Description Practices to be implemented to prevent discharges of potential pollutants from irrigation systems, discharges from potable water sources, water line, hydrant flushing and other similar activities from entering storm drains and watercourses.

Applications These practices are implemented where irrigation and water flushing practices exist at a construction site.

Standards and Specifications

- Offsite flows shall be routed around construction sites to prevent runoff from scouring the construction site and carrying sediment loads downstream.
- Broken irrigation and waterlines shall be shut off at the source to prevent excess water flow and repaired immediately.
- Irrigation systems shall be scheduled to water construction areas without over-watering and causing runoff. Considerations should be made for site-specific conditions such as soil type, slopes, season, and vegetation type when developing watering schedules.
- Inlets and watercourses shall be protected with bales or other suitable BMPs from potentially polluted discharges at construction sites. In addition, when possible, non-polluted water resulting from waterline or hydrant flushing shall be reused for irrigation purposes.

Maintenance and Inspection

- Inspect irrigation areas routinely for excess watering; repair any leaking waterlines as soon as possible.
- Perform routine spot-checks to ensure non-stormwater discharge mana control techniques are properly implemented.

GP 5: Wind Erosion Control

Description Practices, such as applying water or dust palliatives, to be implemented during construction operations to prevent wind erosion from exposed soil surfaces.

Applications These practices are limited to exposed soil where wind erosion is expected.

Limitations The effectiveness of this application can be limited by soil, temperature, and wind velocity.

Standards and Specifications

- Irrigation practices can be applied to a project site until the soil is moist and can be repeated as necessary. However, the soil shall not be over-saturated causing runoff to flow from the project site. The distribution system shall be equipped with a proper spray system to ensure even water distribution. When a distribution system is unavailable, at least one mobile unit shall be available at all times to apply water or a dust palliative to the project site. All non-potable tanks, pipes, and other conveyances shall be marked "non-potable water-do not drink."
- Seeding, mulching, soil binders, and surface roughening are also temporary methods to prevent wind erosion. Refer to BMPs EC 1, EC 4, and EC 6.

Maintenance and Inspection

- Inspect protected areas routinely for adequate protection and signs of degradation.
- Perform routine spot-checks to ensure wind erosion control techniques are properly implemented.

GP 6: Paving Operations

Description Practices to be implemented during paving and grinding operations to prevent associated stormwater pollutants from entering storm drains and watercourses.

Applications These practices are implemented where paving and grinding operations such as surfacing, resurfacing, or sawcutting may cause pollutants to enter stormwater runoff.

Limitations These practices are limited to dry weather conditions.

Standards and Specifications

- Protect drainage inlet structures and manholes with filter fabric during paving applications.
- Do not conduct paving operations when rainfall is predicted.
- Use drip pans or absorbent materials under equipment not in use to catch/contain leaks.
- Use only non-foaming and non-toxic coating materials for asphalt trucks and spreading equipment; follow vehicle cleaning and maintenance guidelines to properly clean asphalt-coated equipment offsite (BMP GP 8); dispose of hardened asphalt debris and aggregate debris by following guidelines for concrete waste management (BMP WM 1).
- Apply temporary perimeter controls when asphalt material is used in embankments or shoulder backing to prevent materials from entering the storm drains or watercourses; examples of perimeter controls are silt fences (BMP SC 3), berms (BMP EC 8), and drainage swales (BMP EC 13).
- Do not wash waste sweepings from exposed aggregate concrete into storm drains inlets; sweepings shall be placed back into the aggregate base stockpile.
- Residuals from grinding operations shall not be allowed to remain on the pavement surface or flow across the pavement surface into a watercourse; residuals shall be cleaned up or contained.
- Recycle digout material and excess asphalt when possible during pavement grinding and removal; if material cannot be reused, store or dispose of properly.
- When using thermoplastic striping techniques or performing pavement application/removal, inspect equipment for leaks, do not overfill tanks, and do not transfer material near stormwater inlets, storm sewer systems, or watercourses.

- During raised or recessed pavement marker application, make sure to transfer or load bituminous material away from storm drains and watercourses; do not overfill melting tanks so as to prevent splashing; and release all pressure from melting tanks before removing lids while filling or servicing. Follow proper disposal methods for collecting excess bituminous material from the roadway after removal of pavement markers.

Maintenance and Inspection

- Inspect equipment and vehicles routinely for leaks.
- Identify spills or leaks into to the storm drain at or near work areas and report to the CDOT illicit discharge hotline.
- Containment structures or other perimeter controls shall be inspected routinely and repaired when signs of degradation are visible.
- Perform routine spot-checks to ensure paving and grinding operations are properly implemented.

GP 7: Street Sweeping and Vacuuming

Description Practices to remove sediment transported onto streets to prevent the sediment from entering a storm drain or watercourse.

Applications These practices are implemented anywhere sediment is tracked from the project site onto public or private roads, typically at points of egress.

Limitations Sweeping and vacuuming may not be effective when soil is wet or muddy.

Design Guidelines

- Do not use kick broom or sweeper attachments.
- Visible sediment tracking shall be swept and vacuumed on a daily basis.
- If not mixed with debris or trash, consider incorporating the removed sediment back into the project.

Maintenance and Inspection

- Inspect potential sediment tracking locations daily.
- Inspect ingress/egress access points daily and sweep tracked sediment as needed, or as required by the engineer.
- Be careful not to sweep up any unknown substance or object that may be potentially hazardous.
- Adjust brooms frequently; maximize efficiency of sweeping operations.
- After sweeping is completed, properly dispose of sweeper wastes at an approved dumpsite in conformance with the CDOT Standard Specifications.

GP 8: Vehicle and Equipment Management

Description Practices to be used during vehicle and equipment fueling, cleaning, and maintenance to prevent associated stormwater pollutants from entering storm drains and watercourses.

Applications Facilities or designated construction work areas where vehicles and equipment are fueled, cleaned, or maintained.

Standards and Specifications

- Perform cleaning, washing, and maintenance in a centralized station offsite; onsite activities are highly discouraged.
- Designated onsite stations should preferably be located indoors on impervious surfaces 50 feet away from watercourses, configured with a sump, and bermed to collect the wastewater.
- Wastewater shall not be discharged into the CDOT right-of-way; wastewater shall be contained for percolation and evaporation.
- Constructed berms shall be durable and leakproof.
- Eliminate or reduce the amount of toxic or hazardous solvent used; alternative suggestions are recommended in Section 3.2, EPA.
- Use proper waste or recycling drums for used or spilled fluids; separate and recycle materials when possible.
- Use drip pans or absorbent materials under equipment to catch/contain leaks.
- Do not pour liquid waste into floor drains, sinks, or to storm drain inlets.
- Avoid hosing down work stations.
- Routinely check vehicles and equipment for leaking oil or fluids.
- Proper spill and illicit discharge reporting and cleanup procedures shall be followed for both hazardous and non-hazardous materials.

Maintenance and Inspection

- In general, designated vehicle fueling, cleaning, and maintenance areas shall be inspected on a regular basis; once per week.
- Inspect equipment and vehicles routinely for leaks.
- Maintain an ample supply of cleanup materials at all designated maintenance areas where leaks and spills are likely to occur.

- Identify spills or leaks into to the storm drain at or near CDOT work areas and report to the CDOT illicit discharge hotline.
- Containment structures or other perimeter controls shall be inspected routinely and repaired when signs of degradation, such as leaks, are visible.

APPENDIX A

SWMP Checklist

To ensure that all necessary components of the SWMP have been included in the bid documents, the following SWMP checklist can be used:

Stormwater Management Plan Checklist

1. Items listed below that are applicable to your project must be included in the contract documents.

SWMP-Additional Information **Required for Projects with CDPS Permit.**	
	Runoff coefficient pre-construction___ post construction___
	Existing soil data
	Existing vegetation
	Other water quality measures not included in SWMP referenced in other contract plans and specifications
	STORMWATER DISCHARGE ASSOCIATED WITH CONSTRUCTION ACTIVITY PERMIT APPLICATION SUBMITTED TO CDPHE- permit application process is subject to revision. Checked with CDOT water quality and regional environmental for revisions to application process.
	Signatory requirements obtained for permit
Site Information Referenced In Plan Sheets **Required For All Projects.**	
	General location map
	Discharge locations — projects with drainage plans
	Receiving waters listed
	On site wetlands mapped and shown on the plans
	Endangered species habitat mapped and shown on the plans
	Historic preservation information identified
	Other protected environments or structures
Stabilization Practices **Required For All Projects With Earth Disturbances**	
	Area of disturbance quantified
	Planting or seed plan included (species rates, types, method of planting, and soil preparation)
	Description of interim stabilization (i.e., required for detours, stockpiles, temporary mulching between seeding windows)

SWMP-Additional Information	
	Description of permanent stabilization
	Additional quantities included for incremental seeding and mulching (minimum 25 percent of total)
	Soil preparation — fertilizer, surface roughening defined
	Work access plan defined adjacent to sensitive environments (wetlands, forests, endangered species habitat)
Structural Best Management Practices **Required For All Projects With Earth Disturbances**	
	208 PAY ITEMS INCLUDED IN PLANS as described in code item book
	REVISED M-107-1 STANDARD INCLUDED if any
	BMP locations included in tab/ or plan sheets
	Relevant project special provisions included in specifications document
	Additional details and special provisions included
	Erosion control supervisor pay item included (projects with permits)
	SWMP reviewed with construction project engineer
	Sediment removal and disposal paid for separately
	Equipment hours included for erosion control
	Force account and additional as directed items included for unforeseen conditions
	Concrete washout area defined

STORMWATER MANAGEMENT PLAN - ADDITIONAL INFORMATION

Estimated runoff coefficient
Pre-construction: 0.45 Post-construction: 0.5

Existing data describing soil or quality of discharge: Soils are moderate deep to shallow. They are formed in erosive sandy material and contain high percentages of rock

Existing vegetation: Woodlands of the intermountains mixed with grasses, shrubs and forbs.

Proposed sequence for major activities, location of any other potential pollution source, areas used for storage of building materials, soils or wastes, and location of any dedicated asphalt or concrete batch plants: see water quality and erosion control specifications, and documents submitted by the contractor at the preconstruction conference.

100-year Flood plain boundaries: see bridge hydraulic information sheet (if existent).

Description of the construction activity, estimate of the total site area and of the area expected to undergo excavation, and name of the receiving water: see CDPS stormwater permit application.

Site map and construction site boundaries: see title sheet

Areas of cuts and fills and areas of soil disturbance: see plan and profile sheets and roadway cross sections.

Surface waters: see title sheet and bridge hydraulic information sheet (if existent)

Materials handling and spill prevention: see water quality specification (107.25).

Inspection and maintenance: see erosion control specifications (107.25 or 208).

Contract Document location of erosion control and stormwater quality management measures not referenced above nor included on the Stormwater Management Plan Sheet(s):

ROADWAY AND DRAINAGE PLANS.

SEEDING PLAN

NATIVE SEEDING

Soil preparation* fertilizer*, seeding, mulch tackifier and mulching will be required for an estimated 5 acres of disturbed area within the right-of-way limits which are not surfaced. The following types and rates shall be used:

COMMON NAME	BOTANICAL NAME	POUNDS PLS/ACRE
Western wheatgrass	Pascopyrum smithii v. rosanna	6.0
Arizona fescue	Festuca arizonica v. redondo	3.0
Blue grama	Bouteloua gracilis v. hachita	2.0
Sandberg bluegrass	Poa sandbergii	2.0
Slender wheatgrass	Elymus trachycaulus v. primar	5.0
Green needlegrass	Stipa viridula v. lodorm	4.0
Yarrow	Achillea millefolium	0.1
Rocky Mountain penstemon	Penstemon strictus v. bandera	0.5
Blackeyed Susan	Rudbeckia hirta	0.5
TOTAL		23.1

SEEDING APPLICATION: Drill seed 0.25 to 0.5 inches into the soil. In areas not accessible to a drill, hand broadcast at double the above rate and rake to a depth of 0.25 to 0.5 into the soil.

MULCHING APPLICATION: 1 1/2 tons of certified weed free hay per acre mechanically crimped into the soil in combination with an organic mulch tackifier per standard provision 213.

SPECIAL REQUIREMENTS: Due to low precipitation rates hydroseeding and hydromulching will not be allowed. Do not apply fertilizer in areas adjacent to wetlands or waterways.

*FOR INFORMATION ONLY

FERTILIZER	AVAILABLE (%)	LBS/ACRE
Nitrogen	18	27
Phosphorus	46	69
Potassium	0	0

Nitrogen 135 LBS
Phosphorus 345 LBS
Soil preparation 5 Acres

NOTES

CONCRETE WASHOUT WILL BE PERFORMED AT A LOCATION PRE-APPROVED BY THE ENGINEER.

DISTURBED SURFACES SHALL BE LEFT IN A ROUGHENED CONDITION AT ALL TIMES. ROUGHEN VERTICAL DEPTH SHALL BE 2 TO 4 INCHES.

CONTRACTOR SHALL NOT STOCKPILE TOPSOIL IN TEMPORARILY IMPACTED WETLANDS NOR USE AREA AS ACCESS ROAD.

IT IS ESTIMATED 50 BACKHOE HOURS USING A BACKHOE IN THE 200-250 HORSE POWER RANGE WILL BE REQUIRED FOR EROSION CONTROL AS DIRECTED.

EROSION LOGS AND FENCE (PLASTIC) WILL BE REQUIRED FOR WETLAND PROTECTION.

SEDIMENT REMOVAL AND DISPOSAL OF MATERIAL GENERATED BY STORM RUN-OFF WILL BE PAID FOR VIA SEDIMENT REMOVAL AND DISPOSAL (LS) REMOVE SEDIMENT FROM BEHIND OR WITHIN BMP'S IN ACCORDANCE TO STANDARD SPECIAL PROV. 208.

TOPSOIL, SEED AND MULCH ERODABLE SURFACES IN ACCORDANCE WITH DISTURBANCE LIMITS REFERENCED IN THE STANDARD SPECIFICATION 208. IT IS ESTIMATED THAT A MINIMUM OF 3 MOBILIZATIONS FOR SEEDING, MULCHING AND MULCH TACKIFIER WILL BE REQUIRED AND SHALL BE INCLUDED IN THE PRICE OF THE WORK.

LOCATION & TABULATION			
STA.	EROSION LOG	EROSION BALES (WEED FREE)	FENCE (PLASTIC)
490+40 TO 495 RT.	460		Δ 460
499+60 TO 500+40 RT&LT TOES & ABOVE CULVERTS	160		
499+60 TO 500+40 RT 60' ACROSS CHANNEL			80
499+80 TO 500+20 RT 95'			40
507+28 TO 510 RT.	272		Δ 272
488+87,493+70,509+78 LT		27 (9 PER INLET)	
(DITCH CHECKS AS DIRECTED) AS DIRECTED	210 50	20	
TOTAL	1152 LF	47 EACH	852 LF

Δ 10 FT OFFSET FROM TOE

ROADWAY PROJECT TOTALS

PAY ITEM	DESCRIPTION	UNIT	QUANTITY
203	BACKHOE	HR	50
208	EROSION CONTROL SUPERVISOR	LS	1
208	EROSION BALES (WEED FREE)	EACH	47
208	EROSION LOG	LF	1152
208	SEDIMENT REMOVAL AND DISPOSAL	LS	1
212	SEEDING (NATIVE)	ACRE	5
213	MULCHING (WEED FREE HAY)	ACRE	5
213	MULCH TACKIFIER	LBS	750
216	SOIL RETENTION BLANKET (STRAW/COCONUT)	SY	300**
607	FENCE (PLASTIC)	LF	85
700	EROSION CONTROL	FA	1

** As directed by the Engineer.

Computer File Information						Sheet Revisions			
Creation Date:		Initials:		R-					
Last Modification Date:		Initials:		R-					
Full Path:				R-					
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Colorado Department of Transportation
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SAMPLE STORMWATER MANAGEMENT PLAN

Designer:		Structure Numbers	
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Glossary

Not all the terms included below are used in this guide. However, most of the terms included below are commonly used by the various professional disciplines associated with erosion control and stormwater quality who might be using this guide.

AASHTO: American Association of State Highway and Transportation Officials.

Absorption: The assimilation or taking up of water or other solutions by soil or other material.

Abstraction: That portion of rainfall which does not become runoff. It includes interception, infiltration, and storage in depressions.

Adsorption: The adhesion in an extremely thin layer of molecules (such as gases, solutions, or liquids) to the surface of solid bodies or liquids with which they are in contact.

ADT: Average Daily Traffic.

Aesthetic: Pleasing to look at. Emphasis on Beauty.

Allowable Headwater Depth: The depth or elevation of the flow impoundment for a drainage facility above which damage, some other unfavorable result, or a significant flood hazard could occur.

Anti-seep collar: A watertight curtain constructed around a pipe or other conduit and placed through a dam, dike, or roadway embankment for the purpose of reducing seepage losses and piping failures.

Anti-vortex device: A device, usually a vertical or horizontal plate, carefully designed and placed at the entrance of a pipe to prevent air from entering the structure when the pipe is flowing full.

Apron: A floor or lining to protect a surface from erosion, for example, the pavement below chutes, spillways, culverts, or at the toes of dams.

Aquatic life: Wildlife living or growing on, in, or adjacent to water.

Aquifer: A porous, water-bearing geologic formation. Generally restricted to materials capable of yielding an appreciable supply of water.

Backwater: The increase in water surface elevation induced upstream from such things as a bridge, culvert, dike, dam, another stream at a higher stage, or other similar structures or conditions that obstruct or constrict a channel relative to the elevation occurring under natural channel and floodplain conditions.

Baffles:	Vanes, guides, grids, grating, or similar devices placed in a conduit to deflect or regulate flow and effect a more uniform distribution of velocities.
Bank:	The side slopes or margins of a channel between which the stream is normally confined.
Barrel:	The usually mild sloping closed conduit used to convey water under or through a dam; part of a principal spillway.
Base flow:	In the U.S. Geological Survey's annual reports on surface-water supply, the discharge above which peak discharge data are published.
Bed:	The bottom of a channel.
Bed load:	Sediment that is transported in a stream by rolling, sliding, or skipping (saltating) along the bed or very close to it; considered to be within the bed layer.
Bedrock:	The more or less solid rock in place either on or beneath the surface of the earth. It may be soft, medium, or hard and have a smooth or irregular surface.
Benthic region:	The bottom of a body of water which supports the benthos.
Benthos:	The plant and animal life whose habitat is the bottom of a sea, lake, or river.
Best Management Practices (BMPs):	Schedule of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States.
BOD:	Biological Oxygen Demand.
CDOT:	Colorado Department of Transportation.
CDPHE:	Colorado Department of Public Health and Environment.
CDPS:	Colorado Discharge Permit System.
CFR:	Code of Federal Regulations. Codifies and publishes, at least annually, Federal regulations currently in force.
Channel:	A natural stream that conveys water; a ditch or channel excavated for the flow of water.
Channel, open:	A channel having a water surface exposed at all points to atmospheric pressure.
Channel slope:	Fall per unit length along the channel centerline.

Compaction: With respect to construction work with soils, engineering compaction is any process by which the soil grains are compressed to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per unit of volume, increasing the shear and bearing strength, and reducing permeability.

Conduit: Any channel intended for the conveyance of water, whether open or closed.

Contour: An imaginary line on the surface of the earth connecting points of the same elevation, or a line drawn on a map connecting points of the same elevation.

CRS: Colorado Revised Statutes.

Crushed stone: Aggregate consisting of angular particles produced by mechanically crushing rock.

Cut: Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

Cut-and-fill: Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

Cutoff trench: A long, narrow excavation constructed along the center line of a dam, dike, levee, or embankment and filled with relatively impervious material intended to reduce seepage of water through porous strata.

Debris: Broken remains of plants, objects, and rocks that form trash or remains.

Deposition: The accumulation of material dropped because of a reduced carrying capacity of the transporting agent, water, or wind.

Design highwater: The elevation of the water surface as determined by the flow conditions of the design floods.

Design life: The period of time for which a facility is expected to perform its intended function.

Design storm: A selected rainfall pattern of specified amount, intensity, duration, and frequency that is used as a basis for determining the design discharge.

Detention time: The theoretical time required to displace the contents of a tank or pond at a given rate of discharge (volume divided by rate of discharge).

Dike: An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands.

Discharge: The flow of a stream, canal, or aquifer. (Hydraulics) Rate of flow, especially fluid flow; a volume of fluid passing a point per unit time commonly expressed as cubic meters per second, cubic feet per second, gallons per minute, or millions of gallons per day.

Disturbed area: An area in which the natural vegetative soil cover has been removed or altered, and therefore, is more susceptible to increased erosion.

Drain: A buried pipe or other conduit (closed drain). A ditch (open drain) for carrying off surplus surface water or groundwater.

Drainage: The removal of excess surface water or groundwater from land by means of surface or subsurface drains.

Drainage basin: A geographical area or region that is so sloped and contoured that surface runoff from streams and other natural watercourses is carried away by a single drainage system by gravity to a common outlet or outlets. Also referred to as a watershed or drainage area.

Drop structure: A structure for dropping water to a lower level and dissipating surplus energy; a fall. The drop may be vertical or inclined.

Embankment: A man-made deposit of soil, rock, or other material used to form an impoundment or surface for construction.

Energy dissipator: A device used to reduce the energy of flowing water.

EPA: Environmental Protection Agency.

Erosion: Process whereby soil materials are detached and transported by water, wind, ice, or gravity.

Evapotranspiration: The combined loss of water from a given area and during a specific period of time, by evaporation from the soil surface and by transpiration from plants.

FEMA: Federal Emergency Management Agency.

FHWA: Federal Highway Administration.

Filter fabric: A woven, water permeable material generally made of synthetic products such as polypropylene and used in stormwater management and erosion and sediment control applications to trap sediment or prevent the clogging of aggregates by fine soil particles.

Flood: An overflow or inundation that comes from a river or other body of water. Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream.

Flood control:	Methods or facilities for reducing flood flows.
Flood frequency:	The average time interval between occurrences of a hydrological event of a given or greater magnitude, usually expressed in years. May also be called recurrence interval.
Floodplain:	The lowland that borders a stream and is subject to flooding when the stream overflows its banks.
Freeboard:	A vertical distance between the elevation of the design highwater and the top of a dam, diversion ridge, or highway structure.
Frequency of storm (design storm frequency):	The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur.
Froude number (F):	A calculated number of classifying water flow as critical (F=1), supercritical (F>1), or subcritical (F<1). Represents the effect of gravity on flowing water; the ratio of inertial forces to gravitational forces.
Grade:	The slope of a road, channel, or natural ground.
Graded stream:	A stream in which, over a period of years, the slope is delicately adjusted to provide, with available discharge and with prevailing channel characteristics, just the velocity required for transportation of the sediment load supplied from the drainage basin.
Gradient:	Change of elevation, velocity, pressure, or other characteristics per unit length; slope.
Grading:	Any stripping, cutting, filling, stockpiling, or any combination thereof, including the land in its cut-and-filled condition.
Groundwater table:	The free surface of the groundwater.
Head loss:	Energy loss due to friction, eddies, changes in velocity, and/or the direction of flow.
Head (Hydraulics):	The height of water above any plane or reference.
Headwater:	The source of a stream. The water upstream from a structure or point on a stream.
Headwater depth:	Depth of water above the inlet flow line at the entrance of a culvert or similar structure.
Herbicide:	Chemical formulation used to control weeds or brush.
Hydrograph:	A graph showing for a given point on a stream or for a given point in any drainage system the discharge, stage (depth), velocity, or other property of water with respect to time.

Hydrologic cycle:	The circuit of water movement from the atmosphere to the earth and back to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.
Hydroplane:	To skid on a wet surface such as pavement because a film of water on the surface causes the tires to lose contact with it.
Hydroseeder:	A machine designed to apply seed, fertilizer, lime, and short fiber wood or paper mulch to the soil surface.
Impervious:	Not allowing infiltration.
Impoundment:	Generally, an artificial collection or storage of water, as a reservoir, pit, dugout, sump, etc.
Infiltration rate:	A soil characteristic determining or describing the maximum rate at which water can enter the soil under specified conditions including the presence of an excess of water.
Intermittent stream:	A stream or portion of a stream that flows only in direct response to precipitation.
Invert:	The lowest point on the inside of a drain, conduit, or channel.
Land use:	A term which relates to both the physical characteristics of the land surface and the human activities associated with the land surface.
Manning's equation (Hydraulics):	An equation used to predict the velocity of water flow in an open channel or pipeline.
Mean velocity:	The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-sectional area of the reach.
Mean depth (Hydraulics):	Average depth; cross-sectional area of a stem or channel divided by its surface or top width.
Mitigate:	The act of lessening, offsetting, or compensating an impact on surface waters.
Nonpoint source pollution:	Pollution that enters a water body from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.
Normal depth:	Depth of flow in an open conduit during uniform flow for the given conditions.
NPDES:	National Pollutant Discharge Elimination System.
Nutrient(s):	A substance necessary for the growth and reproduction of organisms. In water, those substances that promote growth of algae and bacteria; mainly nitrates and phosphates.

Outfall: The point, location, or structure where wastewater or drainage discharges from a drain to a receiving body of water.

Outlet: The point at which water discharges from such things as a stream, river, lake, tidal basin, pipe, channel, or drainage area.

PCB: Polychlorinated Biphenyls.

Peak Discharge: The maximum instantaneous flow from a given storm condition at a specific location.

Percolation: The movement of water through soil.

Percolation rate: The rate, usually expressed as a velocity, at which water moves through saturated granular material.

Perennial stream: A stream that maintains water in its channel throughout the year.

Pervious: Allowing movement of water through some material.

Pesticides: Chemical compounds used for the control of undesirable plants, animals, or insects. The term includes insecticides, herbicides, algalcides, rodenticides, nematicides, fungicides, and growth regulators.

pH: A number denoting the common logarithm of the reciprocal of the hydrogen ion concentration. It is a numerical measure of acidity of hydrogen ion activity and of alkalinity. A pH of 7 denotes neutrality, higher values indicate alkalinity, and lower values indicate acidity.

Piping: Loss of soil through subsurface flow channels or "pipes" developed by seepage water.

Plunge pool: A device used to dissipate the energy of flowing water that may be constructed or made by the action of flowing.

Pollutant: Dredged spoil, dirt, slurry, solid waste, incinerator residue, sewage, sewage sludge, garbage, trash, chemical waste, biological nutrient, biological material, radioactive material, heat, wrecked or discarded equipment, rock, sand, or any industrial, municipal, or agricultural waste. [25-8-103(15), CRS].

Pollution: Man-made, man-induced, or natural alteration of the physical, chemical, biological, and radiological integrity of water. [25-8-103(16), CRS]. The presence in a body of water (or soil or air) of substances of such character and in such qualities that the natural quality of the environment is impaired or rendered harmful to health and life or offensive to the senses.

Porosity: The ratio of void volume to total volume in a material.

Porous pavement: A pavement through which water can flow at significant rates.

Rainfall intensity: The rate at which rain is falling at any given instant, usually expressed in millimeters per hour or inches per hour.

Rational method: A means of computing storm drainage flow rates (Q) by use of the formula Q = CIA, where C is a coefficient describing the physical drainage area, I is the rainfall intensity, and A is the drainage area.

Receiving water: The body of water into which runoff or effluent is discharged.

Runoff: That portion of precipitation that flows from a drainage area on the land surface, in open channels, or in a stormwater conveyance system.

Runoff coefficient: Fraction of total rainfall that will appear at a conveyance as runoff. [40 CFR 122.26(b)(11)].

Saturation point: In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.

Scour: The clearing and digging action of flowing air or water, especially the downward erosion caused by stream water in sweeping away mud and silt from the outside bank of a curved channel or during a flood.

Sediment: Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Sheet flow: Water, usually storm runoff, flowing in a thin layer over the ground surface.

Slope: Degree of deviation of a surface from the horizontal; measured as a numerical ratio, percent, or in degrees.

Soil: The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

Sod: A section of grass-covered soil held together by matted roots.

Stabilization: Providing adequate measures, vegetative and/or structural, that will prevent erosion from occurring.

State waters: Any and all surface and subsurface waters which are contained in or flow in or through this state, but does not include waters in sewage systems, waters in treatment works of disposal systems, waters in potable water distribution systems, and all water withdrawn for use until use and treatment have been completed. [25-8-103(19), CRS].

Storm drain:	A drain that carries stormwater and surface water, street wash, and other wash waters or drainage, but excludes sewage and industrial wastes. Also called a storm sewer.
Stormwater:	Stormwater runoff, snow melt runoff, and surface runoff and drainage. [40CFR 122.26(b)(13)].
Stormwater runoff:	See runoff.
Structural:	Relating to something constructed or built by a man.
Surface water:	All water the surface of which is exposed to the atmosphere.
Suspended solids:	Solids either floating or suspended in water, sewage, or other liquid wastes.
SWMP:	Stormwater Management Plan.
Tailwater depth:	The depth of flow immediately downstream from a discharge structure.
Toe (of slope):	Where the slope stops or levels out. Bottom of the slope.
Topography:	General term that includes characteristics of the ground surface such as plains, hills, mountains, degree of relief, steepness of slopes, and other physiographic features.
Toxicity:	The characteristic of being poisonous or harmful to plant or animal life; the relative degree or severity of this characteristic.
Transpiration:	The process by which water vapor escapes from living plants and enters the atmosphere.
Trash rack:	Grill, grate, or other device at the intake of a channel, pipe, drain, or spillway for the purpose of preventing oversize debris from entering the structure.
Turbidity:	Cloudiness of a liquid, caused by suspended solids; a measure of the suspended solids in a liquid.
Unified soil classification system (engineering):	A classification system based on the identification of soils according to their particle size, gradation, plasticity index, and liquid limit.
Uniform flow:	A state of steady flow when the mean velocity and cross-sectional area remain constant in all sections of a reach.
Urban runoff:	Surface runoff from an urban drainage area that reaches a stream or other body of water or sewer.
Velocity, permissible:	The highest velocity at which water may be carried safely in a canal or other conduit without channel bed scour or bank erosion.
VOC:	Volatile Organic Compounds.

Water table:	The upper surface of the free groundwater in a zone of saturation.
Water quality:	A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water resource:	The supply of groundwater and surface water in a given area.
Water right:	A right granted to a specified user to use waters of the state for a beneficial purpose.
Watercourse:	A definite channel with bed and banks within which concentrated water flows, either continuously or intermittently.
Weir:	Device for measuring or regulating the flow of water.
Wetted perimeter:	The length of the line made by the intersection of the plane, or the hydraulic cross-section, with the wetted surface of the channel.
WQCV:	Water Quality Capture Volume.

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