# Connecticut Guidelines for

# Soil Erosion & Sediment Control

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*By the Council on Soil and Water Conservation in Collaboration with Connecticut Department of Energy and Environmental Protection*

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# Chapter 1 – Purpose and Function of the Guidelines

## Introduction

The Connecticut Guidelines for Soil Erosion and Sediment Control (hereafter referred to as "the Guidelines") amends and replaces the 2002 Connecticut Guidelines for Soil Erosion and Sediment Control. The Guidelines are intended to provide information to government agencies and the public on soil erosion and sediment control. The Guidelines are a useful reference for projects that require erosion and sediment control planning, design, and implementation.

> **What's New in this Chapter?**
>
> - Streamlined history of soil erosion and sediment control policy as well as the regulatory basis of the Guidelines
> - Summary of major revisions to the Guidelines and where to find information on future updates
> - Updated contact information for where recommendations for improving the Guidelines can be submitted.

The Guidelines fulfill the requirements of Connecticut's Soil Erosion and Sediment Control Act (Public Act 83-388, codified in sections 22a-325 through 22a-329 of the Connecticut General Statutes) by providing guidance to municipal planning and zoning commissions. Contained within the Guidelines are methods and techniques for minimizing erosion and sedimentation based on the best currently available technology.

As a useful reference, the Guidelines may be designated as a primary guiding document, or as the foundation and minimum requirements for development of best management practices for construction activities for several programs beyond the original intent of the legislation that required the creation of this document. Such programs include water planning; coastal resource management; tidal wetlands; structures / dredging / fill in tidal, coastal, and navigable waters; inland wetlands and watercourses; diversion of water; dam safety; solid waste management; and the stormwater general permit programs (See Regulatory-Permit Index, Appendix A).

While erosion can be caused by wind, ice, gravitational creep, and other geological processes, water accelerated erosion is unquestionably the most severe type of erosion in Connecticut. While the Guidelines make minor reference to controlling wind-generated erosion, the primary focus of the Guidelines is to prevent and control water-erosion and sedimentation.

## Statement of the Problem

While all lands erode, not all land can be considered a source of sediment pollution. There has always been naturally occurring erosion. However, major problems can occur when human activity causes large amounts of sediment to enter our wetlands, watercourses and storm drain systems. The tendency of pollutants to adhere to the surface of, and move with, soil particles escalate the environmental damage.

Erosion on agricultural land occurs mainly as sheet and rill erosion over a period usually measurable in years. Conversely, on developing land, erosion is frequently in the form of gully erosion on land disturbed for a year or less. Both conditions result in lower quality of soil and water resources (see Chapter 2, Sediment Pollution and Damage). However, gully erosion, which is the result of concentrated flows of surface runoff, generates high sediment volumes requiring costly clean-up and the continual need for site stabilization during development. A construction site typically erodes at a rate of 50 tons/acre/year. This erosion rate is five times greater than cropland erosion and 250 times greater than woodland erosion. Each year more than one million acres of land in the United States are converted to urban use. These land use changes are the source of much of the sediment that pollutes our streams, rivers, lakes, ponds, and reservoirs.

The Guidelines are intended to assist landowners, developers, commission members, engineers, contractors, municipal staff, state staff and landscape architects to control sediment pollution caused by land disturbing activities.

## History

### Historical context for soil erosion and sediment control policy

In 1864, George Perkins Marsh published "Man and Nature on Physical Geography as modified by Human Action", which described the effects of deforestation and subsequent land management on erosion processes. George Perkins Marsh was far from the last to observe the impact on erosion processes. Yet, large areas of the United States were devastated by erosion caused by unfavorable climatic conditions coupled with abuse and mismanagement of the country's crop lands. It wasn't until these conditions cumulated and resulted in the devastating Dust Bowl of 1934, that the nation began enacting a soil erosion and sediment control policy. In 1935 Congress passed The Soil Conservation Act marking the first national recognition of the need for erosion and sediment control. The Act created the Soil Erosion Service, (also known as the Soil Conservation Service or SCS, now known as the Natural Resources Conservation Service or NRCS), an agency within the U.S. Department of Agriculture.[1]

Over the next 40 years, federal recognition would manifest into state soil conservation districts and eventually into local requirements by planning and zoning boards. By 1977 more than 70 Connecticut communities had adopted some form of erosion and sediment control requirements. However, only half of these were effective in solving erosion problems in developing areas. The Connecticut General Assembly responded to the limited effectiveness of local regulations, by enacting the Soil Erosion and

[1] https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_021255.pdf

Sediment Control Act, which is now sections 22a-325 through 22a-329 of the Connecticut General Statutes, in 1983.

The major goal of this policy was to create "a statewide coordinated erosion and sediment control program which shall reduce the danger from stormwater runoff, minimize non-point sediment pollution from land being developed and conserve and protect the land, water, air and other environmental resources of the state." In addition to increasing state oversight of municipal planning and zoning commissions, the Act required that guidelines be developed to outline methods and techniques for minimizing erosion and sedimentation based on the best currently available technology.

### Guidelines Established and Revised

The first guidelines were published in January of 1985 and were the result of a task force that included many state and federal agencies, private corporations, and individuals. They included excerpts from many sources but relied heavily on documents from the SCS in Storrs, Connecticut and the Virginia Soil Erosion and Sediment Control Handbook published in 1980. In 1988 the guidelines were republished with several corrections.

## Guidelines Cited in General Permit for Construction Activities

In 1992 the Federal Environmental Protection Agency (EPA) mandated that states, like Connecticut, who had been given the authority to administer provisions of the Federal Water Pollution Control Act (33 U.S.C. Section 466 et seq.) and issue National Pollution Discharge Elimination System (NPDES) permits, make provisions for the regulation of discharges of stormwater and dewatering waste waters from construction activities. As a result, the Connecticut Department of Environmental Protection (now called the "Connecticut Department of Energy and Environmental Protection" or CT DEEP) issued the General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities (Construction General Permit) for these activities on sites whose construction activities resulted in the disturbance of 5 acres or more of land. Among other things, the Construction General Permit requires the development of stormwater pollution control plans that include provisions for erosion and sediment controls during construction. Those plans are required to ensure and demonstrate compliance with the guidelines.

Unlike the Soil Erosion and Sediment Control Act, the Construction General Permit also affects state agencies. Agencies like the Connecticut Department of Transportation have, over time, established independent specifications for erosion and sediment control measures, which need consolidation with the guidelines or modification to demonstrate the compliance required by the general permit.

The Construction General Permit has been reissued several times with and without modifications since it was first issued in 1992. Most recently, the Construction General Permit was reissued in 2020 with the following key provisions:

- Construction projects disturbing five acres or more that are required to receive municipal approval (Locally Approvable projects) must submit a registration to the CT DEEP and have a qualified professional prepare a Stormwater Pollution Control Plan (Plan).
- Construction projects disturbing more than one acre that are not reviewed and approved by a local land-use commission (Locally Exempt projects) must submit a registration to the CT DEEP along with a Plan prepared by a qualified professional for Department review.
- Provisions to follow the Connecticut Guidelines for Soil Erosion and Sediment Control.
- Conditions applicable solely to larger solar array projects including stormwater control measures for solar array projects.
- Updated design storm precipitation using NOAA Atlas 14, Volume 10, Version 2 rather than the older NWS Technical Paper #40.
- Post-construction stormwater management (retention and treatment) requirements consistent with the statewide and CTDOT MS4 General Permits.

## Major Changes

The 2021 revisions to the Guidelines were made in conjunction with revisions to the Connecticut Stormwater Quality Manual. Given the limited funding available for revisions to both documents, updates to the Guidelines were focused on the Department's highest priorities, as determined by the CT DEEP project team and stakeholder workgroup that consisted of representatives of state agencies, municipalities, and other organizations with a role in stormwater management in Connecticut.

The primary objectives of the 2021 revisions to the Guidelines are to:

- Incorporate updated information, consistent with regional soil erosion and sediment control guidance, on the selection, design, construction, and performance of the soil erosion and sediment control Functional Groups and Measures.
- Resolve conflicts and improve consistency between the Guidelines and the Connecticut Stormwater Quality Manual for more effective integration of construction-phase and post-construction stormwater management.
- Update the Guidelines for consistency with the CT DEEP stormwater general permit programs, specifically the Construction Stormwater General Permit.

- Incorporate climate change and resilience considerations for soil erosion and sedimentation control.
- Enhance the usability of the Guidelines from the perspective of project designers and reviewers.

## Format Changes

Appendices that provided miscellaneous reference materials, which can now be accessed online, have been removed or streamlined. Where necessary, figures and tables have been updated to reflect changes to the text or the current state of the practice.

## Technical Changes

The 2021 version of the Guidelines incorporates revisions that include but are not limited to:

- Elements from the June 2011 Low Impact Development (LID) Appendix, where relevant.
- Information on soil erosion and sediment control for Solar Array Projects contained in the current Construction General Permit and applicable CT DEEP policy has been incorporated into the Guidelines, either directly or by reference.

Some new control measures were added, including:

- Fiber Rolls (Included in Check Dams and in Filter Socks)
- Filter Sock
- Vegetated Waterway
- Temporary Lined Channel
- Permanent Lined Waterway
- Temporary Stream Crossing
- Pumping Settling Basin

Several existing measures were updated, including:

- Stream Deflectors
- Soil Bioengineering for Stabilization
- Dust Control (Tackifiers, Soil Stabilizers and Polymer Flocculants)
- Level Spreader
- Outlet Protection
- Stone Check Dam
- Temporary Sediment Basin

- Stone Slope Protection

The section regarding Temporary Lined Chutes that are constructed of concrete or bituminous pavement were removed from this manual.

## Adoption of the Guidelines

This manual will be used for guidance immediately upon its effective date. Any design that has completed preliminary design phase (approximately 50% of full design) as of the effective date, however, will not be subject to this updated guidance. If this is the status of your project, you must immediately communicate this to the appropriate review authority. However, all projects received or permitted after one year from publication must comply with the updated Guidelines. Any reference in DEEP General Permits for adherence to the guidelines, criteria, recommendations and/or requirements specified in the Manual shall be considered to have adopted these dates and criteria.

Any references in municipal regulations shall at least meet the dates above, but, if they so choose may adopt an earlier date of compliance with the updated guidance.

## How to use the Guidelines?

The Guidelines are intended to serve as a technical guide for meeting the requirements of the Soil Erosion and Sediment Control Act and to assist in implementing the requirements of laws and statutes relating to construction-phase stormwater management and erosion and sedimentation control. The use of words such as “shall,” “will,” and “must” within design or implementation standards is meant to emphasize the direction which will ensure that the control measure or design procedure will serve its intended purpose.

The Guidelines provide technical details that are not site specific. Examples are provided which may not be applicable or sufficient to meet all engineering standards and building codes. Measures requiring an engineered design must be evaluated on a case-by-case basis by a professional engineer licensed to practice in Connecticut.

Innovative modifications to the control measures or design procedures contained in this guide are acceptable, and encouraged, especially if they improve upon sediment-loss mitigation. However, designers and plan reviewers must be sure that the modified procedure will be successful. Designers must present to plan reviewer’s sufficient technical data that show the proposed modification is at least as effective as the guideline measure meant to be replaced.

While these Guidelines promote an integrated approach to construction-phase and post-construction stormwater management, the Guidelines are not intended to provide design guidance on post-construction stormwater management measures.

The reader should refer to the Connecticut Stormwater Quality Manual for guidance on post-construction stormwater management measures, including source controls and pollution prevention, non-structural LID site planning and design strategies, and structural stormwater Best Management Practices (BMPs).

The stormwater management standards contained in the Connecticut Stormwater Quality Manual require the development and implementation of a soil erosion and sediment control plan in accordance with these Guidelines as part of an overall stormwater management plan for the site.

This document contains, to the extent possible, measures that will help prevent or correct sediment and erosion control problems when selected, designed, and maintained in accordance with the Guidelines and good engineering practice. However, the use of the Guidelines does not relieve the user of the responsibility of complying with laws and regulations that cite the Guidelines.

Any or all the material contained in this manual may be reproduced, copied, or reprinted with the appropriate credit given.

## Updates and Future Revisions

The Council on Soil and Water Conservation and CT DEEP may periodically update these Guidelines pending the availability of funding. Technical information regarding updates to the Guidelines will be available at:

https://portal.ct.gov/DEEP/Water/Soil-Erosion-and-Sediment-Control-Guidelines/Guidelines-for-Soil-Erosion-and-Sediment-Control

Future versions of the Guidelines will reflect the technical updates found on the website. Notices regarding future revisions of the Guidelines will also be posted at this website.

# Chapter 2 – The Erosion and Sedimentation Process

## Definition

Soil erosion and sedimentation is a three-stage process:

*1) Detachment ➔ 2) Transport ➔ 3) Deposition*

**What's New in this Chapter?**

- Minor updates to erosion and sedimentation process definitions
- Inclusion of consideration of climate change impacts on erosion and sedimentation.

Soil erosion involves the wearing away of the surface of the land by the action of wind, water, ice, and gravity. Once worn away, the detached soil particles are transported and ultimately deposited, resulting in sedimentation. Natural, or geologic erosion and sedimentation occur over long periods of geologic time resulting in the wearing a way of mountains and the building up of floodplains, coastal plains, deltas, etc., to create the topography we know today. Except for some cases of shoreline and stream channel erosion and sedimentation, natural erosion and sedimentation occur at a very slow rate.

Erosion and sedimentation become a problem when they are accelerated beyond natural rates. Accelerated erosion is primarily the result of the influence of human activities on the environment. Once exposed, unprotected soil is then subject to rapid erosion by the action of wind, water, ice, or gravity.

As stated in Chapter 1, erosion can be caused by water, wind, ice, and gravitational creep. The focus of these Guidelines is minimizing or preventing erosion caused by water.

## Types of Erosion

Raindrop erosion or raindrop splash initiates the erosion process. Individual soil particles and small soil aggregates are detached and transported with splashing water droplets as the raindrop impacts the soil (see Figure 2-1). Although raindrop splash is incapable of moving sands or coarser materials very far, very fine particles can be suspended in water. They are then susceptible to and contribute to sheet erosion.

*Figure 2- 1. Rain Drop Splash*

Sheet erosion is the removal of a thin, uniform layer of soil from the land surface caused by shallow sheets of water running off the land. These very shallow moving sheets of water are seldom the detaching agents, but the flow transports soil particles which are detached by raindrop impact and splash. The shallow surface flow rarely moves as a uniform sheet for more than a few feet on land surfaces before concentrating in surface irregularities (see Figure 2-2).

Rill erosion develops as shallow surface flows begin to concentrate in the low spots and irregularities of the land surface. As the flow changes from the shallow sheets to deeper flows in these low areas, the velocity and turbulence increase. The energy of this concentrated flow can both detach and transport soil materials. This action begins creating tiny channels called rills (see Figure 2- 2). Rills are small but well-defined channels that are, at most, only a few inches (about 5 centimeters) deep.

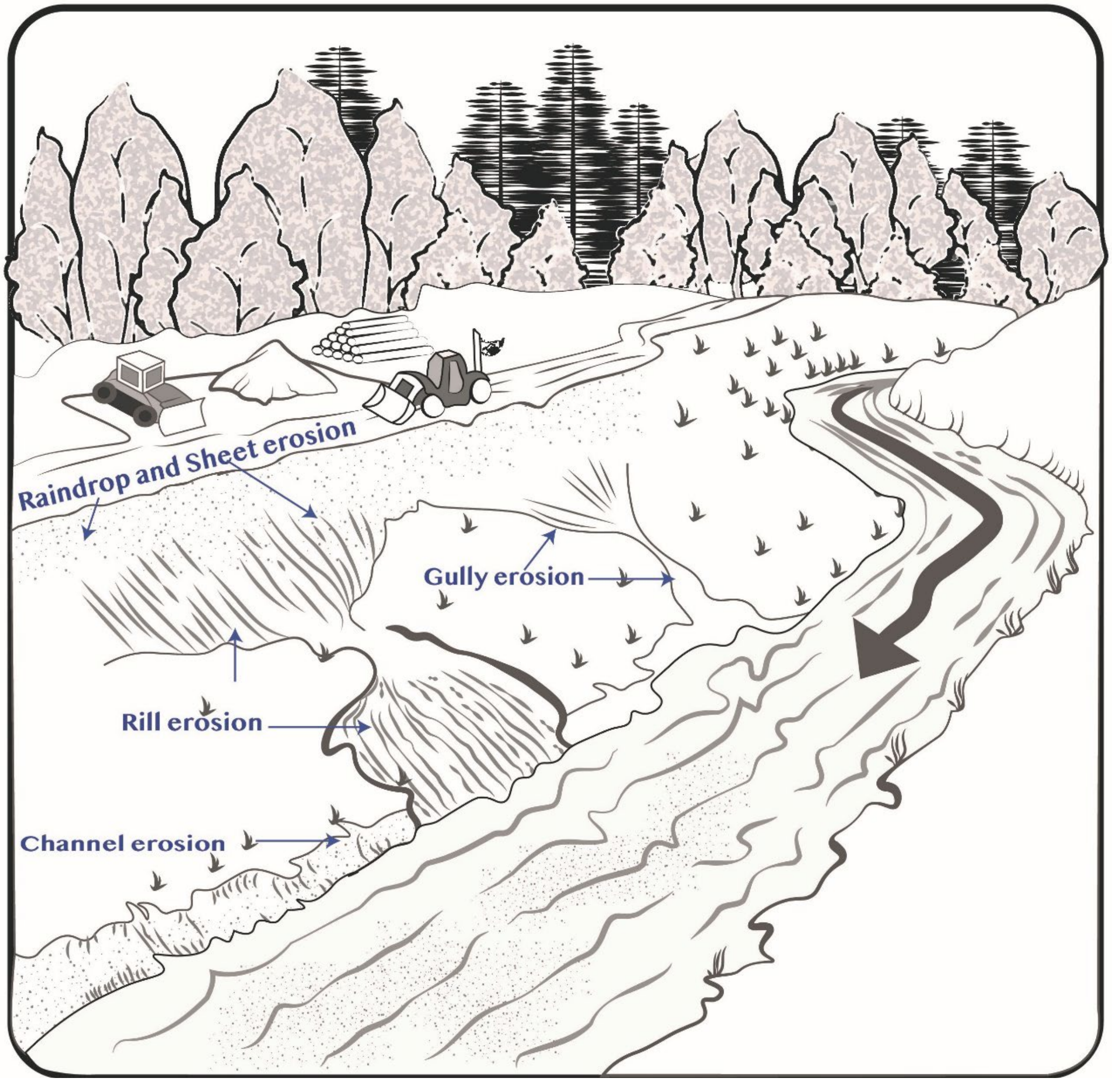
Gully erosion occurs as the flows in rills come together to form larger channels (see Figure 2- 2 and Figure 2- 3). Size is the major difference between gully and rill erosion. Gullies are too large to be repaired with conventional tillage equipment and usually require heavy earthmoving equipment and special techniques

*Figure 2- 2. Gully Erosion and the Possible Progression*

Image Source: Jean Pillo, CPESC, Eastern Connecticut Conservation District

for stabilization. Typically, they reach depths in excess of 1 foot but on rare occasions reach depths as much as 75 to 100 feet deep. Channel erosion occurs as the volume and velocity of runoff concentrate in drainage channels and cause movement of the stream bed and bank materials.

*Figure 2- 3. Types of Erosion*




Shoreline erosion occurs on tidal and inland waters as daily high tides, wave action, and storm surges erode coastal and estuarine shorelines. Existing shoreline structures can be heavily damaged by severe wave action, significant patterns of tidal exchange or flushing rates, freshwater input or existing basin characteristics and channel contours. Wave action caused by boat wakes can also cause shoreline erosion. Sediment displaced by land erosion can render shipping channels and harbors impassable and adversely impact coastal and estuarine habitats. Significant alteration of shoreline configurations, particularly within high velocity flood zones, can occur when the natural erosion patterns are altered. Tidal wetlands, intertidal flats, beaches and dunes, rocky shore fronts, bluffs and escarpments can be greatly affected through changes in their natural characteristics or functions.

## Factors Influencing Erosion

The erosion potential of any area is determined by a combination of four principal factors: soil characteristics, vegetative cover, topography, and climate. Although each of the erosion factors is discussed separately here, they are interrelated in determining erosion potential and no one factor determines erosion potential alone.

Erosion potential during dewatering activities is a function of the turbidity of the water being pumped and the discharge velocities of the pump.

Table 2. 1 summarizes how erosion potential is influenced by these various factors. Understanding these four factors of soil erosion will aid the designer and planner in selecting the appropriate soil erosion control measure. Planning for soil conservation and water management requires knowledge of the relationship among these four factors that cause loss of soil and how these factors can be influenced to reduce such losses. In order to better understand the relationship of planned activities to soil erosion, a predictive soil erosion loss model, the Revised Universal Soil Loss Equation (RUSLE2), was developed. See Appendix B for a discussion of RUSLE.

*Table 2. 1. Factors Influencing Erosion Potential*

| Factor | Erosion Potential | |
|---|---|---|
| | Lower | Higher |
| **Soil Characteristics** | | |
| **Soil Texture** | Gravel and Coarse Sand | Fine Sand and Silt |
| **Organic Content** | Highly Organic | No Organic |
| **Soil Structure** | Blocky | Granular |
| **Soil Permeability** | Sand/Gravel | Silt/Clay |
| **Vegetative Cover** | | |
| **% Cover** | 100% | 0% |
| **Type of Cover** | Trees with Mulch | No Cover |
| **Topography** | | |
| **Slope Length** | Short | Long |
| **Slope Gradient** | Flat | Steep |
| **Climate** | | |
| **Rainfall Intensity** | Low Intensity | High Intensity |
| **Rainfall Frequency** | Infrequent | Frequent |
| **Rainfall Duration** | Short Duration | Long Duration |
| **Wind** | Calm | Gusty |
| **Temperature** | Frozen | Thawed |
| **Special Cases** | | |
| **Dewatering Discharge Velocities** | Low Velocity | High Velocity |

## Soil Characteristics

Soil characteristics that influence erosion by rainfall and runoff are those properties which affect the infiltration capacity of a soil and those which affect the soil's resistance to detachment and transport by falling or flowing water. The following four characteristics are important in determining soil erodibility:

- Texture (particle size and gradation)
- Organic matter content
- Structure
- Permeability

Soils containing high percentages of fine sands and silt are normally the most erodible. Terrace escarpment soils in the Connecticut River valley are examples of soils that contain higher percentages of fine sands and silts and are very prone to erosion when disturbed. As the clay and organic matter content of soil increases, the erodibility decreases. Clays act as a binder to soil particles, thus reducing erodibility. However, while clays tend to resist erosion, once eroded they are easily transported by water and the soil particles remain in suspension longer. In Connecticut, the existence of clay soils is very limited.

Gravelly soils are usually the least erodible. Soils high in organic matter have a more stable structure that improves their permeability. Such soils resist raindrop detachment and infiltrate more rainwater. Soils with high infiltration rates and permeabilities either prevent or delay and reduce the amount of runoff.

## Vegetative Cover

Vegetative cover plays an important role in controlling erosion in the following ways:

- Protects the soil surface from the impact of falling rain
- Holds soil particles in place
- Enhances the soil's capacity to absorb water
- Slows the velocity of runoff
- Removes subsurface water between rain events through the process of evapotranspiration
- Improves infiltration rates

Soil erosion and sedimentation can be significantly reduced by limiting and/or staging the removal of existing vegetation and by decreasing the area and duration of exposure. Special consideration should be given to maintaining existing vegetative cover on areas of high erosion potential such as erodible soils, steep slopes, ditches, and the banks of streams.

### Topography

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

### Climate

Climate is the long-term average of atmospheric influences, principally moisture (including rainfall), temperature, wind, pressure, and evaporation. Understanding climate's impacts on frequency, intensity, and duration of rainfall can bring context to the amounts of runoff produced in each 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 and regional changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year.

Additionally, wind can potentially remove more sediment than rainfall. Its impact on the land is generally limited to large areas that are unprotected for long periods of time. However, there are areas of special concern. This is particularly true of the sandy soils found in the Connecticut River Valley, which can be very susceptible to wind erosion if left unprotected during hot, dry weather. Wind can also agitate water bodies sufficiently to induce erosive wave action and/or cause the resuspension of deposited sediments.

Springtime is a period of higher erosion potential as the coastal storm track increases rainfall potential. Additionally, because the ground is still partially frozen, the absorptive capacity of the soil is reduced. While frozen soils are relatively erosion resistant, they melt from the top down, creating a soft erodible surface over a hard impervious sub-surface. In Connecticut, thawing of the soils often occurs in conjunction with the early spring rains combined with snow melt. Additionally, soils with high moisture content are subject to frost heaving and can be very easily eroded upon thawing.

## Types of Sediment and Sedimentation

From the time the soil particle is detached (either by rain drop splash or moving water), the velocity, turbulence, and the size and types of material available are the primary factors determining the nature of the sediment load. The sediment is being transported as suspended load, bed load, or both.

Suspended load is generally comprised of very fine material (clays and silts) and stays in suspension for long periods of time resulting in a condition called turbidity. The amount of these materials in suspension is dependent on the type of soil and the resistance to detachment by the erosive agent. Turbidity is measured with a nephelometer and recorded as nephelometric turbidity units (NPU). In Connecticut, any increase in turbidity from the norm is considered pollution.

Bed load is the sediment that moves on or near the stream bed. Typically, this material moves at velocities less than the surrounding flow and can be measured in tons per unit of time. Bed loads are normally comprised of sands, pebbles, and cobbles.

The amount of the total sediment load being carried as suspended load and/or bed load is related directly to the flow and volume of the water. The movement of the sediment load tends to be in balance with flow conditions. This has an important bearing on channel stability. If the flow becomes loaded beyond its transporting capacity, deposition will occur. However, if the load is less than the transporting capacity, the flowing water attacks the channel to achieve a balance between load and capacity. Any change in sediment load or flow characteristics will influence channel stability and formation.

Deposition is the inverse of detachment. It occurs when the carrying capacity of the flow is reduced to a point below that needed to carry the sediment load. Deposition is a selective process. As flows slow down, the coarser fragments fall out of the water column first, followed by finer and finer particles, resulting in a noticeable gradation of particle sizes in the sediments.

Sediment deposits may occur in water bodies or on land. Deposits occur in water as a faster flowing stream flows into a slower one or into an area of slack water such as a pond or lake or ocean. A stream flowing from a steeper gradient to a lesser one will also lose velocity and carrying capacity and will form deposits. Additionally, deposition can take place on the inside bends of rivers and stream where flow velocities tend to be slower than on the outside of the bends. Deposits can also occur on land when the runoff loses velocity and hence the capacity to carry the same sediment load.

## Sediment Pollution and Damage

Sediment pollution is soil out of place. It is the direct and indirect result of human activities that lead to severe soil loss. From the more than four billion tons of sediment delivered to our nation’s water bodies, about one billion tons reach the ocean. Although about 10% of the sediment is estimated to be generated by highway construction and land development, these activities could represent over 50% of the sediment load carried by many streams draining small sub-watersheds that are undergoing development.

Sediment pollution causes physical, chemical, and biological damage. The type of damage is related to the size of the sediment particle. Table 2. 2 shows the relationship of particle size and character to damage or impact.

*Table 2. 2. Particle Size vs Damage Impact*

| Damage Impact with Change in Particle Size | | | |
|---|---|---|---|
| | Boulders, Cobbles, Gravel | Very Coarse to Medium Sand | Fine Sands, Silts, and Clays |
| **Biological** | ▪ Burying of benthic (aka bottom living) organisms<br>▪ Habitat degradation by damaging rooted plants and possibly changing the substrate (e.g., cobble to sand<br>▪ Decrease in biological diversity<br>▪ Increase in embeddedness and loss of interstitial spaces in gravel | | ▪ Loss of aquatic eggs, larva, and fry<br>▪ Clogging of fish gills increasing disease and susceptibility<br>▪ Damage to food chain<br>▪ Decrease in biological diversity<br>▪ Increase in algal blooms downstream impoundments<br>▪ Reduced ability to grow plants on eroded land |
| **Chemical** | ▪ Water temperature increases from increase sunlight absorption caused by shallowing of water body | | ▪ Nutrient transport (causing increased eutrophication of downstream waterbodies and lost fertility from eroded lands)<br>▪ Water temperatures increase from sunlight absorption caused by water opacity (aka cloudiness or turbidity)<br>▪ Can result in lower dissolved oxygen levels |
| **Physical** | ▪ Reduced channel capacity, navigation obstruction requiring dredging, reduced flood storage capacity, increasing future flood damage from floods and increasing frequency of floods, increasing maintenance on culverts and storm drains, loss of reservoir storage capacity for drinking and industrial water supply<br>▪ Loss of land | | ▪ Turbidity adversely affecting use for surface water drinking supply and manufacturing, increasing filtration costs<br>▪ Poor aesthetics<br>▪ Widening of channel<br>▪ Loss of deeper pools and refuge habitat<br>▪ Loss of cut-bank habitat |

## Land Use Changes and Development Impacts on Erosion and Sedimentation

Land use changes and land development activities affect the natural or geologic erosion process by:

- Removing the existing protective vegetative cover.
- Prolonging the exposure of unprotected disturbed areas.
- Exposing underlying soil or geologic formations less pervious and/or more erodible than original soil surface.
- Compacting soils with heavy equipment and increasing impervious surfaces, thereby reducing rainfall absorption and increasing runoff.
- Modifying drainage areas.
- Altering the topography in a manner that results in shortened times of concentration of surface runoff (e.g., altering steepness, distance and surface roughness, and installation of "improved" storm drainage facilities).
- Altering the groundwater regime (e.g., placing a detention basin at the top of a slope).

Reshaping of land during construction or development alters the soil cover and the soil in many ways, often detrimentally affecting on-site drainage and stormwater runoff patterns. Many people may be adversely affected regardless of the size of the area being developed. Erosion and sediment from these areas often cause considerable economic damage to individuals and to society in general. Sediment deposition in waterways and reservoirs creates or aggravates flooding and surface water pollution problems. The result is damage to public and private property. Additionally, erosion and sedimentation may have adverse impacts on recreation, natural resources, and wildlife due to the alteration and/or loss of aquatic habitat.

It is because of these adverse effects that steps must be taken to control the erosion and sedimentation that is associated with land use changes and development.

## Climate Change Impacts

As noted above, water resources in Connecticut are affected by climate conditions. Much of the climatic conditions can be mitigated with thoughtful planning. However, when those climate conditions begin to change, this creates additional stressors in water resources and erosion control infrastructure when it is also not considered in the planning and design. These additional stressors can include increasing temperatures, changing precipitation patterns, extreme events (storms, floods, and drought), and rising sea levels. These changing conditions have implications for construction-phase and post-construction stormwater management.

Ongoing and future climate change will continue to increase the potential for erosion and sedimentation. The observed and predicted future changes to Connecticut's climate) directly influence the climate factors that affect erosion potential, including rainfall intensity, rainfall frequency, rainfall duration, wind, and temperature. Table 2. 3 demonstrates that the observed conditions, where we have reliable long-term measures, have already seen significant changes and will likely be even more so in the near future. As such evaluating climate impacts on with a static value is detrimental for current and future planning and designs. Therefore, in general it is suggested that planners and designers take careful consideration of current and projected climate values when considering site options.

- More intense downpours have greater erosion potential as a result of increased energy associated with rainfall directly onto exposed soils and increased runoff generation potential.
- More frequent high-intensity rainfall events and longer-duration storms also increase erosion potential. Projected increases in the number of days of precipitation over 1 inch, as well as the total amount of precipitation falling in the heaviest 1% of rainfall events are important factors in determining erosion potential and sedimentation.
- An increase in the occurrence of extreme storms also increases the potential for wind-induced erosion.
- Warmer temperatures contribute to a reduction in the duration of frozen ground conditions and an earlier spring thaw. Coupled with an increase in high-intensity precipitation, warming temperatures can result in increased erosion risk in the early spring.
- Increased sediment and associated pollutant loads, combined with warmer air and water temperatures, will increase the potential for harmful algal blooms,

**Summary of Climate Change Impacts in Connecticut**

- By 2050, average temperatures are expected to increase about 5°F, with increases thereafter dependent on emissions choices now.
- Average precipitation is expected to increase about 8% (4 inches/year).
- Indices of hot weather, summer drought, and extreme precipitation are expected to increase.
- Sea level is expected to rise by up to 20 inches by 2050 and to continue increasing after that.
- Small changes in mean sea level have a big impact on the frequency of flooding.
- Areas that experience flooding every few years now should expect flooding multiple times a year by 2050.

Source: Connecticut Institute for Resilience & Climate Adaptation (CIRCA) Fact Sheets

Temperature and Precipitation

Sea Level Rise

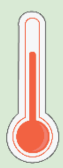
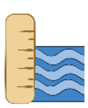
loss of high-quality headwater streams and cold-water habitat, further degradation of impaired waters, and negative impacts on recreational use of waters.

- Sea level rise and increased frequency and intensity of coastal storms has implications for erosion and sedimentation along the Connecticut coast and tidally-influenced areas. Continued rising sea levels and more frequent and intense coastal storms will result in greater potential for coastal erosion and flooding.

These Guidelines incorporates climate change and resilience considerations for erosion and sedimentation control, including:

- Preserving pre-development site hydrology through the use of LID site planning and design strategies (Chapter 3) and erosion and sedimentation control measures (Chapters 4 and 5)
- Discussion of updated design storm precipitation for design of erosion and sedimentation controls and post-construction stormwater management measures (Chapter 5).

*Table 2. 3. Observed, Projected and Potential Soil Erosion Impacts of Climate Change*

| | Climate Change Observations\Measurements | Future Climate Change Predictions | Potential Impact to Soil Erosion & Sediment Control |
|---|---|---|---|
| **Temperature**  | Connecticut's observed annual and seasonal temperatures have observed upward trends since measurements began in 1895 and continue to do so. CIRCA reported that at the beginning of the 20th century Connecticut's annual average temperature was 47F, and in 2015 the average annual temperature was 50F. With more extreme warming trends occurring in the coldest days. | CIRCA reports a similar warming trend is expected to continue, with average temperature increasing by 5 degrees by 2050 and warming of the coldest days as much as 9.51 F. | Warmer temperatures contribute to a reduction in the duration of frozen ground conditions and an earlier spring thaw. Coupled with an increase in high-intensity precipitation, warming temperatures can result in increased erosion risk in the early spring. |
| **Sea Level Rise**  | According to NOAA's National Water Level Observation Network, mean sea level at Bridgeport Connecticut has risen 3.8 mm/ year and 2.72 mm/year at New London buoy since 1964. | As demonstrated by the Connecticut Institute of Resilience and Climate Adaptation, fairly consistent model agreement predicts Connecticut's coastline will see approximately a 20" rise by 2050 compared to the National Tide Datum (1983-2001 data). Beyond 2050, models are directionally consistent but predictions to the magnitude are less certain. None the less | Sea level rise and increased frequency and intensity of coastal storms has implications for erosion and sedimentation along the Connecticut coast and tidally influenced areas. Continued rising sea levels and more frequent and intense coastal storms will result in greater potential for coastal erosion and flooding. |

| | Climate Change Observations\Measurements | Future Climate Change Predictions | Potential Impact to Soil Erosion & Sediment Control |
|---|---|---|---|
| | | increases from 2050 levels are a consistent prediction. Therefore, at this time it is recommended that future planning consider 2050 scenarios and expect increasing sea level. | |
| **Precipitation-Intensity**  | The heaviest rainfall events have significantly increased. As noted in CIRCA's 2019 CT-PSCAR, "the 4th National Climate Assessment noted the daily 20-year return level precipitation increased by 0.08-0.25 inches (depending on season) during 1948-2015, the 5-year maximum daily precipitation increased by 27% during 1901-2016, and the 99th percentile of daily precipitation increased 55% during 1958-2016. For frequency, the number of 2-day precipitation events exceeding 5-year recurrence interval increased by 74% during 1901-2016 and by 92% during 1958-2016." | These trends are expected to continue. As noted in CIRCA's CT-PSCAR, "[b]y the late century under RCP8.5, precipitation in the wettest day of the year would increase by 20-30%, and extreme events such as daily precipitation with a return period of 20 years in the present climate would occur 3-4 times as often in the Northeast compared to the late 20th century."[2] | More intense downpours have greater erosion potential as a result of increased energy associated with rainfall directly onto exposed soils and increased runoff generation potential<br><br>More frequent high-intensity rainfall events and longer-duration storms also increase erosion potential. Projected increases in the number of days of precipitation over 1 inch, as well as the total amount of precipitation falling in the heaviest 1% of rainfall events are important factors in determining erosion potential and sedimentation.<br><br>Increased rainfall will impact the existing infrastructure as |

[2] Walsh, J., Wuebbles, D., Hayhoe, K., Kossin, J., Kunkel, K., Stephens, G., Thorne, P., Vose, R., Wehner, M., Willis, J., Anderson, D., Doney, S., Feely, R., Hennon, P., Kharin, V., Knutson, T., Landerer, F., Lenton,T., Kennedy, J., Somerville, R. (2014). Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T.C. Richmond, and G. W. Yohe (eds.), U.S. Global Change Research Program, Washington DC, pp. 19-67.

| | Climate Change Observations\Measurements | Future Climate Change Predictions | Potential Impact to Soil Erosion & Sediment Control |
|---|---|---|---|
| **Precipitation-Quantity**  | Annual and seasonal averages have also measure increases. As noted in 2019 CT-PSCAR, "Easterling et al. (2017) showed that annual precipitation during 1986-2015 increased by 5-15% over most of the Northeast relative to the 1901-1960 climatology, and the largest increase was found for the fall season (+15% over most of the region)."[3] | Again these trends are expected to continue, As noted in the 2019 CT-PSCAR, "[b]ased on output from CMIP5 models (RCP8.5), Walsh et al. (2014) and Easterling et al. (2017) found that by the end of the 21st century precipitation amount in the Northeast during winter and spring would increase significantly (by 10-30%) with a high degree of model consensus;"[2] | the capacity of many infiltration systems will be exceeded more frequently than the original design anticipated.<br>Additionally, increased precipitation can wash away seeding. |
| **Wind**  | Wind speed trends are less certain, however year to year analyses can be obtained from NOAA's National Center for Environmental Information | Similarly, predications for wind speed trends are less certain. | An increase in the occurrence of extreme storms also increases the potential for wind-induced erosion. |

[3] Easterling, D.R., Kunkel, K.E., Arnold, J.R., Knutson, T., LeGrande, A.N., Leung, L.R., Vose, R.S., Waliser, D.E., Wehner, M.F. (2017). Precipitation change in the United States. In: Climate Science Special Report:Fourth National Climate Assessment, Volume I. Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.). U.S. Global Change Research Program, Washington DC, pp. 207-230.

# Chapter 3 – Erosion and Sediment Control Plans

This chapter is a guide for preparing a typical soil erosion and sediment control plan (hereafter referred to as an "E&S plan") for construction activity where land disturbance exceeds one half acre, including but not limited to those projects that are subject to the Connecticut Department of Energy and Environmental Protection (CT DEEP) General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities (Construction General Permit).

This chapter is divided into three parts:

### Part I – General Guidelines

Presents the basic information with which all site planners and plan reviewers should be familiar. It describes criteria for developing an effective E&S plan, including plan content and format.

### Part II – Planning Process

Describes a procedure for developing an E&S plan from the review of available data and Low Impact Development (LID) site planning and design considerations through the final selection and design of erosion and sediment control measures ("E&S measures").

### Part III – Plan Requirements and Preparation

Presents details on the consolidation of planning information into a written document, the minimum information required, and plan format. This procedure is written in general terms to be applicable to all types of construction projects.

**What's New in this Chapter?**

- New and revised information based on the Construction General Permit.
- Guidance on incorporating Low Impact Development (LID) site planning and design considerations in a typical E&S Plan.
- Updated information on statewide GIS mapping resources.

## Part I – General Guidelines

### Definition of an E&S Plan

The Connecticut General Statutes (CGS) §22a-327(5) defines an E&S plan as:

*"... a scheme that minimizes soil erosion and sedimentation and includes, but is not limited to, a map and a narrative. The map shall show topography, cleared and graded areas, proposed area alterations and the location of and*

*detailed information concerning erosion and sediment measures and facilities. The narrative shall describe the project, the schedule of major activities on the land, the application of conservation practices, design criteria, construction details and the maintenance program for any erosion and sediment control facilities that are installed."*

The E&S plan consists of two components: a narrative which describes the project in general terms and a map (drawing) which illustrates in detail what is contained in the plan and how it will be implemented. The information required by the statute for the drawing is typically contained collectively in the site drawing(s) and the erosion and sediment control drawing(s) referenced later in this chapter. The narrative is also typically contained on the site drawings but may be a separate document due to its length, particularly in larger projects that have more than one construction phase. For sites where the E&S measures require engineering analysis and design, the hydrologic and hydraulic calculations and other support documents are part of the E&S plan and are attached to the narrative. Some types of supporting information may also be included on the site drawings.

## Plan Adequacy

CGS §22a-327(5) sets minimum requirements for E&S plans mandated under the Soil Erosion and Sediment Control Act (CGS §§22a-325 through 22a-329). This law specifically requires local planning and zoning commissions to consider erosion and sediment controls and provide for certification that an adequate E&S plan has been submitted. Many municipal planning and zoning commissions have cited these Guidelines in their regulations and frequently require them as the standard to follow. Other requirements may be mandated by the Construction General Permit, which requires preparation and implementation of a Stormwater Pollution Control Plan (SWPCP) – a specific type of E&S plan that meets the E&S plan requirements described in these Guidelines.

Additional regulatory agencies, such as a municipal inland wetland agency, the U.S. Army Corps of Engineers, and CT DEEP, may request the submission of an E&S plan for review and approval. These other areas of regulatory control can include inland wetlands and watercourses, water quality planning, diversion of water, tidal wetlands and tidal, coastal, and navigable waters, and other stormwater general permits including the Municipal Separate Storm Sewer System (MS4) general permits. Regardless of the regulating authority, E&S plans shall contain sufficient information to show that the potential problems of soil erosion and sedimentation have been addressed for a proposed project.

The length and complexity of the plan is directly related to the size of the project, the severity of site conditions, and the potential for off-site damage (see Table 3. 1). E&S plans are site specific, and as such may require a variety of expertise. E&S plans shall be signed and sealed by a qualified professional to meet the needs of the plan at hand, such as those defined as a qualified soil erosion and sediment control professional in the General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities, including landscape architects or professional engineers that meet certain qualifications as outlined in the General Permit. Site planners and plan reviewers may use the checklists contained in Part III of this chapter as a guide to E&S plan content. The procedure outlined in this chapter is recommended for the development of all plans.

E&S plans must be prepared and certified by a qualified professional engineer, or a qualified soil erosion and sediment control professional as defined in the Construction General Permit.

*Table 3. 1 E&S Plan Complexity*

| E&S Plan Complexity | Site Features |
|---|---|
| Simpler ↓ | • Single house<br>• Low Soil Erodibility<br>• Flat Terrain<br>• No Wetlands or Watercourses Nearby<br>• Low Density Population<br>• ≤ 5 Acres to be Disturbed |
| More Complex | • Subdivision with roads<br>• High Soil Erodibility<br>• Steep Slopes<br>• In or Near Wetlands or Watercourses<br>• Dense Population<br>• >5 Acres to be Disturbed<br>• Located within Public Water Supply Watershed |

## Minimum Standards and Specifications

Chapter 5 of these Guidelines contains the minimum standards and specifications for E&S measures. Whenever any of these measures are to be employed on a site, the specific measure should be clearly marked on the plan. The plan shall contain diagrams and notes related to the installation and maintenance of the measures.

Modifications to the standard measures contained in these Guidelines or new and innovative E&S measures may also be employed. Such modifications or measures shall be thoroughly described in detail to the satisfaction of the reviewing agency. The modified or new measure shall be at least as effective as the Guideline measure being replaced.

# Part II– Selection & Planning Process

## LID Site Selection

Historically, sites for development have been selected based upon the availability of property where zoning and wetland restrictions can be compatible with development needs. Existing infrastructure is also a major determining factor in the selection of potential sites for development. Irrespective of the ultimate use or location of the proposed development, erosion and sediment control needs including consideration of LID site planning and design principles, should be an integral part of the site selection process.

## Review of Available Information

In Connecticut, there are many online sources of digital information[4] that are available to the site planner or engineer in developing E&S plans.

These information sources include but are not limited to:

1. Coastal Zone Management Enhancement Program, Strategies and Assessments
2. CT DEEP GIS Open Data Website (including but not limited to GIS for the following categories Impairments, Cold Water Habitats, Environmental Justice, Tidal Wetlands, Natural Diversity Database)
3. Connecticut Environmental Conditions Online (CT ECO), Maps and Geospatial Data for Everyone

[4] See Appendix C- Agency Contact Information

4. Federal Emergency Management Agency (FEMA) Natural Flood Hazard Layer (NFHL) Viewer
5. National Wetland Inventory — US Fish and Wildlife Service
6. United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Web Soil Survey and Geospatial Data Gateway
7. United States Geological Survey (USGS), the Natural Map – Data Delivery

## Site Investigations and Limitations

A review of existing information can assist the planner in determining initially if the site is compatible with the development needs, if limitations exist that will impact site development, and initial LID site planning and design considerations to preserve pre-development site hydrology, and ultimately avoid or minimize construction and post-construction stormwater impacts. Features such as existing topography, wetlands, watercourses, surface and groundwater quality, habitats of endangered species, steep and flood prone areas can be generally identified by reviewing existing information. Projects that propose filling flood prone areas or inland wetlands require permits or approvals from local agencies and may require state and/or federal permits. These permits are sometimes difficult to obtain, if at all, and may result in the need for costly mitigation procedures.

Potential need for and general locations of post-construction structural stormwater control measures, such as infiltration systems, other retention, and treatment stormwater Best Management Practices (BMPs), and stormwater quantity control measures can be initially identified. For example, it is common that developing a site may result in decreased infiltration and increased runoff (e.g., wooded land to grass or vegetation to pavement). In this case, infiltration systems, treatment BMPs, and peak runoff attenuation BMPs may be needed to reduce or eliminate the anticipated changes to runoff quality, volume, peak rate of discharge, and timing, as well as groundwater recharge.

The presence of wetlands and flood prone areas can severely limit the siting construction-phase E&S measures and post-construction stormwater BMPs on the site, not to mention other structural features such as buildings and roads.

Soil limitations that may require special considerations when siting proposed improvements and associated construction can be identified from the published soil surveys. Complex sites, such as subdivisions with road construction, shopping centers, schools, apartment complexes, and projects with multiple phases, may require a more detailed soil survey by a soil scientist or geologist to identify problems not indicated by a general soil survey. Highly erodible soils coupled with the proximity of a sensitive resource (e.g., public water supply reservoir, cold water fisheries, endangered species habitat, water quality impaired waters) may require greater efforts and costs to control soil erosion and sedimentation.

The data collected during the preliminary site selection process will need to be supplemented and clarified with data collected in the field. This supplemental data collection may include mapping of wetlands by a soil scientist or, in the case of tidal wetlands, a wetlands ecologist. This field mapping will confirm soil types and wetland locations. Land surveys to locate property boundaries and to confirm topography and watercourse locations will be needed. Vegetation patterns and conditions both on site and on adjacent areas will need to be determined. Soil borings and/or test pits may be required to determine depth to bedrock, soil bearing strength, subsoil texture and groundwater characteristics to inform the overall development plan for a site and to support the selection of LID site planning and design techniques as well as the design of structural stormwater BMPs to address post-construction stormwater runoff.

The combined data is used to develop the following maps:

### Site Locus Map

A map that shows the site's relationship to roads and environmental features such as major water courses. The USGS Quadrangle Map or local street map may be used as the base map for identifying the location of the site.

### Detailed Existing Conditions Map

A map or maps of the site where 1 inch represents no more than 100 feet containing detailed information on topography, drainage patterns, soils, existing vegetation, adjacent areas, and coastal resources, where appropriate.  A map scale of 1" = 40' is generally suitable but may vary depending on site complexity, size of site, or requirements of the reviewing agency.

By analyzing the data collected during the review of the existing information and the detailed site investigations, site limitations are identified. The site planner should also be able to determine those areas that will need special consideration during the development of the site plan including the most appropriate areas on the site for development, conservation, and use of E&S measures and post-construction stormwater controls.

### Topography

Show the existing contour elevations at intervals from 1 to 5 feet depending upon the requirements of the governing regulatory agency.  Existing topographic maps (e.g., USGS Quadrangle Map or mapped digital elevation data) can be a good starting point; however, the information should be verified by a field investigation. On larger tracts of land (generally greater than 25 acres in size) , aerial imagery with 2-foot contour intervals is suggested, especially in areas proposed for intensive development where existing topography may cause serious site limitations. Show areas on the site and adjacent to the site with slopes of 15% and greater.

## Drainage Patterns

Show the location of all existing drainage patterns, drainage swales, other drainage ways, and drainage boundaries; perennial and intermittent streams; and 100-year flood zone and floodway boundaries available from CT ECO or FEMA mapping,

## Soils

Determine the major soil type(s) on the site and show them on the detailed site drawing. General soils information can be obtained from the online USDA NRCS Web Soil Survey (WSS). The WSS USDA contain tables that identify soil capabilities and suitability for certain management and conservation practices. These tables will help to assist in identifying soil limitations. Show areas of:

- Poorly drained soils (Hydrologic Soil Group C and D soils, for example) and highly erodible soils as defined by USDA NRCS soil map units and slope. In general, gravel soils tend to be the least erodible, while silty soils are the most erodible.
- Soils suitable for infiltration based on field evaluation of soils (soil textural classification and/or field infiltration testing) and areas best suited for infiltration for the siting of post-construction stormwater infiltration systems (Hydrologic Soil Groups A and B soils).
- Soils unsuitable or least suitable for infiltration (Hydrologic Soil Group C and D soils) for the siting of areas of development/building.
- Areas inappropriate for the infiltration of stormwater runoff from land uses with a significant potential for groundwater pollution.

## Wetlands

Show the boundaries of inland wetlands and watercourses on the site as delineated in the field by a Certified Soil Scientist or Professional Wetland Scientist. Field verify upland soil types on the site during the field delineation. Show regulatory buffers such as upland review areas and applicable stream or riparian buffer requirements. Since regulated areas and buffers vary from town to town, it is important that the site planner consult with the individual town wetland staff early in the development of the site plan. It is also important to field delineate and show unique or significant wetland types such as vernal pools and associated review areas.

## Vegetation

Identify and show the existing vegetation types (deciduous forest, coniferous forest, meadow, etc.), as well as dominant plant community classification and patterns on the site. Features such as tree clusters, grassy areas, tidal and/or inland wetlands vegetation, and unique vegetation should be shown on the detailed map. Include all significant tree species with a Diameter at Breast Height (DBH) of 24 inches and greater. In addition, existing exposed soil areas, such as borrow pits, should be indicated.

### Bedrock

Identify areas of shallow bedrock or ledge based on soils mapping, test pits or soil borings, and visible outcrops.

### Coastal Resources and Other Sensitive Areas

If the project is within the coastal area management zone (i.e., Connecticut Coastal Boundary), identify and show all coastal resources on-site including tidal wetlands, beach soils, dunes, bluffs, escarpments, coastal flood hazard areas, coastal waters, estuarine embayment's, intertidal flats, submerged aquatic vegetation and shellfish concentration areas. If applicable, identify and show the location of the Connecticut Coastal Jurisdiction Line (CJL), which is the jurisdictional limit for tidal, coastal, and navigable waters.

Other sensitive areas that are not necessarily identified as a coastal watercourse but which need to be identified and mapped include inland wetlands, watercourses in general, and watercourses supporting cold water fisheries, waters with identified water quality impairments or approved Total Maximum Daily Loads (TMDLs), endangered species habitat identified by the CT DEEP Natural Diversity Database and terrace escarpments located in the Connecticut River valley.

Additionally, determine if the site is located within a public water supply watershed or Aquifer Protection Area (APA) by referring to Public Water Supply mapping maintained by the Connecticut Department of Public Health (CT DPH) and Aquifer Protection Area mapping maintained by CT DEEP. Show the watershed and APA boundaries on the site locus map. CGS §§ 8-3i and 22a-42f require the applicant to notify the affected water utility of any projects located within the public water supply watershed area.

When the project is located in a public drinking water supply watershed or APA, consult CT DPH source water protection program guidance and the applicable APA regulations of the municipality in which the project is located. Identify measures needed to reduce potential impacts to the public water supply caused by the development activities. It is suggested that a copy of the plan be submitted to the water utility and/or municipality (i.e., Aquifer Protection Area agency) for their review and comments.

### Adjacent Areas

Investigate areas adjacent to the site which will either impact or be impacted by the project. Features such as perennial and intermittent streams, roads, houses or other buildings, or wooded areas should be shown. The governing regulatory agency may require that wetlands, watercourses, and downstream culverts which will receive runoff from the site be analyzed to determine their ability to retain or discharge projected runoff. Identify sensitive downstream areas, such as existing stream bank erosion, hydraulic constraints, public water supply reservoirs, Aquifer Protection Areas, and in-stream recreation areas. Identify approved and future development site(s) in the upper watershed area. In addition to the hydraulic concerns raised in the Drainage Patterns subsection, evaluate the environmental conditions in areas down slope and up slope from the construction project. The potential for sediment deposition on down slope properties should be analyzed so that appropriate erosion and sediment controls can be planned. Downslope wetlands and watercourses (especially those containing drinking water reservoirs or cold-water fisheries habitat) that will receive runoff from the site are concerns.

## Principles of Site Planning and Low Impact Development for Erosion and Sediment Control

The primary function of erosion and sedimentation controls is to absorb erosional energies and reduce runoff velocities that force the detachment and transport of soil and/or encourage the deposition of eroded soil particles before they reach any sensitive area. Erosion and sedimentation control principles are all formulated on the premise that it is easier, cheaper, and less environmentally damaging to reduce soil detachment in the first place than it is to control its transport and deposition or to remediate damage after it occurs.

Incorporating LID principles during site planning is valuable for the purpose of controlling soil erosion and sedimentation throughout construction, in addition to maintaining pre-development site hydrology and addressing post-construction stormwater runoff. The goals of a LID approach are to minimize the volume of runoff generated, maximize the treatment capabilities of the landscape, and control runoff as close to the sources as possible. The following sections describe non-structural LID site planning and design techniques that can be readily integrated with standard E&S measures. Specific E&S measures are discussed in detail in Chapter 5 of these Guidelines.

Additional guidance on non-structural LID site planning and design techniques and structural stormwater BMPs can be found in:

- Connecticut Stormwater Quality Manual
- CT DEEP Fact Sheet: Considering Low Impact Development Principles in Site Design (Appendix B of the CT DEEP Construction General Permit)

### Fit the Development to the Site – Determination of Developable Area

Start by selecting a site that is suitable for a specific proposed activity and consider the ecological needs of the site. Sites with resource limitations should be developed in conformance with the capacity of the site to support such development, rather than by attempting to modify a site to conform to a proposed activity.

Based on the various site constraints and environmental resources shown in the Existing Conditions Map, identify the developable area on the site by removing areas where development is either restricted by regulation (i.e., wetlands, watercourses, vernal pools) or areas where avoidance/preservation is recommended (upland buffer areas, steep slopes, erodible soils, etc.) to prevent or minimize erosion and sedimentation during construction and to maintain pre-development hydrology and minimize post-construction stormwater impacts. The following avoidance strategies apply when determining the developable area on a site:

- Protect as much undisturbed land as possible to maintain the natural hydrologic functions of the site (infiltration, groundwater recharge, runoff, etc.)
- Utilize the natural drainage system whenever possible. If the natural drainage system of a site can be preserved (or a vegetated open conveyance system can be designed) instead of being replaced with piped storm sewers or concrete channels, the potential for downstream damages from increased runoff can be minimized, making compliance with stormwater management criteria easier.
- Utilize the existing topography.
- Minimize land disturbance associated with clearing and grading.
- Concentrate development on the flattest area of the site to avoid excessive slope cuts or fills where possible.
- Avoid the compaction of natural soils to maintain natural infiltration capacity and avoid compaction of areas on the site proposed for engineered infiltration systems. The restoration of a soil's infiltration capacity can be achieved through the use of soil amendments or surface roughening (e.g., tilling, discing, scarifying, or tracking) for natural areas compacted during construction.
- Avoid steep slopes and soils with severe limitations for the intended uses, including highly erodible soils.
- Avoid flood prone areas, wetlands, beaches, dunes, stream banks and other sensitive areas and, when possible, keep floodplains free of fill or obstructions.
- Keep stockpiles, borrow areas, access roads and other land-disturbing activities away from critical areas (such as steep slopes and highly erodible soils) that drain directly into wetlands and water bodies.
- Avoid siting buildings in drainage ways, over watercourses, and over storm drainage systems.

- Locate post-construction stormwater infiltration systems in pervious soils (Hydrologic Soil Groups A and B soils). Utilize the NRCS "Soil Based Recommendations for Storm Water Management Practices" in the design process.
- Where feasible, construct impervious surfaces (development, buildings, parking, etc.) on less pervious soils (Hydrologic Soil Group C and D soils).

The remaining developable area on the site should be the focus of additional LID site planning and design strategies to **reduce and minimize** construction and post-construction stormwater impacts.

### Keep Land Disturbance to a Minimum

The more land that is kept in vegetative cover, the more surface water will infiltrate into the soil, thus minimizing stormwater runoff and potential erosion. Keeping land disturbance to a minimum not only involves minimizing the extent of exposure at any one time, but also the duration of exposure. Phasing, sequencing, and construction scheduling are interrelated. Phasing divides a large project into distinct sections where construction work over a specific area occurs over distinct periods of time and each phase is not dependent upon a subsequent phase in order to be functional. A sequence is the order in which construction activities are to occur during any phase. A sequence should be developed on the premise of "first things first" and "last things last" with proper attention given to the inclusion of adequate erosion and sediment control measures. A construction schedule is a sequence with timelines applied to it and should address the potential overlap of actions in a sequence which may conflict with each other.

- Cluster buildings to minimize the amount of disturbed area, concentrate utility lines and connections in one area, and provide for more open space. The cluster concept not only lessens the area subject to erosion, but reduces potential increases in runoff, and generally reduces development costs.
- Limit areas of clearing and grading by concentrating construction activities on the least critical or sensitive areas. Protect natural vegetation from construction equipment with fencing, tree armoring, mobile low-pressure tracks and retaining walls or tree wells. Land disturbance should be minimized by using maximum allowable slopes at the perimeter of disturbed areas.
- Route traffic patterns within the site to avoid existing or newly planted vegetation.

- Phase developments so that areas which are actively being developed at any one time are minimized and only that area under construction is exposed. Clear only those areas essential for construction. Consider restricting the start of a later phase contingent upon the completion of a prior phase. At any given point of time, when the disturbed area exceeds 5 acres and drains to a common point of discharge the construction of a sedimentation basin is indicated. Restrictive phasing can sometimes keep the disturbed area below this 5-acre threshold.
- Consider natural erosion and sediment control measures which could be left in place and subsequently folded into stabilization and re-vegetation such as fiber rolls, compost and/or plantings.
- Sequence the construction of storm drainage and sewer systems so that they are operational as soon as possible during construction. Ensure all outlets are stable before directing storm drainage to them. See Chapter 4 for examples of sequences for large construction sites.
- Schedule construction so that final grading and stabilization is completed as soon as possible. Include early stabilization or covering of stockpiled topsoil or other erosive materials when they will not be used within 30 consecutive days. Grading and stabilization of steep slopes and erodible soils with severe limitations should be sequenced early in the construction so that grading work proceeds from the highest to lowest elevation.
- Schedule construction where possible to avoid disturbing large or critical areas during frozen ground conditions (December through February) and spring thaw (March through mid-April).
- Use planning tools such as flow charts, to develop feasible sequences and schedules in the most environmentally sound and cost-effective way. Additionally, they can be used by financial lenders to develop funding schedules.
- Schedule the implementation of erosion and sediment controls so that they are timed to match the erosion and sediment needs created by the sequencing in each phase.

## Reduce Runoff and Slow the Flow

Runoff comes primarily from impervious surfaces, such as rooftops, roadways or any smooth, hard surface that prevents or reduces water from infiltrating into the ground. Detachment and transport of eroded soil must be kept to a minimum by absorbing and reducing the erosive energy of runoff. The volume and velocity of runoff increases during development because of reduced infiltration rates caused by the increase of impervious and compacted surfaces. Minimize the extent of impervious areas on the site, particularly Directly Connected Impervious Area[5] through the following strategies:

- Minimize impervious areas. Encourage infiltration where appropriate and promote contact between runoff and pervious land surfaces.[6] Keep paved areas such as parking lots and roads to a minimum. This complements cluster developments in eliminating the need for duplicating parking areas, access roads, and other impervious areas.
- Keep in mind that increases in runoff may require control measures or channel improvements.
- Use diversions, stone check dams, silt fences, geoblock, and similar measures to break flow lines and dissipate stormwater energy.
- Consider collecting and detaining runoff when there is an increased potential for flooding and resultant damage to downstream facilities.
- Avoid diverting one drainage system into another without calculating the potential for downstream flooding or erosion.
- Perform runoff calculations to determine the effect of the development on the existing drainage system. Make changes where necessary to avoid downstream damage and to comply with runoff requirements of the reviewing agency.
- Determine the potential need for detention systems. Attempt to locate detention systems outside of floodplains, wetlands, and watercourses, and adjacent to steep escarpments.

## Keep Clean Runoff Separated

Clean runoff should be kept separated from sediment laden water and should not be directed over disturbed areas without additional controls. Additionally, prevent the mixing of clean off-

[5] Directly Connected Impervious Area (DCIA) is impervious area with a direct hydraulic connection to a storm drainage system or a waterbody via continuous paved surfaces, gutters, drainpipes, or other conventional conveyance and detention structures that do not reduce runoff volume.
[6] Slope stability and soil permeability must be considered when considering infiltration options.

site generated runoff with sediment laden runoff generated on-site until after adequate filtration of on-site waters has occurred.

- Segregate construction waters from clean water.
- Divert site runoff to keep it isolated from wetlands, watercourses, and drainage ways that flow through or near the development until the sediment in that runoff is trapped or detained.

### Use Distributed Controls

While it may seem less complicated to collect all waters to one point of discharge for treatment and just install a perimeter control, it can be more effective to apply internal controls to many small sub-drainage basins or long overland flow areas within the site. By reducing sediment loading from within the site, the chance of perimeter control failure and the potential off-site damage that it can cause is reduced. Small, distributed systems also offer a major technical advantage as one or more of the systems can fail without undermining the overall integrity of the site control strategy. It is generally more expensive to correct off-site damage than it is to install proper internal controls. Common types of distributed erosion and sedimentation controls include but are not limited to:

- Control erosion and sedimentation in the smallest drainage area possible. It is easier to control erosion than to contend with sediment after it has been carried downstream and deposited in unwanted areas.
- Direct runoff from small, disturbed areas to adjoining undisturbed vegetated areas to reduce the potential for concentrated flows and increase settling and filtering of sediments.
- Implement interim and permanent soil stabilization practices for managing disturbed areas and soil stockpiles, including a schedule for implementing the practices.
- Ensure that existing vegetation is preserved to the maximum extent practicable and that disturbed portions of the site are minimized and stabilized throughout the duration of the construction activity at the site.
- Use erosion control barriers downgradient or mid-gradient of exposed soils or disturbed areas. Ensure long overland flows on disturbed areas are properly segmented throughout construction.

- Where construction activities have permanently ceased or when final grades are reached in any portion of the site, implement stabilization and protection practices within seven days. Areas that will remain disturbed but inactive for at least fourteen calendar days should receive temporary seeding or soil protection within seven days unless site conditions warrant shorter time periods for these provisions.
- Use long-term, non-vegetative stabilization and protection sufficient to protect the site through the winter for areas that will remain disturbed beyond the seeding season.
- Always maintain temporary or permanent vegetation or other ground cover in all areas of the site, except those undergoing active disturbance, in order to prevent erosion and soil compaction during construction activities.
- Use native plant species for all new temporary and permanent vegetation. Do not use chemical fertilization, herbicides, or pesticides except as necessary to establish such vegetation (this may include herbicides to control invasives when other control strategies are not available or effective).
- Use a reverse slope bench for any slope steeper than 3:1 (horizontal: vertical) that exceeds 15 feet vertically, except when engineered slope stabilization structures or measures are included or a detailed soil mechanics analysis has been conducted to verify stability. Engineered analyses and measures must be designed by a CT licensed Professional Engineer with experience in geotechnical engineering or soil mechanics.
- Concentrated runoff from development should be safely conveyed to stable outlets using riprap channels, waterways, diversions, storm drains, or similar measures.
- Design conveyance systems to withstand the velocities of projected peak discharges. Where feasible lengthen and curve vegetative swales.
- Determine the need for sediment basins. Sediment basins are required on larger developments where major grading is planned and where it is impossible or impractical to control erosion at the source.[7] Sediment basins are needed on large and small sites when sensitive areas such as wetlands, watercourses, and roadways would be impacted

[7] For requirements, see the current CT DEEP General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities.

by off-site sediment deposition. Do not locate sediment basins in wetlands or permanent or intermittent watercourses. Sediment basins should be located to intercept runoff prior to its entry into the wetland or watercourse.

- Grade and landscape around buildings and septic systems to divert water away from them.

### Implement a Thorough Maintenance and Follow up Program

E&S measures must be maintained and adopted to address ever changing site and environmental conditions. Having a failing E&S measure that is not promptly repaired is like having no control at all. A site cannot be effectively controlled without thorough periodic checks of the erosion and sediment control measures and repairs of failures. These measures must be maintained just as construction equipment must be maintained and materials checked and inventoried. Monitoring, maintenance and possible change or adaptation of erosion and sediment controls is essential to the success of an E&S plan.

## Select Erosion and Sediment Control Measures

Erosion and sediment controls are used to dissipate erosive energies, requiring that their performance and structural limitations be considered. Increases in runoff occurring during development are caused by reduced infiltration resulting from the removal of vegetation, the removal of topsoil, compaction, and the construction of impervious surfaces. These increases must be considered when providing for erosion control.

Table 3. 2 is a matrix to guide the selection of soil erosion and sediment control measures. Following the measure selection matrix in steps from left to right, the user can identify the potential problems and solutions for control of these problems. To use the control measures selection matrix, follow the four basic steps:

### Step 1 – Identify Problem Areas and Ecological Needs

Areas where erosion will need to be controlled will usually fall into categories of disturbed areas, drainage ways, and dewatering operations.

### Step 2 – Identify Control Problems

Problems fall into the three broad categories of soil detachment, water and sediment transport, and sediment deposition. Identify the type of erosion the problem area is expected to experience.

- For areas having rain drop erosion, sheet erosion, or rill erosion, focus on controlling sediment detachment.
- For areas expected to experience gully erosion or concentrated flows, focus on controlling water movement.

- For areas where soil detachment cannot be prevented due to construction limitations, focus on controlling sediment deposition.

### Step 3 – Identify Control Strategies

Select a strategy or strategies to control the problem, using the measures selection matrix as a guide.

There may be several strategies used individually or in combination to provide the solution. For example, if a cut slope is to be protected, the strategies may be to conserve existing site resources, protect the exposed surface, direct water from the slope, detain sediments at the toe of the slope, or any combination thereof. If no water except that which falls directly on the slope has the potential to cause erosion and if the slope is relatively short, protecting the soil surface may be all that is required to solve the problem.

Structures are generally more costly than vegetative controls. However, they are often necessary since not all disturbed areas can be protected with vegetation. Structural measures are often used as a second or third line of defense to capture suspended sediment before it leaves the site.

### Step 4 – Select the Appropriate Measures from the Control Groups

Once strategies to solve the erosion and sediment problem are identified, the measures selection matrix leads to the group or groups of control measures that will accomplish each strategy. Control measures within each group have a similar function. Therefore, any measure within a group could address the problem in question.

The final step in erosion and sediment control planning is selecting the measure(s) within a group(s) that address the specific erosion and sediment problem. Select the measures which are most effective and feasible for the site.

Once the specific measures have been selected, the plan key symbols provided in the measure's selection matrix can be placed on the erosion and sediment control drawings to show where the measures will be applied or installed. Standardized design, plan, and construction specification sheets can then be completed for each control measure.

Table 3. 2 Measures Selection Matrix

| **Identify Problem Areas** | **Identify Control Areas** | **Identify Strategy** | **Select Specific Measure** | | **Plan Key** |
|---|---|---|---|---|---|
| | | | **Functional Group** | **Measure** | |
| Disturbed Areas | ***Control Soil Detachment*** | Preserve and Conserve Existing Site Resources | Protect Vegetation | Tree Protection | TP |
| | | | Preserve and Conserve Soil | Top Soiling | TO |
| | Raindrop Splash | | | Land Grading | LG |
| | | | | Surface Roughening | SR |
| | Sheet and Rill Erosion | | | Dust Control | DC |
| Short or Shallow Slopes | | Protect Surface | Vegetative Soil Cover | Temporary Seeding | TS |
| | | | | Permanent Seeding | PS |
| | | | | Sodding | SO |
| | Wind Erosion | | | Landscape Planting | LP |
| | | | Non-Living Soil Protection | Temporary Soil Protection | TSP |
| Steep Slopes | | | | Mulch for Seed | MS |
| | | | | Landscape Mulch | LM |
| | | | | Temporary Erosion Control Blanket | ECB |
| Long Slopes | | | | Permanent Turf Reinforcement Mat | TRM |
| | | | | Fiber Rolls | FR |
| | | | | Stone Slope Protection | SSP |
| Stockpile Areas | | Protect Surface and/or Convey Runoff | Stabilization Structures | Retaining Walls | RW |
| | | | | Riprap | RR |
| | Control Water Movement | | | Gabions | G |
| Borrow Areas | | | | Permanent Slope Drain | PSD |

| Identify Problem Areas | Identify Control Areas | Identify Strategy | Select Specific Measure: Functional Group | Select Specific Measure: Measure | Plan Key |
|---|---|---|---|---|---|
| Drainage Ways<br>Wetlands and Watercourses<br>Waterbodies<br>Areas of Flooding & Existing Erosion<br>Drainage Outlets<br>Travel Areas | Gully Erosion<br>Channel & Stream Erosion<br>Natural Resource Degradation | Convey Runoff | | Channel Grade Stabilization Structure | CSS |
| | | | | Temporary Lined Chute | TC |
| | | | | Temporary Pipe Slope Drain | TSD |
| | | | Drainageways and Watercourses | Vegetated Waterway | VW |
| | | | | Temporary Lined Channel | TLC |
| | | | | Permanent Lined Waterway | PW |
| | | | | Temporary Stream Crossing | TSC |
| | | | | Temporary Fill Berm | TFB |
| | | Direct Runoff | Diversions | Water Bar | WB |
| | | | | Temporary Diversion | TD |
| | | | | Permanent Diversion | PD |
| | | Intercept Groundwater | Subsurface Drains | Subsurface Drain | SD |
| | | Detain Runoff | Detention Structures | Detention Basin | DB |
| | | Diffuse Runoff | Energy Dissipators | Level Spreader | LS |
| | | | | Outlet Protection | OP |
| | | | | Stone Check Dam | SCD |
| | Control Sediment Deposition | Detain Sediments | Sediment Impoundments, Barriers and Filters | Temporary Sediment Basin | SB |
| | | | | Temporary Sediment Trap | TST |
| | | | | Fiber Rolls | FR |
| | | | | Filter Sock | FS |
| | | | | Hay Bale Barrier | HB |

| Identify Problem Areas | Identify Control Areas | Identify Strategy | Select Specific Measure | | Plan Key |
|---|---|---|---|---|---|
| | | | Functional Group | Measure | |
| Dewatering | Project Onsite and Offsite Areas | | | Geotextile Silt Fence | GSF |
| | | | | Turbidity Curtain | TC |
| | | | | Vegetative Filter | VF |
| | | Control Mechanically Moved Waters and Soils | Tire Tracked Soils | Construction Entrance | CE |
| | | | Dewatering | Pump Intake and Outlet Protection | PuP |
| | | | | Pumping Settling Basin | PSB |
| | | | | Portable Sediment Tank | PST |
| | | | | Dewatering of Earth Materials | DWM |

# Part III – E&S Plan Requirements

## Plan Format

The E&S plan should be an integral part of the overall site plan. However, for the purposes of review, certification, bonding, and enforcement, the E&S plan narrative and drawings should be developed so that they can be separated from the overall site plan (which include construction drawings), as needed, to facilitate their use. On non-complex projects, the E&S plan need not be separate if clarity of information is maintained.

To facilitate plan review, certification, implementation, and the construction inspection process:

I. Place the information needed for construction on the construction drawings or in the specifications package.

II. Make all construction drawings for a specific project the same size sheet.

III. Make the soil erosion and sediment control drawings a part of the overall construction drawings for the project.

IV. For larger projects, show the installation requirements and specifications for measures to be used on a separate sheet from the plan view sheets. For small projects, if room allows for details to be clearly shown, placing details on the plan view sheet can be advantageous.

V. Place the phases of development, associated sequences of major operations, and maintenance program during construction either in the narrative portion of the plan or on the construction drawings.

VI. Attach all supporting information, such as design calculations, boring logs, test pit logs, and infiltration test results, to the narrative. Show the location of all borings, test pits, and infiltration tests on the drawings. For simple projects, show them on the erosion and sediment control drawings.

## Monitoring and Maintenance

The E&S plan and any revisions shall identify an agent or agents who have the responsibility and authority for the implementation, operation, monitoring, inspection, and maintenance of E&S measures. Such agent(s) shall be familiar with each control measure used including its limitations, installation, inspection, and maintenance. When control measures fail, or are found to be otherwise ineffective, such agent(s) shall coordinate plan revisions with a qualified professional engineer or a qualified soil erosion and sediment control professional, as defined in the Construction General Permit, and any approving agency when that agency's approval is required. Such agent(s) shall have the additional responsibility for ensuring all erosion and sediment controls are properly installed and maintained throughout the construction site.

Each measure has inspection requirements included in the measure's section entitled "Maintenance." Many of the measures require inspections at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater; some others require daily inspection. Only the permanent measures have less frequent inspections. More frequent inspections than those identified in the measure may be necessary for sites that are heavily traveled and before major storms.

More stringent inspection requirements may apply for projects subject to the Construction General Permit, other CT DEEP stormwater general permits, or municipal E&S control requirements.

Inspections performed pursuant to the Construction General Permit must be performed by a "qualified inspector" as defined in the Construction General Permit.

## E&S Plan Checklists

These checklists are intended to be of assistance in preparing and approving E&S plans and serve as a reminder of major items that typically need to be considered when developing the plan. Agencies may have their own checklists that should be checked against the following items.

## Narrative

i. A narrative description of the nature of the construction activity including the project purpose. An estimate of the total area of the project site and the total area of the site that is expected to be disturbed by construction activities.
ii. An estimate of the average runoff coefficient of the site after construction activities are completed.
iii. The name of the immediate receiving water(s) and the ultimate receiving water(s) of the discharges.
iv. Identification of site-specific erosion or sediment control concerns and issues.
v. The expected sequence of all construction activities on the site and corresponding erosion and sediment controls, including phases of development if more than one phase is planned.
vi. The approximate planned start and completion dates for each phase of the project.[8]
vii. Either provide or identify where in the E&S plan the following information is found:
    a. the design criteria, construction details, and maintenance program for the erosion and sediment control measures to be used,
    b. the sequence of major operations within each phase, such as installation of erosion control measures, clearing, grubbing, excavation, grading, drainage and utility installation, temporary stabilization, road base, paving for roadways and parking areas, building construction, permanent stabilization, removal of temporary erosion control measures
    c. The approximate duration (in calendar days) required for the major operations identified in the sequence
viii. Identify other possible local, state, and federal permits required.
ix. Identify the Low Impact Development (LID) site planning and design strategies to be used.
x. A listing of all other documents to be considered part of the E&S plan (e.g., reports of hydraulic and hydrologic computations, boring logs, test pit logs, field infiltration testing results, soils reports, etc.)

## Support Documents (as may be needed to support Engineering Designs)

i. Hydraulic Calculations
    a. Size and locations of existing and planned channels, waterways, and velocity dissipation controls with design calculations and construction details.
    b. Pre-development peak flows with calculations.

[8] These are often subject to change depending on markets, financing, permit approvals and weather conditions. A change in a start date can cause a restriction or prohibition in the use of proposed measures, and thereby require revisions to the E&S plan.

c. Post-development peak flows with calculations.
d. Pre to post-development changes in peak flows.
e. Off-site effects of increased peak flows or volumes.
f. Design calculations and construction details for engineered measures used to control on and off-site erosion caused by the project.
g. Design calculations and construction details for engineered measures used to control erosion at stormwater discharge points.
h. Design calculations and construction details for engineered measures used to control groundwater (i.e., seeps, high water table, etc.)

ii. Post-construction Stormwater Management Calculations (refer to the Connecticut Stormwater Quality Manual for specific requirements)

iii. Boring logs, test pit logs, field infiltration testing results, soils reports, etc.

## Site Drawing(s) Checklist

### Jurisdictional Features Required on All Maps or Drawings

i. North arrow
ii. Scale (including graphical scale)
iii. A title block containing the name of the project, the author of the map or drawing, the owner of record for the project, date of drawing creation, and any revision dates
iv. Property lines
v. Legend identifying the symbols used
vi. For plans containing E&S measures which require an engineered design, the signature and seal of a professional engineer licensed to practice in Connecticut

### Site Locus Map

i. Scale (1:24,000 recommended)
ii. Project location (show property boundaries and at least the area that is within 1,000 feet of the property boundaries)
iii. Roads, streets, buildings
iv. Major drainage ways (named watercourses, at a minimum)
v. Identification of any public drinking water supply watershed area and Aquifer Protection Areas

### Topography, Natural Features and Regulatory Boundaries

i. Existing contours (2-foot intervals, 1-foot intervals in “flat” locations) including areas on the site with slopes of 15% and greater
ii. Proposed grades and elevations

iii. Limits of cuts and/or fills
iv. Soils - Hydrologic Soil Groups and areas of highly erodible soils
v. Areas of shallow bedrock or ledge
vi. Areas of shallow groundwater, seeps, and springs
vii. Field delineated inland wetlands boundaries and regulatory buffer areas (upland review area) and vernal pool boundaries and associated upland protection buffer areas
viii. FEMA identified 100-year floodplains and floodways
ix. Streams (intermittent and perennial), lakes, ponds, drainage ways, dams/impoundments, and any associated water quality impairments and TMDLs. Existing vegetation types (coniferous forest, deciduous forest, meadow, etc.) including unique vegetation, plant community classification, significant tree species with a Diameter at Breast Height (DBH) of 24 inches and greater, and vegetation identified for preservation and non-disturbance during construction.
x. Tidal wetland boundaries and coastal resource limits (e.g., Coastal Jurisdiction Line, shellfish beds, submerged aquatic vegetation, Connecticut Coastal Boundary)
xi. Public water supply watershed, well head protection areas, Aquifer Protection Areas (including EPA Sole Source Aquifers)

### Drainage Patterns

i. Existing and proposed drainage patterns (including offsite areas, if required)
ii. Drainage area boundaries including size of drainage areas
iii. Size and location of culverts and storm sewers (existing and proposed)
iv. Size and location of existing and proposed channels or waterways
v. Major land uses of surrounding areas

### Road and Utility Systems

i. Proposed and existing roads and buildings with their location and elevations
ii. Access roads: temporary and permanent
iii. Location of existing and proposed septic systems
iv. Location and size of existing and proposed sanitary sewers
v. Location of other existing and proposed utilities, telephone, electric, gas, drinking water wells, etc.

### Clearing, Grading, Vegetation Stabilization

i. Areas to be cleared, and sequence of clearing
ii. Disposal of cleared material (off-site and on-site)
iii. Areas to be excavated or graded, and sequence of grading or excavation
iv. Areas and acreage to be vegetatively stabilized (temporary and/or permanent)
v. Planned vegetation with details of plants, seed, mulch, fertilizer, planting dates, etc.

## Erosion & Sediment Control Drawings (can be combined with Site Drawings)

i. Location of E&S measure on site plan drawing with appropriate symbol
ii. Construction drawings and specifications for measures
iii. Inspection and maintenance requirements of measures during construction of project
iv. Person responsible for inspection and maintenance during construction of project
v. Maintenance requirements of permanent measures after project completion
vi. Organization or person responsible for maintenance of permanent measures having the authority to maintain and upgrade control measures as designed or as needed to control erosion and sedimentation
vii. Handling of emergency situations (e.g., severe flooding, rains, or other environmental problems).
viii. If not provided in the narrative, the information listed in checklist paragraph 1.6 (see Narrative)

# Chapter 4 – Construction Phasing and Sequencing, and Special Treatments

This chapter provides guidance on construction phasing and sequencing, with sample construction sequences provided for large or potentially high-impact construction project types that involve difficult soil erosion and sediment control challenges. This chapter also addresses the integrated use of combinations of erosion and sediment control measures for specialized applications (i.e., special treatments). These types of construction activities have higher potential for adverse impacts and therefore require careful phasing and sequencing, and/or the use of multiple erosion and sediment control measures.

The measures described in this chapter should be implemented in conjunction with the guidance provided in Chapter 3 (Erosion and Sediment Control Plans) and Chapter 5 (Functional Groups and Measures), as well as the requirements of the CT DEEP Construction General Permit and other applicable local, state, and federal permits or approvals

## Part I – Construction Phasing and Sequencing

Construction phasing and sequencing are closely related and equally important concepts for soil erosion and sediment control.

- Construction phasing divides a construction project into multiple phases, which are distinct and complete sets of activities that have a specific functional goal wherein the work to be completed in one phase is not dependent upon the execution of work in a later phase in order to make it functional. Phasing involves disturbing only a part of a site at any given time to minimize the amount of area that is exposed and subject to erosion. Earth-disturbing activities and construction are completed, and soils are effectively stabilized on one part of the site before work begins on another part of the site.

- Construction sequencing is a site-specific work schedule that coordinates the timing of site development related land-disturbance activities and the implementation of temporary and permanent erosion and sediment control measures during any particular phase to minimize soil erosion and sedimentation.

Proper construction sequencing is required for all construction projects regardless of size. Wherever practicable, site construction activities shall be phased, with each phase having its own construction sequence and erosion and sediment control measures, to avoid the disturbance of over 5 acres at one time or 3 acres for sites that discharge directly to impaired waters consistent with the requirements of the CT DEEP Construction General Permit. Phasing and construction sequence are particularly important for large construction projects, which are defined as projects with a total land disturbance of 5 acres or greater, and projects that discharge directly to impaired waters. Large construction projects typically involve major construction activities (e.g., earthmoving, extensive drainage work or land grading) and heavy earthmoving equipment and may last more than one construction season (typically March through December). Phasing and sequencing are also recommended for smaller construction projects, particularly if they involve large cuts or fills, sites where land disturbance might affect water quality or sensitive natural resources, or complex construction activities.

Elements to consider when phasing construction activities include:[9]

- Not performing all site-disturbing activities at once
- The coordination of cuts and fills to minimize the movement and storage of soils on, off, and around the site
- Managing runoff separately in each phase
- Determining whether water and sewer connections and extensions can be accommodated
- Providing separate construction and residential accesses to prevent conflicts between residents living in completed stages of the site and construction equipment working on later stages

Detailed construction sequencing schedules should, at a minimum, include:[8]

- Design and installation criteria
- The erosion and sediment control measures that are to be installed
- Principal development activities
- Construction activities that should be completed and erosion and sediment control measures that should be installed before other construction activities are started
- Compatibility with the general contract construction schedule

Each phase of construction, regardless of the number of sequences it contains, requires a **preconstruction meeting** . Preconstruction meetings shall include the owner of record or authorized agent, the qualified professional who designed the project, all site contractors and subcontractors to be involved in construction, the qualified inspector who will be conducting inspections, representatives of the municipality in which the project is located, utility representatives (if any), and the agent or agents who have the responsibility and authority for the implementation, operation, and maintenance of the erosion and sediment controls. The purpose of the preconstruction meeting is to convey the design, stormwater control measures, erosion and sediment controls, plan implementation and routine site inspections, and contract requirements for the project prior to earth disturbance. The preconstruction meeting may identify modifications needed to the construction sequence and additional or modified erosion and sediment control measures. Such meeting shall also include a site walk of the project site. The preconstruction meeting agenda shall include, at a minimum, a review of the erosion and sediment control plan (E&S plan), permit conditions, the contractors' sequences and schedules for construction, site restrictions, and other special needs. Written documentation of the

[9] Rhode Island Soil Erosion and Sediment Control Handbook (Revised August 2014, Updated 2016).

preconstruction meeting shall include the date of the meeting and a report summarizing the meeting.

This section provides sample construction sequences for the following types of large or potentially high-impact construction projects:

- Buildings and Parking Lots
- New Roadway Construction and Roadway Reconstruction or Widening
- Underground Utility Projects
- Solar Array Projects

The typical construction sequences provided in this section are not intended as detailed site-specific sequences and shall be modified as necessary to meet specific project needs, site conditions, and regulatory requirements. These sequences assume work to be continuous and without delay. When work is suspended within the sequence, additional erosion and sediment controls may be required. Erosion and sediment controls shall be installed and maintained as dictated by the construction schedule and as specified in the E&S plan. Although required for all erosion and sediment control measures, inspections are not specifically listed in the construction sequences provided in this section. Inspection frequencies are specified in Chapter 5 for each functional measure as well as in the CT DEEP Construction General Permit.

## Building Sites and Parking Lots

This sequence applies to a single phase of a multi-phase project involving construction of buildings and parking lots.

1. Stakeout (i.e., mark limits with survey stakes by licensed surveyor) the limits of construction necessary to facilitate the preconstruction meeting. This is to assure that there is a clear understanding of the area to be disturbed for all parties.
2. Hold preconstruction meeting.
3. Stakeout the remainder of and install construction fencing or other physical barrier along the limits of construction, tree protection zones, and permanent post-construction stormwater controls.
4. Delineate, flag, and maintain setback/buffer distances between construction activities and nearby wetlands, water bodies, and sensitive resources, if applicable.
5. Install the construction entrance.
6. Install temporary and permanent safety and construction signage.
7. Install perimeter erosion and sediment controls and tree protection measures in accordance with the E&S plan.
8. Install temporary measures to protect permanent post-construction stormwater controls as they are installed and throughout the construction phase of the project so that they will function properly when they are brought online. Fence off areas where infiltration measures are proposed to prevent compaction of the underlying soils.
9. Cut trees within the defined clearing limits and remove cut wood. Chip brush and slash, and stockpile chips for future use or remove off site. Clearing and grubbing limits should

be defined by the design engineer in accordance with roadway design standards for safety (i.e., safe clear zone) and with consideration towards minimizing area of land disturbance and avoiding and protecting sensitive areas and natural features (see Low Impact Development site planning and design techniques described in Chapter 3).

10. Initiate appropriate soil stabilization measures as specified in the E&S plan during all phases of construction on all disturbed areas.
11. Install structural erosion and sediment control measures to divert flows away from exposed soils, retain flows, or otherwise limit runoff and minimize the discharge of sediment and other pollutants from the site (i.e., sediment basins or traps) in accordance with the E&S plan. Prior to installing structural measures, inspect existing site conditions to ensure discharge locations are stable. If not stable, review discharge conditions with the design engineer and implement additional soil stabilization measures prior to installing structural controls.
12. Strip and stockpile topsoil for reuse on the site. Preserve existing topsoil on the construction site to the maximum extent feasible and as necessary to support healthy vegetation. Manage the stockpiled soil in accordance with the functional measures described in Chapter 5 - Preserve and Conserve Soils. Either remove tree stumps to an approved disposal site or stockpile area to be chipped, or chip in place as indicated on the plans.
13. Make required cuts and fills. Prepare the subgrade for the topsoil areas, parking areas, and the building pad. Allow a reasonable amount of area around the footprint of the building for the construction activities. Coordinate cuts and fills to minimize the movement and storage of soils on, off, and around the site, and avoid performing all site-disturbing activities at once, leaving portions of the disturbed site vulnerable to erosion.
14. Begin construction of the building.
15. Install sanitary sewers, drainage systems and utilities to within 5 feet of the building or as otherwise modified by the design engineer to adjust for unforeseen site conditions.
16. Install permanent post-construction stormwater controls.
17. Prepare subbase, slopes, parking areas, shoulder areas, access roads, and any other area of disturbance for final grading.
18. Install pavement base material.
19. Where undesirable or unintentional soil compaction has occurred through storage of materials, use of construction equipment, or construction vehicle access, restore soil permeability and other physical, biological, and chemical soil functions to pre-compaction conditions through the use of soil amendments or surface roughening (e.g., tilling, discing, scarifying, or tracking).
20. Place topsoil where required. Complete the perimeter landscape plantings.
21. Fine grade, rake, seed, and mulch to within 2 feet of the curbing.

22. Upon substantial completion of the building, complete the balance of site work and stabilization of all other disturbed areas.
23. Install first course of pavement.
24. When all other work has been completed, repair and sweep all paved areas for the final course of pavement. Inspect the drainage system and clean as needed.
25. Install final course of pavement.
26. After site is stabilized, remove temporary erosion and sediment controls and bring drainage systems and permanent post-construction stormwater controls online.

### Limitations of Sequence

This construction sequence does not include the construction of an access road (see construction sequence for Roadway Construction, Reconstruction, or Widening), and it is not intended for redevelopment of previously developed sites. A more complex construction sequence is required for redevelopment of existing building site(s). Separate construction sequences are required for each phase of phased building development projects.

## New Roadway Construction and Roadway Reconstruction or Widening

This construction sequence applies to a single phase of new roadway construction, roadway reconstruction, or roadway widening.

1. Stakeout (i.e., mark limits with survey stakes by licensed surveyor) the limits of construction necessary to facilitate the preconstruction meeting. This is to assure that there is a clear understanding of the area to be disturbed for all parties.
2. Hold preconstruction meeting.
3. Stakeout the remainder of and install construction fencing or other physical barrier along the limits of construction, tree protection zones, and permanent post-construction stormwater controls.
4. Delineate, flag, and maintain setback/buffer distances between construction activities and nearby wetlands, water bodies, and sensitive resources, if applicable.
5. Secure the areas from vehicular traffic and pedestrian access and provide for maintenance and protection of traffic (for roadway reconstruction and widening).
6. Install the construction entrance. Install temporary and permanent safety and construction signage.
7. Install perimeter erosion and sediment controls and tree protection measures in accordance with the E&S plan.
8. Install temporary measures to protect permanent post-construction stormwater controls as they are installed and throughout the construction phase of the project so that they will function properly when they are brought online. Fence off areas where infiltration measures are proposed to prevent compaction of the underlying soils.
9. Cut trees within the defined clearing limits and remove cut wood. Chip brush and slash, and stockpile chips for future use or remove off site. Clearing and grubbing limits should be defined by the design engineer in accordance with roadway design standards for

safety (i.e., safe clear zone) and with consideration towards minimizing area of land disturbance and avoiding and protecting sensitive areas and natural features (see Low Impact Development site planning and design techniques described in Chapter 3).

10. Initiate appropriate soil stabilization measures as specified in the E&S plan during all phases of construction on all disturbed areas.
11. Install structural erosion and sediment control measures to divert flows away from exposed soils, retain flows, or otherwise limit runoff and minimize the discharge of sediment and other pollutants from the site (i.e., sediment basins or traps) in accordance with the E&S plan. Prior to installing structural measures, inspect existing site conditions to ensure discharge locations are stable. If not stable, review discharge conditions with the design engineer and implement additional soil stabilization measures prior to installing structural controls.
12. Strip topsoil within the right-of-way and slope limits and stockpile clean, invasive species free topsoil for reuse on the site. Preserve existing topsoil on the construction site to the maximum extent feasible and as necessary to support healthy vegetation. Manage the stockpiled soil in accordance with the functional measures described in Chapter 5 - Preserve and Conserve Soils. Either remove tree stumps to an approved disposal site or stockpile area to be chipped, or chip in place as indicated on the plans.
13. Cut or fill the proposed roadway to establish the subgrade. Coordinate cuts and fills to minimize the movement and storage of soils on, off, and around the site, and avoid performing all site-disturbing activities at once, leaving portions of the disturbed site vulnerable to erosion.
14. Install sanitary sewers and drainage facilities starting at the outfall and proceeding upgradient. Install remaining utilities (water, gas, electric, cable, fiber optic, telephone). Ensure that the drainage outlet protection is in place prior to any flow being allowed to discharge.
15. Install permanent post-construction stormwater controls.
16. Place, grade, and compact the roadway base material.
17. Where undesirable or unintentional soil compaction has occurred through storage of materials, use of construction equipment, or construction vehicle access, restore soil permeability and other physical, biological, and chemical soil functions to pre-compaction conditions through the use of soil amendments or surface roughening (e.g., tilling, discing, scarifying, or tracking).
18. Place topsoil and grade in all slope areas to within 2 feet of the proposed curbing.
19. Install first course of pavement.
20. Install curbing if required.
21. Apply stabilization measures to remaining disturbed areas in accordance with the E&S plan (topsoil, seeding, sodding, mulching, etc.)
22. Inspect and clean drainage system, as needed.
23. Install the final course of pavement.

24. After roadway shoulders are stabilized, remove temporary erosion and sediment controls and bring drainage systems and permanent post-construction stormwater controls online.

### Limitations of Sequence

Roadway reconstruction and widening projects come in many shapes and sizes and are highly project and site specific (e.g., most require varying degrees of horizontal and/or vertical realignment, some add only a single lane, some widen on one side of road, some on both, etc.). Although the sample construction sequence accounts for maintenance and protection of traffic, which is an important consideration for roadway reconstruction and widening projects, other project and site factors should be considered in developing a detailed sequence of construction for roadway reconstruction and widening projects.

## Underground Utility Projects

This sequence applies to the initial construction or reconstruction of underground utility lines in developed or undeveloped areas. These utilities may include, but are not limited to, sewer, water, subsurface drainage, gas, electric, telephone and cable.

1. Stakeout (i.e., mark limits with survey stakes by licensed surveyor) the limits of construction necessary to facilitate the preconstruction meeting.
2. Hold preconstruction meeting.
3. Stakeout the remainder of and install construction fencing or other physical barrier along the limits of construction, tree protection zones, and permanent post-construction stormwater controls.
4. Delineate, flag, and maintain setback/buffer distances between construction activities and nearby wetlands, water bodies, and sensitive resources, if applicable.
5. Secure the areas from vehicular traffic and pedestrian access. Provide for maintenance and protection of traffic.
6. Install temporary and permanent safety and construction signage.
7. Install all erosion and sediment controls and tree protection measures in accordance with the E&S plan.
8. Install temporary measures to protect permanent post-construction stormwater controls, if required, as they are installed and throughout the construction phase of the project so that they will function properly when they are brought online. Fence off areas where infiltration measures are proposed to prevent compaction of the underlying soils.
9. Sawcut pavement as shown on the plans.
10. Excavate trench, stockpile suitable materials. Use dewatering measures as needed. Remove unsuitable materials to a secured stockpile area. Whenever practicable, excavate no more than the linear feet of the construction project that can be completed and backfilled in the course of a normal workday.
11. Install utilities.

12. Backfill the trench with materials that meet the specification standards and required compaction.
13. On a daily basis repeat Items 9 through 12.
14. Where undesirable or unintentional soil compaction has occurred through storage of materials, use of construction equipment, or construction vehicle access, restore soil permeability and other physical, biological, and chemical soil functions to pre-compaction conditions through the use of soil amendments or surface roughening (e.g., tilling, discing, scarifying, or tracking).
15. Restore paved areas and apply stabilization measures in accordance with the E&S plan (topsoil, seeding, sodding, mulching, etc.).
16. After site is stabilized, remove temporary erosion and sediment controls and bring any permanent post-construction stormwater controls online.

### Limitations of Sequence

Utility installation can be challenging depending on existing site conditions. It is essential that the above outlined sequence be used to address existing site conditions. Dewatering and handling of surplus materials, as well as blasting, require site-specific sequencing and methods.

## Solar Array Projects

This sequence applies to solar array projects on undisturbed or previously cleared land and is intended to supplement the requirements in Appendix I (Stormwater Management at Solar Array Construction Projects) of the CT DEEP Construction General Permit as well as the requirements of other applicable local, state, and federal permits or approvals specific to solar array projects.

1. Stakeout (i.e., mark limits with survey stakes by licensed surveyor) the limits of construction necessary to facilitate the preconstruction meeting.
2. Hold preconstruction meeting.
3. Stakeout the remainder of the limits of construction, tree clearing limits (if applicable), locations of the solar array and inverter and transformer pads, and locations of permanent post-construction stormwater controls.
4. Delineate, flag, and maintain setback/buffer distances between construction activities, including activities associated with an access road or the electrical interconnection necessary for the solar array, and nearby wetlands, water bodies, sensitive resources, and property boundaries, consistent with the CT DEEP Construction General Permit solar array requirements as well as the requirements of other applicable local, state, and federal permits or approvals.
5. Install the construction entrance, perimeter fencing, and temporary and permanent safety and construction signage.
6. Install perimeter erosion and sediment controls in accordance with the E&S plan.

7. If tree clearing is necessary, cut trees within the defined clearing limits and remove cut wood. Chip brush and slash and stockpile chips for on-site use or remove off site. If tree clearing and stump removal is required beyond installing permitter controls, permitter controls must be stabilized first. Tree and stump removal should be limited to that required to install perimeter control and related activities (ie topsoil stockpile and tree/stump handling area).
8. Remove tree stumps from the solar array area and chip for on-site use or remove off site. No felled timber shall be left on the project area upon completion.
9. Initiate appropriate soil stabilization measures as specified in the E&S plan during all phases of construction on all disturbed areas.
10. Install structural erosion and sediment control measures to divert flows away from exposed soils, retain flows, or otherwise limit runoff and minimize the discharge of sediment and other pollutants from the site (i.e., sediment basins or traps) in accordance with the E&S plan. Prior to installing structural measures, inspect existing site conditions to ensure discharge locations are stable. If not stable, review discharge conditions with the design engineer and implement additional soil stabilization measures prior to installing structural controls.
11. Remove topsoil only in areas where necessary (i.e., where underground structures or conduits are proposed) and stockpile topsoil for reuse on the site. Preserve existing topsoil on the construction site to the maximum extent feasible and as necessary to support healthy vegetation. Manage the stockpiled soil in accordance with the functional measures described in Chapter 5 - Preserve and Conserve Soils.
12. Grade the site as needed to smooth irregularities in the ground created by tree removal and topsoil removal, if applicable. Seed (with temporary or permanent mix, as appropriate), mulch, or otherwise stabilize exposed soil.
13. Install access road (i.e., road used for the sole purpose of gaining access to the site from a public road or right-of-way or a road used solely to provide access between separate internal areas of fenced solar arrays and any other roads).
14. Install any other necessary roads including, but not limited to, perimeter road or road used to service the solar arrays.
15. Install solar arrays (e.g., supports, racking materials, and array modules), concrete pads for electrical equipment, and site features (e.g., permanent fencing and gates). This can occur after stabilization of any exposed soils.
16. Complete electrical work including aboveground and underground electrical wiring, underground conduit, inverters and transformer equipment, utility poles, etc.
17. Where undesirable or unintentional soil compaction has occurred through storage of materials, use of construction equipment, or construction vehicle access, restore soil permeability and other physical, biological, and chemical soil functions to pre-compaction conditions through the use of soil amendments or surface roughening (e.g., tilling, discing, scarifying, or tracking).

18. Place topsoil where required.
19. Fine grade, rake, seed, and mulch.
20. Plant other landscaping/vegetation, if applicable.
21. After site is stabilized, remove temporary erosion and sediment controls and bring permanent post-construction stormwater controls online.
22. Conduct equipment testing, inspections, and commissioning of the system.

### Limitations of Sequence

Solar array construction projects are highly site-specific. The above typical construction sequence does not reflect site-specific factors and unique applications such as installation of solar arrays on closed landfills, which have specific engineering and regulatory challenges.

# Part II – Special Treatments

This section addresses the integrated use of combinations of sediment and erosion control measures for specialized applications (i.e., special treatments). The following conditions or types of construction activities and associated special treatments are included in this section:

- Water Management and Slope Stability
- Stream Deflectors
- Construction Access Roads
- Utility Watercourse Crossings
- Soil Bioengineering
- Solar Array Projects
- Erosion and Sediment Control in Coastal Shoreline Environments

## Water Management and Slope Stability

Although not intended as geotechnical engineering design guidance, this section identifies important water management and slope stability considerations for the design of new slopes and the long-term stability of existing slopes. Three common types of slopes are addressed in this section – cut slopes, fill slopes, and existing slopes.

### Cut Slopes or Cuts into Existing Slopes

Before the extent and depth of the cut are determined, the following information should be gathered. In some instances, some of the following information may not be required. In those cases, detailed descriptions of the reasons for not gathering the information should be provided.

- **Visually assess the undisturbed slope if one exists.**

  - Look for signs of sloughing, sliding, and seepage. This information may prove important in determining the reaction of the slope to the proposed changes. With an undisturbed slope, determine the degree of slope. It may also prove helpful to determine the type of vegetation growing on the existing slope.
- **Investigate the underlying material.**
  - This could be done by using existing soil surveys or existing borings or test pits in the area. If this information does not exist, then information should be gathered through borings or test pits. Keep in mind that the extent of the information should not stop at the proposed toe of slope but should extend below the proposed bottom of the excavation.
- **Evaluate the soil layers for engineering characteristics.**
  - This can be performed in the field but is more likely to be performed through laboratory analysis of samples collected from borings or test pits to determine soil properties such as composition, permeability, and friction angle. These properties should be evaluated for each different type of soil encountered in the borings.

In the design, minimize the amount of runoff that will be allowed to flow towards and onto the proposed slope. Several measures exist within these Guidelines to help limit the amount of runoff allowed to flow over the embankment,, (e.g., Temporary Pipe Slope Drain, Temporary Lined Chute).

## Slope of Placed Fill

As in the preceding section, the following information should be gathered prior to final design.

Determine the purpose of the fill. Will it need to support a building foundation? Will additional fill be added at some future time? It is important to recognize the limitations of the specific fill which is to be used. It is best to compact the fill in layers (known as lifts). The extent and precision of the compaction will depend on the future use of the fill. It is often critical to strip existing topsoil and organic material off the existing slope and foundation area before filling takes place.

The designed slope angle must be suitable for the material that will be utilized. In some designs the toe of the fill slopes can be protected with riprap to allow an increase in the slope of the fill. The riprap can also be used to protect the slope from the erosive effects of water flow.

In a best-case scenario, the fill should be from one source and be of homogeneous material.  If several types of material are to be used, then it is important to make logical decisions on the placement sequence. For instance, it is unwise to place several layers of sand against a natural slope, only to backfill downslope of the sand with a fine silt or clay without providing adequate drainage.

It will be important to visually assess field conditions in the area of the proposed fill. One of the things to look for is the proximity of the fill to any existing slopes. Also note existing drainage patterns above the site. Filled slopes should not be subjected to concentrated overland flow.

### Failure of an Existing Slope

In many cases, natural and manmade slopes show signs of failure. Among these signs are cracks in the downgradient slope, cracks in the ground surface at the top of the slope running parallel to the break in slope, bulges or piles on the slope, and hollow areas on the slope. Sometimes slopes fail after or during a heavy rain or during spring months when the groundwater table is high. It is important to consider the timing of the failure for clues regarding the mode of failure. If the location is critical, these slopes will need to be repaired or stabilized.

Seepage and water are major factors in many slope failures. If seepage or overland flow is causing or worsening the slope condition, use engineered measures to convey runoff, direct runoff, and intercept groundwater (see Measure Selection Matrix, Chapter 3).

Precautions should be taken to prevent accumulated water from flowing on or down the slope.

### Possible Slope Repairs

The actual construction techniques used for the repair of some slope failures can be simple, consisting of a combination of measures found within these Guidelines. Some of the measures can be changed and modified to fit the situation or the preferences of the designer.

Figure 4- 1, Figure 4- 2 and Figure 4- 3 illustrate three different designs for the repair of slope failures that integrate the use of several erosion and sediment control measures to create a stable slope. Figure 4- 1 shows a drainage blanket covered with 4 to 6 inches of topsoil. Figure 4- 2 shows the use of gabions. When slope stabilization is associated with a waterway, this method can be modified to include the addition of topsoil above the expected water surface within the waterway as illustrated in Figure 4- 1. Drains shown in Figure 4- 3 intercept subsurface water in a series of subsurface drains to create a stable slope.

Many parameters need to be considered in the design of stable slopes. These Guidelines are not meant to be a detailed engineering design manual for slope stabilization but are meant to assist engineers and regulators in asking appropriate questions during design review and construction of projects resulting in new slopes.

Measures used to address water management within slopes for initial slope design and for the repair of slope failures include Land Grading, Subsurface Drain, Permanent Diversion with Subsurface Drain and any of the slope stabilization measures in the Stabilization Structures Functional Group.

*Figure 4- 1 Slope Repair Example 1: Using Drainage Blanket Covered with Topsoil*

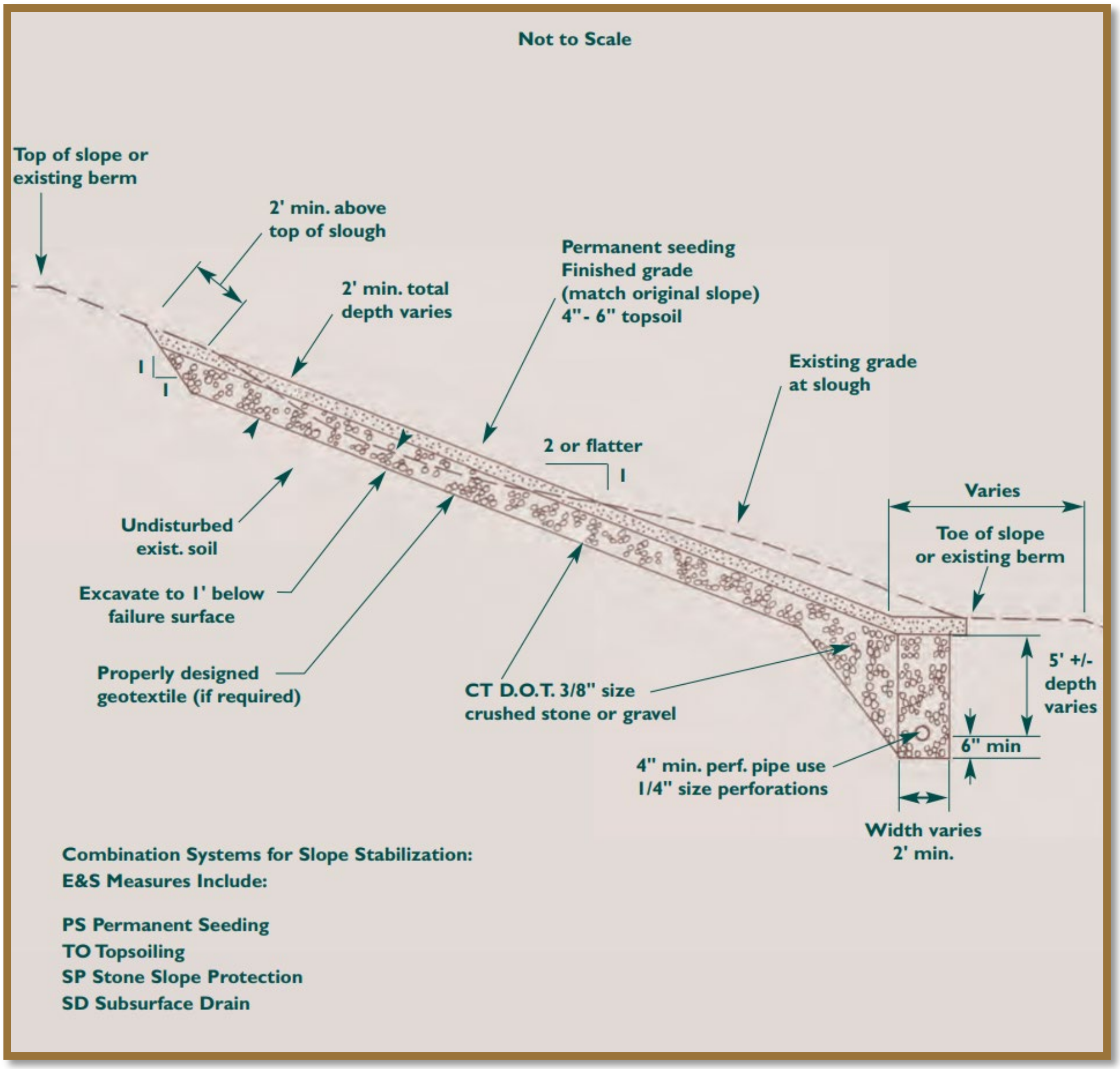


*Figure 4- 2 Slope Repair Example 2: Using A Gabion Blanket, Source: USDA-NRCS*

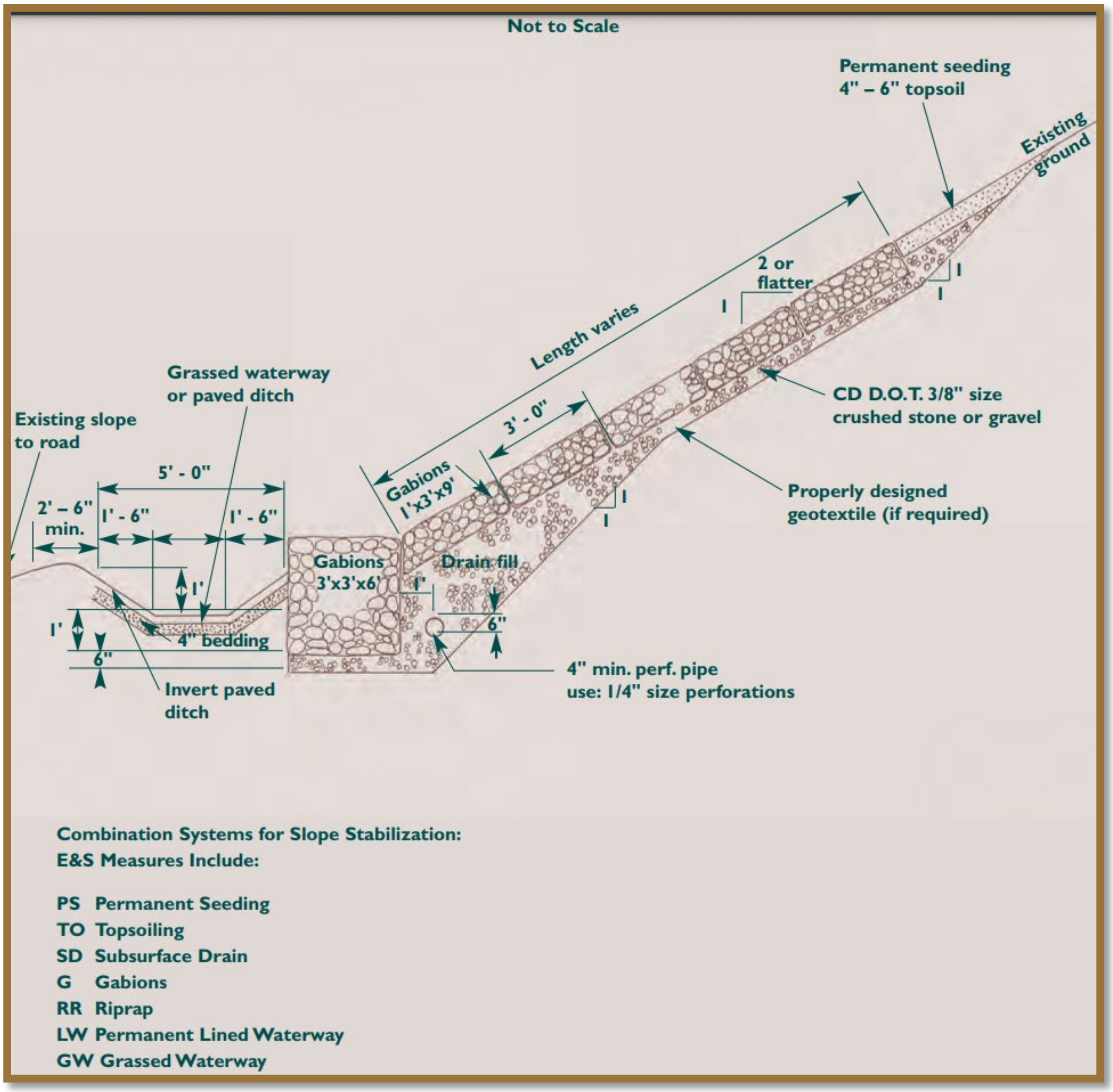


*Figure 4- 3 Slope Repair Example 3: Using Multiple Subsurface Drains, Source: USDA-NRCS*

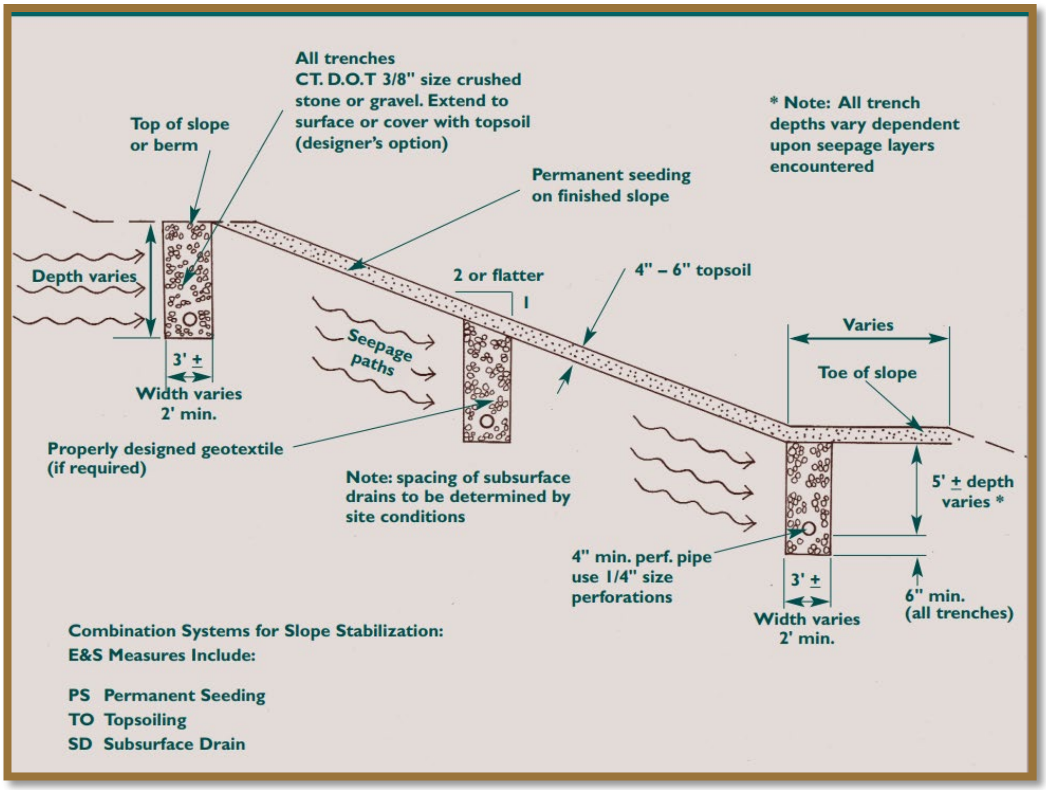
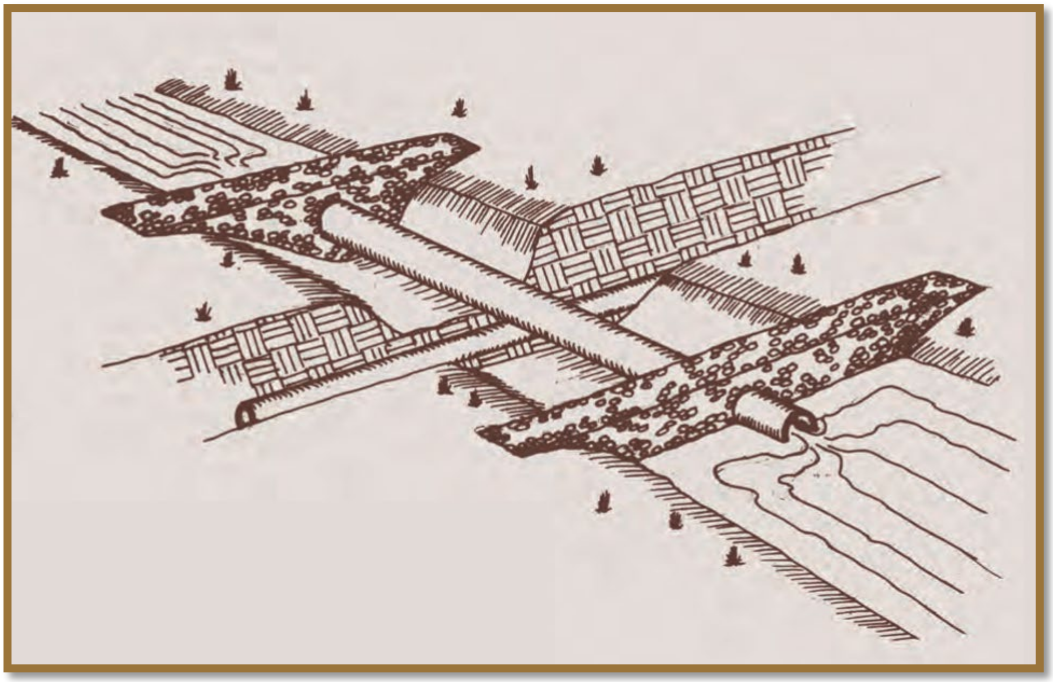



*Figure 4- 4 Pipe Flume Crossing Illustration, Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.*



## Stream Deflectors

Stream deflectors are structures placed within a stream channel that are used to divert flows away from a road, structure, utility, or unstable streambank. They may also be designated for the establishment of meanders, the concentration of flows, or aquatic habitat improvement. Deflectors can be constructed of a variety of materials, including rock, riprap, timber, or other materials.

Because of the nature of these structures and the effect that they can have on stream flow, they should be designed by a licensed professional engineer, fluvial geomorphologist, or other professional experienced in hydraulics and flow dynamics. An aquatic biologist should be consulted if the purpose is to improve aquatic habitat.

Important considerations in planning the use of stream deflectors are diversion direction, velocity, and effects on downstream conditions and structures. Extreme care must be taken to ensure that the redirected flow will not create a problem at another point in the stream. Questions to be answered in planning and design of stream deflectors include:

- Will the deflected water negatively impact the opposite bank?
- Will the increased velocities and tractive stresses cause unacceptable bank and bed erosion?
- Are the construction materials suitable for the planned longevity?
- Are the deflectors located and spaced for optimum results?
- Are the deflectors properly sized as to height and lateral extent?
- Are the deflectors designed to withstand loading from snags, ice, and debris? Deflectors designed with sufficiently low profiles should be overtopped during high flows and should not be susceptible to loading from ice, snags, debris, etc.

Depending on the design and site conditions, any number of erosion and sediment control measures (that are related to slope stabilization structures, drainage ways, watercourses, and sediment filters) may be used. See USDA Forest Service publication Wildlife and Fisheries Habitat Improvement Handbook, June 1992, for additional guidance on stream deflector design and construction.

## Construction Access Roads

Construction access roads are typically unpaved roadways consisting of a surface course and associated side slopes. During wet weather such roadways can generate significant quantities of sediment if not constructed with adequate erosion and sediment control measures.

To control erosion and flow conditions, utilize one or more of the following erosion and sediment control measures:

- Construction Entrance where the construction access road meets a paved access point
- Temporary Diversion and Temporary Lined Channel to control concentrated flows where they enter and cross the construction access road

- Temporary Stream Crossing to carry concentrated flows across the construction access road
- Outlet Protection, Level Spreader or Check Dam to dissipate energy and convert concentrated flows to sheet flow from diversions and in temporary channels
- Water Bar to maintain natural drainage patterns and break flow lines within the construction access road
- Geotextile Silt Fencing, Filter Sock and Straw Bale Barrier to provide protection at the toe of fill slopes and the discharges from water bars
- Temporary Soil Protection or Temporary Seeding/Permanent Seeding with Mulch for Seed to protect disturbed side slopes
- Dust Control when construction access road conditions create airborne dust.

Construction access roads should be carefully planned, choosing materials and erosion control measures to maintain the usefulness of the construction access road during wet weather while minimizing the potential for erosion. Consider the volume and type of construction traffic as well as the extent of natural ground that must be altered to accommodate the traffic. If no grading is required and the construction traffic is intermittent (such as access roads used to maintain utility lines) the measures may be limited to water bars, and/or some top dressing with gravel or stone in areas where the vegetation over soft soil is destroyed by the traffic. After access is no longer needed seeding and mulching of the disturbed area is required.

For construction access roads that require grading and filling or are to be heavily used, the creation of a stable, tractable, bearing surface resistant to erosion should be planned. If the existing soil and subsoil are not well drained, plan on importing a road base material such as that meeting the requirements in the CTDOT Standard Specifications for Roads, Bridges, Facilities and Incidental Construction. When the construction access road follows the same route as the permanent design road, constructing the grades and subgrade for the permanent roadway early in the construction may be advantageous.

Where possible, construction access roads should conform to the contours of the land, avoiding grades steeper than 10% and creating side slopes no steeper than 2:1. If the side slopes are steeper than 2:1, then use engineered slope stabilization methods (see Stabilization Structures Functional Group).

For solar array projects, maintain an undisturbed buffer of at least 10 feet between a construction access road and downgradient wetlands or waters unless the access road passes between two wetlands or waters and the undisturbed buffer cannot be achieved. In general, construction access roads that are constructed in or across wetlands require additional considerations:[10]

- **Avoid putting the construction access road in a wetland whenever possible.** Explore all feasible and prudent alternatives before determining that a wetland crossing is absolutely necessary. When avoidance is not possible, consider crossings that will cause

[10] See Appendix A, for possible regulatory requirements.

the least impact. This may involve locating the construction access road so that it crosses the wetland at its narrowest width or uses areas previously disturbed for access or other purposes. Also, consider the road's impact to adjacent uplands.

- **Minimize the width of the construction access road through the wetlands (generally no wider than 14 feet).** It is preferable to have a passing point created before and after the wetland crossing, but internal passing points may be needed if the crossing is long and sight line restrictions exist.
- **Consider the soil conditions.** Expect deep organic wetland soils to require geotextiles, wooden mats (mud mats), or other materials during use to keep construction access road materials separated from wetland soils. In shallow organic wetland soils, brush matting, wooden mats, and/or crushed stone may be sufficient to support a stable travel surface.[11]
- 
- **Prevent obstructions to surface and subsurface flow across and through the construction access road and provide adequate drainage.** This may require the use of crushed stone or multiple cross culverts, particularly if the wetland does not contain a well-defined watercourse channel or the crossing is long. If the wetland soils are susceptible to seasonal high-water tables or flooding, then give additional consideration for maintaining flows across or over the construction access road without causing erosion or siltation during such times.
- **Plan how the construction access road will be removed, and the wetland restored.** A road stabilization geotextile can assist in keeping imported soils segregated from the wetland soils and make wetland restoration easier.

Inspection of the construction access road and the associated erosion and sediment controls should occur at the end of each day the road is used and repairs to controls made immediately. If the road is not used for more than a week, inspect the erosion and sediment controls at a frequency as required by the erosion and sediment control measures used and in accordance with inspection requirements of applicable local, state, and federal permits or approvals. Repairs may include regrading or top dressing the traveled surface with additional aggregate to eliminate ruts, as well as those repairs required by each erosion and sediment control measure used.

## Utility Watercourse Crossings

Utility line construction, by virtue of its contiguous, linear nature, may require crossing of wetlands, streams, and intermittent watercourses. Although the time of in-stream construction should be limited to one month or less, there is the potential during that time for excessive sediment loss into a watercourse by both the disturbance of the approach areas and by the

[11] Additional requirements may be necessary in accordance with the US ACE Connecticut General Permit.

work within the stream bed and banks. Therefore, methods that allow for "working-in-the-dry" are recommended and described below.

Three "working-in-the-dry" methods employed for watercourse crossings include: (1) pipe flume crossing, (2) diversion channel crossing, and (3) sequential cofferdam crossing. The preferred utility watercourse crossing method depends upon the stream flow characteristics and the anticipated duration of construction. Regardless of the method used, a professional engineer licensed to practice in Connecticut is required to design any diversion channels and linings, temporary culverts, cofferdams, or other structures used.

### Pipe Flume Crossing

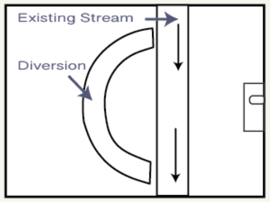
Used when in-stream construction will last less than 72 hours, and the contributing drainage area is less than 100 acres. It consists of a pipe and cofferdams of sandbags or gravel at each end of the pipe placed within the channel. The pipe is sized to handle the anticipated flow during the construction period. Check weather forecasts to avoid construction during anticipated storms. Upon completion of the utility installation, the watercourse channel between the cofferdams is re-established with stream bedding material that is equivalent to the pre-construction bedding material. The cofferdams and pipe are then removed, and channel banks stabilized (see Figure 4- 4).

### Diversion Channel Crossing

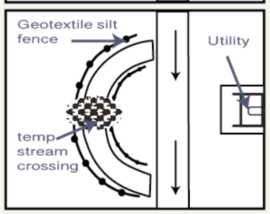
Used when in-stream construction will last longer than 72 hours. It consists of the construction of a temporary diversion channel (stabilized as needed with a channel lining to prevent erosion) with associated cofferdams and riprap to divert water flows around the stream, and a temporary stream crossing for construction access (see Temporary Channel Lining, Permanent Channel Lining, and Temporary Stream Crossing measures). The diversion channel is designed to safely pass flows in accordance with the CTDOT Drainage Manual section on "Temporary Hydraulic Facilities."

As with the pipe flume crossing, water that is trapped between the cofferdams is removed using the measures given in the Dewatering Functional Group. Upon completion of the utility installation, the watercourse channel between the cofferdams is re-established with stream bedding material that is equivalent to the pre-construction bedding material. Channel banks are then stabilized, the cofferdams removed, new cofferdams constructed at the inlet and outlet to the diversion channel, and the diversion channel backfilled and stabilized. Once started, stream relocation occurs without interruption until natural channel flows are re-established and the bank stabilization measure applied. See Figure 4- 5 for the recommended construction sequence and Figure 4- 6 for an illustration of a diversion channel crossing in progress.

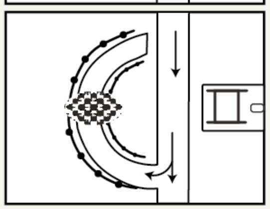
*Figure 4- 5 Diversion Channel Crossing Sequence, Source:  Adapted from "Damming by the Numbers" Erosion Control. July/August, 1995.*



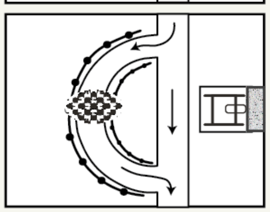

1. Excavate diversion channel with ends blocked. Install temporary channel lining.



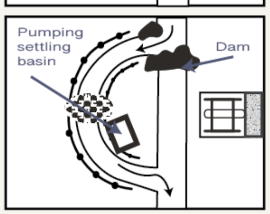

2. Install temporary stream crossing andperimeter E&S controls for diversion channel.



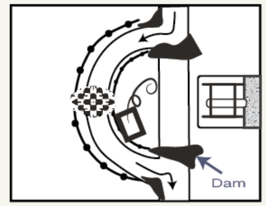
3. Open downstream end of diversion allowing water pressure to equalize in diversion.



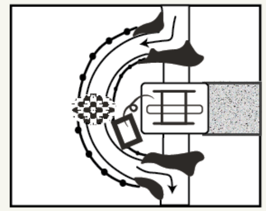
4. Open upstream end of diversion. Some sedimentation will occur.



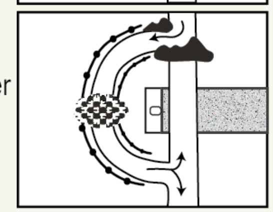

5. Construct non-erodable dam in the upstream end of the existing stream channel. Construct pumping settling basin.



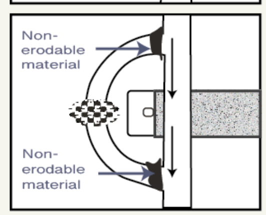

6. Construct non-erodable dam in the downstream end of the existing stream channel. Dewater blocked stream channel.



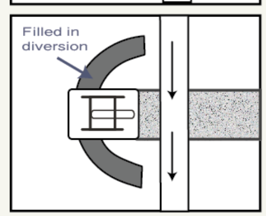
7. Construct utility across blocked streambed, detwatering as necessary.



8. After re-establishing stream channel, remove dam from downstream end of existing channel.



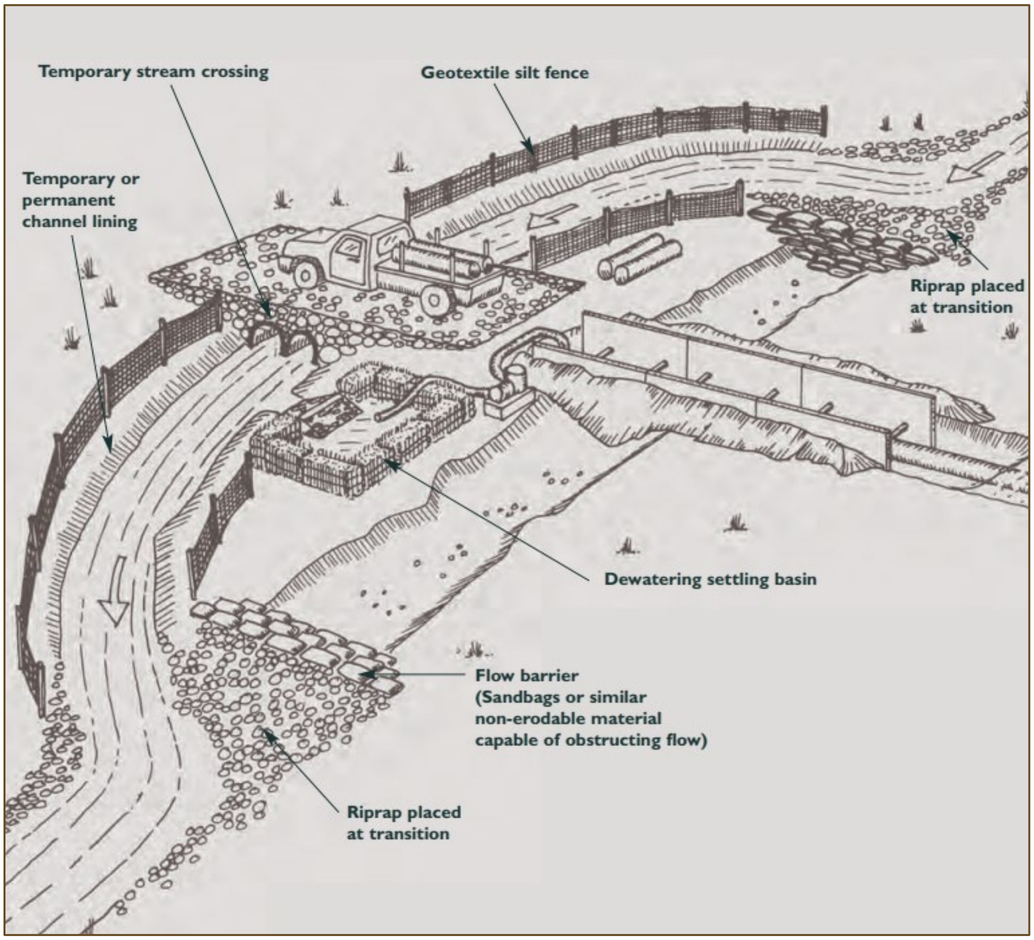

9. Remove dam from upstream end of existing channel. Fill in downstream and upstream end of diversion with non-erodable material.




10. Remove temporary stream crossing from diversion channel. Fill diversion channel continue utility contruction and stabilize disturbed soils.

*Figure 4- 6 Diversion Channel Crossing Illustration,*

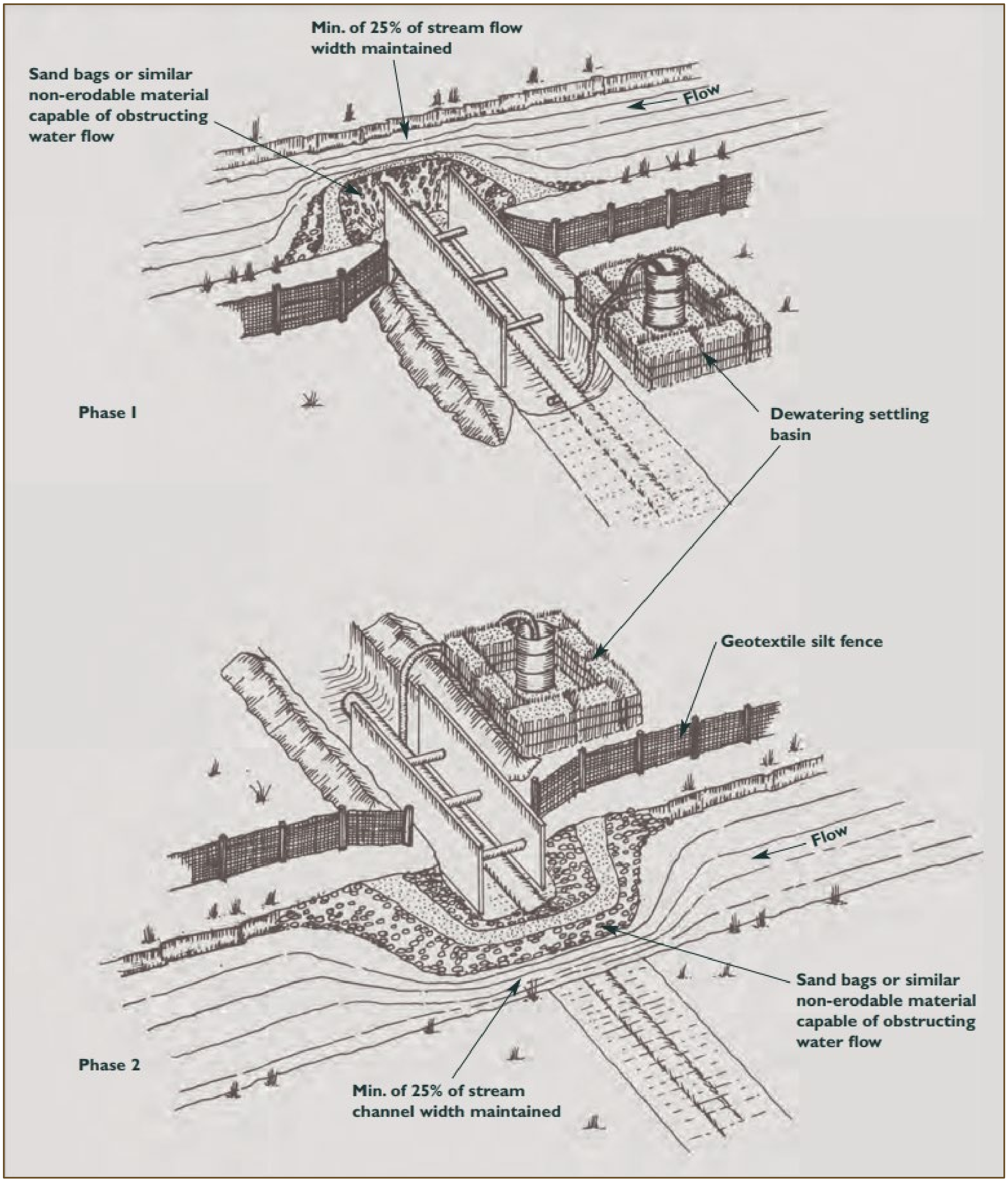
*Adapted from Virginia Erosion and Sediment Control Handbook. 1992*




## Sequential Cofferdams

Used only during low flows (typically between the months of June and October) when a diversion channel crossing is not practical, and the stream is wide enough (at least 10 feet) to make cofferdam installation practical. It consists of isolating more than half the watercourse channel from flow using sandbags or similar non-erosive material capable of obstructing water flow, constructing half the utility in the isolation area, removing the cofferdam, and reconstructing so that the remaining half of the utility can be constructed in the dry. To reduce the potential for flood damage to neighboring properties the height of the cofferdam should not exceed that which is needed to keep low flows out of the construction area and should allow for overtopping during storm events (see Figure 4- 7 ). Regardless of the method used, water that is trapped between or within cofferdams should be removed using the measures given in the Dewatering Functional Group.

*Figure 4- 7 Sequential Cofferdam Crossing Detail, Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.*




## Soil Bioengineering

Soil bioengineering is the use of live and dead plant materials in combination with natural and synthetic support materials (e.g., rock, wood, concrete, and geotextiles) for slope stabilization, erosion reduction, and vegetative establishment. The main construction materials are live cuttings and/or dead plant materials from suitable plant species, installed in specific configurations that provide soil protection and reinforcement.

Under certain conditions, soil bioengineering installations work well in conjunction with structural components to create a more permanent erosion control system with enhanced aesthetics and other environmental benefits. These benefits include the establishment of diverse and productive riparian habitats, shade, and the addition of organic matter to the watercourse, cover for fish, and water quality improvement.

Soil bioengineering techniques are applicable to upland slopes, stream banks, surface erosion, cut and fill slope stabilization, earth embankment protection (other than dams), small gully repair, and some shorelines. The bioengineering techniques described in this section are generally not appropriate for marine shorelines, which tend to be higher energy environments (see section on "Erosion and Sediment Control in Coastal Shoreline Environments" at the end of this chapter). Soil bioengineering techniques may not effectively mitigate severe scour (greater than 4 feet deep), severe roadway erosion, or deep-seated slope instabilities. In these situations, soil bioengineering can be used in combination with other engineering techniques.

Common soil bioengineering techniques include but are not limited to:[12]

- Fascines The placement of groups or bundles of twigs, whips, or branches which are staked into rows of shallow trenches, on the contour, then filled with soil. To stabilize slopes by slowing water movement down the slope, increasing infiltration, trapping slope sediments, and increasing soil stability with root systems. Can be used on sloping areas such as road cuts, slumped areas, road fills, gullies, and streambanks subject to erosion, seepage, or weathering, which have a low to medium hazard potential should slope failure occur.

- Bioengineering Fiber Rolls - A fiber roll is a coconut fiber, straw, or excelsior woven roll encased in netting of jute, nylon, or burlap used to dissipate energy along bodies of water. As a bioengineering technique, fiber rolls are used to dissipate energy along waterways; slow, filter, and spread overland flows for slope protection and to help prevent sheet and rill erosion and thus minimizes gully development; help reduce sediment loads to receiving waters by filtering runoff and capturing sediments; and provide a good medium for the introduction of herbaceous vegetation. Fiber rolls are suitable for streambanks, channels, and bodies of water where shear stress is low and water levels are relatively constant; along the toe, top, face, and at-grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow; at the end of a downward slope where it transitions to a steeper slope; and as check dams in unlined ditches (avoid using them in channels that are actively incising or in reaches with large debris loads or potential for significant ice buildup). They can be installed

[12] Rhode Island Soil Erosion and Sediment Control Hand Book (Revised August 2014).

along with permanent measures for source control and revegetation and along with temporary or permanent mulches

Fiber rolls can also be used as sediment barriers (see Sediment Impoundments Barriers and Filters) around the perimeter of a project, downslope of exposed soil areas, and around temporary stockpiles.

- Live Crib Walls - A combination of structural elements and vegetation. The structure is a hollow box-like structure made with an interlocking arrangement of untreated logs or timber members spiked together and anchored into the slope and filled with suitable earth fill materials. The vegetation is usually layers of live branch cuttings, which root inside the structure and extend into the slope. Live crib walls are used to protect exposed or eroded streambanks from the erosive forces of flowing water and stabilize the toe of slope, and to reduce steepness and provide stability where space is limited and a vertical structure is needed. Not intended to be used where the integrity of a road or structure is dependent on the crib wall since it is not designed to resist large lateral earth pressures.

- Live Staking - A stake or pole fashioned from live woody material (usually willow or poplar cuttings) that root easily and grow rapidly under certain conditions. Live staking is used to create a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by contributing to the reduction of excess soil moisture. Suitable for the repair of small earth slips and slumps that are frequently wet, the repair of raw streambanks, and for relatively uncomplicated sites when construction time is limited and an inexpensive vegetative method of stabilization is desired. Not intended to be used where structural integrity is required or where large lateral earth pressures must be resisted.

- Tree Revetments - A tree revetment consists of tree trunks and branches (without the root wad) overlapped and anchored to the earth with cables or earth anchors. Tree revetments are used to stabilize banks by absorbing energy, reducing velocity, capturing sediment, and enhancing conditions for colonization of native species. They are used primarily for bank stabilization in areas that are eroded or undercut and should not be used near bridges or other structures where there is a potential for downstream damage if a revetment dislodges and should not be used in streams that are flashy or in need of heavy maintenance.

A multi-disciplinary, site-specific approach is necessary for the design of functional soil bioengineering systems, combining the expertise of hydraulics engineers, geotechnical engineers, engineering geologists, landscape architects, horticulturists, biologists, water quality specialists, environmental planners, and others.

Detailed engineering design guidance on soil bioengineering techniques is contained in the following chapters of the USDA Natural Resources Conservation Service National Engineering Handbook, Part 650 (Engineering Field Handbook):

- Chapter 16 - Soil Bioengineering for Streambank and Shoreline Protection
- Chapter 18 - Soil Bioengineering for Upland Slope Protection and Erosion Reduction

## Solar Array Projects

Solar development in Connecticut and other states is an important strategy to further greenhouse gas emission reductions and other renewable policy objectives. Construction of large-scale solar arrays entails unique stormwater and erosion and sediment control challenges. If not properly managed, stormwater discharged during and after the construction of solar arrays can be a significant source of pollution resulting from increased runoff, erosion, and sedimentation, which can adversely impact wetlands or other natural resources. It is vitally important to stabilize soil, minimize soil disturbance and soil compaction, and manage the total runoff volume and velocity. Proper stormwater management practices can significantly mitigate the loss of topsoil, erosion and sediment discharges from disturbed areas and stormwater outlets, and erosion along downstream channels and streambanks.

As part of the reissuance of the CT DEEP Construction General Permit, CT DEEP has developed specific design and construction requirements for solar array construction projects that are subject to the general permit (Appendix I of the general permit), in addition to the other terms and conditions of the general permit. These requirements include both construction-phase erosion and sediment control measures consistent with these Guidelines and post-construction stormwater management measures in accordance with the Connecticut Stormwater Quality Manual, as amended.

Solar array projects that involve land disturbance but are not subject to the general permit (i.e., those that do not result in one or more acres of land disturbance) should implement the solar array provisions of the general permit as best practices to the maximum extent practicable.

## Erosion and Sediment Control in Coastal Shoreline Environments

Most of the erosion and sediment control principles and functional measures described in these Guidelines are applicable to construction activities statewide. However, coastal shoreline environments pose a unique set of challenges for soil erosion and sediment control due to the erodible nature of sandy soils combined with the intensity of wind and wave action commonly found along marine shorelines. Construction activities and sites waterward of Connecticut's Coastal Jurisdiction Line (CJL) and within coastal flood hazard areas are particularly susceptible to coastal erosion and inundation. Managing coastal erosion is particularly important as communities seek methods of adapting to sea level rise and increased coastal erosion and inundation driven by climate change.

"Living shoreline" techniques are the preferred approach for erosion control in most coastal shoreline environments. Living shorelines are a set of shoreline erosion control practices, ranging from non-structural vegetated approaches to hybrid hard structural/restorative natural methods, that address erosion, inundation, and water quality in a manner that improves or protects the ecological condition of the coastline. Such practices are designed to restore, enhance, maintain, or create natural coastal or riparian habitat (e.g., intertidal flats, tidal marsh, beach/dune systems, and bluffs), functions, and processes and to mitigate flooding or shoreline erosion through a continuous land-water interface.

Common living shoreline techniques for coastal environments include but are not limited to:[13]

- **Dune Creation and Restoration –** the placement of compatible sediment on an existing dune, or creation of an artificial dune by building up a mound of sediment at the back of the beach. Planting the dune with native, salt-tolerant, erosion-control vegetation with extensive root systems such as beach grass helps hold the sediments in place. Sand fencing can also be installed to trap windblown sand to help maintain and build the volume of a dune. Dune projects can also incorporate an engineered core within the dune such as coir fabric filled with sand or woven sleeves of non-biodegradable geotextile fabric that are filled with sediment (i.e., geotubes). Dune projects are appropriate for almost any area with dry beach at high tide and sufficient space to maintain some dry beach even after the new dune sediments are added to the site, and can be done independently, or in conjunction with a beach nourishment project.

- **Beach Nourishment –** the placement of sediment along the shoreline of an eroding beach from an outside source such as an offshore borrow site. It widens and/or elevates the beach and usually moves the shoreline seaward, increasing the natural protection that a beach can provide against wave energy and storms. This may be a component of a dune restoration/creation effort or a stand-alone project.

- **Coastal Bank Protection –** coastal bank protection, including slope grading, terracing, toe protection, and planting of natural vegetation reduces the steepness and protects the toe of the bank from further erosion. Coir logs and root wads are used to protect bank toes from erosion, while planted vegetation develops strong root systems. Natural coastal bank protection projects are appropriate for almost any tide range, topographic slope, or grain size, provided that the toe of the bank is situated above mean high water where it will not be regularly inundated.
- **Joint Planted Revetment -** revetments are shore-attached structures built along the shoreline to prevent erosion of the bank. Revetments are typically constructed from rock or concrete armor units, although alternative materials such as gabion baskets,

[13] Living Shorelines in New England: State of the Practice, Prepared for The Nature Conservancy by Woods Hole Group, July 2017.

rubble/debris, and even felled trees can also be used. The interstitial spaces in a traditional revetment can be planted to provide ecological benefits and help to stabilize the soil under the revetment.[14]

- **Marsh Creation and Enhancement –** marsh vegetation, such as native low (*Spartina alterniflora*) and high marsh (*Spartina patens*) species, are planted along the shoreline. Roots help hold soil in place, and shoots break small waves and increase sedimentation. Vegetation projects such as this are a minimally invasive approach. Fringing marsh living shoreline projects have proven successful with or without protective structures such as fiber rolls or sills, but projects without protective structures are most likely to be successful on sheltered waterways where there is low natural wave action and limited wave action from boating activities. Toe protection (e.g., natural fiber rolls, shell bags or, in some cases, stone) is important to hold the toe of the marsh platform in place where there is higher wave activity or threat of boat wakes.
- **Living Breakwaters –** constructed nearshore to break waves on the structure rather than on the shoreline to reduce erosion and promote accumulation of sand and gravel landward of the structure. Living breakwaters can be constructed of living reef materials (oysters/mussels) or bagged or loose shells, as well as stone or precast concrete structures (e.g., reef balls). Can be used in combination with other living shorelines practices to reduce the wave energy allowing the establishment of a beach or vegetated (typically marsh) shoreline in its lee.

The successful application of living shorelines practices is an emerging area of practice in the northeast and a key approach for coastal resilience and adaptation efforts along the Connecticut shoreline. The following resources provide detailed planning and engineering design guidance for living shoreline techniques:

- CT DEEP Living Shorelines Web Page
- CIRCA Green Infrastructure and Living Shorelines Web Page
- Living Shorelines in New England: State of the Practice (The Nature Conservancy and Woods Hole Group, July 2017)
- Systems Approach to Geomorphic Engineering (SAGE)
- Living Shorelines Engineering Guidelines (Stevens Institute of Technology and NJDEP, revised February 2016)
- Living Shorelines: The Science and Management of Nature-Based Coastal Protection (CRC Marine Science): Bilkovic, Donna Marie, Mitchell, Molly M., La Peyre, Megan K., Toft, Jason D.

[14] Living Shorelines Engineering Guidelines, Prepared for New Jersey Department of Environmental Protection by Stevens Institute of Technology, revised February 2016.

# Chapter 5 – The Functional Groups and Measures

## Introduction

This chapter provides detailed guidance on the individual soil erosion and sediment control measures that are addressed in the Guidelines. The measures are organized into the following functional groups:

Protect Vegetation

- Preserve and Conserve Soil
- Vegetative Soil Cover
- Non-Living Soil Protection
- Stabilization Structures
- Drainageways and Watercourses
- Diversions
- Subsurface Drains
- Energy Dissipators
- Sediment Impoundments, Barriers, and Filters
- Tire Tracked Soils
- Dewatering

Each of the measures within the functional groups is described in its own section of this chapter. The following information is provided for each measure to assist designers and reviewers select, implement, and maintain soil erosion and sediment control measures that are appropriate for a given project and site:

- Definition, purpose, and applicability of the measure
- Planning and selection considerations
- Specifications including materials, design criteria, and installation methods
- Inspection and maintenance considerations.

### What's New in this Chapter?

- References to updated design storm precipitation in Appendix D.
- Elimination of permanent Detention Basin measure. Design of post-construction stormwater quantity controls are addressed in the Connecticut Stormwater Quality Manual (SWQM) and CTDOT Drainage Manual.
- Greater emphasis on use of local seed sources that contain native or naturalized species to Connecticut for temporary and permanent vegetative soil cover.
- Updated guidance on fertilizer usage and best management practices.
- Updated Landscape Planting measure, including web-based resources for CT plant hardiness zone map, landscaping plant selection and planting details, and native plant sources.
- Addition of Cellular Confinement System and Articulating Concrete Block measures for slope stabilization.
- Elimination of the use of Hay Bale Barriers and replacement with Straw Bale Barriers as the preferred material for baled sediment barriers.
- Addition of Inlet Protection and Filter Sock (straw wattle, compost filter sock, and fiber roll) sediment barrier measures.
- Updated post-storm inspection criteria consistent with Construction General Permit.
- Updated Level Spreader design guidance consistent with CT SWQM design guidance.

# Protect Vegetation

## Planning Considerations

> **What's New in this Section?**
>
> - Protecting existing vegetation is an important aspect of Low Impact Development (LID)

The measure included in this group is Tree Protection.

The Tree Protection measure is used on sites where woody vegetation is intended to be kept as a site amenity. The protection and preservation of existing trees is an important aspect of Low Impact Development (LID) site planning and design and therefore, erosion and sediment control. Because it takes 20 to 30 years for newly planted trees to provide the benefits of mature trees, preserving natural areas and minimizing the limits of clearing and grading should be prioritized during planning. Established trees and shrubs are already adapted to their growing environment and have a root system that assists in keeping soils stable. By controlling construction equipment access and protecting as much of the root zone as possible existing vegetation can sometimes be retained. It can be less expensive to protect and maintain existing vegetation than to import new vegetation, which must recover from the transplanting process.

## Tree Protection

### Definition

The protection of desirable trees from mechanical and other injury during construction.

### Purpose

To ensure the survival of desirable existing trees for their effectiveness in soil erosion and sediment control during construction and after the adjacent land is developed, and because they provide significant other environmental benefits.

### Applicability

Where individual trees and forested areas are subject to land disturbing activities and where the protection and preservation of trees will aid in erosion and sediment control or provide other environmental benefits.

### Planning Considerations

It is best to consult an arborist or landscape architect licensed to practice in Connecticut[15] when considering tree protection options. The following are important planning considerations for tree protection.

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[15] CGS §23-61b. of the Connecticut General Statutes requires licensing for arboriculture: "No person shall advertise, solicit or contract to do arboriculture within this state at any time without a license issued in accordance with the provisions of this section". "Arboriculture" means any work done for hire to improve the condition of fruit, shade or ornamental trees by feeding or fertilizing, or by pruning, trimming, bracing, treating cavities or other methods of improving tree conditions, or protecting trees from damage from insects or diseases or curing these conditions by spraying or any other method; "Arborist" means one who is qualified to perform arboriculture and is licensed by the State Tree Protection Examining Board as provided in CGS §23-61b.

### Importance of Tree Protection

Trees can:

- stabilize the soil and prevent erosion,
- decrease stormwater runoff through canopy interception and root zone absorption,
- moderate temperature changes and provide shade,
- moderate the effects of sun and wind,
- provide visual buffers,
- filter pollutants from the air and produce oxygen,
- provide habitat for wildlife, and
- preserve and increase property values by increasing aesthetic values.

### Considerations for Tree Protection and Preservation.

Natural areas of existing vegetation should be preserved wherever feasible. Several factors weigh on the decision to retain specific trees or groups of trees.

> **Location:** Compatibility with the Developed Site - Trees must be appropriate for the intended use of the developed site. To avoid conflicts, review the location of proposed overhead and underground utilities, paved surfaces (like driveways, walkways, and patios), walls, water lines, septic tanks, underground drainage, and buildings. Determine if the existing trees to remain might interfere with these features when they grow to mature height, crown, and root spread. Select trees whose natural growth habit will remain contained within the design space.

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CGS §20-369 of the Connecticut General Statutes requires licensing for landscape architecture: "No person, except as provided in this chapter, shall engage in the practice of landscape architecture in this state or use the title "landscape architect" or display or use any words, letters, figures, title, signs, seal, advertisement or other device to indicate that such person practices or offers to practice landscape architecture in this state, unless such person has first secured a license as provided in this chapter." Landscape architecture means "rendering or offering to render the service of site planning, which may involve and encompass the design or management of land, the arrangement of natural and artificial elements, including, but not limited to, grading and incidental drainage, soil and erosion control, and planting plans, and the determination and consideration of inherent problems of the land relating to natural and artificial forces with concern for resource conservation in accordance with accepted professional standards of public health, safety and welfare, such service to be rendered to clients by consultation, investigation, reconnaissance, research, planning, specification, design or periodic observation; but does not include the physical implementation of such service, including, but not limited to, the actual on-site performance of grading, drainage, soil and erosion controls and planting work normally performed by builders, general contractors and subcontractors." "Landscape architect" means a person who holds a license to practice landscape architecture in this state as provided in CGS §20-369.

Condition: Trees should be healthy, preferably of good visual form, and reasonably free of large rotted or broken limbs or trunk sections that could threaten the structural integrity of the tree.

Check for evidence of diseases and pests that may seriously affect the health or survivability of the tree. Trees that leaf out abnormally late in the spring or that drop their leaves abnormally early in the fall are showing signs of stress and may have root problems which can have a significant impact on the tree's ability to withstand high winds, ice, and snow, especially if left in an exposed location. Consult a licensed arborist or landscape architect if there is any doubt as to the structural integrity of the tree.

Longevity: Long-lived, slow growing tree species, such as oak, hickory, beech, and some maples, should be given greater consideration for protection, particularly the larger specimens of these species. Beech trees do poorly in construction sites and may be difficult to save if their root systems are disturbed. Fast growing, brittle trees, such as birch, cherry, and poplar, are of limited long-term value. Naturally seeded young trees of appropriate species should be given preference especially when older trees on the site are of declining health. These vigorous young trees will typically grow faster than the equivalent nursery grown tree planted after development. Retaining groups of these trees provides the additional benefit of avoided land disturbance, and making it less subject to erosion.

When an individual tree is to be retained it is described by its size (normally the trunk diameter in inches at 4.5 feet above ground level, known as diameter at breast height or DBH), and by its species. Groups of trees, or forested areas to be retained, are described by their average tree size, including average height, species distribution, and density.

Aesthetic values: Trees that are well positioned in the landscape, well formed, unusually large, rare, uncommon, or unusually shaped can enhance the aesthetics of any site and are good candidates for protection and preservation.

Sanitation: Elm, black locust and some of the willows are noted for being "dirty." They drop twigs, bark, seeds, fruit, and plant exudates. Trees which seed prolifically, or sucker profusely are generally less desirable for retention.

Comfort: Trees relieve the heat of summer and buffer strong winds throughout the year. Deciduous trees drop their leaves in winter, allowing the sun to warm buildings and soil. Evergreens are more effective wind buffers.

Regulatory: Some natural areas including riparian corridors, wetlands and floodplains are protected by federal, state, and local policy. Review federal, state, and local requirements to ensure vegetated buffers are maintained.

Wildlife: Where appropriate, consideration should be given to retaining trees that provide food, cover, and nesting sites for wildlife.

## Stresses of Construction

Construction activities expose trees to a variety of stresses or conditions which may injure or cause a tree to decline in health and die within two to five years:

Above Ground Impacts: Construction related stresses exerted on the tree above the ground can cause significant damage:

- Excessive thinning or the removal of most trees from a group may leave remaining trees subject to wind throw. It is best to retain groups of trees rather than individuals.
- Improper pruning of trees can create future hazards by promoting disease and decay, and by altering the structure of the tree. Improper pruning can easily destroy the tree's aesthetic value or kill it.
- Equipment damage to tree trunks and lower branches increases the likelihood that wood boring insects will attack and damage or kill the tree and allows a path of entry for disease and decay organisms.

Below Ground Impacts: In natural growing conditions, tree roots extend out from the trunk from one to two times the height of the tree. Commonly the root zone extends well beyond the average extent of the branches of the tree. About 90% of the working roots, those that take in essential water, air, and nutrients, are usually located within the top 12 inches of soil. Construction related activities within a tree's root zone can cause significant damage.

- Raising the grade as little as six inches in the root zone area can retard the normal exchange of gases in the soil and small roots may suffocate. Raising the grade may also elevate the water table and drown the roots.
- Lowering the grade by 6 to 8 inches can remove most of the topsoil, destroy feeder roots and expose the upper root system to drying and freezing. Lowering the grade may also lower the water table, inducing drought. At a minimum, grading should not take place within the Critical Root Zone (see below) of any tree to be retained.
- Excavations may cut a large portion of the root system, depriving the tree of water and nutrients, and increasing the chance of disease and wind throw.
- Compaction of the soil by even limited operation of construction vehicles or equipment within the root zone of a tree will compact the soil severely, crushing the soil structure. This in turn inhibits the flow of air and water within and through the soil, altering the soil environment to the detriment of the tree.
- Breakage of roots can be caused by the operation of heavy equipment within the root zone of a tree.
- Construction chemicals or refuse disposed of in the soil can change soil chemistry or be toxic to trees.

### Tree Protection Zone and Critical Root Zone

The Tree Protection Zone (TPZ) is defined as a circular area surrounding a tree or group of trees with a diameter twenty times the DBH (diameter of the trunk of the tree measured at 4.5 feet above the ground). (See Example Calculation 5. 1 for an example calculating TPZ). Where groups of trees or forested areas require delineation of the TPZ, trees within 20 feet of the edge of the group or forest that have a larger DBH than the outermost trees should be noted to properly establish the TPZ. The TPZ encompasses and creates a buffer to the critical root zone. (See Figure 5- 1).

The Critical Root Zone (CRZ) is defined as a cylindrical area, with a diameter ten times the DBH, including the soil within this area to a depth of two to three feet. (See Example Calculation 5. 1 for example calculating CRZ). Where tree roots are severely crowded by sidewalks, paved surfaces, or buildings, and restricted by linear strips between sidewalks and roads, the CRZ should be extended to encompass the Tree Protection Zone (see below) where there are roots present. All TPZs should be delineated on the grading drawings.

When a significant portion of the TPZ or any portion of the CRZ must be impacted, obtain guidance from a licensed arborist or landscape architect. Disturbance within the CRZ can seriously threaten tree survival. The arborist or landscape architect should provide specific guidance on whether to keep or remove the tree, including measures to maintain tree health and safety. These measures may include clean cutting of roots exposed by excavation, maintaining grades and mulch (See Landscape Mulch measure), ensuring proper aeration and drainage, construction of tree wells and tree walls (see Figure 5- 1 and Figure 5- 2), pruning (see Figure 5- 3), mechanical protection of the tree trunk (see Figure 5- 5), and the possibility of tunneling under the CRZ[16] (see Figure 5- 4). When grades must be changed or trenching is to occur either within the TPZ or CRZ, the undisturbed portion of the CRZ must be protected by a fence.

*Example Calculation 5. 1 Calculating the Extent of TPZ and CRZ*

*Given:* Trunk is 15” or 1.25’

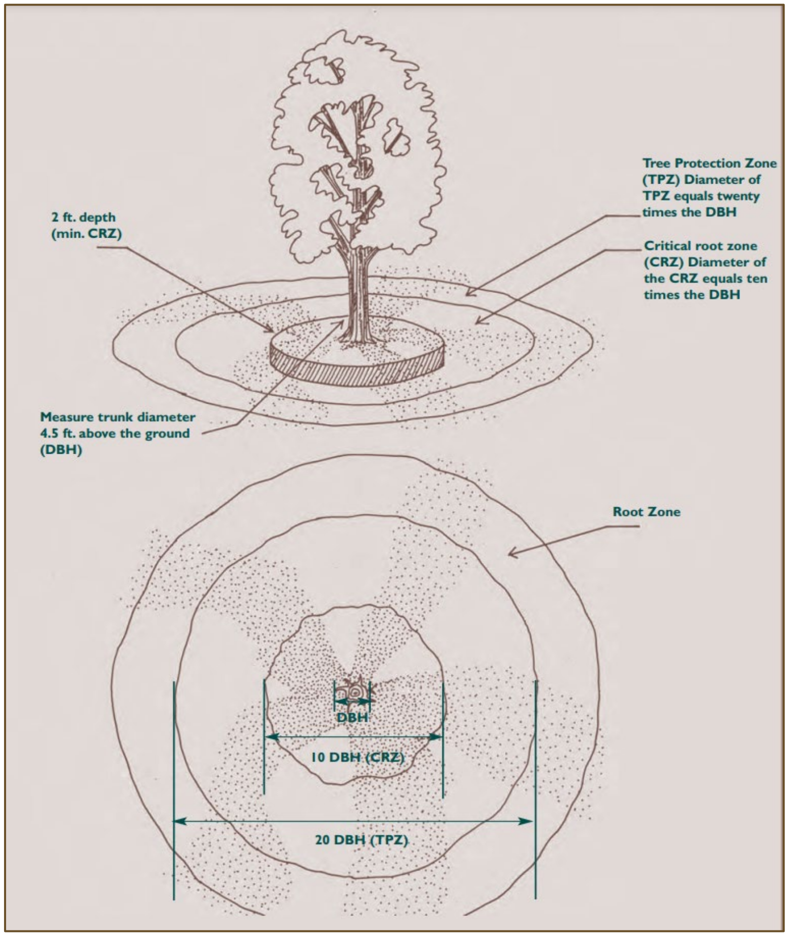
*Solution:*

TPZ diameter (ft)= Trunk DBH (ft)x20=1.25 x 20=25 feet,

CRZ diameter (ft) = Trunk DBH (ft) x 10 = 1.25 x 10 = 12.5 feet

[16] Tunneling is more expensive initially, but usually causes less soil disturbance and physiological impact on the tree’s root system. The extra cost may offset the potential cost of tree hazard abatement pruning, tree removal, and replacement.

*Figure 5- 1 Diagram of Zones Relating To Tree Protection*




Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.

*Figure 5- 2 Example of Tree Well*

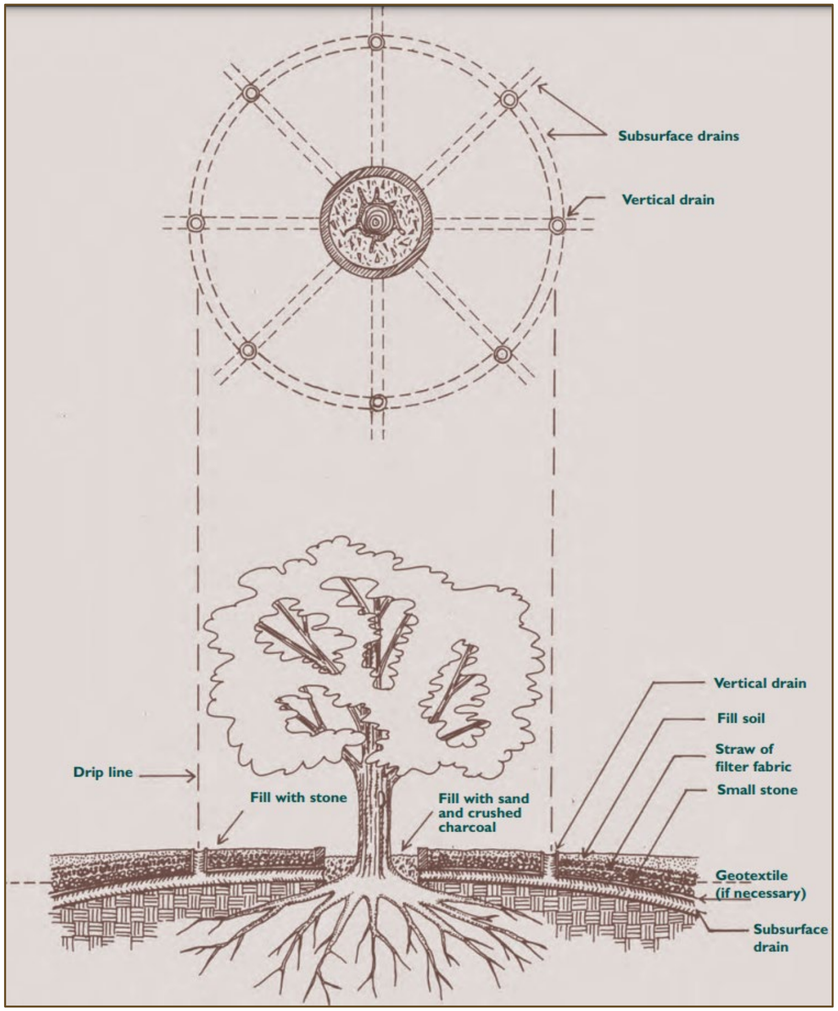
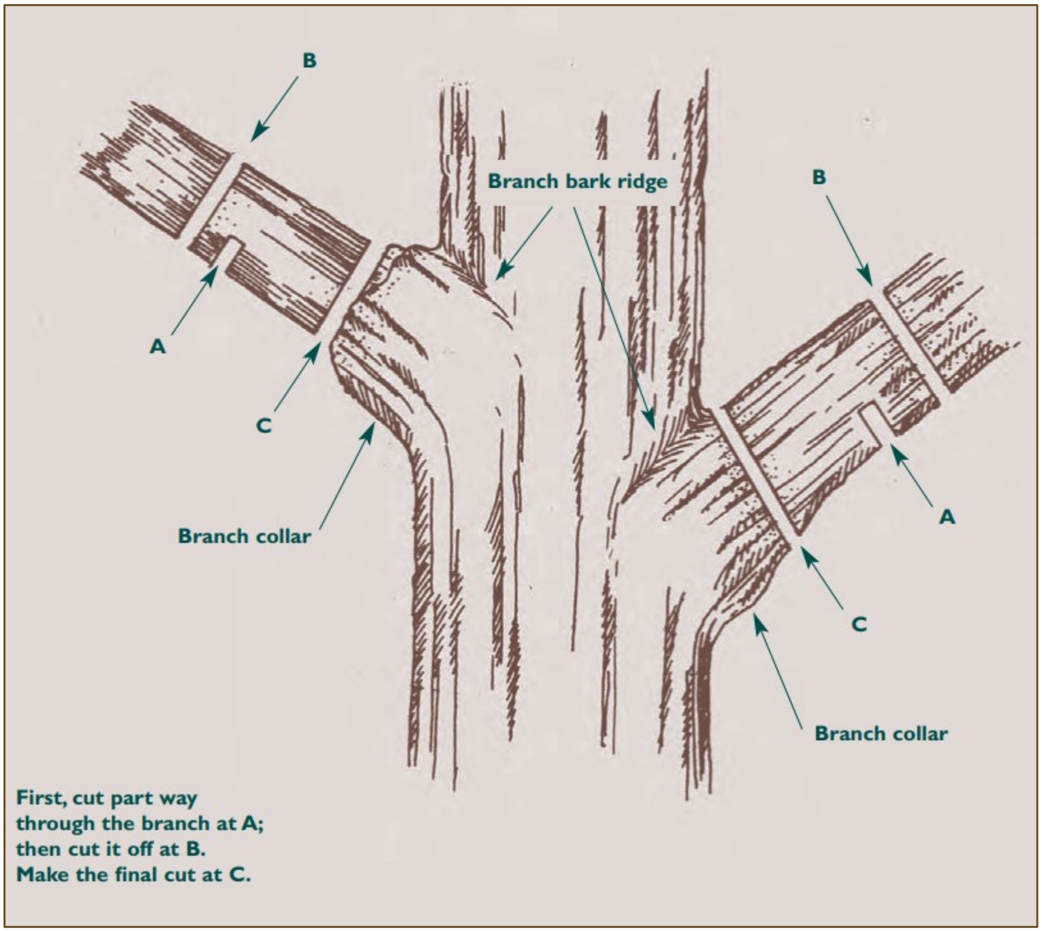


*Figure 5- 3 Pruning Details*




Source: Protecting Trees from Construction Damage - A Homeowner's Guide, University of Minnesota Extension Service. 1993.

*Figure 5- 4 Trenching vs. Tunneling*

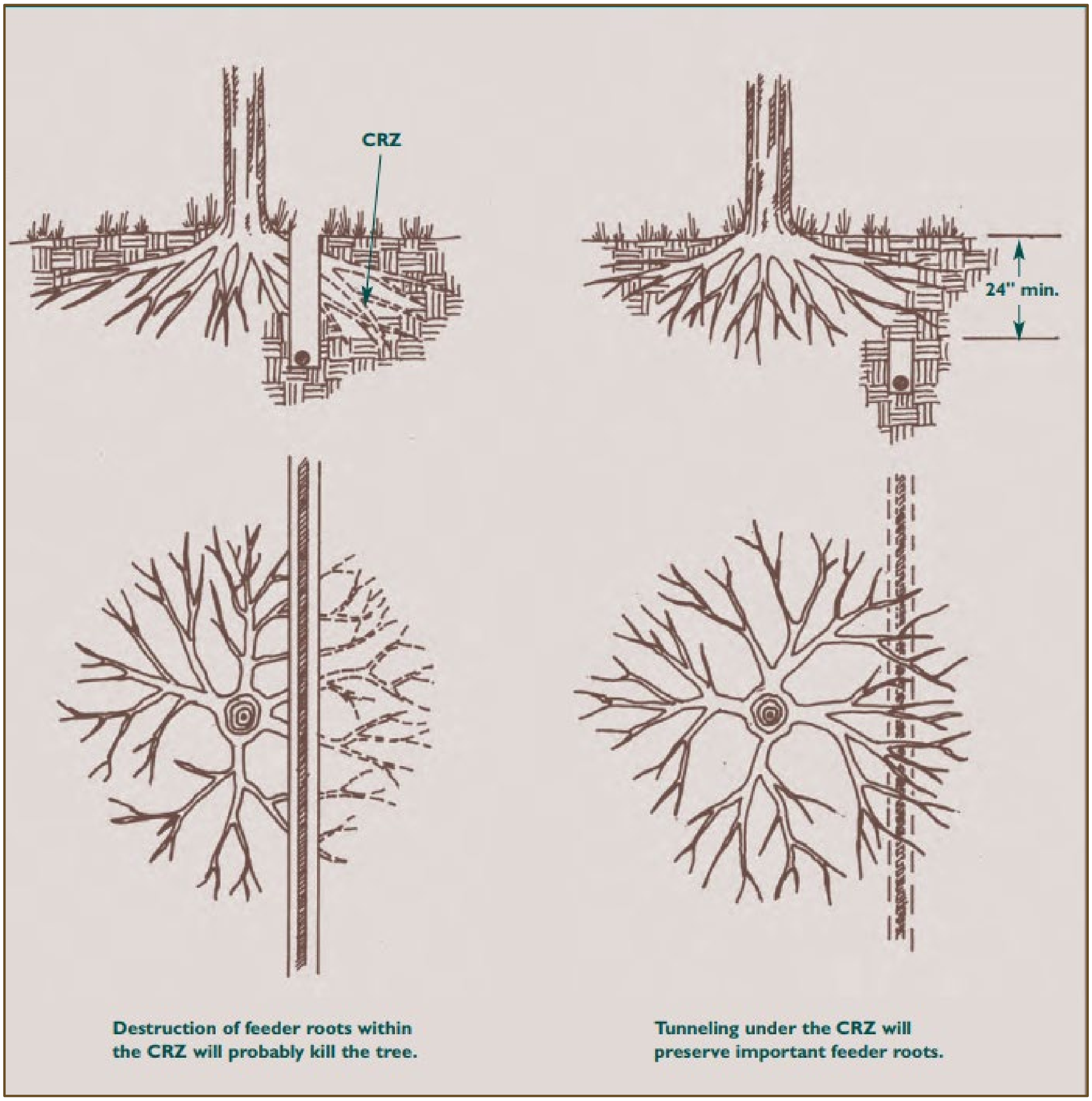
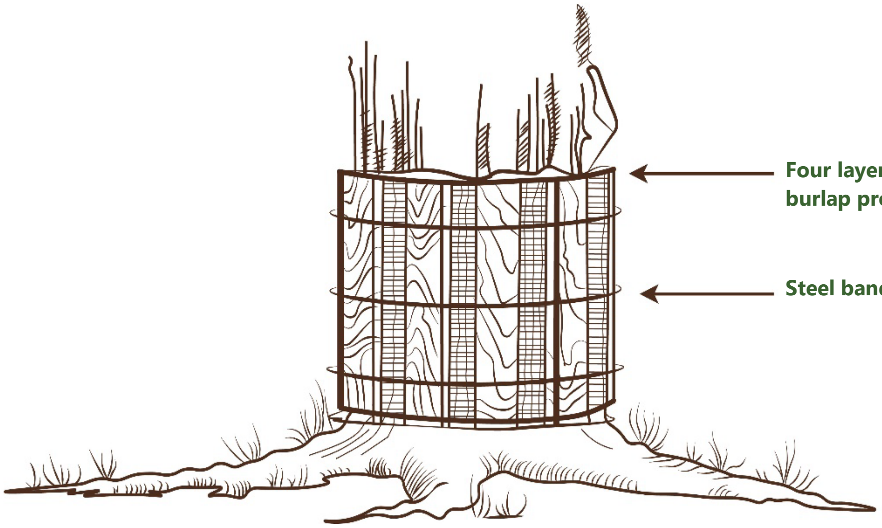


*Figure 5- 5 Mechanical Tree Protection*

Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.


**Correct methods of fencing tree protection**




**Correct tree armoring**

**Note: Use for protecting street tress adjacent to construction area where paved surfaces make it impractical to establish tree protection zone**

### Tree Protection Plans

When the decision has been made to require tree protection, the location and size of the individual trees or groups of trees to be retained should be identified on the erosion and sediment control drawing(s) and described in the E&S plan. Each individual tree to be retained should be described by its size (DBH) and by its species. Groups of trees or forested areas to be retained should be described by their average tree size, height, and species.

## Specifications

### Preconstruction Meeting

At the preconstruction meeting, review with the E&S agent, contractor and on-site construction supervisor or foreman the clearing limits, the trees to be protected, the location of tree protection zone(s), marking requirements for the protected trees and zones, allowed pre-construction trimming, equipment and chemical storage and disposal, and special construction methods to be used when grading is to occur within any tree protection zones.

### Pre-Clearing Tree Marking

Prior to the start of clearing activities, visibly mark or tag trees to differentiate the trees to be retained from those to be cut. Trees to be retained within the limits of clearing are typically marked with surveyor's ribbon applied in a band circling the tree at a height visible to equipment operators. Trees to be removed are typically spray painted with an "X" at a height visible to the equipment operator.

### Pre-Clearing Tree Protection Zone Marking

Mark the tree protection zones and restrict access by equipment. Use devices which will effectively protect the roots, trunk, and tops of trees retained within the protection zone.

> **Fencing:** Fencing is required to identify the protection zones of trees to be retained within 40 feet of a proposed building or excavation. Fencing shall be highly visible, of sturdy construction, and at least 3 feet high. Fences may be snow fence, chain link, board fence, geotextile silt fence, plastic fence, or similar materials (see Figure 5- 5). Consider fencing as permanent during the construction period and do not move or remove without the permission of the E&S agent. Where there is work within the tree protection zone, fencing is required to protect the CRZ.
>
> **Trunk Armoring:** Trunk armoring is a method of last resort to prevent damage to trees in situations where there are sidewalks, paved surfaces, or buildings that prevent adequate fencing the TPZ. This would include cases like urban "tree lawns," where trees grow between road curbs and sidewalks where even the CRZ cannot practically be fenced in (see Figure 5- 5).
>
> **Additional Trees:** Additional trees may be left standing as protection between the trunks of the trees to be retained and the limits of clearing. However, for this alternative to be used, the trunks of the trees in the buffer must be no more than six feet apart to prevent passage of equipment and material through the buffer. Reexamine these additional trees

prior to the completion of construction and either give sufficient treatment as may be necessary to ensure their survival or remove them.

### Preconstruction Pruning[17]

Before beginning construction, examine the trees selected for retention with a licensed arborist or landscape architect to determine if there is a need for pruning or temporarily tying back selected branches. This is to prevent unnecessary damage and breakage if equipment inadvertently strikes the branches. Typically, branches lower than 16 feet over travel ways will require tree pruning to facilitate the passage of vehicles.

### Equipment Operation and Storage

Prohibit and prevent heavy equipment travel, and storage or stockpiles of any construction materials, including topsoil, within the tree protection zone of any tree to be retained.  Refuel equipment only in designated fueling areas.

### Storage and Disposal of Hazardous or Toxic Materials

Properly store and contain all materials toxic to plants no closer than 25 feet from the tree protection zone of any trees to be retained. Do not dispose of hazardous or toxic materials such as paint, acid, nails, gypsum board, wire, chemicals, fuels, and lubricants in such a way as to contaminate soils or injure vegetation.

## Maintenance

Inspect tree protection zones weekly during site construction for damage to the tree crown, trunk, and root system and soil compaction. When trees have been damaged or when tree protection zones are violated during construction, immediately consult a licensed arborist or landscape architect to determine how damage should be addressed.

At the end of construction, once construction equipment is no longer expected to be used in the area, remove fences and barriers used for tree protection. The cleanup after a construction project can be a critical time for tree damage. Trees protected throughout the development operation are often destroyed by carelessness during the final cleanup and landscaping.

# Preserve and Conserve Soil

## Planning Considerations

The measures in this group include Topsoiling, Land Grading, Surface Roughening, Dust Control

and Stockpile Management. All five measures involve manipulating or amending

> **What's New in this Section?**
>
> - Revised and consolidated information on stockpiling. Revised guidance on use of lime and synthetic fertilizer.

[17] In addition, any activity involving the cutting, removal, harvesting or trimming of trees within the limit of public roads or grounds in the State of Connecticut is subject to CGS §23-65(f). Many towns also have local ordinances which place certain restrictions on tree cutting or pruning.

the soil surface in a fashion that will preserve and conserve the soils on site. These measures can be accomplished on an individual basis, in conjunction with each other, or in conjunction with other types of structural or nonstructural measures.

Topsoiling includes the stripping and (re)application of topsoil to improve soil fertility and enhance vegetative growth.

Land Grading places restrictions on slope lengths and grades for cuts and fills to reduce erosion for the establishment of a stable slope.

Surface Roughening is the creation of a rough surface on a slope and is applied after land grading has occurred. It is usually done in preparation for seeding and/or mulching.

Dust Control is applicable at all stages of site development and involves anchoring fine particles of soil by applying various materials.

Stockpile Management are procedures and measures to manage stockpiles of topsoil and other materials to reduce or minimize erosion of stockpile materials.

## Topsoiling

### Definition

The application of topsoil to promote the growth of vegetation following the establishment of final grades.

### Purpose

To provide a suitable growth medium for final site stabilization with vegetation.

### Applicability

- Where the texture, pH, or nutrient balance of the available soil (sands, gravels, or other unconsolidated materials) cannot be modified by reasonable means to provide an adequate growth medium.
- Where the existing soil material is too shallow to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth.
- Where high quality turf is desirable to prevent erosion and withstand intensive use and/or meet aesthetic requirements.
- Where landscape plantings are planned.
- Where extensive filling and cutting of slopes has occurred.
- Only on slopes no steeper than 2:1.

### Planning Considerations

Topsoil is the surface layer of a soil profile (known as the A horizon of a soil), generally characterized as being darker than the subsoil due to the presence of organic matter. This layer is the major zone of root development, containing most of the nutrients available to plants, and supplying a large amount of the water used by plants, and is the zone where the respiration of plant roots occurs.

Consider the following:

- **Need –** Vegetative growth is more rapid on sites with at least 4 inches of topsoil. Also, the health and quality of vegetation is better when topsoil is present. Topsoiling is strongly recommended where landscape plantings or high maintenance turf will be grown. Topsoiling is required when establishing vegetation on shallow soils, and soils with a pH of 4 or below (acidic).
- **Availability –** Determine if sufficient volume of topsoil exists on the site. If not, it will be necessary to identify additional sources of topsoil.
- **Costs –** Compare the cost of topsoiling to the cost of preparing a seedbed in subsoil (See Permanent Seeding, Sodding and Landscape Planting measures). Limed and fertilized subsoils with proper seedbed preparation may provide an adequate growth medium if moisture is not limiting. However, soil augmentation with synthetic fertilizer should be avoided or minimized to prevent negative impacts of nutrients in surface water (see Vegetated Soil Cover). Stripping, stockpiling, and reapplying topsoil, or importing topsoil can be expensive. Additionally, imported topsoil may contain weed seeds or invasive plants that are objectionable to the establishment of the permanent vegetation and may require additional treatments.
- **Scheduling –** The application of topsoil must be scheduled so as not to delay seeding or sodding operations. This delay increases the exposure time of critical areas, thereby increasing maintenance cost of existing controls.
- **Stockpiles Management –** Topsoil stockpiles need to be located away from construction activities. If topsoil is to be stockpiled longer than 30 days, it must be protected with a temporary seeding, matting or other acceptable means of preventing erosion.
- **Application Limitations –** Care must be taken when applying topsoil to subsoil if the two soils have contrasting textures or strongly contrasting density (i.e., hardpan). Topsoil applied to a compacted subsoil can result in water flows between the two soil layers, causing the topsoil to slough. Where hardpan exists, it must be loosened with appropriate equipment such as a disk or harrow prior to spreading topsoil to ensure adequate bonding. Additionally, for slopes 2:1 through 5:1 slope tracking is required prior to the placement of topsoil to improve bonding (see Surface Roughening measure).

## Specifications

### Materials

Topsoil shall inclusively mean a soil:

- meeting one of the following soil textural classes established by the United States Department of Agriculture Classification System based upon the proportion of sand, silt, and clay size particles after passing a 2-millimeter (mm) sieve and subjected to a particle size analysis:
  - loamy sand, including coarse, loamy fine, and loamy very fine sand,
  - sandy loam, including coarse, fine, and very fine sandy loam,

    - loam, or
    - silt loam with not more than 60% silt.
- containing not less than 6% and not more than 20% organic matter as determined by loss-on-ignition of oven dried samples dried at 105 degrees centigrade.
- possessing a pH range of 6.0-7.5, except if the vegetative practice being used specifically requires a lower pH, then pH may be adjusted accordingly.
- having soluble salts not exceeding 500 ppm; and
- that is loose and friable and free from refuse, stumps, roots, brush, weeds, frozen particles, rocks, and stones over 1.25 inches in diameter, and any material that will prevent the formation of a suitable seedbed or prevent seed germination and plant growth.

Topsoil may be of natural origin or manufactured by blending composted organic materials with organic deficient soils, mineral soils, sand, and lime such that the resulting soil meets the material specifications listed above. All topsoil shall be analyzed by a recognized soil testing laboratory for organic content, pH, and soluble salts requirements given above.

### Calculating Topsoil Needs

Topsoiling needs can be calculated by using the values given in Table 5. 1. Calculate topsoil needs in advance of stripping to determine if there is sufficient topsoil of good quality to justify stripping.

### Topsoil Stripping

Stripping shall be confined to the immediate construction area. A four to six inch stripping depth is common, but depth may vary depending on the soil. Place all perimeter dikes, basins, and other sediment controls prior to stripping.

*Table 5. 1 Topsoil Required for Application of Various Depths*

| Depth (inches) | Cubic Yards/ 1,000 sq. feet | Cubic Yards/ Acre |
|---|---|---|
| 4 | 12.4 | 537 |
| 5 | 15.5 | 672 |
| 6 | 18.6 | 806 |

### Stockpile Management

Stripped topsoil shall be stockpiled on-site in such a manner that natural site drainage is not obstructed and no off-site sediment damage results. In all cases, locate stockpiles to maximize the distance from wetlands and/or watercourses. When the stockpile is downgradient from a long slope, divert runoff water away from or around the stockpile (see Temporary Diversion measure).

The side slopes of all stockpiles shall not exceed 2:1. Install a geotextile silt fence or hay bale barrier around the stockpile area approximately 10 feet from the proposed toe of the slope (see Geotextile Silt Fence, Filter Sock, and Straw Bale Barrier measures). Stabilize the stockpiled material if it is to remain for a period of 30 days or longer (see Temporary Soil Protection, Temporary Seeding, Permanent Seeding, and Mulch for Seed measures for application timing requirements). The seed mix used depends upon the stockpiled material and the length of time it is to remain stockpiled. Information gathered from test pits or soil borings and soil delineation can be used to plan the type of seed and any soil amendments that are appropriate for the stockpile. After the stockpile has been removed, the site should be graded and permanently stabilized.

If a stockpile is located off-site, local zoning approval may be required. In addition to the above criteria, stockpiles that are located off-site require a construction entrance pad installed at that site (see Construction Entrance measure). Depending on the volume of traffic, the installation of "truck crossing" signs and sweeping of the roadway (see Dust Control measure) may also be necessary.

### Application of Topsoil

**Site Preparation:** Install and/or repair erosion and sediment control measures such as diversions, grade stabilization structures, waterways, silt fence, and sediment basins before topsoiling. Maintain these measures during topsoiling.

**Bonding:** After bringing the subsoil to grade (and immediately prior to spreading the topsoil), the subgrade shall be loosened by discing, scarifying, or tracking to a depth of a least 4 inches to ensure bonding of the topsoil and subsoil (see Surface Roughening measure). For a tracking description, see Surface Roughening measure.

**Applying Topsoil:** Distribute the topsoil uniformly to a minimum depth of 4 inches. Maintain approved grades when spreading topsoil. Correct any irregularities in the surface resulting from topsoiling or other operations in order to prevent the formation of depressions or water pockets.

Note: Do not place topsoil if the subgrade or the topsoil is frozen or excessively wet.

Ensure good contact with the underlying soil and obtain a uniform firm seedbed for the establishment of vegetation. Avoid excessive compaction as it decreases infiltration of runoff, increases runoff velocity and volume, and inhibits seed germination.

**Liming:** Where the pH of the subsoil is 6.0 or less, ground agricultural limestone shall be spread in accordance with the soil test to attain a pH of 6.0 to 6.5 or to attain a pH as required by the vegetative establishment practice being used.

**Stabilizing Applied Topsoil:** Immediately following topsoil applications, protect the topsoil from erosion by either sodding, seeding and/or mulching (see measures in the Short-Term Non-Living Soil Protection Group and the Vegetative Soil Cover Group).

#### Maintenance

Inspect and maintain in accordance with the surface protection measure(s) used.

## Land Grading

### Definition

Reshaping of the ground surface by excavation or filling or both, to obtain planned grades.

### Purpose

- To control surface runoff and reduce erosion potential.
- To prepare for the establishment of a vegetative cover on those areas where the existing land surface is to be reshaped by grading.

### Applicability

- Where grading to planned elevations is practical for the purposes set forth above.
- On slopes no steeper than 2:1. For slopes steeper than 2:1, see the slope stabilization measures in the Stabilization Structures Functional Group.
- Does not apply to bedrock cuts or faces.

### Planning Considerations

Consistent with Low Impact Development (LID) site planning and design strategies (see Chapter 3), utilize the existing topography and natural features as much as possible when developing a grading plan. This minimizes the degree of land disturbance and avoids extreme grade modifications within a site development.

The two primary factors that determine the potential for excessive erosion on any site are length of slope and steepness. Long slopes without provisions for surface water diversions are much more susceptible to erosion than shorter slopes. As slopes become steeper, the potential for erosion also increases.

Obtain sufficient topographic, soils, hydrologic, and geologic information to determine what limitations, if any, are to be considered in a development plan and grading operation. Final slope stability, the impact of the grading operations on adjacent properties and drainage patterns, and the effect of land disturbance on existing vegetation, ground and surface water resources are examples of concerns that must be addressed during planning for land grading.

In situations where geologic and hydrologic conditions clearly indicate a potential stability problem, structural measures shall be considered. Consider the presence of bedrock. Seepage combined with steep slopes and the proximity of bedrock very often result in an unstable condition. Surface and subsurface drains may be needed to remove excess water.

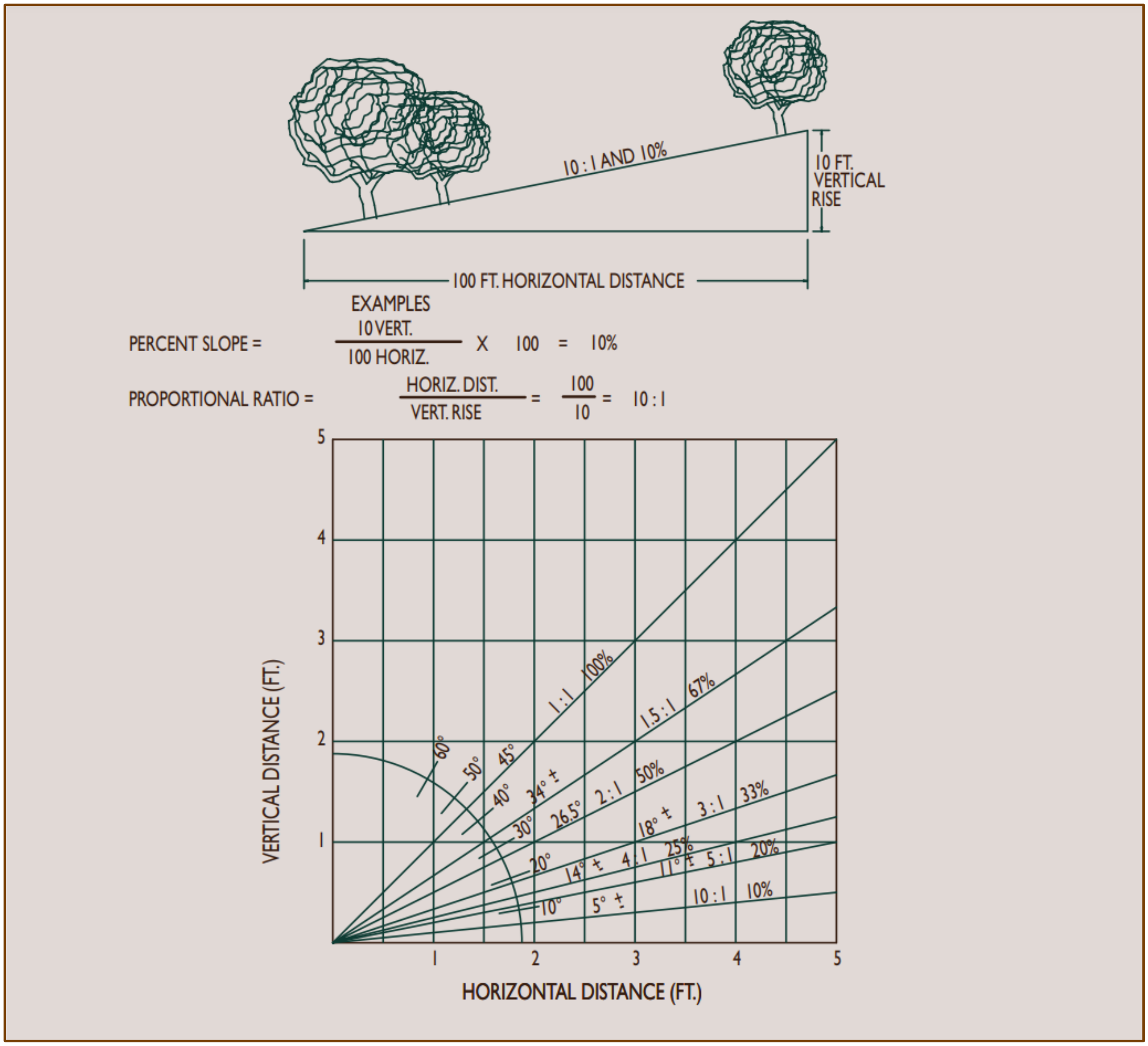
For fill slopes that will take more than 1 day to construct, consider requiring the use of a Temporary Fill Berm and associated Temporary Pipe Slope Drain, as may be needed. At the end of the workday divert erosive stormwater runoff away from the unstable slope to a stable discharge point.

## Design Criteria

### Slope Defined

Slope is the relationship of horizontal distance to vertical distance and is referenced as either horizontal to vertical, a ratio of horizontal to vertical, or a percentage of the vertical divided by the horizontal. Figure 5- 6 identifies the methods by which slope is determined.

*Figure 5- 6 Determining Slope, Source: USDA-NRCS*




### Slope Gradient Limitations

Vegetated Mowed Slopes: Where a slope is to be vegetated and mowed, the slope shall not be steeper than 3:1; flatter slopes are preferred because of safety factors related to the operation of equipment.

Vegetated Unmowed Slopes: Where a slope is to be vegetated but not mowed, the slope shall not be steeper than 2:1.

**Structurally Stabilized Slopes:** For slopes steeper than 2:1, or when slopes are steeper than 3:1 and the change in elevation exceeds 15 feet without a cross slope bench, engineered structural design features shall be incorporated. Applicable engineered measures may include those found in the Stabilization Structures Functional Group (see Table 3. 2, Selection Matrix) or other structural measures designed by the engineer.

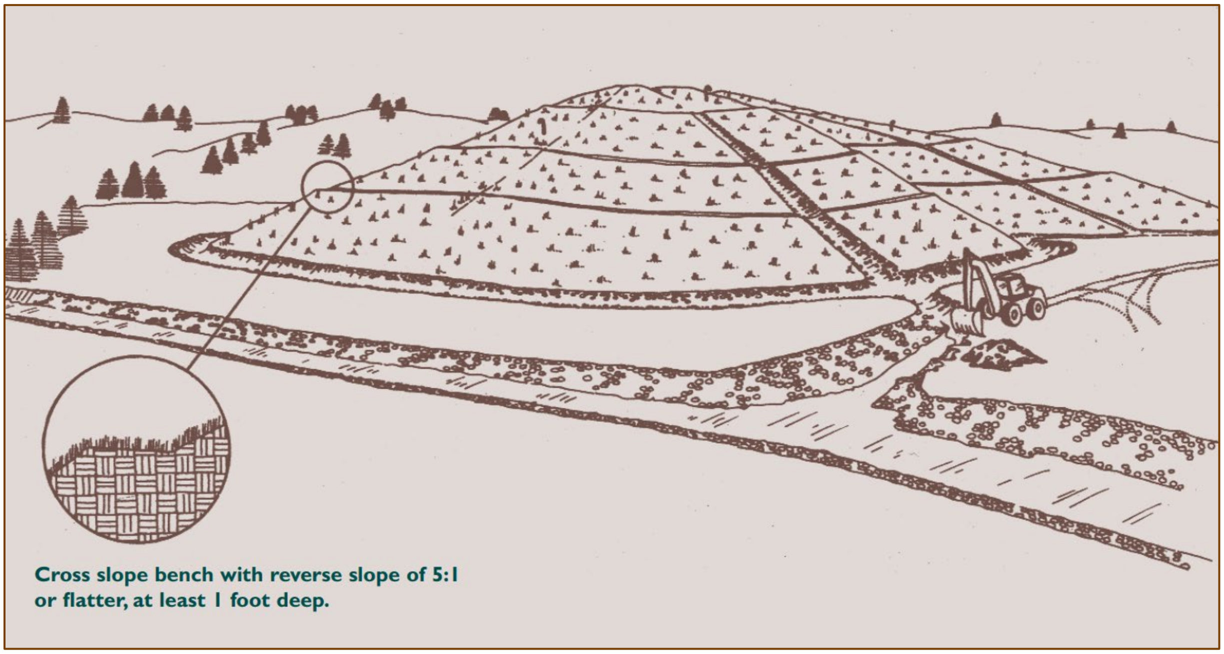
**Exceptions:** Slope limitations may be increased providing detailed soil mechanics analysis

### Reverse Slope Benches

Reverse slope benches are required whenever the vertical height of any slope steeper than 3:1 exceeds 15 feet (see Figure 5- 7), except when engineered slope stabilization measures are included in the slope and/or a detailed soil mechanics analysis calculation has confirmed an acceptable factor of safety exists for the finished slope. Using the following design criteria provide:

- spacing between benches into nearly equal segments and convey the surface and subsurface water to a stable outlet while still considering soils, seeps, rock outcrops, and other site conditions.
- bench width(s) of at least 6 feet (or sufficient to accommodate construction and long-term maintenance equipment).
- reverse slope(s) of 5:1 or flatter between the outer edge of the bench and the toe of the upper slope.
- a minimum bench depth of 1 foot.
- bench gradient(s) to a stable outlet of at least 1% but not greater than 2%; and
- no total flow length(s) within the bench exceeding 800 feet unless accompanied by appropriate design and computations to demonstrate adequate capacity and stability.

*Figure 5- 7, Illustration of Reverse Slope Bench*




## Controlling Water Movement

Make provisions to safely convey surface runoff to storm drains, protected outlets, or to stable watercourses to ensure that runoff will not damage slopes or other graded areas. See measures in the Stabilization Structures Group, Vegetated Waterway, Permanent Diversion, Outlet Protection, and related measures. For slope designs that include engineered slope stabilization measures and where the change in elevation exceeds 15 feet without the inclusion of a reverse slope bench, perform an engineering analysis to determine the measures required to ensure runoff will not damage the slope or other graded areas. For all other slopes perform the following analysis.

**Surface Water:** Maximum allowable overland flow distance in feet to the top of the designed slope with no diversion of surface water is determined by use of the formula:

*Equation 5. 1 Maximum Overland Flow Distance*

$$A = X(15 - Y) \ \& \ B \leq 15X \quad where;$$

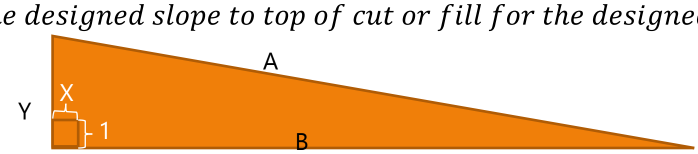
$$A = Maximum\ overland\ flow\ distance\ in\ feet\ above\ the\ crest\ of\ the\ design\ slope$$

$$B = Maximum\ horizontal\ distance\ in\ feet, shall\ not\ exceed\ 15X$$

$$X = Side\ slope; horizontal\ distance\ in\ feet\ to\ one\ foot\ vertical\ (e.g = 2\ designed\ for\ slope\ 2{:}1)$$

$$Y = Height\ of\ designed\ slope\ in\ feet\ measured\ vertically\ from\ toe\ elevation$$

$$of\ the\ designed\ slope\ to\ top\ of\ cut\ or\ fill\ for\ the\ designed\ slope$$



Either divert surface water from the face of all cut and fill slopes using diversions, ditches and drainageways or otherwise convey it down the slope using other appropriate measures. Surface water may be allowed to flow down cut and fill slopes when all the following conditions exist:

- the length of overland flow (in feet) to the crest of the designed slope does not exceed the distance “A”.

- the face of the slope is already stable, or the face of the slope is protected from surface runoff until it is stabilized (stability can be predicted by applying the Revised Universal Soil Loss Equation. See Appendix B).

- the face of the slope is not subjected to any concentrated flows of surface water from natural drainage ways and structures such as graded drainageways and downspouts; and

- the maximum total horizontal overland flow (A) plus maximumhorizontal distance (B) (does not exceed 15 times the side slope (X)) of the cut or fill slopes.

***An example that uses the formula referenced above:***

*Example Calculation 5. 2 Maximum Allowable Overland Flow Distance*

*Example Problem:* Determine the maximum allowable overland flow distance, A, for a 3:1 side slope with a vertical interval of 7 feet.

*Given:* X = 3 Y = 7

*Solution:* A = X(15-Y)

A = 3(15-7)

A = 24'

*Summary:* A = 24' and B = 15(X), Since X=3 then 15'(3') = 45'

*Therefore:* If the overload flow distance is <24, then A+XY and no diversion or cross slope bench is required. If overload flow distance is ≥24 feet, then a diversion or cross slope bench will be needed.

Subsurface Water: Subsurface drainage shall be provided where necessary to intercept groundwater seepage that would otherwise adversely affect slope stability or create excessively wet site conditions that would hinder or prohibit desired vegetative growth (see Subsurface Drain measure).

### Other Design Limitations

Slopes shall not be created close to property lines so as to endanger adjoining properties without adequately protecting such properties against erosion, sedimentation, slippage, settlement, subsidence, or other related damage. Soil material used for earth fill shall be obtained from an approved borrow pit or other designated area. The fill material shall be free of brush, rubbish, large rocks, logs, stumps, building debris, and other objectionable material that would interfere with, or prevent construction of, satisfactory fills. It should be free of stones over 2 inches in diameter where compacted by hand or walk-behind mechanical tampers or over 6 inches in diameter where compacted by rollers or other equipment.

Frozen material shall not be placed in the fill, nor shall the fill material be placed on a frozen foundation.

Stockpiles, borrow areas, and spoil areas shall be located away from steep slopes and surface waters and shall be shown on the plans. Soil stockpiles shall be subject to the provisions of this measure.

All disturbed areas shall be stabilized in accordance with the E&S measures contained in these Guidelines.

## Installation Requirements

1. Protect all graded or disturbed areas including slopes during clearing and construction in accordance with the approved erosion and sediment control plan until they are permanently stabilized.
2. Construct and maintain all erosion and sediment controls in accordance with the approved erosion and sediment control plan.
3. Clear and grub area to be graded. In filled areas where fill exceeds 5 feet in depth, grubbing may not be required.
4. Strip and stockpile topsoil required for the establishment of vegetation in amounts necessary to complete finished grading of all exposed areas.
5. Use only fill materials that are free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory fills. Frozen material or soft, saturated, or highly compressible materials shall not be incorporated into fills. Rock fill and other clean fill[18] may be used providing it does not interfere with the construction of structures.
6. Place and compact all fill in layers not exceeding 1 foot in thickness. No embankment layer shall be deposited on surfaces of snow or ice nor shall it be placed on frozen or unstable surfaces. Where embankments are to be constructed on slopes steeper than 3:1, deeply scarify the existing slope or cut into steps before filling is begun (see Surface Roughening). If fill placement is not completed within 1 day, then install temporary erosion and sediment controls, such as Temporary Fill Berm, as necessary to redirect runoff water away from the unstable slope until fill placement resumes.

[18] Clean fill is defined by Regulations of Connecticut State Agencies (RCSA)§ 22a-209-1.

7. Compact all fills as required to reduce erosion, slippage, settlement, subsidence, or other related problems. Fill that is intended to support buildings, structures, conduits, and other facilities shall be compacted in accordance with the design specifications.
8. Prior to final seeding, roughen slopes 2:1 through 5:1 to reduce runoff velocities unless the engineer directs otherwise. (See Surface Roughening measure)
9. If areas are to be topsoiled, refer to the Topsoiling measure.
10. During all phases of construction keep reverse slope benches free of sediment.
11. The treatment of seeps or springs encountered during construction shall be reviewed and addressed by the engineer in accordance with generally accepted engineering standards.
12. Apply permanent soil stabilization measures to all graded areas within 7 days of establishing final grade. (See measures in the Vegetative Soil Cover Functional Group.) If final grading is to be delayed for more than 30 days after land disturbance activities cease, temporary soil stabilization measures shall be applied in accordance with the Temporary Seeding measure and associated measures in the Short-Term Non-Living Soil Protection Functional Group.

### Maintenance

Inspect and maintain all erosion and sediment control measures implemented during land grading operations according to their respective requirements.

## Surface Roughening

### Definition

A rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine grading them.

### Purpose

- To promote the establishment of vegetative cover with seed.
- To reduce stormwater runoff velocity and increase infiltration.
- To reduce sheet erosion and provide for sediment trapping.

### Applicability

- On disturbed slopes whose gradients are between 2:1 and 4:1, inclusive.
- Not for slopes that are to be finished with a stable rock face, stone slope protection, or sod

### Planning Considerations

It is difficult to establish vegetation on smooth, hard surfaces. Roughened slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first; however, roughened slopes encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity.

Roughened loose soil surfaces, augment with lime and fertilizer only if necessary, based on soil test results, and provide seed protection from the erosive effects of rainfall and wind. Depressions in the surface provide microclimates which generally provide a cooler and more favorable moisture level than hard flat surfaces; this microclimate aids seed germination.

Different methods can be used for achieving a roughened soil surface on a slope. The selection of an appropriate method depends upon the type of slope. Roughening methods include grooving and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether it is a cut or fill slope.

It is important to avoid excessive compaction of the soil surface when roughening the surface. Tracking with dozer treads is preferable to not roughening at all but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff may be increased.

## Specifications

### For Areas Which Will Not Be Mowed

**Cut Slope Applications:** Cut slopes between 2:1 and 4:1, inclusive, shall be tracked or grooved (see Figure 5- 8). Grooving or tracking consists of using machinery to create a series of ridges and depressions which run perpendicular to the direction of the slope (on the contour). Grooves may be made with any appropriate implement which can be safely operated on the slope and which will not cause undue compaction. Suggested implements include discs, tillers, spring tooth harrows, dozer track cleats or the teeth on a wheeled loader bucket. Such grooves shall not be less than 3 inches deep nor further than 15 inches apart.

**Fill Slope Applications:** Fill slopes between 2:1 to 4:1, inclusive, shall be grooved or allowed to remain rough as they are constructed. As lifts of the fill are constructed, soil and rock materials may be allowed to fall naturally onto the slope surface after filling is completed if the surface is not sufficiently roughened. After filling is completed, if the surface is not sufficiently roughened groove or track surface the same as for cut slopes. Slopes shall not be bladed or scraped to produce a smooth, hard surface, except where slopes are meant to be used as a travel way for vehicles and additional erosion and sediment controls are installed.

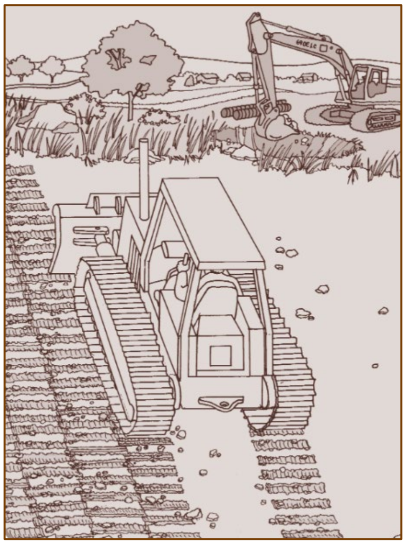
### Areas Which Will Be Mowed

Mowed slopes should not be steeper than 3:1. Excessive roughness is undesirable where mowing is planned. Surface roughening is not recommended for areas to be sodded (See Sodding measure). Areas to be seeded and mowed may be roughened with shallow depressions such as those that remain after harrowing, raking, or using a cultipacker seeder. Depressions formed by such equipment should be at least 1 inch deep and not further than 12 inches apart. The final pass of any equipment shall be on the contour (perpendicular to the direction of the slope).

#### Roughening With Tracked Machinery

Roughening with tracked machinery on soils with a high clay content is not recommended unless no alternatives are available. Undue compaction of surface soil results from this practice. Sandy soils do not over-compact, and may be tracked. In sandy soils tracking may not be as effective as other described roughening methods. When tracking is the chosen surface roughening technique, it shall be done by operating tracked machinery up and down the slope to leave horizontal depressions in the soil. As few passes as possible of the machinery should be made to minimize compaction. See Figure 5- 8.

*Figure 5- 8, Tracking Slopes*



#### Stabilizing with Seed and/or Mulch

Immediately following surface roughening, protect the soil from erosion by seeding and/or mulching (See measures in the Short-Term Non-Living Soil Protection Functional Group and the Vegetative Soil Cover Functional Group).

### Maintenance

Inspect and maintain in accordance with the surface protection measure(s) used.

## Dust Control

### Definition

The control of dust on construction sites, construction roads, and other areas where dust is generated.

### Purpose

To prevent the movement of dust from exposed soil surfaces, which may cause both off-site and on-site damage, be a health hazard to humans, wildlife, and plant life, or create a safety hazard by reducing traffic visibility.

### Applicability

- On unstable soils subject to construction traffic.
- Where unstable soils are located on hilltops or long reaches of open ground and can be exposed to high winds.

### Planning Considerations

When construction activities expose soils, fugitive dust is emitted both during these activities (i.e., excavation, demolition, vehicle traffic, rock drilling and other human activities) and as a result of wind erosion of the exposed earth surfaces. Large quantities of dust can be generated during “heavy” construction activities, such as road and street construction, subdivision, commercial or industrial development, and construction of solar arrays.

In planning for dust controls:

- Limit the amount of exposed soil by phasing construction to reduce the area of land disturbed at any one time and by using, as soon as possible, stabilization measures such as anchored Temporary Soil Protection, Temporary Seeding or Permanent Seeding with anchored Mulch for Seed, Landscape Plantings with Landscape Mulch, Sodding or Stone Slope Protection.
- Maintain as much natural vegetation as is practicable. Undisturbed vegetative buffers (minimum of 50-foot width) left between graded areas and areas to be protected can be very effective.
- Identify and address sources of dust generated by construction activities. Limit construction traffic to predetermined routes. Paved surfaces require mechanical sweepers to remove soil that has been deposited or tracked onto the pavement. On unpaved travel ways and temporary haul roads, use road construction stabilization measures and/or water as needed to keep the surface damp. Stationary sources of dust, such as rock crushers, use fine water sprays to control dust. If water is expected to be needed for dust control, identify the source of water in advance. Pumping from streams, pond and similar waterbodies may require approval from the municipal inland wetland agency.
- Identify and address sources of wind generated dust. Provide special consideration to hilltops and long reaches of open ground where slopes may be exposed to high winds. Consider breaking up long reaches with temporary windbreaks constructed from brush piles, geotextile silt fences, or straw bales. Plan on stabilizing slopes early. Mulch for seed will require anchoring when used.
- Consider water quality when selecting the method and/or materials used for dust control. When considering the use of calcium chloride, be aware of the following: the receiving soil's permeability to prevent groundwater contamination; the timing of the application to rainfall to prevent washing of salts into sensitive areas such as wetlands and watercourses; and proximity to sensitive areas such as watercourses, ponds, established or soon to be established area of plantings, where salts could impair or destroy plant and animal life. Additionally, some materials used for dust control may be rendered ineffective by degraded water quality if it is used for mixing.

Consider using dust control measures only after it is determined that other measures for soil stabilization cannot be practically applied.

## Specifications

### Mechanical Sweeping

Use mechanical sweeping on paved areas where dust and fine materials accumulate as a result of truck traffic, pavement saw cutting spillage, and wind or water deposition from adjacent disturbed areas. Sweep daily in heavily trafficked areas.

#### Water

Periodically moisten exposed soil surfaces on unpaved traveled ways to keep the traveled way damp.

#### Non-Asphaltic Soil Tackifier

Non-asphaltic soil tackifiers can be used in conjunction with water to bind very fine particulate matter and increase particle size. Non-asphaltic soil tackifier consists of a powder, emulsified media, or liquid soil stabilizer of organic, inorganic, or mineral origin, including, but not limited to the following: modified resins, calcium chloride, complex surfactant, copolymers, or high-grade latex acrylics. Materials used shall meet local, state, and federal guidelines for intended use. All materials are to be applied according to the manufacturer's recommendations and all safety guidelines shall be followed in storing, handling, and applying materials.

Important considerations:

- The solutions shall be non-asphaltic, nontoxic to human, animal and plant life, non-corrosive, and nonflammable.
- Shall never be applied directly to or within 100 feet of any surface waterbody.
- Should only be considered after conventional erosion and sediment control measures are installed. Conventional measures should be used to minimize the need for soil tackifiers.
- Soils should be tested ahead of application, so the appropriate soil tackifier type is selected.

### Maintenance

Inspect areas with dust control measures daily. Repeat application of dust control measures when fugitive dust becomes evident.

## Stockpile Management

### Definition

Procedures and measures to manage stockpiles of topsoil and other types of construction materials, including, but not limited to: paving materials such as Portland cement concrete (PCC) rubble, asphalt concrete (AC), asphalt concrete rubble, aggregate base, aggregate sub base or pre-mixed aggregate, asphalt minder (so called "cold mix" asphalt), and pressure treated wood.

### Purpose

To reduce or minimize erosion of stockpile materials.

### Applicability

- Any construction site.

### Planning and Design Considerations

Stockpile management of topsoil and other types of erodible soils is necessary to prevent unnecessary damage resulting from erosion of stockpile material.

### Requirements for All Stockpiles

- Be sure that all anticipated stockpile areas and stockpile management techniques are illustrated in the construction and site plans and flagged in the field.
- Locate stockpiles so that natural drainage is not obstructed. Attempt to maximize the distance of stockpiles from wetlands, watercourses, drainage ways, and steep slopes.
- Protect all stockpiles from stormwater run-on using a temporary perimeter sediment barrier such as berms, dikes, filter socks, geotextile silt fences, sandbag, gravel bags, or straw bales.
- When the stockpile is downgradient from a long slope, divert runoff water away from or around the stockpile (see Temporary Diversion measure).
- Install a geotextile silt fence, filter sock, or straw bale barrier around the stockpile area approximately 10 feet from the proposed toe of the slope (see Geotextile Silt Fence, Filter Sock, and Straw Bale Barrier measures).
- The side slopes of stockpiled material that is erodible should be no steeper than 2:1.
- Stockpiles that are not to be used within 30 days need to be seeded and mulched immediately after formation of the stockpile (see Temporary Seeding, Permanent Seeding and Mulch for Seed measures).
- Implement wind erosion control measures as appropriate on all stockpiled material.
- After the stockpile has been removed, the site should be graded and permanently stabilized.
- If a stockpile is located off-site, local zoning approval may be required. In addition to the above criteria, stockpiles that are located off-site require a construction entrance pad installed at that site (see Construction Entrance measure). Depending on the volume of traffic, the installation of "truck crossing" signs and sweeping of the roadway (see Dust Control measure) may also be necessary.

### Additional Requirements for Active Stockpiles

- All stockpiles should be protected with a temporary linear sediment barrier prior to the onset of precipitation.
- Stockpiles of "cold mix" should be placed on and covered with plastic or comparable material prior to the onset of precipitation.

### Maintenance

- Inspect and verify that measures are in place prior to the commencement of construction activities.

- Inspect the stockpile management measures at least once a week and within 24 hours of the end of a storm that generates a discharge.[19]
- Repair and/or replace perimeter controls and covers as needed to keep them functioning properly.
- After the stockpile has been removed, the site should be graded and permanently stabilized.

## Vegetative Soil Cover

### Planning Considerations

> **What's New in this Section?**
>
> - Revised guidance on use of lime and synthetic fertilizer.

The measures included in the vegetative soil cover group include Temporary Seeding, Permanent Seeding, Sodding and Landscape Planting. These measures serve the common function of stabilizing the soil through the establishment of a vegetative cover.

The Temporary Seeding measure is applicable to those areas where the phasing and sequencing of a project require an initial disturbance followed by an extended period of inactivity that is greater than 30 days but less than 1 year. It is important to note that temporary seedings will not provide the same level of protection that permanent vegetation will provide. Temporary seeding mixtures do not develop a "turf" or "sod." Temporary seedings do not generally receive the same level of maintenance as permanent seedings. This measure is used with the Mulch for Seed measure.

The Permanent Seeding measure is applicable to those areas that have been disturbed and will remain so for 1 year or more. It is also applicable to those areas that have been brought to a final grade and ready for final vegetation establishment. This measure is used with the Mulch for Seed, Topsoiling, Temporary Erosion Control Blanket and Permanent Turf Reinforcement Mat measures.

The Sodding measure is recommended for lands needing rapid establishment and highly effective grass cover. It provides almost instantaneous soil protection with high aesthetic value and is very useful in critical watersheds, particularly at times outside of the recommended seeding dates. This measure may be used following the Topsoiling and Permanent Turf Reinforcement Mat measures.

[19] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

The Landscape Planting measure is most used where aesthetics, wildlife habitat and noise control are needed. It is frequently used in conjunction with the Landscape Mulch measure.

The early establishment of either temporary or permanent vegetative cover can reduce and prevent costly maintenance operations for other erosion control systems. For example, the frequency of cleaning out sediment basins will be reduced if the drainage area of the basin is seeded where grading and construction are not taking place. The establishment of grass cover is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

## Temporary Seeding

### Definition

Establishment of temporary stand of grass and/or legumes by seeding and mulching soils that will be exposed for a period greater than 1 month but less than 12 months.

### Purpose

To temporarily stabilize the soil and reduce damage from wind and/or water erosion and sedimentation until permanent stabilization is accomplished.

### Applicability

- Within the first 7 days of suspending work on a grading operation that exposes erodible soils where such suspension is expected to last for 1 to 12 months. Such areas include soil stockpiles, borrow pits, road banks and other disturbed or unstable areas.

*Not for use on areas that are to be left dormant for more than 1 year. Use permanent vegetative measures in those situations. Seed must be applied during a growing season for it to be successful. It is critical to time seeding so that it establishes during the growing season and erodible soils are stabilized throughout winter seasons when the vegetative cover are dormant. Specifications*

#### Seed Selection

Select grass species appropriate for the season and site conditions from Table 5. 2. Use local seed sources that contain native or naturalized species to Connecticut and that can be certified as “invasive free” whenever possible.

#### Timing Considerations

Seed with a temporary seed mixture within 7 days after the suspension of grading work in disturbed areas where the suspension of work is expected to be more than 30 days but less than 1 year. Seeding outside the optimum seed germination dates given in Table 5. 2 Temporary Seeding Rates and Dates may result in either inadequate germination or low plant survival rates, reducing erosion control effectiveness.

#### Site Preparation

Install needed erosion control measures such as diversions, grade stabilization structures, sediment basins and grassed waterways in accordance with the approved plan.

Grade according to plans and allow for the use of appropriate equipment for seedbed preparation, seeding, mulch application, and mulch anchoring. All grading should be done in accordance with the Land Grading measure.

### Seedbed Preparation

Loosen the soil to a depth of 3-4 inches with a slightly roughened surface. If the area has been recently loosened or disturbed, no further roughening is required. Soil preparation can be accomplished by tracking with a dozer, discing, harrowing, raking, or dragging with a section of chain link fence. Avoid excessive compaction of the surface by equipment traveling back and forth over the surface. If the slope is tracked, the cleat marks shall be perpendicular to the anticipated direction of the flow of surface water (see Surface Roughening measure).

### Soil Amendments

See Permanent Seeding measure for information on the use of soil amendments such as lime and fertilizer for seedbed preparation, which also apply to the Temporary Seeding measure.
Seeding

Apply seed uniformly by hand, cyclone seeder, drill, cultipacker type seeder, or hydro seeder at a minimum rate for the selected seed identified in Table 5. 2. Increase seeding rates by 10% when hydroseeding.

### Mulching

Temporary seedings made during optimum seeding dates shall be mulched according to the Mulch for Seed measure. Note when seeding outside of the optimum seeding dates, increase the application of mulch to provide 95%-100% coverage.

## Maintenance

Inspect seeded area at least once a week and within 24 hours of the end of a storm that generates a discharge[20] for seed and mulch movement and rill erosion.

Where seed has moved or where soil erosion has occurred, determine the cause of the failure. Bird feeding may be a problem if mulch was applied too thinly to protect seed. In this situation, reseed and remulch. If movement was the result of wind, then repair erosion damage (if any), reapply seed and mulch, and apply a binding agent. If failure was caused by concentrated runoff, install additional measures to control water and sediment movement, repair erosion damage, reseed, and reapply mulch and a binding agent or use Temporary Erosion Control Blanket measure.

Continue inspections until the grasses are firmly established. Grasses shall not be considered established until a ground cover is achieved which is mature enough to control soil erosion and to survive severe weather conditions (approximately 80% vegetative surface cover).

[20] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours.

*Table 5. 2 Temporary Seeding Rates and Dates*

| Species[21] | Seeding Rates[22] (lbs. / acre) | Seeding Rates[22] (lbs. / 1,000 $ft^2$) | Optimum Seed Depth[23] (inches) | Optimum Seed Germination Dates[24] | Plant Characteristics |
|---|---|---|---|---|---|
| **Annual ryegrass** *Lolium multiflorum* | 160-200 | 4-5 | 0.5 | Mar 15-June 15; Aug 1 - Oct 15 | May be added in mixes. Will mow out of most stands. |
| **Perennial ryegrass** *Lolium perenne* | 160-200 | 4-5 | 0.5 | Mar 15-June 30; Aug 1- Oct 15 | Use for winter cover. Tolerates cold and low moisture. |
| **Winter Rye** *Secale cereale* | 75-150 | 2-3- | 1.0 | Apr 15 - June 30; Aug 15 - Oct 15 | Quick germination and heavy spring growth. Dies back in June with little regrowth. |
| **Oats** *Avena sativa* | 200 | 5 | 1.0 | Mar 15 - June 15; Aug 1 - Sept 15 | In northern CT. will winter kill with the first killing frost and may through-out the state in severe winters. |
| **Winter Wheat** *Triticum aestivum* | 120 | 3 | 1.0 | Apr 15 - June 30; Aug 15 - Oct 15 | Quick germination with moderate growth. Dies back in June with no regrowth. |
| **Millet** *Echinochloa crusgalli* | 20 | 0.5 | 1.0 | May 15-July 15 | Warm season small grain. Dies with frost in September. |

[21] Listed species may be used in combinations to obtain a broader time spectrum. If used in combinations, reduce each species planting rate by 20% of that listed.

[22] Higher range of seeding rates is recommended for later season plantings. These rates may also vary if applied in mixes.

[23] Seed at twice the indicated depth for sandy soils.

[24] May be planted throughout summer if soil moisture is adequate or can be irrigated. Fall seeding may be extended 15 days in the coastal towns.

| Species[21] | Seeding Rates[22] (lbs. / acre) | Seeding Rates[22] (lbs. / 1,000 ft$^2$) | Optimum Seed Depth[23] (inches) | Optimum Seed Germination Dates[24]: Mar. 15 | Apr 15 | May 15 | June 15 | July 15 | Aug 15 | Sept 15 | Oct 15 | Plant Characteristics |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sudangrass** *Sorghum bicolor* | 30 | 0.7 | 1.0 | | | May 15- July 31 | | | | | | Tolerates warm temperatures and droughty conditions. |
| **Buckwheat** *Fagopyrum esculentum* | 50 | 1 | 1.0 | | April 1- August 31 | | | | | | | Hardy plant that will reseed itself and is good as a green manure crop. |
| **Weeping lovegrass** *Eragrostis curvula* | 15 | 0.3 | 0.25 | | | | June 1-30 | | | | | Warm-season perennial. May bunch. Tolerates hot, dry slopes, acid infertile soils. Excellent nurse crop. Usually winter kills. |
| **CTDOT All Purpose Mix[25]** | 150 | 3.4 | 0.5 | March 15-June 15 | | | | | August 1- October 15 | | | Suitable for all conditions. |

[25] See Permanent Seeding Table 5. 5 for seeding mixture requirements.

# Permanent Seeding

## Definition

Establishment of permanent stand of grass and/or legumes by seeding and mulching exposed soils with a seed mixture appropriate for long term stabilization.

## Purpose

To permanently stabilize the soil with a vegetative cover that will prevent damage from wind and/or water erosion and sedimentation.

## Applicability

- On disturbed or erodible soils that have been brought to final grade or where the suspension of work is expected to exceed 1 year, and
- Where slope gradients are no steeper than 2:1. For slopes steeper than 2:1, use slope stabilization measures from the Stabilization Structures Functional Group.

## Planning Considerations

There are several factors that should be considered when evaluating a site related to the site's specific location, the characteristics of the soil, and the climatic conditions, for the establishment of permanent vegetation.

### Time of Year

Seeding dates in Connecticut are normally March 15 through June 30 and August 15 through October 31. Spring seedings give the best results and spring seedings of all mixes with legumes is recommended. There are two exceptions to the above dates. The first exception is when seedings will be made in the areas of Connecticut known as the Coastal Slope and the Connecticut River Valley. The Coastal Slope includes the coastal towns of New London, Middlesex, New Haven, and Fairfield counties. In these areas, except for crown vetch[26], the final fall seeding dates can be extended an additional 15 days. The second exception is frost crack or dormant seeding. In this type of seeding, the seed is applied during the time of year when no germination can be expected, normally November through February. Germination will take place when weather conditions improve. In this type of seeding, mulching is extremely important to protect the seed from wind and surface erosion and to provide erosion protection until the seeding becomes established.

### Topsoiling Needs

The need to topsoil is determined by a combination of existing soil fertility and intended use. The poorer the site is in terms of natural fertility and soil texture, the greater the need for topsoil. This is especially true on sites where a high-quality vegetative cover is needed either for erosion control or aesthetics.

### Soil Texture and Moisture Levels

Soil texture (ratio of gravel, sand, silt, clay, and organic matter) can affect the choice of a seed mixture for vegetating disturbed areas. For example, sites which have soils with a large

[26] When crown vetch is seeded in late summer, at least 35% of the seed should be hard seed (unscarified).

percentage of sands and gravels will tend to be droughty and therefore require a drought tolerant mixture. Conversely, sites that exhibit somewhat poorly or poorly drained characteristics will require a mixture that will tolerate wet conditions. Soil texture of the site may warrant consideration for the use of topsoil (see Topsoiling measure) or sodding (see Sodding measure).

#### Available Sunlight

Seed mixes should be adjusted depending on the light available on site. Sites in full shade will require a different seed mix from those with partial sun and full sun.

### Intended Use

Referring to Table 5. 4, consider the ultimate use and maintenance requirements of the area when choosing a seed mixture to be used. There are two levels of maintenance: areas that will be mowed and areas that will remain unmowed.

Areas that will be mowed can have different levels of maintenance and a different frequency of mowing. Golf courses, athletic fields and recreation areas will require more intensive management than roadside banks and medians.

Areas such as spoil banks, gravel pits and steep road banks once seeded and established will require no further mowing and little, if any, maintenance.

### Topography or Finished Grade

Do not use permanent seeding on slopes steeper than 2:1. Under saturated conditions slopes could develop deep or shallow surface failures. In cases such as this, maintenance can be a constant problem and there can be danger to structures. A thorough site investigation is needed to determine if alternatives such as benching or other structural methods are needed to ensure soil stability before seeding is done.

### Cool Season versus Warm Season Grasses

Cool season grasses are those species that normally begin growth very early in the spring (late March to early April) and will continue to grow until warm weather begins in mid-June. At the onset of hot weather, cool season grasses will enter a stage of dormancy and exhibit little growth. They will maintain that dormant state until the cooler weather of the fall (end of August) and will then begin to grow again until late fall (end of October). Warm season grasses on the other hand, do not begin vigorous growth until warm weather (late May) and will continue growth until cool weather in the late fall (mid- September). Some cool season grasses  are sod formers, such as bluegrass, while theothers such as the perennial ryes, do not form sod. See Table 5. 2 for seeding times, Table 5. 3 for liming rates and Table 5. 4 to select the appropriate seed mix for the site's needs.

### Presence of Mulch

Sometimes seeding will occur after a previous application of mulch. If wood chips, bark or similar materials were used on the seeding area, plan on either removing the mulch or incorporating it into the soil and applying more nitrogen (see Seedbed Preparation and Soil

Nutrient Amendments). Previously applied hay and straw mulch can be incorporated into the soil without adding supplemental nitrogen.

## Specifications

### Seed Selection and Quantity

Select species appropriate to the intended use and soil conditions from Table 5. 4 and Table 5. 5 or use mixture recommended by the NRCS. For seed mixtures containing legumes, select the type and amount of inoculant that is specific for the legume to be used.

If possible use local seed sources that contain native or naturalized species to Connecticut, native or naturalized species appropriate for erosion control on dry and wet sites include:

#### Dry Sites

- Creeping Red Fescue (Festuca rubra)
- Canada Wild Rye (Elymus canadensis)
- Annual Ryegrass (Lolium multiflorum)
- Perennial Ryegrass (Lolium perenne)
- Little Bluestem (Schizachyrium scoparium)
- Indian Grass (Sorghastrum nutans)
- Switch Grass (Panicum virgatum)
- Upland Bentgrass (Agrostis perennans)
- White wood aster (Eurybia divaricata, syn. Aster divaricatus)
- Butterfly weed (Asclepias tuberosa)

#### Wet Sites

- Riverbank Wild Rye (Elymus riparius)
- Creeping Red Fescue (Festuca rubra)
- Little Bluestem (Schizachyrium scoparium)
- Big Bluestem (Andropogon gerardii)
- Switch Grass (Panicum virgatum)
- Upland Bentgrass (Agrostis perennans)
- Nodding Bur Marigold (Bidens cernua)
- Hollow-Stem Joe Pye Weed (Eupatorium fistulosum/Eutrochium fistulosum)
- New England Aster (Aster novae-angliae)
- Boneset (Eupatorium perfoliatum)
- Blue Vervain (Verbena hastata)
- Soft Rush (Juncus effusus)
- Wool Grass (Scirpus cyperinus)
- Wild blue phlox (Phlox divaricata)

Commercial seed suppliers should also be consulted in the selection of an appropriate seed mix for permanent vegetative cover for erosion control.

When buying seed, make sure the quality of the seed is specified for pure live seed and germination rate. Ask the supplier for an affidavit of purity and germination rate if there is any question. Expect a purity between 95% and 98% and a germination rate between 70% and 90%. Some seeding mixtures call for pure live seed. The equation for pure live seed and an example of calculating pure live seed is given below.

*Equation 5. 2 PLS*

$$Pure\ Live\ Seed\ (PLS) = \frac{\%\ Germination\ x\ \%\ Purity}{100}$$

*Example Calculation 5. 3 PLS and Lbs/Acre*

*Example:* Perennial Rye Grass (PRG) seed with 90% germination and 98% purity. *Need 10lbs/acre.*

*Solution:* $PLS = \frac{90x98}{100} = \frac{8,820}{100} = 88\%$ *then,*

$$Amount\ needed\ \frac{10lbs\ of\ PRG}{acre}$$

$$= 10\frac{}{0.88} = \mathbf{11.36lbs/acre}$$

Recommended to increase your seeding rate if a dormant seed application is made. Hydroseeding is made in season and an increase in the seeding rate is not necessary.

### Timing

Seed with a permanent seed mixture within 7 days after establishing final grades or when grading work within a disturbed area is to be suspended for a period of more than 1 year. Seeding is recommended from March 15 through June 30 and August 15 through October 31, with the following exceptions:

- For the coastal towns and in the Connecticut River Valley final fall seeding dates can be extended an additional 15 days, and
- Dormant or frost crack seeding is done after the ground is frozen.

### Site Preparation

Grade in accordance with the Land Grading measure and install needed erosion control measures such as diversions, grade stabilization structures, sediment basins and grassed waterways

Install all necessary surface water controls.

Where possible, grade as needed and feasible to permit the use of appropriate equipment for seedbed preparation, seeding, mulch application, and mulch anchoring.

For areas to be mowed remove all surface stones 2 inches or larger. Remove all other debris such as wire, cable, tree roots, pieces of concrete, clods, lumps, or other unsuitable material.

### Seedbed Preparation

Apply topsoil, if necessary, in accordance with the Topsoiling measure.

With many new turf seedings or soddings, especially on sites where the original topsoil has been removed and replaced, there is insufficient organic matter in the soil to support good grass growth and establishment. This increases the reliance on supplemental nitrogen fertilizers to ensure good lawn grow-in.

- If soil organic matter is below 3%, incorporate compost or another organic matter source into the soil to raise the organic matter content to at least 3%; a minimum of 5% is preferable.
- If the soil test indicates the soil is low in organic matter before a new seeding is initiated, compost or another source of organic matter can be added to the soil and incorporated to a depth of no deeper than 6 inches before the grass seed is sown or sod laid. Soil amendments should be consistent with any nutrient management plans that may be in place.
- If using compost, be sure that it is mature and stable. Green compost can produce toxic compounds during breakdown that can kill the new seedlings or sod.

### Soil Amendments

If vegetation can be established without fertilizer, then do not fertilize. The use of fertilizer should be minimized in areas adjacent to all wetlands and surface waters and avoided in watersheds with known nutrient impairments. Before applying limestone and/or fertilizer, test the soil to confirm if fertilizer or other soil amendments are needed. Soil testing may be conducted by the University of Connecticut Soil Testing Laboratory, another university soil testing laboratory, or a commercial soil testing laboratory. Information on soil testing and procedures are also available from commercial nurseries, lawn care professionals, or other reliable sources.

If soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 300 pounds per acre or 7.5 pounds per 1,000 square feet using fertilizer of the following analysis – 10 percent available Nitrogen (N), 10 percent available Phosphoric Acid (P), 10 percent available Potassium (K). Fertilizer should always be applied to meet the requirements of the site. Listed in order, N-P-K (Nitrogen-Phosphorus-Potassium) are the three most abundant ingredients listed on a fertilizer label. Nutrients should be primarily slow-release whether synthetic or organic. Slow-release nutrients are not salt-based, and so will not burn grass. Slow-release nitrogen is also known as water-insoluble nitrogen. The addition of surplus nitrogen or phosphorus may cause pollution of water ecosystems.

If fertilizer is to be used, the following best management practices should be followed to minimize and optimize fertilizer usage:[27]

- Do not apply fertilizer, soil amendment, or compost within 20 feet of a surface waterbody unless applied with the use of a drop spreader, rotary spreader with a deflector, or targeted spray liquid, in which case such application may occur on any portion of lawn that is located not less 15 feet from a surface waterbody.
- Compost made from leaves typically contains low amounts of phosphorus and can be used to improve organic matter levels if necessary.
- Use slow-release formulations (50 percent or more water-insoluble nitrogen) to encourage more complete uptake.
- Avoid using combination products that include both fertilizers and pesticides.
- Do not apply fertilizer prior to when rain is forecast, which can reduce fertilizer effectiveness and increase the risk of surface and groundwater contamination.
- Do not apply fertilizer to saturated or frozen ground. Avoid spreading fertilizer on impervious surfaces (sidewalks, patios, driveways, etc.).
- Use a phosphorus-free fertilizer on sites near or bordering waterbodies, unless soil tests indicate that the soils are low in phosphorus. Restrictions apply to the use of fertilizers on established lawns containing phosphorus in Connecticut.[28] Such restrictions do not apply to establishing new grass or repairing lawns with seed or sod, however, before applying fertilizer, a soil test must be taken to. Additionally it is recommended that confirmation must be sought to ensure site specific exceptions or requirements are followed. The application of fertilizers containing phosphate on lawns between November 15 and March 15 is prohibited.
- Leave a buffer strip of unfertilized grass or other vegetation around waterbodies.
- The amount of nitrogen (N) and/or phosphorus (P) and potassium (K) to be applied should be determined based on soil testing results.
    - If a soil test indicates that P and/or K are adequate, there is no need to apply these and only N may be necessary. P levels are generally adequate if the extractable P is in the high or greater range, or above optimum range, or above 10 ppm (modified Morgan P). In these cases, fertilizers that contain only N (e.g., urea, ammonium sulfate, corn gluten) are preferable than blended N-P-K fertilizers. If only blended grade fertilizers available, choose the one with the lowest P.
    - Fertilize at a rate of no more than 1 pound of N per 1,000 square feet (SF). Typically apply one-half to one-third (or less) of that recommended on the fertilizer bag label and then monitor response and adjust as needed. If the site is

[27] University of Connecticut, New England Regional Nitrogen and Phosphorus Fertilizer and Associated Management Practice Recommendations.
[28] CGS §22-111yy

not to be fertilized after establishment, then 1 pound of slow-release nitrogen per 1,000 SF is typically necessary to prevent nutrient deficiency and plant death.
- If the P reading is low, apply 0.5 pound of P per 1,000 SF before seeding and incorporate to a 3 to 4-inch depth, and another 0.5 pound of P per 1,000 SF using a surface broadcast spreader after grass has emerged.

- For areas that were previously mulched with wood chips or bark, either remove the mulch or incorporate it into the soil and apply additional nitrogen at a rate that is determined by soil tests at the time of seeding.
- If lime is necessary to raise the soil pH, apply lime in accordance with the application rates given in Table 5. 3. A pH of 6.2 to 7.0 is optimal for most grass species.

*Table 5. 3 Soil Texture vs. Liming Rates*

| NRCS Hydrologic Soil Group | Soil Texture | Lime (tons/acre) | Lime (lbs./1,000 ft$^2$) |
|---|---|---|---|
| D | Clay, clay loam and high organic soil | 3 | 135 |
| B or C | Sandy loam, loam, silt loam | 2 | 90 |
| A | Loamy sand, sand | 1 | 45 |

Work lime and fertilizer into the soil to a depth of 3 to 4 inches with a disc or other suitable equipment. Continue tillage until a reasonably uniform, fine seedbed is prepared. For areas to be mowed the final soil loosening and surface roughening operation is by hand, harrow, or disk. If done by harrow or disc, it is generally done on the contour. Areas not to be mowed can be tracked with cleated earthmoving equipment perpendicular to the slope (see Surface Roughening measure). However, for seeded areas where Temporary Erosion Control Blankets are to be used instead of mulch, prepare the seed bed in accordance with blanket manufacturer's recommendations.

Inspect seedbed just before seeding. If the soil is compacted, crusted, or hardened, scarify the area prior to seeding (see Surface Roughening measure).

### Seed Application

Apply selected seed at rates recommended by the supplier uniformly by hand/broadcast, cyclone seeder, drill, cultipacker type seeder, or hydroseeder (slurry including seed, fertilizer.). Normal seeding depth is from 0.25 to 0.5 inch. Increase seeding rates by 10% when hydroseeding or frost crack seeding.

All seeded areas require irrigation/watering for successful germination, particularly seed mixtures sown in the spring. Consider the germination rate of all seed types in a seed mixture. Apply mulch according to the Mulch for Seed measure.

### Irrigation for Summer Seeding

Water is essential when establishing any new seeding, particularly when seeding outside of the recommended seeding dates during the summer months. Any irrigation that provides water to a new seed bed requires care needs to be taken not to exceed the infiltration rate of the soil. New seedbeds should be moist during the germination and the early establishment period before the seedlings root into the soil. After establishment, each application must be uniformly applied with 1 to 2 inches of water per application, soaking the ground to a depth of 4 inches.

## Maintenance

### Initial Establishment

Inspect seeded area at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater during the first growing season.

Where seed has been moved or where soil erosion has occurred, determine the cause of the failure. Bird damage may be a problem if mulch was applied too thinly to protect seed. Re-seed and re-mulch. If seed movement was the result of wind, repair erosion damage (if any), re-apply seed and mulch, and apply mulch anchoring. If failure was caused by concentrated water movement, (1) install additional measures to control water and sediment movement, (2) repair erosion damage, (3) re-seed and (4) re-apply mulch with anchoring or repair/use Temporary Erosion Control Blanket measure and/or Permanent Turf Reinforcement Mat measure). Using Temporary Erosion Control Blanket measure and/or Permanent Turf Reinforcement Mats at the time of seeding is an effective prevention method and care should be taken to apply these measures then if applicable.

If there is no erosion, but seed survival is less than 100 plants per square foot after 4 weeks of growth, re-seed as planting season allows.

Continue inspections until at least 100 plants per square foot have grown at least 6 inches tall or until the first mowing.

### First Mowing

Allow most turfgrass to achieve a height of least 4-6 inches and plants in general should be at least 6 inches before mowing it the first time. Mower blades must always be sharp. The first mowing should remove approximately one third of the growth, depending upon the type of grass and where it is being used. Do not mow grass below 3 inches.

Do not mow while the surface is wet. Mowing while the surface is still wet may pull many seedlings from the soil and often leaves a series of unnecessary ruts.

If the seeding was mulched, do not attempt to rake out the mulching material. Normal mowing will gradually remove all unwanted debris.

### Long-Term Maintenance

Mow and fertilize at a rate that sustains the area in a condition that supports the intended use. When mowing if appropriate, the height of cut may be adjusted downward, slowly and never more than 1/3 of the leaf blade per mowing event, as new plants become established. Carry out any fertilization program in accordance with approved soil tests that determine the proper amount of lime and fertilizer needed to maintain a vigorous sod yet prevent excessive leaching of nutrients to the groundwater or runoff to surface waters.

Although weeds may appear to be a problem, they shade the new seedlings and help conserve surface moisture. Do not apply weed control until is at least 3-4 months old and the new seeding has been mowed at least four times.

The following long-term maintenance practices are recommended to reduce the need for fertilizer, watering, and overall maintenance of established turf areas:[29]

- Test soils every 1 to 3 years to determine suitability for supporting a lawn, and to determine how to optimize growing conditions.
- Use efficient irrigation techniques, watering only when needed and allowing the water to penetrate deeper into the soil will encourage deeper root growth. Consider use of rain barrels or rain gardens for stormwater reuse.
- Mow high, mow frequently, and keep mower blades sharp. Lawns should not be cut shorter than 3 inches. Keep clippings on the lawn to release stored nutrients back into the soil.
- Mulch mow grass clippings into the lawn in order to help soil retain moisture and to recycle nutrients, which can help reduce need for future fertilizer applications.
- Once established most lawns require little or no fertilizer to remain healthy. Avoid unnecessary applications of fertilizers and pesticides. If fertilizer is to be used, follow best management practices to minimize and optimize fertilizer usage:
    - Fertilize no more than twice a year - once in May-June (not before spring green up), and once in September or before mid-October.
    - Use slow-release formulations (50 percent or more water-insoluble nitrogen) to encourage more complete uptake.
    - Following label rates fertilize at a rate of no more than ½-1 pound of nitrogen per 1000 square feet. Typically apply one-half to one-third (or less) of that recommended on the fertilizer bag label and then monitor lawn response and adjust as needed.
    - Use a phosphorus-free fertilizer on lawns near or bordering waterbodies, unless soil tests indicate that the soils are low in phosphorus. Restrictions apply to the use of fertilizers on established lawns containing phosphorus in Connecticut. Before applying fertilizer, confirm what exceptions or requirements might apply to the site. The application of fertilizers containing phosphate on lawns between November 15 and March 15 is prohibited.
    - Do not apply fertilizer prior to when rain is forecast, which can reduce fertilizer effectiveness and increase the risk of surface and groundwater contamination.

[29] University of Connecticut, New England Regional Nitrogen and Phosphorus Fertilizer and Associated Management Practice Recommendations.

- Do not apply fertilizer to saturated or frozen ground. Avoid spreading fertilizer on impervious surfaces (sidewalks, patios, driveways, etc.).
- Where possible leave a buffer strip of unfertilized grass or other vegetation around waterbodies.

*Table 5. 4 Selecting Seed Mix to Match Need*

| Area to be Seeded | Mixture Number[30] | |
|---|---|---|
| | Mowing Desired | Mowing Not Required[31] |
| **BORROW AREAS, ROADSIDES, DIKES, LEVEES, POND BANKS AND OTHER SLOPES AND BANKS** | | |
| **A) Well or excessively drained soil[32]** | 1-5 or 8 | 5-12, 16, or 21 |
| **B) Somewhat poorly drained soils** | 2 | 5 or 6 |
| **C) Variable drainage soils** | 2 | 5,6, or 11 |
| **DRAINAGE DITCH AND CHANNEL BANKS** | | |
| **A)Well or excessively drained soil** | 1-4 | 9-12 |
| **B) Somewhat poorly drained soils** | 2 | |
| **C) Variable drainage soils** | 2 | |
| **DIVERSIONS** | | |
| **A)Well or excessively drained soil** | 2-4 | 9-11 |
| **B) Somewhat poorly drained soils** | 2 | |
| **C) Variable drainage soils** | 2 | |

[30] The numbers following in these columns refer to seed mixtures in Table 5. 5. Mixes for shady areas are in bold italics print (including mixes 19 through 23).

[31] Native flower seeds can enhance aesthetics, wildlife value and pollinator health in no-mow areas. Consider adding a species like Hollow-Stem Joe Pyeweed, or New England Aster to wet areas or Butterfly Weed or White Wood Aster to dry areas.

[32] See county soil survey for drainage class. Soil surveys are available from the County Soil and Water Conservation District Office.

| | | |
|---|---|---|
| **EFFLUENT DISPOSAL** | | 5 or 6 |
| **GRAVEL PITS** | | 25-27 |
| **GULLIED AND ERODED AREAS** | | 3-5, 8, 10-12 |
| **MINESPOIL & WASTE, AND OTHER SPOIL BANKS (If toxic substances & physical properties not limiting)**[33] | | 5-18, 25-27 |
| **SHORELINES (Fluctuating water levels)** | | 5 or 6 |
| **SKI SLOPES** | | 4, or 10 |
| **SOD WATERWAYS AND SPILLWAYS** | 1-4, 6-8 | 1-4, 6-8 |
| **SUNNY RECREATION AREAS (Picnic areas and playgrounds or driving and archery ranges, nature trails)** | 1, 2 or *22* | |
| **CAMPING AND PARKING, NATURE TRAILS (Shaded)** | 19, *20 or 22* | |
| **D DUNES (Blowing sand)** | 24 | |
| **WOODLAND ACCESS ROADS, SKID TRAILS AND LOG YARDING AREAS** | | 9, 10, 16, *21*, 25 |
| **LAWNS AND HIGH MAINTENANCE AREAS** | 1, 19, *20 or 28* | |

[33] Use mix 26 when soil passing a 200-mesh sieve is less than 15% of total weight. Use mix 26 & 27 when soil passing a 200-mesh sieve is between 15 and 20% of total weight. Use mix 26, 27 & 28 when soil passing a 200-mesh sieve is above 20% of total weight.

*Table 5. 5 Seed Mixtures for Permanent Seeding*

| No. | Seed Mixture [34] | Lbs/Acre | Lbs/ 1,000 Sq. Ft. |
|---|---|---|---|
| 1 | Kentucky Bluegrass | 20 | 0.45 |
| | Creeping Red Fescue | 20 | 0.45 |
| | Perennial Ryegrass | 5 | 0.10 |
| | Total | 45 | 1.00 |
| 2 | Creeping Red Fescue | 20 | 0.45 |
| | Redtop | 2 | 0.05 |
| | Tall Fescue or Smooth Bromegrass | 20 | 0.45 |
| | Total | 42 | 0.95 |
| 3 | Creeping Red Fescue | 20 | 0.45 |
| | Panicledleaf Tick Trefoil with inoculant[35] | 8 | 0.20 |
| | Tall Fescue or Smooth Bromegrass | 20 | 0 .45 |
| | Total | 48 | 1.10 |
| 4 | Creeping Red Fescueor Tall Fescue | 20 | 0.45 |
| | Redtop | 2 | 0.05 |
| | Panicledleaf Tick Trefoil with inoculant[10] | 8 | 0.20 |
| | Total | 30 | 0.70 |
| 5 | White Clover | 10 | 0.25 |
| | Perennial Rye Grass | 2 | 0.05 |
| | Total | 12 | 0.30 |
| 6 | Creeping Red Fescue | 20 | 0.50 |
| | Redtop | 2 | 0.05 |
| | Perennial Rye Grass | 20 | 0.50 |
| | Total | 42 | 1.05 |
| 7 | Smooth Bromegrass | 15 | 0.35 |
| | Perennial Ryegrass | 5 | 0.10 |

[34] Wildflower mix containing New England Aster, Baby's Breath, Black Eye Susan, Catchfly, Dwarf Columbine, Purple Coneflower, Lance-leaved Coreopsis, Cornflower, Ox-eye Daisy, Scarlet Flax, Foxglove, Gayfeather, Rocky Larkspur, Spanish Larkspur, Corn Poppy, Spurred Snapdragon, Wallflower and/or Yarrow may be added to any seed mix given. Most seed suppliers carry a wildflower mixture that is suitable for the Northeast and contains a variety of both annual and perennial flowers. Seeding rates for the specific mixtures should be followed.

[35] Use proper inoculant for legume seeds, use four times recommended rate when hydroseeding.

| No. | Seed Mixture [34] | Lbs/Acre | Lbs/ 1,000 Sq. Ft. |
|---|---|---|---|
| | Panicledleaf Tick Trefoil with inoculant[10] | 10 | 0.25 |
| | Total | 30 | 0.79 |
| 8 | Switchgrass | 101 | 0.25 |
| | Weeping lovegrass | 3 | 0.07 |
| | Little Bluestem | 101 | 0.25 |
| | Total | 23 | 0.57 |
| 9 | Creeping Red Fescue | 10 | .25 |
| | Crown Vetch (Chemung, Penngift) with inoculant[10] | 15 | .35 |
| | (or Flatpea with inoculant[10]) | (30) | (.75) |
| | Tall Fescue or Smooth Bromegrass | 15 | .35 |
| | Redtop | 2 | .05 |
| | Total | 42 (or 57) | 1.00 (or 1.40) |
| 10 | Creeping Red Fescue | 20 | 0.45 |
| | Redtop | 2 | 0.05 |
| | Crown Vetch with inoculant[10] | 15 | 0.35 |
| | (or Flatpea with inoculant[10]) | (30) | (0.75) |
| | Total | 37 (or 52) | 0.85 (or 1.25) |
| 11 | Panicledleaf Tick Trefoil with inoculant[10] | 8 | 0.20 |
| | Crown Vetch with inoculant[10] | 15 | 0.35 |
| | Creeping Red Fescue or Tall Fescue or Smooth Bromegrass | 20 | 0.45 |
| | Total | 43 | 1.00 |
| 12[36] | Switchgrass | 101 | 0.25 |
| | Perennial Ryegrass | 5 | 0.10 |
| | Crown Vetch with inoculant[10] | 15 | 0.35 |
| | Total | 45 | 1.05 |
| 13 | Crown Vetch with inoculant[10] | 10 | 0.25 |
| | (or (Flatpea with inoculant[10]) | (30) | (0.75) |
| | Switchgrass | 5 | 0.10 |
| | Perennial Ryegrass | 5 | 0.10 |
| | Total | 20 (or 40) | 0.45 (or 0.95) |
| 14 | Crown Vetch with inoculant[10] | 15 | 0.35 |
| | (or (Flatpea with inoculant[10]) | (30) | (0.75) |
| | Perennial Ryegrass | 10 | 0.25 |
| | Total | 25 (or 40) | 0.60 (or 1.00) |
| 15 | Switchgrass | 5 | 0.10 |
| | Big Bluestem or Little Bluestem | 5 | 0.10 |
| | Perennial Ryegrass | 5 | 0.10 |
| | Panicledleaf Tick Trefoil with inoculant[10] | 5 | 0.10 |
| | Total | 20 | 0.40 |

[36] Considered to be a warm season mix.

| No. | Seed Mixture [34] | Lbs/Acre | Lbs/ 1,000 Sq. Ft. |
|---|---|---|---|
| 16 | Tall Fescue | 20 | 0.45 |
| | Flatpea with inoculant[10] | 30 | 0.75 |
| | Total | 50 | 1.20 |
| 17 | Deer Tongue with inoculant[10] | 10 | 0.25 |
| | Panicledleaf Tick Trefoil with inoculant[10] | 8 | 0.20 |
| | Perennial Ryegrass | 3 | 0.07 |
| | Total | 21 | 0.52 |
| 18 | Deer Tongue with inoculant[10] | 10 | 0.25 |
| | Crown Vetch with inoculant[10] | 15 | 0.35 |
| | Perennial Ryegrass | 3 | 0.07 |
| | Total | 28 | 0.52 |
| 19[37] | Chewings Fescue | 35 | 0.80 |
| | Hard Fescue | 30 | 0.70 |
| | Colonial Bentgrass | 5 | 0.10 |
| | Panicledleaf Tick Trefoil with inoculant[10] | 10 | 0.20 |
| | Perennial Ryegrass | 20 | 0.50 |
| | Total | 100 | 2.30 |
| 20 | Creeping Red Fescue | 60 | 1.35 |
| 21 | Creeping Red Fescue | 40 | 0.90 |
| | Tall Fescue | 20 | 0.45 |
| | Total | 60 | 1.35 |
| 22 | Creeping Red Fescue | 15 | 0.35 |
| | Flatpea with inoculant[10] | 30 | 0.75 |
| | Total | 45 | 1.10 |
| 23 | Tall Fescue | 150 | 3.60 |
| 24 | American Beachgrass | 58,500 culms/acre | 1,345 culms/ 100 sq. ft. |
| 25 | Switchgrass | 4.0 | 0.10 |
| | Big Bluestem | 4.0 | 0.10 |
| | Little Bluestem | 2.0 | 0.05 |
| | Sand Lovegrass | 1.5 | 0.03 |
| | Panicledleaf Tick Trefoil | 2.0 | 0.05 |
| | Total | 13.5 | 0.33 |
| 26 | Flatpea | 10.0 | 0.20 |
| | Perennial Pea | 2.0 | 0.05 |
| | Crown Vetch | 10.0 | 0.20 |
| | Tall Fescue | 2.0 | 0.20 |
| | Total | 24.0 | 0.65 |
| 27 | Orchardgrass | 5.0 | O.10 |

[37] CTDOT All purpose mix

| No. | Seed Mixture [34] | Lbs/Acre | Lbs/ 1,000 Sq. Ft. |
|---|---|---|---|
| | Tall Fescue | 10.0 | 0.20 |
| | Redtop | 2.0 | 0.05 |
| | Birds-foot Trefoil | 5.0 | 0.10 |
| | Total | 22.00 | 0.45 |
| 28 | Turf Type Tall Fescue or Perennial Rye | 175-250 | 6-8 |

## Sodding

### Definition

Stabilizing fine-graded disturbed areas with the use of cut pieces of turf.

### Purpose

- To permanently stabilize the soil.
- To immediately reduce erosion and the production of dust.
- To filter runoff water, reduce pollution.
- To improve site aesthetics.

### Applicability

- On slopes 2:1 or flatter, except on very short slopes where the slope length is no longer than the width of the cut sod. If mowing is required, do not use sod on slopes steeper than 3:1.
- If mowing is required, do not use sod on slopes steeper than 3:1.
- In areas where concentrated surface runoff would prevent the establishment of protective vegetation by normal seeding procedures.
- In channels where the design velocity does not exceed 5 feet per second (fps) with a duration of 1 hour or less when the velocity is at or near 5 fps (for well-established, good quality sod). For design velocities that exceed 5 fps, refer to the Riprap and Permanent Turf Reinforcement Mat measures.
- On sediment producing areas such as drainageways carrying intermittent flows, around drop inlets, in grassed drainageways, cut and fill slopes, and other areas where conventional methods of turf establishment may be difficult or risky.
- Where establishing turf grass and lawn is needed in the shortest time possible.

### Planning Considerations

While the initial cost of sod is much higher than seed and mulch/erosion control blankets, sodding has some distinct advantages. Properly installed, turfgrass sod provides the following benefits which may justify the initial added expense:

- Provides initial higher level of erosion control than seeding and mulching, capable of withstanding heavier rainfalls and velocities without failure and subsequent need for repair;

- Is an immediate soil cover and erosion protection where concentrated surface runoff would prevent the establishment of sod by normal seeding procedures;
- Establishes a grass cover outside of the non-seeding dates.
- Offers immediate filtration of storm water runoff;
- Allows use of site in a much shorter length of time;
- Provides a quality-controlled product, free from weeds, with predictable results; and
- Immediate aesthetic benefits.
- Although sodding allows for quick establishment of vegetation and immediate erosion protection, sod can have fertilizer requirements and as well as high initial watering requirements for establishment, which may increase the potential for nutrient impacts to surface waterbodies or groundwater until sod is rooted.
- In drainageways and intermittent waterways where concentrated flow will occur, properly installed sod is preferable to seed because there is no time lapse between installation and the time when the channel is protected. Sodding can reduce maintenance to other sediment controls by keeping them free from silt, sediment, and other debris that can result from conventional methods of turf establishment. However, sod is limited in its ability to withstand high velocity and/or long duration flows.

Note: The application of sod within a drainage way should be based on a determination that vegetation will satisfactorily resist channel velocities. Channel velocities for the design storm should not exceed 5 fps with a duration of less than 1 hour at or near 5 fps.

As with any other seeding or planting of vegetation, a decision on topsoiling must be made. The poorer the site in terms of natural fertility and soil texture, and where a high-quality vegetative cover is needed either for erosion control or aesthetics, the greater the need for topsoil.

## Specifications

### Materials

Turfgrass species that are used for sod production have stoloniferous or rhizomatous grasses and have the ability to form a uniform, dense turfgrass surface. These turfgrasses are cut at a uniform thickness and small amount of soil (±0.25 inch) that can easily root at another location. Sod comes in standard size sections strong enough to support their own weight and retain their size and shape when suspended from a firm grasp on one end of the section.

### Timing Limitations

Sod may be placed at a site anytime during the year for slope stabilization but shall not be installed on frozen ground, nor for waterway applications during the months of December, January, or February.

Sod shall be harvested, delivered, and installed within 36 hours. Plan site preparation (see below) and delivery of sod accordingly. Have sod delivered to the site as soon as practical after harvesting. During hot weather, delivery should be made within 6 hours and may be extended to 48 hours during cool seasons. Installing sod during the hot summer months of July and August is discouraged as it will pose challenges. If it must be moved and installed during this period, sod may need to be cut thicker and will require frequent irrigation. Lapses in irrigation can quickly result in sod drying out.

### Selection of Sod

- Select sod grown from seed of improved varieties and maintained with cultural practices that produce healthy turfgrass growth that will be free of any serious thatch, weed, insect, disease, and other pest problems.
- Select species and varieties best suited for the sites to be stabilized. Use mixtures tested and approved by field inspectors.
- Select sod at least 15 months old but no older than three years. Cultivated turf grass is usually considered ready for harvest when a cut portion of sod 3 feet long by 1 to 1.5 feet wide will support its own weight when suspended vertically from the upper 10% of the section. The most common age of sod when harvested is 15 to 24 months.
- Select sod cuts of width and length suited to the equipment and job. In New England, most sod is cut as either 9 square foot (1.5 foot wide by 6 foot long) pieces or 10 square foot (2 foot wide by 5 foot long) pieces, with the 10 square foot being the most common. Sod may also be available in “big rolls” which are 4 feet wide by 50 to 62.5 feet long. These “big rolls” can be cut with 1 seam down the middle, where there will be two 2-foot sections on each 4-foot wide roll, or they can be cut without a seam. Mechanical equipment is required for installation as each roll will weigh approximately 1,000 pounds. Sod may be harvested and rolled and stacked on pallets. Rhizomes develop in the top inch of soil. The thinner the sod is cut the more quickly they will develop and root into the soil. However, the thinner the sod, the greater the need for irrigation as the thin sod will be more susceptible to drying out.
- For sod used along waterways, the sod type shall consist of plant materials able to withstand the design velocity (see Vegetated Waterway measure).

### Site Preparation

- Prior to soil preparation, bring to grade areas to be sodded in accordance with the approved plan.
- Install and/or repair other sediment control measures needed to control water movement into the area to be sodded.
- Clean soil surface of trash, debris, large roots, branches, stones, and clods in excess of 1 inch in length or diameter. Do not apply sod to gravel or non-soil surfaces.
- Place topsoil as needed, meeting the requirements of Topsoiling measure.
- See Permanent Seeding section for information regarding if soil amendments are necessary. When necessary, spread these amendments evenly over the area to be sodded, and incorporate into the top 3 to 6 inches of the soil (if possible) by discing, harrowing, or other acceptable means (see Surface Roughening measure).
- Fill or level any irregularities in the soil surface resulting from topsoiling or other operations in order to prevent the formation of depressions or water pockets.

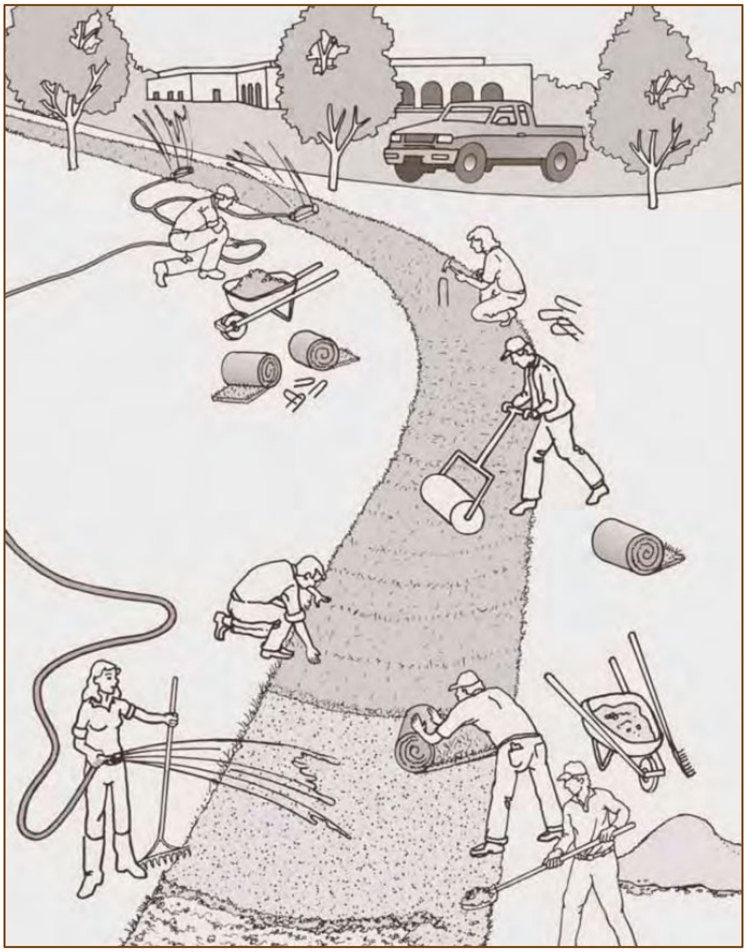
Note: Lightly irrigate the soil immediately prior to laying the sod to provide moisture to soil surface and encourage rooting. Irrigating the soil surface prior to installing sod during hot, dry weather is also important to soil surface temperatures as sod can quickly dry out. Irrigation is critical after the installation is complete to maintain sod health and prevent drought stress. If sod is not watered after installation, can dry up causing shrinkage between sod pieces.

### Sod Installation

See Figure 5- 9, for depiction of these described installation steps.

- Install the first row of sod in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger lateral joints to promote more uniform growth and strength. Take care to ensure that sod is not stretched or overlapped and that all joints are butted tight in order to prevent voids which would cause drying of the roots.
- On slopes 3:1 or steeper or wherever erosion may be a problem, lay sod with staggered joints perpendicular to the direction of flow (i.e., on the contour) and secure by pegging or other approved methods. If the site of sodding is to be mowed, the use of wood pegs or biodegradable staples is recommended over metal staples for anchoring to reduce problems caused by mowing equipment hitting metal staples should they get lifted over time from the sod surface. Also, for these areas, sod cut into long strips and rolled for transport is desired because it minimizes the number of sections.
- As sodding is completed, roll, and tamp the sod to ensure contact with the soil.
- After rolling, irrigate the sod to a depth sufficient to thoroughly wet the underside of the sod pad and the 4 inches of soil below the sod.

*Figure 5- 9 Sodding Installation*



Sodded Waterway Installations

- Follow site preparation requirements listed above.
- Use a sod capable of withstanding the design velocity. Lay sod strips perpendicular to the direction of channel flow, taking care to butt the ends of strips tightly.
- As sodding of clearly defined areas is completed; roll or tamp the sod to ensure contact with the soil.
- Peg or staple to resist washout during the establishment period. Fasten every 3 inches on the leading edge and 1 to 2 feet laterally. If the site of sodding is to be mowed, the use of wood pegs or biodegradable staples is recommended over metal staples for anchoring to reduce problems caused by mowing equipment hitting metal staples should they get lifted over time from the sod surface.
- After rolling, sod shall be irrigated to a depth sufficient to thoroughly wet the underside of the sod pad and the 4 inches below the sod.

### Maintenance

- During the first week, inspect daily and if rainfall is inadequate, then water the sod as often as necessary to maintain moist soil to a depth of at least 4 inches below the sod. Subsequent watering may be necessary to ensure establishment and maintain adequate growth.
- After the first week, inspect sodded area at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater during the first growing season.
- Where sod has died or has been moved or where soil erosion has occurred, determine if the failure was caused by inadequate irrigation, poorly prepared surface, improper anchoring, excessive sedimentation, or excessive flows. If the failure was caused by concentrated flow, check water velocities and duration to ensure it does not exceed 5 fps or a duration greater than 1 hour at or near 5 fps. Install additional measures to control water and sediment, repair erosion damage, and reinstall sodding with anchoring.
- Do not mow until the sod is firmly rooted, usually 2 to 3 weeks. Do not remove more than 1/3 of the grass leaf at any-one cutting.
- Long term maintenance of the sod should be commensurate with the planned use of the area and the same as permanently seeded turfgrass areas. Follow the long-term maintenance recommendations of the Permanent Seeding measure.

## Landscape Planting

### Definition

Planting trees, shrubs, or ground covers for stabilization of disturbed areas.

### Purpose

- To aid in protecting and stabilizing soil.
- To facilitate soil conservation.
- To intercept precipitation and retard runoff.
- Using the right plant palette for the site can:
  - Reduce maintenance requirements
  - Minimize fertilizer and pesticide needs
  - Decrease, if not eliminate, irrigation budgets.
- Other benefits include: sequestering carbon, regulating temperature, buffering winds, providing increased plant diversity, creating wildlife habitat, improving air quality, establishing high-quality riparian buffers, and enhancing site aesthetics.

### Applicability

- Any location where lawn is not necessary.
- Where mowing to maintain an herbaceous plant cover is not feasible such as on steep or irregular terrain.
- Where ornamental plantings are desired to improve site aesthetics.
- Where turf establishment is difficult, such as in shady areas.

- Where woody plants are desirable for soil conservation, plant diversity, or to create or enhance wildlife habitat.
- Where permanent plantings will reduce the extent of lawn and lawn maintenance requirements.
- Where riparian or other functional buffers need to be extended, re-established, or created.
- Where wind breaks are needed.

## Planning Considerations

The initial function of any vegetation to be established on disturbed soils is to prevent soil detachment and subsequent erosion and to re-establish healthy soil profiles. Disturbed sites that do not have an adequate organic layer (A-layer) to support plant growth will require soil amendment or careful selection of pioneer species, such as *Betula sp.*, *Comptonia peregrina*, *Ceanothus americanus*, *Andropogon sp.*, or *Panicum virgatum*, which can aid in the soil formation process inherent to secondary succession on a site. Site conditions will dictate the specific planting palette and design. Plant palettes will need to be adjusted for wet sites, acidic sites, coastal sites, urban sites, and other conditions. Steep slopes (greater than 2:1) should be planted with species appropriate for slope stabilization. Narrow sites will need to be established so that they can be maintained without requiring additional maintenance activities, such as supplemental watering.

Other factors are considered when choosing whether to plant grass and/or other herbaceous vegetation, or whether woody landscape plantings should be utilized.

- Although grass seed can provide quick cover, some disadvantages to using it include: Permanent grass cover requires periodic mowing, fertilization and may include the application of pesticide to maintain the desired aesthetic quality. Consistent mowing can delay the establishment and growth of forbs and woody herbaceous plants that would typically occur through the process of natural succession.
- Grass cover does little to control access by pedestrians or vehicles. In areas of heavy pedestrian use, soil compaction may result in death of the plants, increasing erosion potential.
- Mown trufgrass provides limited value for wildlife. Extensive turfgrass areas adjacent to surface waterbodies such as lakes and ponds may also provide an attractive feeding habitat for wildlife which may become a nuisance (e.g., Canada Geese).

Landscape plantings of trees, shrubs, and ground covers have attributes which provide benefits over grass or herbaceous cover. These benefits include:

- Maximizing the interception and uptake of stormwater
- Sequestering more carbon than grass
- Improving air quality
- Modifying air circulation patterns
- Reducing heating and cooling costs

- Providing shade and helps regulate air temperature
- Preventing blinding reflections
- Softening architectural features
- Screening undesirable views
- Controlling or screening undesirable noises
- Calming and controlling traffic
- Providing wildlife food and shelter
- Restoring natural conditions to a disturbed site

### Landscape Planting Plan

Landscape planting plans should be developed for landscape plantings in conjunction with site grading and drainage The plant palette and placement should be tailored to the site and a licensed Landscape Architect should be retained to provide the technical expertise necessary to select the correct plants and develop the site-specific design. The landscape planting plan should identify the species, location, number of each planting, the type of planting stock (i.e., bare-root, balled and burlapped, etc.), and the timing for planting.

Newly transplanted trees and shrubs which are carefully selected to match the site conditions will need the least aftercare and will become established quickly. Conversely, plants put under stress by being transplanted into an environment they are not well adapted to will need ongoing, sometimes even extraordinary, maintenance. The following characteristics should be considered when developing a landscape planting plan and selecting plant material:

**Adaptability to Site Conditions:** Proper selection of landscape plants requires a careful study of the characteristics of the site, a thorough knowledge of the species available and hardy to the area, and a thorough knowledge of all the potential insect, disease, and cultural problems which may weigh against the plant selected for the required function.

Site characteristics such as soil type, surface and subsurface drainage, and light availability are primary limiting factors that determine if a given plant will survive. Other site-specific factors such as soil composition, soil pH, exposure to salt at shoreline or roadsides, high winds, polluted air, heat from reflected sunlight, or exposure to deer may limit plant survivability. The specific conditions at each site must be considered when selecting the appropriate plant for the site.

**Hardiness Zones:** Landscape plants, whether woody or herbaceous, must be hardy to the area in which they are planted to survive. Hardiness zones are geographical areas mapped according to the approximate range of average annual minimum temperatures. Plants adaptable to conditions in specific zones are said to be hardy in those zones. The USDA maintains an on-line Plant Hardiness Zone Map. The geographic distribution of plant hardiness zones throughout Connecticut reflects the milder conditions along the shoreline and interior portions of the Connecticut River Valley, cooler weather in the northwest hills, and a transitional area dominating the western and eastern portions of the state.

**Mature Height and Spread:** To minimize future maintenance and replacement costs and to enhance long term plant health, select plants to match the species to the site, and place plants to provide adequate space for the plant to grow to its natural mature size.

Consideration must be given to the height and location of overhead utilities, the location and depth of underground facilities, lines of sight around intersections of roadways, road and sidewalk clearance needed for snow removal operations, clearance from buildings, and all other potential situations where the maturing plant will become an obstruction, nuisance, or hazard.

If the space allotted to the plant selected is inadequate, suitable periodic maintenance pruning must be planned in accordance with the needs of the species, limitations of the site, or the intended effect. Normally, plants installed for erosion control purposes are not intended to be pruned and should be selected and placed with knowledge and consideration of mature sizes.

**Growth and Establishment Rate:** Some trees and shrubs attain their mature sizes very rapidly, whereas others are slow to grow to mature size. Some shrubs and vines will become established quite rapidly, with growth characteristics like rooting from the growing tips of the stem and sprouting from root systems and underground stems. Knowing how fast a tree, shrub, or vine will become established and how quickly it will grow to mature size is important to select the right plant, and the number of plants (spacing) for the situation. Growth and establishment rates are also linked to how well the plant has been selected to match the site conditions. Plants that are well adapted to the site will become established quicker, live longer, and will require less aftercare.

**Functional Characteristics:** In addition to selectin plants that will thrive in the site conditions, it is necessary to consider the plant's role in the design. Plants with aggressive root systems can help control erosion and/or stabilize slopes. Shrubs with dense branching, or evergreen foliage might be selected to create a visual barrier or mitigate noise. Deciduous plants with coarse, hairy leaves will absorb dust and help mitigate air pollution. Plants with high nut and berry production can be planted to enhance habitat value for wildlife. Knowing a plant's characteristics can help avoid introducing undesirable attributes to the planting. Where a Salix sp. might be helpful in managing stormwater in one setting, it's high water requirements can result in damage to a septic system if it must seek out the water it needs. Plants with aggressive root structures can damage underground utilities or even create internal pathways for water in earthen dams and dikes. Plants with shallow roots can cause damage to sidewalks or adjacent paved areas. Plants that create a high volume of litter can clog drainage systems or create other maintenance issues related to the buildup of biomass.

**Ornamental Characteristics:** Since these Guidelines are concerned primarily with landscape planting as it relates to soil erosion and sediment control, no attempt has been made to provide guidance on plant selection for ornamental or aesthetic purposes. However, plants in a landscape design can and should be selected for specific functional attributes which contribute to the goal of soil erosion and sediment control.

**Plant Selection:** Many curated search engines exist to aid in the selection of plants for any site and the plant selection process should begin by consulting these resources:

- American Standard for Nursery Stock
- Plant Database maintained by UCONN's College of Agriculture, Health and Natural Resources
- Plant Finder search engine maintained by the Missouri Botanic Garden
- UCONN's Urban Tree Selection Manual
- Connecticut Sea Grant's Connecticut Coastal Planting Guide
- Connecticut Sea Grant's Planting Guide for Riparian Sites
- UCONN, NEMO Rain Garden Guidance
- Rain Garden Planting Guide produced by Rutgers
- Connecticut Native Plant & Sustainable Landscaping Guide
- New England Native Plants Initiative at UCONN
- Plant Selection Guide for Slope Stabilization maintained by the State of Washington Department of Ecology
- Ecological Landscaping Resources, Connecticut College

**Timing of Planting and Transplanting:** When plants may be transplanted depends on how they are grown and sup- plied. Balled and burlapped and container grown plants can be planted any time of the year, provided that the soil at the planting site is not waterlogged or frozen at the time of planting or in the weeks following planting while the plants' roots settle into the soil.

Deciduous trees are normally dug and balled for transplanting in the early spring before flowers or leaves develop. Some species transplant best in either the spring or fall of the year and balled in burlap stock may not be available other than during the optimal season for transplanting. Normally, spring flowering trees are not dug while flowering, so summer availability of field grown balled and burlapped trees is usually somewhat restricted to those dug early in the season.

Balled and burlapped plants may lose 90% or more of their root system from the digging operation. If dug during the active summer growth period, significant stress may be placed on the plant. For this reason, digging and balling operations normally cease during the summer months. Summer digging of deciduous trees may be performed but requires special preparation and aftercare to minimize potentially fatal stresses on the plant. Evergreens may also be dug and balled in burlap in the early spring but are also successfully dug and transplanted in summer after new growth has hardened off.

Trees and shrubs to be planted as bare-root plants should be handled only when dormant in spring, or after leaf fall in autumn.

**Knowing a Plants Area of Origin:** Plant material should be sourced, whenever possible, from nurseries or farms within the same climatic zone as the project site. If material must come from a source in a different zone care should be taken to plant the material when climatic conditions are within the range that the plant experienced in its original location. For example, a tree coming from Virginia to Connecticut typically should not be planted early in the spring or late in the fall when the temperatures and supply of daylight is not comparable to the conditions that it experienced in the nursery.

Landscape Plant Forms, Standards, and Sources**:** Landscape plants may be bought as balled in burlap or similar material, containerized, or as bare rooted stock. All plants shall comply with the American Standard for Nursery Stock (ANSI Z60.1), produced by the American Horticulture Industry Association (AmericanHort), which provides a comprehensive and consistent set of measurement and specification standards for all types of plant material.

The plants identified in the web resources listed in this section are usually available at commercial nurseries balled in burlap, or in containers. Trees and shrubs may also be purchased from the state nursery or from county Soil and Water Conservation Districts. A broad range of plant material is available to fulfill the desired functions of a landscape planting. Information on additional appropriate plants may be obtained from Connecticut licensed Arborists, a landscape architects licensed to practice in Connecticut, the USDA Natural Resources Conservation Service, the Connecticut Agricultural Experiment Station, and the Connecticut Cooperative Extension System.

Planting Details and Specifications: Dr. Ed Gilman from University of Florida, Jim Urban, FASLA, and Brian Kempf and Tyson Carroll of the Urban Tree Foundation have developed a modern, up-to-date, and peer reviewed set of planting details and specifications in AutoCAD, PDF, and Microsoft Word formats. These are designed specifically for landscape architects, engineers, architects, contractors, urban foresters, arborists, municipalities, and state agencies. The planting details include:

- Tree in poorly drained soil
- Tree with berm (modified soil)
- Tree with berm (unmodified soil)
- Tree on slope 5% (20:1) to 50% (2:1) (modified soil)
- Tree on slope 5% (20:1) to 50% (2:1) (unmodified soil)
- Groundcover
- Shrub on slope 5% (20:1) to 50% (2:1) (modified soil)
- Shrub on slope 5% (20:1) to 50% (2:1) (unmodified soil)
- Shrub (modified soil)
- Shrub (unmodified soil)

Invasive Species: Certain introduced shrubs, like Autumn Olive (*Elaegnus umbellata*), Honeysuckles (*Lonicera spp*), Multiflora Rose (*Rosa multiflora*), Rugosa Rose (*Rosa rugosa*) Winged Euonymus (*Euonymus alatus*), and Asiatic Bittersweet (*Celastrus orbiculatus*) have been identified as undesirable because they are not native and are invasive into otherwise naturally vegetated areas. Native plants are preferred in most soil erosion and sediment control applications. The Connecticut Invasive Plant Working

Group of the University of Connecticut maintains a list of invasive plants in Connecticut, which should be consulted to avoid selecting undesirable, non-native invasive plants.

Additionally, it is important to inspect plants to assure they are free of hitch hiker species, invasive insects such as the spotted lanternfly (see the Connecticut Agriculture Experiment Station's Information to aide in identification of this particular species).

Sourcing Material: Planting plans can only be realized when the material can be sourced in the marketplace. It is important to consult with suppliers and growers before finalizing the plant selection to confirm that the specified material will be available. Landscape Architects and Landscape Contractors can assist with confirming the availability of stock by contacting growers and major suppliers, especially for plants that are not typically available at retail nurseries. The State of Connecticut maintains a list of native plant sources which can be consulted as well: http://nenativeplants.uconn.edu/nativePlantSources.php

## Specifications

### Delivery and Storage of Materials

Upon receipt of plant stock, check to see that adequate protection during transit has been provided. If shipped by open truck, the plants should have been covered with a tarpaulin or canvas to minimize desiccation from exposure to the sun and wind. When delivery is made by an enclosed vehicle, the plants should have been carefully packed and adequately ventilated to prevent "sweating" of the plants. Physical injuries should have been prevented by careful packing.

In all cases, plants must be kept cool and moist until planting.

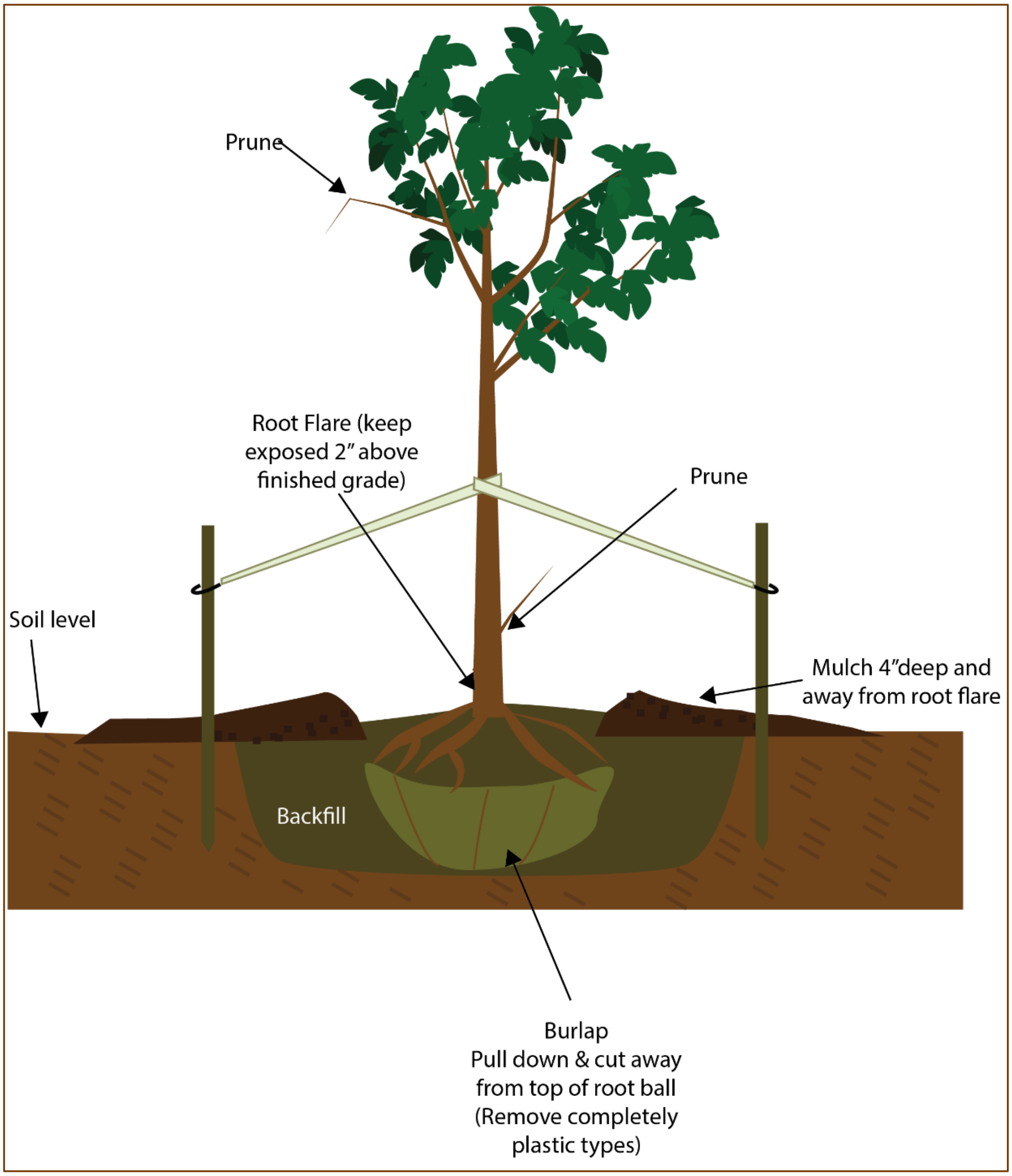
Insofar as practical, all plant material should be planted on the day of delivery. Plants which must be temporarily stored on site should be kept in the shade and protected from drying winds. For balled stock, root balls must be protected by covering the root ball with soil or other acceptable material and must be kept moist. Container stock held on site will require watering if planting is delayed. Bare root plant may be stored in a cool, shaded area for as long as 10 days under ideal conditions. If are not planted within 10 days, they should be "heeled in" (temporarily planted in a trench or in mulch) until they can be permanently planted. All stock should be handled carefully to avoid damage to the roots, trunk, and branching, and as few times as possible.

### Transplanting Procedures

Transplanting balled in burlap (B&B) Plant Material: Figure 5- 10 shows the proper planting of balled in burlap plant material, using a deciduous tree as an illustration.

**Stock Examination:** Proper planting depth of a plant balled in burlap may vary depending upon how the plant was dug and balled. Each plant should be examined to determine if the plant was dug and balled properly. To do this, locate the crown of the plant at the point where the root mass or first major root originates from the stem. This point should be at or slightly below the top of the soil. Also use this point as a reference

*Figure 5- 10 Transplanting Balled and Burlapped Plants*



to determine if excess soil cover has been placed over the root ball by improper digging and balling.

Ball sizes should always be of a diameter and depth to encompass enough of the fibrous and feeding root system as necessary for the full recovery of the plant. Recommended ball depth to diameter ratios are shown in Figure 5- 11. Under certain soil and regional conditions, plants have roots systems of proportionally less depth and greater diameter. Those require a more shallow but wider ball to properly encompass the roots. Conversely, in other soils and in certain regions roots develop greater depth and less spread, requiring an exceptionally deep ball which may be smaller in diameter and greater in depth than the size recommended.

Compare the ball size in relation to the size of the plant, using the current American Standard for Nursery Stock (ANSI Z60.1) and note the size of the roots cut when dug to be balled in burlap. Undersize root balls or large cut roots are a clue that digging may have been improper, and that actual root mass may be inadequate to support the plant during its establishment period.

*Figure 5- 11 Ball Depth to Diameter Ratio*

**Diameter less than 20". Depth not less than 75% of diameter or 3/4 of width.**

**Diameter 20 to 30". Depth not less than 66.6% or 2/3 of width.**

**Diameter 31 to 48". Depth not less than 60% or 3/5 of width. Balls with a diameter of 30" or more should be drum laced.**

**Site Preparation** (see Figure 5- 10: Thoroughly examine the root ball to determine the proper planting depth for each plant (see Stock Examination above). Excavate a planting site whose top width is 3 times the width of the root ball to a depth that is no deeper than the proper planting depth with sloped sides tapering to the surface. The soil under the root ball should remain undisturbed, or if disturbed, should be tamped prior to planting, to prevent settling of the root ball. Since most new roots will grow horizontally from the root ball, compacted soil under the ball will not inhibit rooting.

Planting site preparation should focus on providing the highest quality environment possible for root development during the first year or two after transplanting. Long term survival depends on selecting the proper species for the site. More intensive site preparation will be necessary in urban soil conditions and on disturbed sites than when planting in high quality undisturbed soil.

Handling and Setting the Plant: Set the plant in the planting site so that it is plumb, level, and centered. Do not use the trunks of trees as levers to adjust the position of the root ball, as this may fracture the root ball and damage roots. Instead, move the root ball itself, being careful not to pull on ropes which may lay against bark (especially in spring when bark slips easily).

When the plant is properly positioned in the planting site, cut all twines and other tying material encircling the trunk. For natural burlap wrapping pull it back and cut off the excess and discard, do not tuck it into the hole where it can cause problems with air pockets and moisture retention, both of which may lead to rotted roots. Remove synthetic burlap completely. To test fabric to see if it is synthetic, burn an edge with a match. If it melts, it is synthetic and must be completely removed.

Wire baskets are commonly used to contain and transport some balled and burlapped plant material. Cut and remove all, but at a minimum as much, of the wire basket as possible to avoid future interference with root growth.

Backfilling, Watering and Mulching: After all tying materials and wire baskets are removed as appropriate, backfill the site to original grade with original soil. Soil amendments are unnecessary in most planting situations. Water the backfill soil thoroughly, allowing the water to settle the soil, removing air pockets. Do not pack with feet or tools. Use enough water to ensure thorough saturation of the soil. Add soil to bring the soil level back up to grade when the water has infiltrated. As a temporary measure to aid in establishment, a low (3" to 6") rim of tamped soil can be built to help hold water for subsequent watering. Locate the inside edge of the rim at or outside the edge of the root ball. Mulch the disturbed area with Landscape Mulch (see Figure 5- 10).

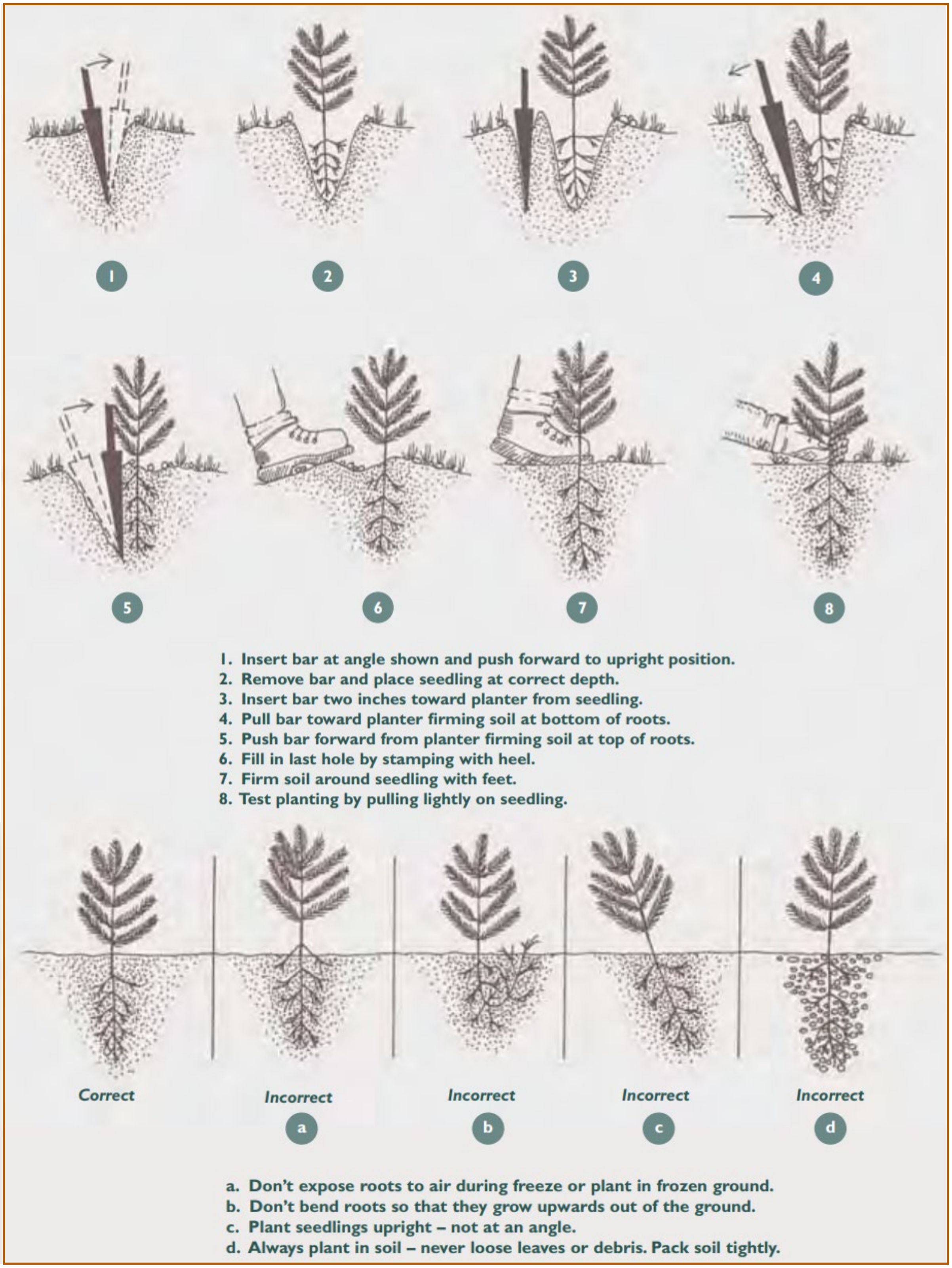
Fertilization: Under normal circumstances, it is typically necessary to fertilize woody plants upon initial planting. Biostimulant products, such as Bio-plex Organics, can be used to stimulate root growth and increase the beneficial mycorrhiza and microbe communities which promote healthy plant growth.

Staking: Staking or guying trees using wire covered with rubber hose sections is not recommended in most circumstances. Failure to remove stakes and wires has caused severe damage to trees by girdling the trees at the point of wire attachment. By allowing the tree to flex somewhat in the wind, the tree will be able to develop a proper taper and anchoring roots to naturally resist movement in the wind. Staking and guying may become necessary due to lose root balls, unusually high or persistent prevailing winds, or other specific conditions. In these cases, use of a flexible and biodegradable type of tree tying material is preferred.

#### Transplanting Bare Root Plant Material

Figure 5- 12 shows how to properly plant bare rooted plants and shows the proper minimum root spread for bare root deciduous shrubs. Dig the hole deep and wide enough to accommodate all the roots and allow them to spread out without bunching or curling (no "J"-shaped roots). If the roots are excessively long, they may be pruned back to a length of 10 to 12

*Figure 5- 12 Planting Bare Root Stock, Source: Virginia Erosion and Sediment Control Handbook, 1992.*




inches. Place the plant at the same depth in the soil at which it was planted when rooted in the nursery. Add soil as necessary to fill planting hole to existing grade. Water thoroughly after planting. Make sure that there are no turned up roots or air pockets in the soil.

Either use landscape mulch or prepare the site by very low cutting of grass and weeds to reduce initial competition. It is very important to prevent grasses, vines, and other vegetation from competing with the newly transplanted plants for sunlight, water, and soil nutrients.

While this section is meant to refer primarily to the planting of relatively small, bare root shrubs, larger plants including trees may be obtained as bare root stock. When larger shrubs or trees are planted bare root, staking and guying will likely be necessary. As above, use of a flexible and biodegradable type of tree tying material is preferred to the traditional hose and wire system.

### Transplanting Container Grown Plants

**Stock Examination:** For plants grown in containers, carefully remove the plant from the container, and inspect the root mass to determine if the plant has well developed roots, and to be sure it has not been recently repotted to a larger pot size. Containerized stock should have well developed roots, but should not be pot bound, which causes roots to encircle the container, resulting in difficulties in establishment.

**Site Preparation:** Site preparation for container grown plants is the same as for balled and burlapped plants.

**Handling and setting the plant:** When container grown plants have well developed root systems that encircle the pot, either loosen the roots or slice the root ball with a sharp knife vertically three or four times, cut- ting about an inch deep. This will promote new roots to develop and spread out, rather than continuing to follow the circular rooting pattern. If excess soil in the pot had buried the original soil level just above the crown of the plant, be sure to adjust the planting depth to place the plant back at or slightly above the original soil level.

**Backfilling, Watering and Mulching:** Backfill the site to original grade with original soil. Soil amendments are unnecessary in most planting situations. Water the backfill soil thoroughly, allowing the water to settle the soil, removing air pockets. Do not pack the soil tightly with feet or tools. Use enough water to ensure thorough saturation of the soil. Add soil to bring the soil level back up to grade when the water has infiltrated. Mulch the disturbed area with landscape mulch.

**Fertilization:** Under normal circumstances, it is not recommended to fertilize woody plants upon initial planting.

## Maintenance

Maintenance of trees, shrubs, and ground covers is an exhaustive topic which is not addressed by these Guidelines. Instead, the most critical maintenance needs for the first year of a newly transplanted plant are described below.

### Inspection Requirements

Inspect plants until they are established or at least monthly for 1 year following planting, and more frequently during hot dry periods for mulch adequacy, soil moisture and general plant condition. When a plant has regrown a sufficient root system such that it can withstand normal variations in climate and soil conditions, and has resumed normal growth, it is established. An established plant will exhibit normal growth patterns of bud break and leaf fall and will have resumed a growth rate considered normal for the species. Larger plants, especially balled in burlap trees which have lost a significant amount of their roots systems upon transplanting will need the most attention during the initial establishment period.

### Mulch and Water

Apply additional landscape mulch around landscape plants as needed to keep soil covered and to inhibit weed growth. Keeping all newly transplanted plants adequately mulched is important to moderate fluctuations in soil moisture and temperature. Trees that are mulched will recover from transplanting, become established, and resume normal growth more quickly than trees planted without the benefit of mulch.

Water plants during hot dry periods when soil around the plants begins to dry out. If leaves of recent landscape plantings are wilted, severe water deficiency is indicated, and permanent damage to the plantings may result if supplemental water is not provided promptly. For successful establishment of new plantings, especially those installed in late spring and early summer, adequate watering during the balance of the summer and into the fall is especially important. Water should be delivered to the root systems as much as possible. Irrigation that is directed to the foliage can cause leaf burn or rot.

> Note: *A useful rule of thumb in Connecticut is that new plantings should receive at least 1 inch of rain per week.*

### Pruning

Prune to remove only dead or damaged limbs on newly planted trees unless an arborist has recommended otherwise. Pruning the top of the tree will severely weaken the tree's ability to grow a healthy new root system in the new site. This is especially important for trees balled in burlap, which lose a large portion of their original root system when they are dug from the field. For new roots to form from plants grown in containers, top pruning should be delayed for at least a year. Ideally, newly planted trees should not be pruned until after their third year, and then only to remove dead and weak branches, and to train the tree's future growth by removing or pruning any wayward branches which will lead to future problems or detract from the natural shape of the plant.

### Insect and Disease Control

All plants in the natural environment are host to a wide variety of insect and disease organisms. When insects or disease problems on a plant become threatening to the life or practical value of the plant, corrective or preventative actions may become necessary. When a problem occurs, positive identification of the host, and then of the insect or disease problem is vital to successfully resolving the problem. Plants should be selected to avoid common insect or disease problems by choosing those species resistant to common plant diseases or unpalatable to common insect problems.

The Cooperative Extension System or a state licensed arborist can help identify insect and disease problems and suggest solutions.

## Short-Term Non-Living Soil Protection

### Planning Considerations

The short-term non-living soil protection measures are Temporary Soil Protection, Mulch for Seed, Landscape Mulch, Temporary Erosion Control Blanket (ECB), Permanent Turf Reinforcement Mat (TRM), and Stone Slope Protection. These measures serve the common function of preventing erosion by providing a non-living cover to erodible surfaces. Except for some TRM, these measures are intended to dissipate the erosive energy of raindrops.

Except for the Temporary Soil Protection and Stone Slope Protection measures, they are intended to promote the establishment and/or maintenance of a vegetative cover.

Temporary Soil Protection is a biodegradable mulch that is applied to a disturbed surface for the sole purpose of protecting the soil for less than 5 months when the establishment of a vegetative cover is not possible (usually during winter and mid-summer).

Mulch for Seed and Landscape Mulch measures also use biodegradable mulches but are intended for use when seeding and with landscape planting, respectively.

ECBs are biodegradable mulches that are manufactured with a netting for anchoring to create a blanket that is used as a substitute for Mulch for Seed where mulch anchoring is needed and may also be used as a substitute for Temporary Soil Protection.

TRMs are geotextiles that are laid on or within the soil surface to permanently assist in holding the roots of herbaceous plants when exposed to water velocities that would normally erode the soil around the roots. They are used in grass-lined swales and are applied with Permanent Seeding and anchored mulches or during Sodding just beneath the sod. Their primary function is to increase the swale's performance limits.

ECBs and TRMs are geotextiles, and some products are hybrids of both measures. Careful attention to the manufacturer's recommendations for use is required.

The Stone Slope Protection measure calls for applying stone or stone aggregates on unstable soils where unfavorable soil conditions exist for the establishment and growth of plants. It is not used where concentrated flows are expected. It may be used as a substitute for Landscape Mulch.

Table 5. 6 is provided to assist in the selection of mulch material by comparing the types of biodegradable mulches commonly used in the Temporary Soil Protection, Mulch for Seed and Landscape Mulch measures.

*Table 5. 6 Planning Mulching Selection Chart*

| Mulch Type | Exposure Period | How Applied | Limitations / Considerations |
|---|---|---|---|
| Temporary Soil Protection - temporary soil cover when seeding dates cannot be met | | | |
| straw/hay | 0-6 months | by hand or<br>blown by machine | preferred over other mulches<br>requires anchoring in windy areas<br>hay will typically supply weed seeds, straw will not |
| cellulose fiber* | not recommended | not recommended | used only as a tackifier for other mulch material |
| wood chips | > 1 year | by hand or<br>graded by machine | restricted to slopes 3 on 1 or flatter<br>must be removed or tilled into ground before seeding or planting<br>may reduce soil fertility during decay process requiring subsequent fertilization for plant growth<br>lasts longer than straw/hay<br>no anchoring required |
| bark chips /<br>shredded bark | 0-1 year | by hand | same as wood chips |
| Mulch for Seed - temporary soil cover until seeds germinate and grow sufficiently to stabilize soil | | | |
| straw/hay | 0-6 months | by hand or<br>blown by machine | requires anchoring in windy areas<br>hay will supply weed seeds, straw will not |

| Mulch Type | Exposure Period | How Applied | Limitations / Considerations |
|---|---|---|---|
| | | | may provide better shading against hot summer sun for seeding done at the beginning of summer |
| cellulose fiber* | 0-6 months | sprayed in slurry with water | no volunteer weed seeds, lawn seeding<br>wood fiber per unit cost generally more expensive than paper fiber, but requires less product for equivalent coverage<br>may be used in summer with seed only if adequate<br>irrigation is planned |
| wood chips | not recommended | not recommended | not recommended |
| bark chips/<br>shredded bark | not recommended | not recommended | not recommended |
| Landscape Mulch – soil cover inhibiting weed growth around planted trees, shrubs & vines | | | |
| straw/hay | not recommended | not recommended | not recommended |
| cellulose fiber* | not recommended | not recommended | not recommended |
| wood chips | > 1 year | by hand or<br>graded by machine | may reduce soil fertility during decay process, requiring application of nitrogen<br>slippage may occur on steeper slopes if wood chips are<br>applied over a large area |
| bark chips/<br>shredded bark | 0-1 year | by hand | same as wood chips |

# Temporary Soil Protection

## Definition

Application of a degradable material that will protect the soil surface on a temporary basis without the intention of promoting plant growth.

## Purpose

To prevent erosion by dissipating the erosive energy of raindrops and encouraging sheet flow over the soil surface.

## Applicability

- When grading of the disturbed area will be suspended for a period of 30 or more consecutive days, but less than 5 months, stabilize the site within 7 days of the suspension of grading using mulch or other materials appropriate for use as a temporary soil protector.
- For surfaces that are not to be reworked within 5 months but will be reworked within 1 year, use Temporary Seeding, Mulch for Seed or when slopes are less than 3:1, wood chips, bark chips or shredded bark.
- For surfaces that are to be reworked after 1 year, use Permanent Seeding and Mulch for Seed.

## Planning Considerations

See Mulching Selection Chart Found in the Group Planning Considerations.

## Specifications

### Materials

Temporary soil protection materials include but are not limited to mulches, tackifiers, and nettings and shall be:

- biodegradable or photo-degradable within 2 years but without substantial degradation for 5 months;
- free of contaminants that pollute the air or waters of the State when properly applied;
- free of foreign material, coarse stems, and any substance toxic to plant growth or which interferes with seed germination; and
- capable of being applied evenly such that it provides 100% initial soil coverage and still adheres to the soil surface, does not slip on slopes when it rains or is watered, does not blow off site, and dissipates rain- drop splash.

Mulches within this specification include, but are not limited to:

Hay: The dried stems and leafy parts of plants cut and harvested, such as alfalfa, clovers, other forage legumes and the finer stemmed, leafy grasses. The average stem length should not be less than 4 inches. Hay that can be windblown should be anchored to hold it in place.

Straw: Cut and dried stems of herbaceous plants, such as wheat, barley, cereal rye, or brome. The average stem length should not be less than 4 inches. Straw that can be windblown should be anchored to hold it in place.

Wood Chips: Chipped wood material from logs, stumps, brush, or trimmings including bark, stems and leaves having a general maximum size of 0.5 inch by 2 inches and free of excessively fine or long stringy particles as well as stones, soil and other debris. No anchoring is required. If seeding is performed where wood chips have been previously applied, prior to the seeding the wood chips should be removed or tilled into the ground and additional nitrogen applied. Nitrogen application rate is determined by soil test at time of seeding.

Bark Chips, Shredded Bark: Tree bark shredded as a by-product of timber processing having a general maximum size of 4 inches and free of excessively fine or long stringy particles as well as stone and other debris. Material use is the same as wood chips.

May also include corn stalks, leaves and other similar materials provided they meet the requirements of the materials section within this specification.

Note: Wood and bark by-products may generate contaminated runoff if improperly stored for extended periods. These materials should only be stored on free draining, gently sloping soils, and only for short periods of time.

If subsequent seeding is performed where cellulose dense mulches (e.g., leaves, excelsior, woodchips, bark chips) have been applied, then prior to seeding either remove the mulch or till it into the ground with the application of nitrogen.

Cellulose fiber is not recommended for use, except as a tackifier for other mulch materials.

Tackifiers within this specification include, but are not limited to:

Water soluble materials that cause mulch particles to adhere to one another, generally consisting of either a natural vegetable gum blended with gelling and hardening agents or a blend of hydrophilic polymers, resins, viscosifiers, sticking aids and gums. Emulsified asphalts are specifically prohibited for use as tackifiers due to their potential for causing water pollution following its application.

Nettings within this specification include but are not limited to:

Prefabricated openwork fabrics made of cellulose cords, ropes, threads, or biodegradable synthetic material that is woven, knotted, or molded in such a manner that it holds mulch in place until temporary soil protection is no longer needed. Examples of netting are tobacco netting (used where flows are not concentrated) and jute netting (typically used in drainageways).

### Substitute Measures

Where tackifiers or nettings are needed to anchor mulch, a Temporary Erosion Control Blanket or Stone Slope Protection may be substituted, providing 100% of the disturbed soil is covered.

### Site Preparation

Prior to mulching, complete the required grading and install and/or repair other sediment control measures needed to control water movement within the area to be mulched.

### Application

**Spreading:** Spread mulch material uniformly by hand or machine resulting in 100% coverage of the disturbed soil.

When spreading hay mulch by hand, divide the area to be mulched into approximately 1,000 square feet and place 2 to 3 bales of hay in each section to facilitate uniform distribution.

When spreading woodchips on slopes, it is particularly important not to spread the chips too thick. Excessive applications tend to slip or slump when saturated.

See Table 5. 7 for suggested application rates of specific mulches when used as temporary soil protection.

*Table 5. 7. Suggested Temporary Soil Protection Application Rates for 100% Cover*

| Mulch | Rate |
|---|---|
| Hay/Straw | 2 – 3 Tons/acre |
| Wood Chips/ Shredded Bark | 6 cu. yds./1000 sq. ft. |

**Anchoring:** Apply tackifiers and/or netting either with the mulch or immediately following mulch application. Expect the need for tackifiers or netting along the shoulders of actively traveled roads, hill tops and long open slopes not protected by wind breaks.

When using netting the most critical aspect is to ensure that the netting maintains substantial contact with the mulch and the mulch, in turn, maintains continuous contact with the soil surface. Without such contact, the material is useless, and erosion can be expected to occur. Install in accordance with manufacturer's recommendations.

### Maintenance

Inspect the temporary soil protection area for mulch movement and rill erosion at least once a week and within 24 hours of the end of a storm that generates a discharge.[38] Where soil protection falls below 100%, reapply soil protection within 48 hours. Determine the cause of the failure. If mulch failure was the result of wind, consider applying a tackifier or netting. If mulch failure was caused by concentrating water, install additional measures to control water and

[38] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

sediment movement, repair erosion damage, re-apply mulch with anchoring or use Temporary Erosion Control Blankets.

Inspections should take place until work resumes.

## Mulch for Seed

### Definition

Application of a mulch that will protect the soil surface on a temporary basis and promote the establishment of temporary or permanent seedings.

### Purpose

- To prevent erosion by dissipating the erosive energy of raindrops and encourage a sheet flow over the soil surface.
- To aid in the growth of herbaceous vegetation by reducing evaporation of water, enhancing absorption of water, helping to anchor seed in place, providing protection against extreme heat and cold and improving soil texture as it decomposes.

### Applicability

Used with Temporary Seeding and Permanent Seeding measures.

### Planning Considerations

See Mulching Selection Chart Found in the Group Planning Considerations.

### Specifications

#### Materials

Mulch for seed, including tackifiers and nettings used to anchor much, shall be:

- biodegradable or photo-degradable within 2 years but without substantial degradation over a period of 6 weeks,
- free of contaminants that pollute the air or waters of the State when properly applied,
- free of foreign material, coarse stems, and any substance toxic to plant growth or which interferes with seed germination, and
- capable of being applied evenly such that it provides 80%-95% soil coverage and still adheres to the soil surface, does not slip-on slopes when it rains or is watered, does not blow off site, dissipates raindrop splash, holds soil moisture, moderates soil temperatures and does not interfere with seed growth.

Types of mulches within this specification include, but are not limited to:

Hay: The dried stems and leafy parts of plants cut and harvested, such as alfalfa, clovers, other forage legumes and the finer stemmed, leafy grasses. Stem length should not average less than 4 inches. Hay that can be windblown must be anchored. Preferred mulch when seeding occurs outside of the recommended seeding dates.

Straw: Cut and dried stems of herbaceous plants, such as wheat barley, cereal rye, or broom. The average stem length should not be less than 4 inches. Straw that can be windblown should be anchored to hold it in place.

Cellulose Fiber: Fiber origin is either virgin wood, post-industrial/pre-consumer wood or post-consumer wood complying with materials specification (collectively referred to as "wood fiber"), newspaper, kraft paper, cardboard (collectively referred to as "paper fiber") or a combination of wood and paper fiber. Paper fiber shall not contain boron, which inhibits seed germination. The cellulose fiber must be manufactured in such a manner that after the addition to and agitation in slurry tanks with water, the fibers in the slurry become uniformly suspended to form a homogeneous product. After hydraulic spraying on the ground, the mulch shall allow for the absorption and percolation of moisture and shall not form a tough crust such that it interferes with seed germination or growth. Generally applied with tackifier and fertilizer. Refer to manufacturer's specifications for application rates needed to attain 80%-95% coverage without interfering with seed germination or plant growth. Not recommended as a mulch for use when seeding occurs outside of the recommended seeding dates.

Other mulches also include corn stalks and other similar organic materials provided they meet the requirements listed in the first paragraph of this section. Does not include materials such as wood chips, bark chips, or cocoa hulls.

Tackifiers within this specification include, but are not limited to:

> Water soluble materials that cause mulch particles to adhere to one another, generally consisting of either a natural vegetable gum blended with gelling and hardening agents or a blend of hydrophilic polymers, resins, viscosifiers, sticking aids and gums. Good for areas intended to be mowed. Cellulose fiber mulch may be applied as a tackifier to other mulches, provided the application is sufficient to cause the other mulches to adhere to one another. Emulsified asphalt is specifically prohibited for use as tackifier due to its potential for causing water pollution following its application.

Nettings within this specification include, but are not limited to:

> Prefabricated openwork fabrics made of cellulose cords, ropes, threads, or biodegradable synthetic material that is woven, knotted, or molded in such a manner that it holds mulch in place until vegetation growth is sufficient to stabilize the soil. Generally used in areas where no mowing is planned. Examples of netting are tobacco netting (used where flows are not concentrated) and jute netting (typically used in drainageways).

### Substitute Measures

Where mulch anchoring is required a Temporary Erosion Control Blanket may be used.

### Site Preparation

Follow requirements of Permanent Seeding or Temporary Seeding.

## Application

Timing: Applied immediately following seeding. Some cellulose fiber may be applied with seed to assist in marking where seed has been sprayed but expect to apply a second application of cellulose fiber to meet the requirements of Mulch for Seed.

Spreading: Mulch material shall be spread uniformly by hand or machine resulting in 80%-95% coverage of the disturbed soil when seeding within the recommended seeding dates. Applications that are uneven can result in excessive mulch smothering the germinating seeds. For hay or straw anticipate an application rate of 2 tons per acre. For cellulose fiber follow manufacturer's recommended application rates to provide 80%-95% coverage.

When seeding outside the recommended seeding dates, increase mulch application rate to provide between 95%-100% coverage of the disturbed soil. For hay or straw anticipate an application rate of 2.5 to 3 tons per acre.

When spreading hay mulch by hand, divide the area to be mulched into approximately 1,000 square feet and place 1.5-2 bales of hay in each section to facilitate uniform distribution.

For cellulose fiber mulch, expect several spray passes to attain adequate coverage, to eliminate shadowing, and to avoid slippage (similar to spraying with paint). Machine clogging can occur if product is improperly loaded or if leftover product is left in machine without cleaning. Comply with the manufacturer's recommendations for application requirements and mulch material specifications.

Estimating Percent Mulch Cover: The following procedure was adapted from the pamphlet entitled "Farming with Residues" by the U.S. Department of Agriculture Soil Conservation Service dated September 1991.

1. Use any line that is equally divided into 100 parts. Fifty-foot cable transect lines are available for this purpose. Another tool is a 50-foot tape measure using the 6-inch and foot marks also works well.
2. Stretch the line across the area to be sampled. Count the number of marks (tabs or knots) that have mulch showing under them when sighting directly above one end of the mark. It is important to use the same point on each mark for accuracy.
3. Walk the entire length of the rope or wire. The total number of marks with mulch under them is the percent cover.
4. Repeat the procedure at least 3 times in different areas and average the results.

Anchoring: When needed, mulch anchoring is applied either with the mulch as with cellulose fiber or applied immediately following mulch application. Expect the need for mulch anchoring along the shoulders of actively traveled roads, hill tops and long open slopes not protected by wind breaks.

When using netting, the most critical aspect is to ensure that the netting maintains substantial contact with the underlying mulch and the mulch, in turn, maintains continuous contact with the soil surface. Without such contact, the material is useless, and erosion occurs. Install in accordance with manufacturer's recommendations.

### Maintenance

Inspect mulched areas at least once a week and within 24 hours of the end of a storm that generates a discharge[39] until the grass has germinated to determine maintenance needs.

Where mulch has been moved or where soil erosion has occurred, determine the cause of the failure. If it was the result of wind, then repair erosion damage (if any), re-apply mulch (and seed as needed) and consider applying a netting or tackifier. If mulch failure was caused by concentrating water, install additional measures to control water and sediment movement, repair erosion damage, re-apply mulch and consider applying a netting or tackifier or use the Temporary Erosion Control Blanket measure.

Once grass has germinated, inspections should continue as required by Temporary Seeding and Permanent Seeding.

## Landscape Mulch

### Definition

Application of a mulch that protects the soil surface on a long-term basis and promotes the growth of landscape plantings.

### Purpose

To prevent erosion by dissipating the erosive energy of raindrops and encouraging infiltration.

To promote growth of plantings and woody vegetation by reducing evaporation of water, enhancing absorption of water, controlling weeds, providing protection against extreme heat and cold and improving soil texture.

To provide a temporary cover for disturbed soil.

### Applicability

Used only with landscape plantings (see Landscape Planting measure) and existing woody vegetation.

### Planning Considerations

Providing adequate organic mulch will enable a newly transplanted tree to become established and grow faster than an equivalent tree which is not mulched during the establishment period.

Plan mulch to be of sufficient depth to block the light that triggers weed seed germination and to prevent those that germinate deep under the mulch from surviving. Since weeds become established within the mulch matrix, a barrier under the mulch is of limited value. The use of black plastic under landscape mulch is not advised because the plastic impedes water and gas

[39] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

exchange in the soil, often creating a soil environment that is more conducive to disease organisms. However, woven geotextiles that are manufactured specifically for use as a weed barrier may be used, particularly when the Stone Slope Protection measure is used as a substitute for landscape mulch.

See Mulching Selection Chart Found in the Group Planning Considerations.

## Specifications

### Materials

Mulch materials must be:

- biodegradable over a period of several years but without substantial degradation within 1 year.
- free of contaminants that pollute the air or waters of the State when applied.
- free of foreign material, and any substance toxic to plant growth; and
- capable of being applied evenly such that it provides 100% soil coverage and still adheres to the soil surface without a mulch anchor, does not slip-on slopes when it rains or is watered, does not blow off site, dissipates raindrop splash, retains soil moisture, moderates soil temperatures, and inhibits the growth of herbaceous plants.

Types of mulches within this specification include, but are not limited to:

**Wood Chips:** Chipped wood material from logs, stumps, brush, or trimmings including bark, stems and leaves having a general maximum size of 0.5 inch by 2 inches and free of excessively fine or long stringy particles as well as stones, soil, and other debris.

**Bark Chips, Shredded Bark:** Tree bark shredded as a by-product of timber processing having a general maximum size of 4 inches and free of excessively fine or long stringy particles as well as stone and other debris.

Note: Wood and bark by-products may generate contaminated runoff if improperly stored for extended periods. These materials should only be stored on free draining, gently sloping soils, and only for short periods of time.

May also include cocoa hulls and other similar materials provided they meet the requirements listed in the first paragraph of this section.

Does not include materials such as hay or cellulose fiber that is used in Mulch for Seed measure.

### Substitute Measures

Stone Slope Protection measure may be used as a substitute for Landscape Mulch. Use with caution due to concerns about heat absorption and light reflection.

### Site Preparation

Follow requirements of Landscape Planting measure and/or Tree Protection measure.

### Application

**Timing:** For trees and shrubs apply after the installation of any weed barrier and within 7 days after planting. For vines and ground covers apply after the installation of any weed barrier either before planting or within 7 days after planting. Periodic reapplication is necessary when the mulch has decayed sufficiently to expose underlying soil or when it no longer inhibits herbaceous growth.

**Spreading:** Spread the mulch materials uniformly to a depth of at least 4 inches over the area disturbed by the hole excavated for planting the tree/shrub or over the entire area that has been or will be planted with vines or ground covers. The suggested application rate for wood chips and shredded bark is 10 $yd^3$/1,000 $ft^2$. Do not pile mulch against any tree or shrub trunk. Avoid excessive depths on slopes where mulch could slip when saturated.

### Maintenance

Inspect 2 to 3 months after the first application and then once a year for mulch movement, rill erosion and decay.

Where mulch has been moved by concentrated waters, install additional measures to control water and sediment movement, repair erosion damage, remove any unwanted vegetation and re-apply mulch. If mulch has decayed exposing underlying soil, repair any erosion damage, remove any unwanted vegetation, and reapply mulch.

## Temporary Erosion Control Blanket (ECB)

### Definition

A manufactured blanket composed of biodegradable / photodegradable natural or polymer fibers and/or filaments that have been mechanically, structurally, or chemically bound together to form a continuous matrix.

### Purpose

To provide temporary surface protection to newly seeded and/or disturbed soils to absorb raindrop impact and to reduce sheet and rill erosion and to enhance the establishment of vegetation.

### Applicability

- On disturbed soils where slopes are 2:1 or flatter.
- Where wind and traffic generated air flow may dislodge standard, unarmored mulches.
- May be used as a substitute for Temporary Soil Protection.
- May be used as a substitute for Mulch for Seed

### Planning Considerations

When considering the use of erosion control blankets, keep in mind the blanket's capability to conform to ground surface irregularities. If the blanket is not capable of developing a continuous contact with the soil, then it must be applied to a fine-graded surface. Some blankets will soften, and when wetted, re-conform to the ground. Also, when the ground is frozen, proper anchoring can be difficult, if not impossible.

Care must be taken to choose the type of blanket which is most appropriate for the specific need of the project. With the abundance of erosion control blankets available, it is impossible to cover all of the advantages, disadvantages, and specifications of all manufactured blankets. There is no substitute for a thorough understanding of the manufacturer's instructions and recommendations in conjunction with a site visit by the erosion and sedimentation plan designer prior to and during installation to verify a product's appropriateness.

The success of temporary erosion control blankets is dependent upon strict adherence to the manufacturer's installation recommendations. As such, a final inspection should be planned to ensure that the lap joints are secure, all edges are properly anchored, and all staking/stapling patterns follow the manufacturer's recommendations.

## Specifications

### Materials

Temporary erosion control blankets shall be composed of fibers and/or filaments that:

- are biodegradable or photodegradable within two years but without substantial degradation over the period of intended usage (five months maximum).
- are mechanically, structurally, or chemically bound together to form a continuous matrix of even thickness and distribution that resist raindrop splash and when used with seedings allows vegetation to penetrate the blanket.
- are of sufficient structural strength to withstand stretching or movement by wind or water when installed in accordance with the manufacturer's recommendations.
- are free of any substance toxic to plant growth and unprotected human skin or which interferes with seed germination.
- contain no contaminants that pollute the air or waters of the State when properly applied; and
- provide either 80%-95% soil coverage when used as a substitute for Mulch for Seed or 100% initial soil coverage when used as a substitute for Temporary Soil Protection measure.

Common materials include but are not limited to straw, wood excelsior fibers, and coconut fibers. Materials shall be selected as appropriate for the specific site conditions in accordance with manufacturer's recommendations. Use of any particular temporary erosion control blanket should be supported by manufacturer's test data that confirms the blanket meets these material specifications and will provide the short-term erosion control capabilities necessary for the specific project.

### Site Preparation and Installation

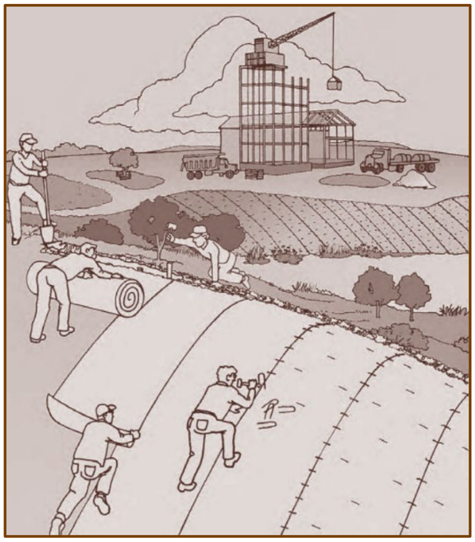
See Figure 5- 13 for an example of ECB installation.

Prepare the surface, remove protruding objects, and install temporary erosion control blankets in accordance with the manufacturer's recommendations. Ensure that the orientation and anchoring of the blanket is appropriate for the site.

The blanket can be laid over areas where sprigged grass seedlings have been inserted into the soil. Where landscape plantings are planned, lay the blanket first and then plant through the blanket in accordance with Landscape Planting measure.

Inspect the installation to ensure that all lap joints are secure, all edges are properly anchored, and all staking or stapling patterns follow manufacturer's recommendations.

*Figure 5- 13 Example of Temporary Erosion Control Blanket Installation*



### Maintenance

Inspect temporary erosion control blankets for failures at least once a week and within 24 hours of the end of a storm that generates a discharge.[40] Blanket failure has occurred when (1) soils and/or seed have washed away from beneath the blanket and the soil surface can be expected to continue to erode at an accelerated rate, and/or (2) the blanket has become dislodged from the soil surface or is torn.

If washouts or breakouts occur, re-install the blanket after regrading and re-seeding, ensuring that blanket installation still meets design specifications. When repetitive failures occur at the same location, review conditions and limitations for use and determine if diversions, stone check dams or other measures are needed to reduce failure rate.

Repair any dislodged or failed blankets immediately.

When used as a substitute for Mulch for Seed, continue to inspect as required by the seeding measure. When used as a substitute for Temporary Soil Protection, continue to inspect until it is replaced by other erosion control measures or until work resumes.

## Permanent Turf Reinforcement Mat

### Definition

A manufactured mat composed of non-biodegradable polymer or synthetic fibers mechanically, structurally, or chemically bound together to form a continuous matrix.

[40] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

## Purpose

- To provide permanent turf reinforcement where design flows exceed the stability of the soils and/or proposed vegetation.
- To enhance the establishment of vegetation as the final surface protection.

## Applicability

- In channels where design velocities exceed the stability limits of the soil and/or vegetation, and a soft-armored approach is desired.
- On unstable soils where intermittent flow exists.
- On disturbed soils with slopes 2:1 or flatter. On shorelines above a protected or stable toe to reduce soil erosion.

## Planning Considerations

As a rule of thumb, when flows over exposed soils exceed 2 feet per second and flows over proposed turf areas exceed 5-6 feet per second, then soil erosion can be expected. Permanent turf reinforcement mats can be one way to reduce the erosion potential and can be used in conjunction with other erosion control measures such as Vegetated Waterway and Permanent Diversion.

Permanent turf reinforcement mats are manufactured in several styles. They can be flat or three-dimensional matrices, laid either on top of or within the soil surface layer. Where permanent turf reinforcement mats are primarily used in areas of concentrated flows, an engineered design is required. Permanent turf reinforcement mats require the application of vegetative soil cover measures.

The requirement for permanent turf reinforcement mats should be identified during the development of the erosion and sediment control plan. Also, permanent turf reinforcement mats may be used as a corrective measure in areas of concentrated flows where repeated failures of vegetative cover have occurred.

Some permanent turf reinforcement mats are manufactured with a temporary erosion control blanket attached to them and do not require a separate mulch application. Permanent turf reinforcement mats should be expected to last the life expectancy specified in the manufacturer’s recommendations. Care must be taken to choose the type of mats which are most appropriate for the specific need of the project. A thorough understanding of the manufacturer’s instructions and recommendations is needed to verify a product’s appropriateness.

## Design Criteria

Where turf reinforcement mats are used in areas of concentrated flows an engineered design is required. For other applications refer to the manufacturer’s recommendations.

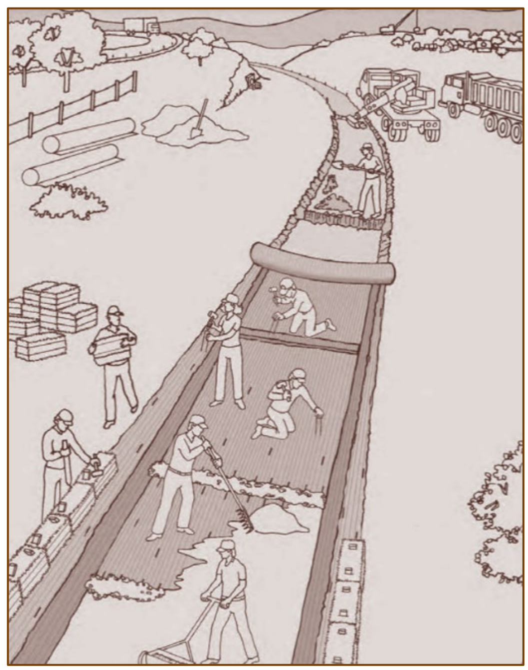
## Materials

Permanent turf reinforcement mats shall:

- consist of ultraviolet light resistant polymer or synthetic fibers mechanically, structurally, and/or chemically bound together for a continuous matrix of consistent thickness.
- contain no contaminants that pollute the air or waters of the state when properly installed; and,
- be free of any substance toxic to plant growth and unprotected human skin or which interferes with seed germination.
- Materials shall be selected as appropriate for the specific site conditions in accordance with manufacturer's recommendations. Use of any particular permanent turf reinforcement mat should be supported by manufacturer's test data that confirms the mat will provide the long-term erosion control capabilities necessary for the specific project.

## Installation Requirements

*Figure 5- 14 Example of TRM Channel Application*



- Prepare site and install in accordance with manufacturer's requirements. Figure 5- 14 shows a typical installation for a grass-lined channel.
- Establish vegetative cover in accordance with the applicable measure found in the Vegetative Soil Cover Control Measure Group of these Guidelines. Modify the sequence of application to meet the manufacturer's requirements for the specific installation.
- Inspect the installation to ensure that the mat is in direct contact with the prepared soil surface, all lap joints are secure, all edges and interior mats are properly anchored and/or treated, backfilling follows the manufacturer's requirements, and the vegetative soil measures used have been correctly applied.

## Maintenance

- Inspect permanent turf reinforcement mats at least once a week and within 24 hours of the end of a storm that generates a discharge[41] for failures until the turf has become

[41] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

established. Mat failure has occurred when soils and/or seed have washed away from beneath or within the mat resulting in a soil surface that can be expected to continue to erode or when the mat has become dislodged from the soil surface. When repetitive failures occur at the same location, review conditions and limitations of turf reinforcement mats and determine if additional controls, (e.g., diversions, stone barriers) are needed to ensure success. Repair mat failures within one workday.

- After the turf has become established, inspect annually or after major storm events.

## Stone Slope Protection

### Definition

Applying stone aggregates for permanent protection on slopes where vegetative soil cover measures are either impractical or difficult to establish.

### Purpose

To permanently reduce runoff and erosion, prevent soil compaction, and prevent shallow surface slope failures by providing a non-vegetative stone cover over the soil surface.

### Applicability

- Where highly erodible soils provide for unfavorable conditions for plant establishment and growth. Where herbaceous plant growth is to be discouraged or controlled.
- Not for use in concentrated flow areas or as a replacement for riprap or other measures designed to control slope stability. Use slope stabilization measures in the Stabilization Structures Functional Group and Subsurface Drain measure. May be used in combination with other slope stabilization measures and subsurface drains.
- For use on slopes 2:1 or flatter. For slopes steeper than 2:1 and for slopes with excessive seepage, an engineer's review of slope stability is required (see Riprap measure).

### Planning Considerations

Typically, stone slope protection is used when there has been difficulty in establishing vegetation as a result of adverse soil conditions or where competing vegetation is to be discouraged, as with landscape plants.  It may take the place of Landscape Mulch, thus requiring less maintenance.

An engineering review is required when the slope to be protected is steeper than 2:1 or when excessive seepage is expected. If the engineering review results in a concern about slope stability, then other slope stabilization measures shall be utilized, possibly in combination with this measure.

### Specifications

#### Materials

Stone used in stone slope protection shall consist of crushed stone or gravel that meets the gradations for CTDOT #3 coarse aggregate (see Table 5. 8) conforming to the CTDOT Standard Specifications Section M.01.01.

### Site Preparation

Bring areas to be stabilized to final grade in accordance with the approved plan. Install and/or repair other sediment control measures as needed to control water movement into the area to be covered with stone.

### Application

Slope the area on which the stone is to be placed to a reasonably true surface prior to placing any stone. Spread the stone by any suitable means which will not crush the stone. Shape the stone to a smooth uniform finished grade. Provide 100% coverage of the disturbed soil with the stone.

*Table 5. 8 CTDOT #3 Coarse Aggregate*

| Square Mesh Sieves | % Passing By Weight |
|---|---|
| 2.5″ | 100 |
| 2.0″ | 90-100 |
| 1.5″ | 35-70 |
| 1.0″ | 0-15 |
| 0.5″ | 0-5 |

### Maintenance

Coarse aggregate conforming to CTDOT Standard Specifications Section M.01.01 will not deteriorate, but may fail by slippage or displacement. If slippage or displacement occur, conduct an engineering analysis to determine the cause. Overland water flow, excessive seepage, deep slope failure or surficial structural failure should be investigated by an engineer. Repair failed areas and/or implement alternate measures to obtain stability.

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## Stabilization Structures

### Planning Considerations

The stabilization structures measures are Retaining Wall, Riprap, Gabion, Cellular Confinement System, Articulating Concrete Block, Permanent Slope Drain, Channel Grade Stabilization Structure, Temporary Lined Chute and Temporary Pipe Slope Drain. Stabilization structures have the primary function of preventing soil erosion when slope gradients are considered to be too steep or water velocities on the slope are too high for the slope to remain stable with a vegetative cover or with the measures in the Short-Term Non-living Soil Protection Functional Group.

The measures in this group can be generally divided into two subgroups: slope stabilization structures and grade stabilization structures. Slope stabilization structures are applied to stabilize slopes and grade stabilization structures are applied to stabilize channels and areas where concentrated flows will occur.

Retaining Wall, Riprap, Gabion, Cellular Confinement System, and Articulating Block measures are capable of being applied to both slopes and channels.

Permanent Slope Drain, Channel Grade Stabilization Structure, and Temporary Lined Chute are used only for channelized flow.

The Retaining Wall measures involve the construction of a structurally designed wall of various materials usually at the bottom of a slope to prevent bank failure due to shallow bedrock, steepness, seepage, or other soil conditions and to lessen the slope gradient above the wall.

The Riprap measure is the use of rock to stabilize slopes with seepage problems and to protect a soil surface from the erosive forces of concentrated runoff.

The Gabion measure takes riprap or other hard durable rock and places it in a flexible wire mesh basket composed of rectangular cells. It can be used in place of the Riprap measure and can be a material used in the Retaining Wall measure.

The Cellular Confinement System measure is a manufactured three-dimensional sheet or mat with cells that are filled with materials such as plantable soil, sand, or aggregate, providing weight and shear resistance while still maintaining vegetation.

The Articulating Concrete Block measure is a manufactured system consisting of concrete blocks that form open cells and that can be filled with plantable soil, sand, aggregate, etc.

The Permanent Slope Drain measure involves an open or closed structure or series of structures, such as pipes, culverts, and manholes, that convey water flows through excessive grade changes.

The Channel Grade Stabilization Structure measure is an open structure used to control the grade and head cutting in natural or artificial channels. It is not used, however, to regulate the flow in a channel or to regulate the water level in a channel.

The Temporary Lined Chute measure consists of an open channel lined with a non-erosive material on slopes steeper than 5:1 where the drainage area is less than 36 acres and its use is for less than one year. When these limitations are exceeded, the use of other measures from the stabilization functional group and waterways functional group are required.

The Temporary Pipe Slope Drain utilizes a flexible or ridge pipe to convey water down a slope from a contributing drainage area of 5 acres or less for a period no greater than 6 months. It is commonly used in association with temporary diversions.

All of the measures described in this section require an engineered design. All local, state, and federal permit requirements must be adhered to. These structures can be used in conjunction with Soil Bioengineering, Living Shoreline, and other bank stabilization and stream/coastal restoration techniques as discussed in the section on special treatments in Chapter 4. Where possible, measures that provide short or long-term benefits to fish and wildlife are preferred.

For measures in this group that are to receive concentrated flows, plan to avoid constructing the measure when the local weather forecast predicts rainfall to occur during the time of construction. Local forecasts may be obtained by listening of local radio and television stations, the National Weather Service broadcasts (162.400 MHZ for CT generally, 162.475 MHZ for northeastern CT., 162-550 MHZ for Southeastern and Southwestern CT) or from the NOAA website.

## Retaining Wall

### Definition

A wall that provides stability to a slope, constructed of mortared block or stone, natural stone, cast-in-place concrete, timber, reinforced earth, gabions, precast concrete modular units, or similar structures.

### Purpose

- To permanently stabilize steep slopes, prevent soil movement, and provide slope protection.
- To help maximize use of space at the base and at the top of the wall.
- Low retaining structures at the toe of a slope make it possible to grade the slope back to a more stable angle that can be successfully revegetated without loss of land. Such structures can also protect the toe against scour and prevent undermining of the cut slope.
- Short structures at the top of a fill slope can provide a more stable road bench or extra width to accommodate a road shoulder.
- To provide drainage through the use of granular backfill.

### Applicability

- Where erosion or slope failure may occur due to excessive loadings, steepness, seepage, or other unstable soil conditions.
- Where space (or right-of-way) is limited.
- Where site constraints won't allow slope stabilization by flattening and seeding.

For slopes where wall construction is not an option, Erosion Control Blanket, Turf Reinforcement Mat, Cellular Confinement System, or Articulating Concrete Block may be able to be used.

### Planning Considerations

Retaining walls are used where site constraints, such as wetland or property boundaries, prevent slope flattening and seeding. Sequence the construction so that the retaining walls are installed with minimum delay. Disturbance of areas where retaining walls are to be placed should be undertaken only when final preparation and placement of the retaining walls can follow immediately behind the initial disturbance.

Retaining walls are major structural features, and proper engineering is essential. Provision must be made for proper drainage and also for stabilizing the soils behind the wall. All retaining walls require a stamp from a CT licensed professional engineer. Selection of materials and type of wall should be based on hazard potential, load conditions, soil parameters, groundwater conditions, site constraints, material availability, cost, and aesthetics.

## Design Considerations

Consider safety, foundation bearing capacity, sliding, overturning, drainage and loads. For prefabricated units, shop drawings should be submitted by the fabricator to the engineer for consideration in the design analysis.

### Safety

Safety railings may be required by local building codes.

### Bearing Capacity

Maintain a minimum factor of safety of 1.5 for the ratio of the allowable bearing capacity to the designed loading. Spread footings and other methods may be used to meet bearing factor requirements.

### Sliding

Use a minimum safety factor of 2.0 against sliding. This factor may be reduced to 1.5 when passive pressures on the front of the wall are ignored.

### Overturning

Use a minimum safety factor of 1.5 as the ratio of the resisting moment (that which tends to keep the wall in place) to the overturning moment.

### Drainage

Unless adequate provisions are designed to control both surface and groundwater behind the retaining wall, a substantial increase in active pressures tending to slide or overturn the wall will result. Provide surface drainage when backfill or natural ground is higher than the top of the wall. Provide subsurface drainage systems with adequate outlets behind the retaining walls as needed to reduce hydrostatic loadings. Design subsurface drains to prevent piping of backfill or existing soils. Drainage systems with adequate outlets should be provided behind retaining walls that are placed in cohesive soils. Drains should be graded or protected by filters so soil material will not move through the drainage system.

### Loads

Consider several different loads or combination of loads when designing a retaining wall. In addition to soil and hydrostatic loadings, consider live loads, surcharge loads, and sloped fill loads.

See Figure 5- 15 through Figure 5- 17 for illustrations of several common types of retaining walls.

*Figure 5- 15 Concrete Retaining Walls*

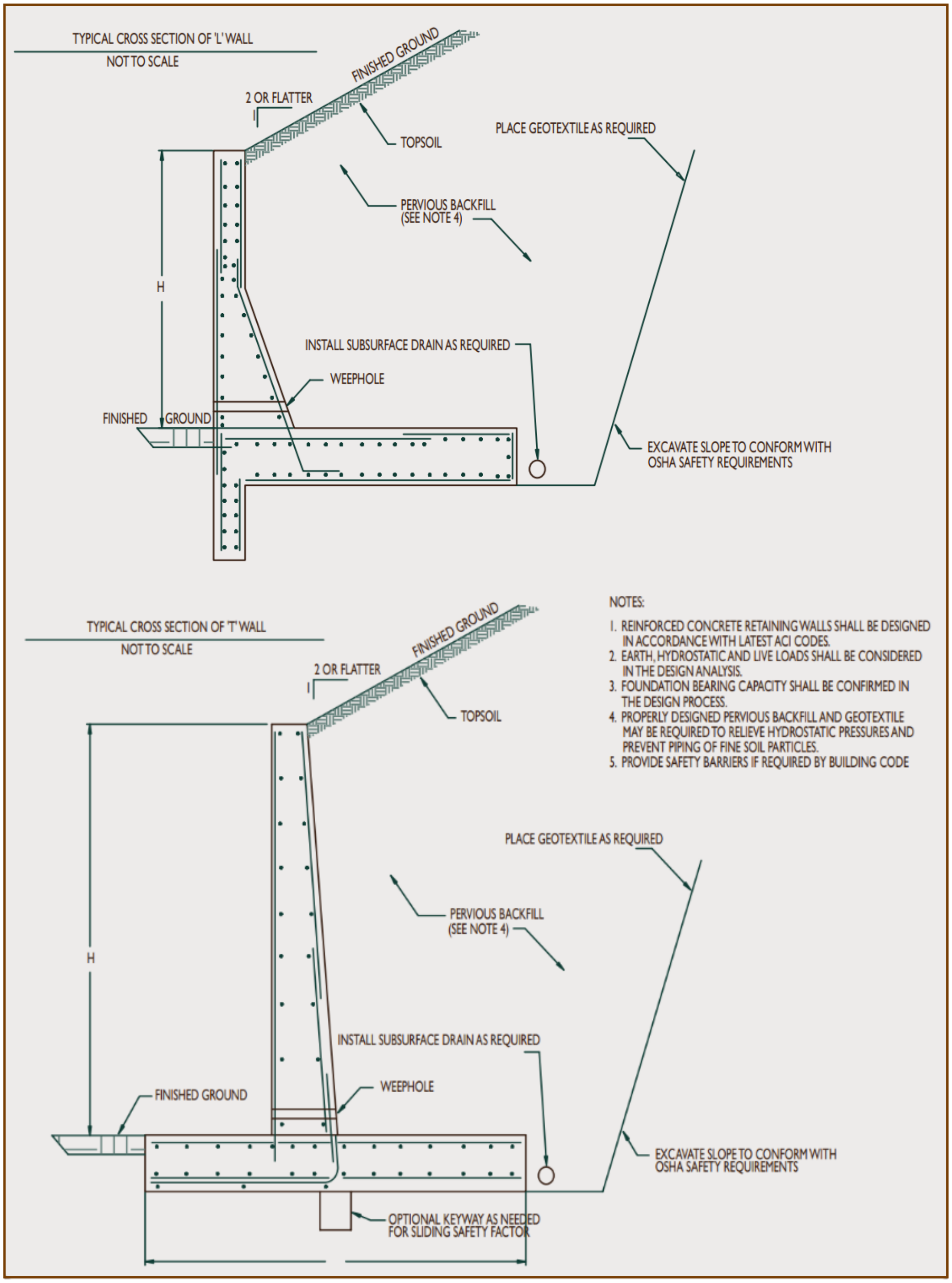


*Figure 5- 16 Precast Retaining Walls*

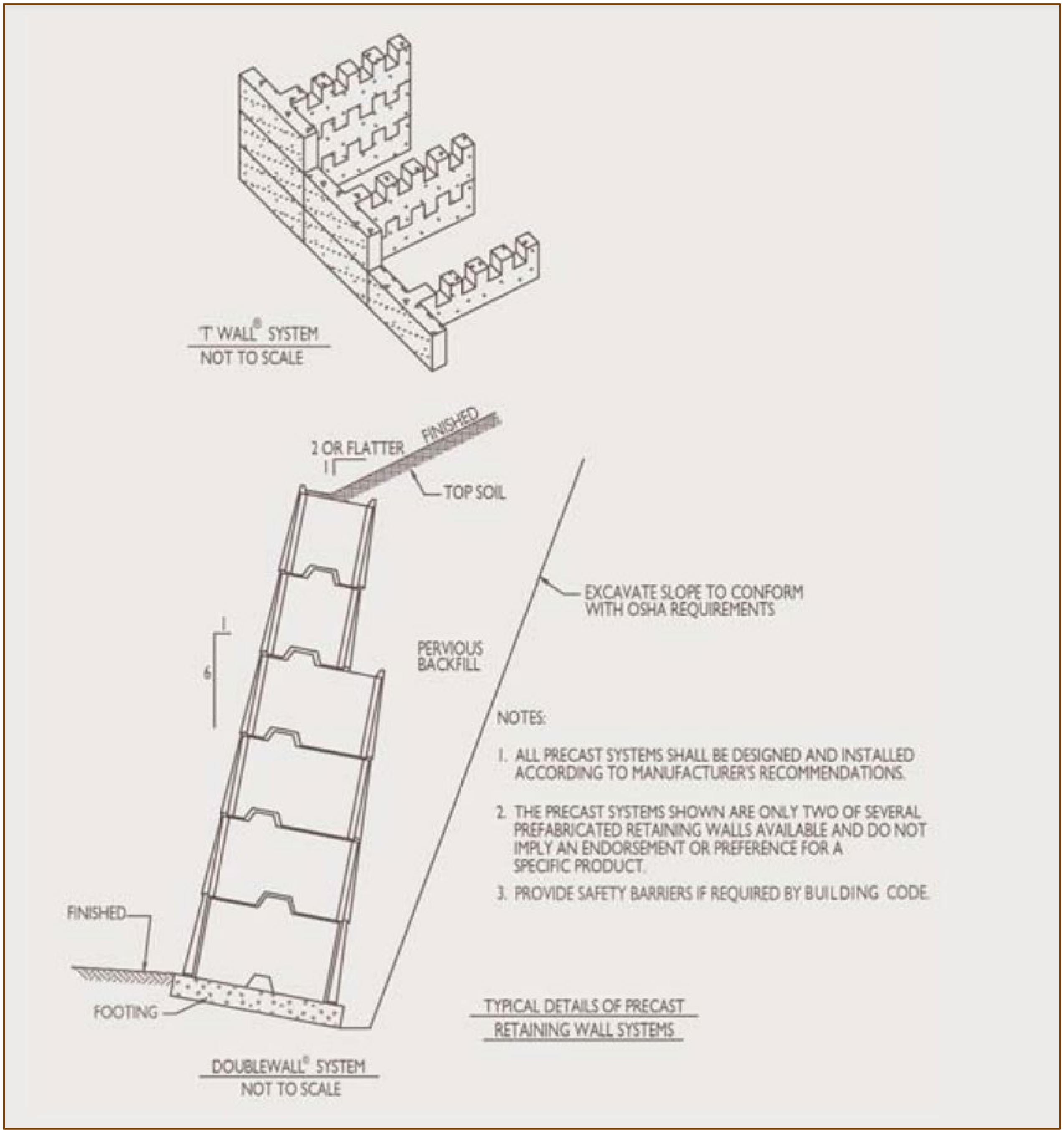
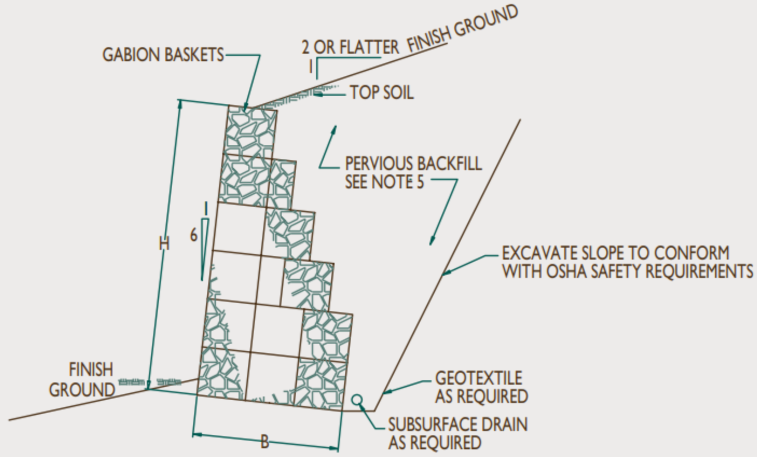


*Figure 5- 17 Gabion Retaining Walls*




TYPICAL CROSS SECTION FOR SURCHARGED WALL
N.T.S

NOTES:

1. SIZES OF INDIVIDUAL GABION BASKETS TO BE DETERMIND ON A CASE BY CASE BASIS,
2. 'H' AND 'B' DIMENSION INDIVIDUALLY DESIGNED BASED UPON EARTH AND HYDROSTATIC LOADINGS.
3. FOUNDATION BEARING CAPACITY TO BE CONFIRMED IN THE DESIGN PROCESS.
4. WIRE BASKETS SHALL CONFORM WITH CT DOT SPECIFICATIONS SECTION 7.04 OR USDA NRCS SPECIFICATION 64.
5. PROPERLY DESIGNED PERVIOUS BACKFILL AND GEOTEXTILE MAY BE REQUIRED TO RELIEVE HYDROSTATIC PRESSURES AND PREVENT PIPING OF FINE SOIL PARTICLES.
6. PROVIDE SAFETY BARRIERS IF REQUIRED BY BUILDING CODE.

## Riprap

### Definition

A permanent, erosion-resistant ground cover of large, loose, angular stone.

### Purpose

- To protect the soil surface from the erosive forces of concentrated runoff and wave action.
- To permanently stabilize slopes that cannot be reliably stabilized with vegetation alone.
- To slow the velocity of concentrated runoff, which in turn increases the potential for infiltration.
- To stabilize slopes that are unstable due to seepage.

### Applicability

- Where highly erodible soils and/or steep slopes provide unfavorable conditions for vegetative stabilization alone.
- On soil-water interfaces where soil conditions, expected flow conditions (including water turbulence, velocity, and waves), and expected vegetative cover, etc., are such or will be such that the soil will erode under the design flow conditions.
- At storm drain outlets, on stormwater conveyance channel side slopes and bottoms, roadside ditches, permanent slope drains, and at the toe of slopes.
- Shorelines subject to wave action.
- Natural stream banks and channels when used in combination with vegetation as part of a

bioengineering solution (see Soil Bioengineering methods in Chapter 4).

## Planning Considerations

- Riprap should be placed as soon as possible after site disturbance begins before additional water is concentrated into the drainage system.
- When designing riprap systems, well-graded riprap should be used rather than uniform riprap because it will form a dense and flexible cover that can adapt well, even on uneven surfaces. Uniform riprap also requires more intensive labor to install compared to graded riprap.
- Use the appropriate size rock for the discharge or flow velocity. If in doubt, go with larger rather than smaller rock. Water will carry away rock that is not sufficiently sized.
- Make sure that the rock is angular and variably sized. Along with the largest diameter needed for the flow rate of the discharge, include enough small, sharp-edged rock to lock the large rock in place.
- Riprap should always be underlain by a filter material consisting of granular bedding material and/or a geotextile fabric to prevent underlying soil from piping through the riprap stone. The bedding and geotextile fabric must be sized properly in order to prevent erosion or undermining of the underlying soils. If filter material is not used, the rock will become buried in the soil on which it was placed.
- An engineering analysis is required when the slope to be protected is steeper than 3:1 or when excessive seepage is expected.
- Adhere to all applicable local, state, and federal permitting requirements particularly for installations in or near surface waters and wetlands.

## Design Criteria

### Sizes - Equivalent Spheres

Riprap sizes can be designated by either the diameter or the weight of the stones. They can also be designated by established published standards, such as that found in the CTDOT Standards and Specifications Section M.12.02 (see Table 5. 9). It is often misleading to think of riprap in terms of diameter since the stones should be angular instead of spherical. It is simpler to specify the diameter of an equivalent size of spherical stone. Table 5. 10 lists some typical stones by weight, spherical diameter, and the corresponding rectangular dimensions. These stone sizes are based upon an assumed bulk weight of 2.65 grams per cubic centimeter (165 lbs./ft.3).

*Table 5. 9 CT DOT Standard Riprap Sizes*

**Standard Riprap: This material shall conform to the following requirements:**

- **A. Not more than 15% of the riprap shall be scattered spalls and stones less than 6 inches on any side.**
- **B. No stone shall be larger than 30 inches on any side, and at least 75% of the weight shall be stones at least 15 inches**

**Intermediate Riprap:** This material shall conform to the following gradation:

| Stone Size | % Of the weight |
|---|---|
| 18 inches | 0 |
| 10 to 18 inches | 30-50 |
| 6 to 10 inches | 30-50 |
| 4 to 6 inches | 20-30 |
| 2 to 4 inches | 10-20 |
| less than 2 inches | 0-10 |

**Modified Riprap:** this material shall conform to the following gradation:

| Stone Size | % of the weight |
|---|---|
| 10 inches | 0 |
| 6 to 10 inches | 20-50 |
| 4 to 6 inches | 30-60 |
| 2 to 4 inches | 30-40 |
| 1 to 2 inches | 10-20 |
| less than 1 inch | 0-10 |

**Special Riprap:** The crushed stone shall meet the gradation requirements of Table M.01.02-2 for No. 3 coarse aggregate.

A diameter of stone in the mixture is specified for which some percentage, by weight, will be smaller. For example, d85 refers to a mixture of stones in which 85% of the stone by weight would be smaller than the diameter specified. Most designs are based on d50 (see Figure 5- 18). In other words, the design is based on the average size of stone in the mixture.

### Gradation

Riprap gradations shall be specified by either the CTDOT Standard Specifications, or other established published standards. Regardless of the standard used, riprap shall be composed of a well-graded mixture down to the one-inch size particle such that 50% of the mixture by weight shall be larger than the d50 size as determined from the design procedure. The diameter of the largest stone size in such a mixture shall be 1.5 times the d50 size. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The CTDOT riprap standards are examples of well graded mixtures (see Table 5. 8).

After determining the riprap size that will be stable under the flow conditions, consider that size to be a minimum and then, based on riprap gradations available in the area, select the size or gradations that equal or exceed the minimum size.

### Thickness

The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter but not less than 12 inches.

### Quality of Stone

Individual rock fragments shall be dense, sound, and free from cracks, seams, and other defects conducive to accelerated weathering. The rock fragments shall be angular in shape. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment. The stone shall be of such quality that it will not disintegrate on exposure to water or weathering, be chemically stable, and shall be suitable in all other respects for the purpose intended. The bulk specific gravity (saturated surface-dry basis) of the individual stones shall be at least 2.65.

Note: *CTDOT Standard Specifications do not accept rounded stone or broken concrete for riprap.*

*Figure 5- 18 Examples of Average $d_{50}$*

**Examples of Average Stone Size for $d_{50}$**

Modified $d_{50}$=0.42 feet or 5 inches

Intermediate $d_{50}$=0.67 feet or 8 inches

Standard $d_{50}$=1.25 feet or 15 inches

Source: Section M.12.02, State of Connecticut Department of Transportation, Standard Specifications for Roads and Bridges and incidental Construction, as amended.

*Table 5. 10 Size of Riprap Stone*

| Weight (lbs.) | Mean Spherical Diameter (ft.) | Rectangular Shape | |
|---|---|---|---|
| | | Length (ft.) | Width, Height (ft.) |
| 50 | 0.8 | 1.4 | 0.5 |
| 100 | 1.1 | 1.75 | 0.6 |
| 150 | 1.3 | 2.0 | 0.67 |
| 300 | 1.6 | 2.6 | 0.9 |
| 500 | 1.9 | 3.0 | 1.0 |
| 1000 | 2.2 | 3.7 | 1.25 |
| 1500 | 2.6 | 4.5 | 1.5 |
| 2000 | 2.75 | 5.4 | 1.8 |
| 4000 | 3.6 | 6.0 | 2.0 |
| 6000 | 4.0 | 6.9 | 2.3 |
| 8000 | 4.5 | 7.5 | 2.5 |
| 20000 | 6.1 | 9.9 | 3.3 |

## Riprap for Slope Stabilization

Riprap for slope stabilization shall be designed so that the natural angle of repose of the stone mixture is steeper than the gradient of the slope being stabilized (see Figure 5- 19 for angles of repose for various shaped riprap).

*Figure 5- 19 Angle of Repose of Riprap in Terms of Size and Shape of Stone,*
*Source: National Cooperative Highway Report #108*

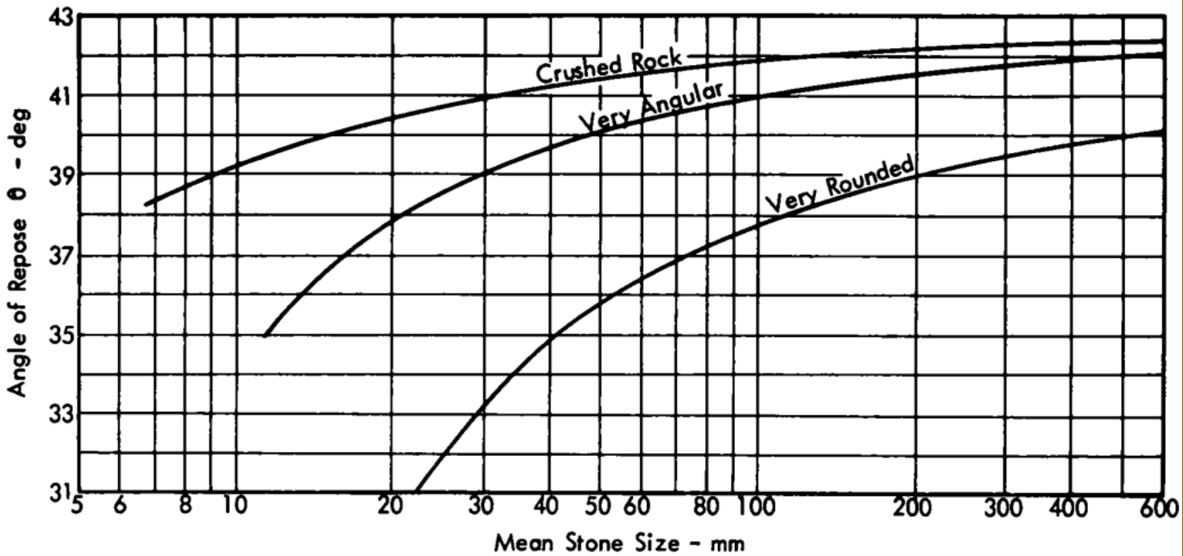



*Figure 24 Angle of repose of riprap in terms of mean size and shape of stone*

## Riprap for Conveyance Channel Stabilization

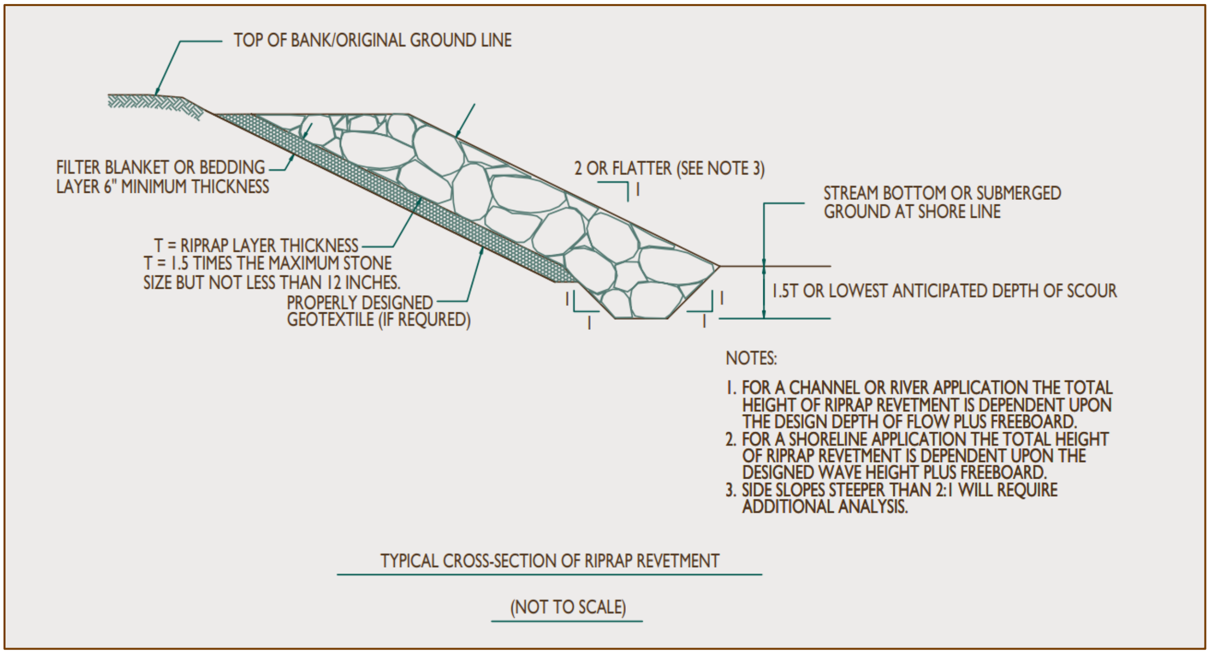
Riprap for conveyance channel stabilization shall be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized (see Permanent Lined Waterway measure). The design procedure, which is extracted from the Federal Highway Administration's Design of Roadside Channels with Flexible Linings, is one accepted method. Other generally accepted published methods may be used.

Riprap shall extend up the banks of the conveyance channel to a height equal to the design depth of flow or to a point where vegetation can be established to adequately protect the channel.

The riprap size to be used in a conveyance channel bend shall extend upgradient from the point of curvature a minimum of 0.4 times the water surface width, and downgradient from the point of tangency a distance of at least 5 times the channel bottom width. The riprap may extend across the bottom and up both sides of the channel or only protect the outside bank, depending upon specific design requirements.

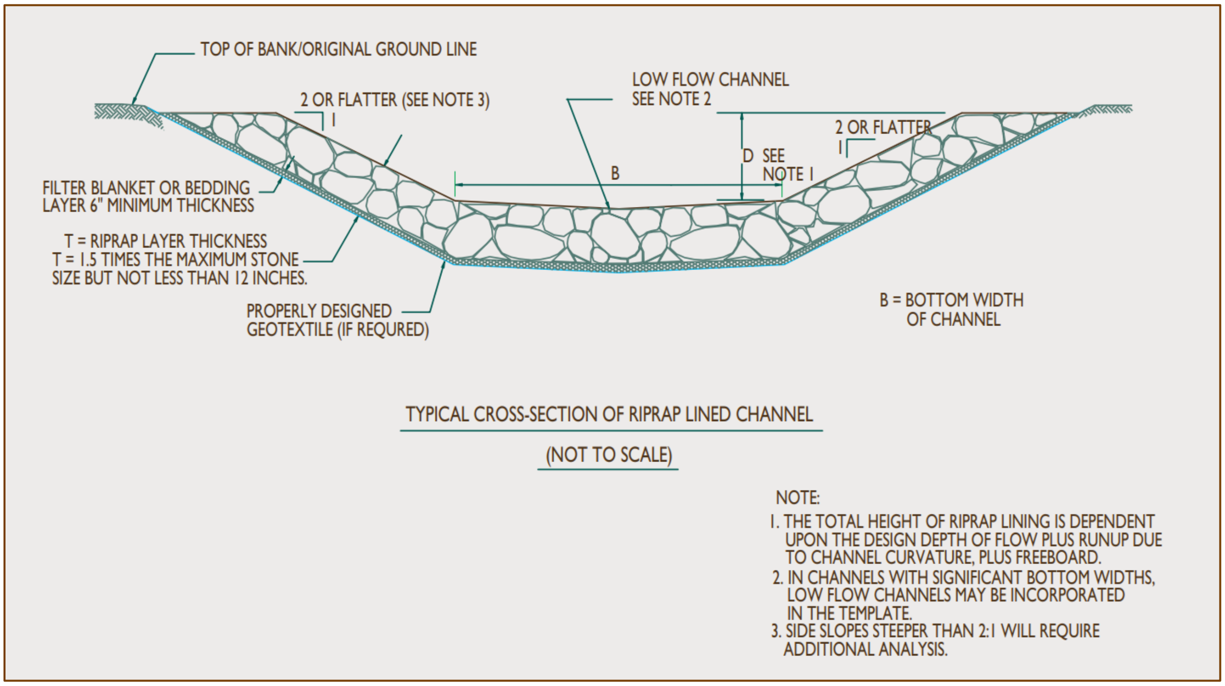
Where riprap is used only for bank protection and does not extend across the bottom of the conveyance channel, riprap shall be keyed into the bottom of the channel to a minimum additional depth equal to 1.5 times the maximum size stone (see Figure 5- 20).

*Figure 5- 20 Riprap for Channel and Shoreline Stabilization*




For riprapped and other lined conveyance channels, the height of channel lining above the design water surface shall be based on the size of the channel, the flow velocity, the curvature, and adequate freeboard (see Figure 5- 21).

*Figure 5- 21 Riprap for Armored Channel Stabilization*



### Riprap for Stream Stabilization

Riprap should be limited to use in natural stream banks and channels when used in combination with vegetation as part of a bioengineering solution (see soil bioengineering measures described in Chapter 4). Riprap should not be used alone for channel stabilization in natural stream channels. Riprap is typically more expensive to install compared to vegetation (i.e., due to equipment and handling costs), is not often considered aesthetically pleasing, and does not provide the secondary benefits provided by vegetated practices (e.g., habitat enhancement). The use of riprap alone can also increase scour at the toe and ends of the riprap and shift an erosion problem downstream or upstream of the installation.

For stream stabilization, the use of riprap is generally limited to critically erosive locations such as the base of the channel side slopes up to the elevation of the one-year flow event. Stability of the stream bank and bed material along with the flow conditions in the stream shall be evaluated in determining site acceptability.

### Riprap for Shoreline Protection

Riprap may be used for shoreline protection on open bodies of water such as lakes, ponds, estuaries, and coastal waters subject to wave action. The waves affecting the shoreline may be wind-driven or created by boat wakes. For more in-depth design criteria concerning these installations, see the U.S. Army Corps of Engineers Coastal Engineering Manual or U.S.D.A. Natural Resources Conservation Service Field Engineering Handbook, Chapter 16 Streambank and Shoreline Protection. Consider soil bioengineering and living shoreline measures as an alternative to or in combination with riprap, as described in Chapter 4.

### Riprap at Outlets

Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structures are contained in the Outlet Protection measure. A properly designed bedding, filter, and/or geotextile underlining is required for riprap used as outlet protection. Where the native material meets the requirements for granular, free-draining bedding material, no additional filter or geotextile is required.

### Filter Blanket or Bedding

A filter blanket or bedding should always be used under all permanent riprap.

The filter material can be either granular stone layer(s), a nonwoven geotextile, or both. The filter materials shall be selected by comparing particle sizes of the overlying material and the underlying material in accordance with the criteria below.

1. Granular Bedding Layer: A granular bedding layer, typically a well-graded gravel, is a viable option when the following relationship exists:

$$\frac{d_{15} filter}{d_{85} base} < 5 < \frac{d_{15} filter}{d_{15} base} < 40$$

$$\text{and} \quad \frac{d_{50} filter}{d_{50} base} < 40$$

In some cases, more than one layer of filter material may be needed. In these cases, filter refers to the overlying material and base refers to the underlying material. The relationships must hold between the filter material and the base material and between the riprap and the filter material. Each layer of filter material shall be a minimum of 6 inches thick.

2. Geotextile (Specifically Intended to Prevent Piping): May be used in conjunction with a layer of coarse aggregate. The geotextile shall be placed along the subgrade between the soils to be protected and the granular bedding layer. The geotextile shall not be used on slopes steeper than 1.5:1 as slippage may occur. The following particle size relationships must exist:

    a. For geotextile adjacent to base materials containing 50% or less (by weight) of fine particles (less than 0.075mm or minus 200 material):

        i. $\frac{d_{85} base\ (mm)}{EOS\ geotextile\ (mm)} > 1$

    where EOS = Equivalent Opening Size to a U.S. Standard Sieve Size, and

        i. Total open area of geotextile is less than 36%.

    b. For geotextile adjacent to all other soils:
        i. EOS less than U.S. Standard Sieve No. 70, and
        ii. Total open area of geotextile is less than 10%.

No geotextile should be used with an EOS smaller than U.S. Standard Sieve No. 100.

Additional design criteria for geotextiles are contained in the latest edition of Designing with Geosynthetics by Robert M. Koerner or design guidance provided by USDA NRCS.

Geotextiles are broken into various classes of woven and non-woven geotextiles. The fabric may be made of woven or non-woven monofilament yarns and should meet the following minimum requirements unless a professional engineer determines that a geotextile with different specifications is required for a specific application.

- Thickness: 20-60 mils
- Grab Strength: 90-120 pounds
- Conforms to ASTM D-1682 or ASTM D-177

In cases where failure of subgrade soils would result in substantial risk to constructed improvements or natural resources, a professional engineer should design the filter blanket to minimize the risk of failure.

## Installation Requirements

### Subgrade Preparation

Prepare the subgrade for the riprap, bedding, filter or geotextile to the required lines and grades. Compact any fill required in the subgrade to a density approximating that of the surrounding undisturbed material. Remove brush, trees, stumps, and other objectionable material.

#### Geotextile

For geotextile filters, use only geotextiles that were stored in a clean dry place, out of direct sunlight, with the manufacture's protective cover in place to ensure the geotextile was not damaged by ultraviolet light. Place the geotextile in accordance with the manufacturer's recommendations.

#### Filter Blanket or Bedding

Immediately after slope preparation, install the filter materials. Spread the filter or bedding materials in a uniform layer to the specified depth. Where more than one distinct layer of filter or bedding material is required, spread the layers so that there is minimal mixing between materials. For large stone, 12 inches or greater, use a 6-inch layer of filter or bedding material to prevent damage to the material from puncture.

#### Stone Placement

Immediately after placement of the filter blanket, bedding and/or geotextile, place the riprap to its full course thickness in one operation so that it produces a dense well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry, controlled dumping of successive loads during final placing, or by a combination of these methods. Do not place the riprap in layers or use chutes or similar methods to dump the riprap which are likely to cause segregation of the various stone sizes.

Take care not to dislodge the underlying material when placing the stones. When placing riprap on a geotextile take care not to damage the fabric – hand placing the first lift of stone or bedding may be necessary to avoid damaging geotextile. If damage occurs, remove, and replace the damaged sheet.

Ensure the finished slope is free of pockets of small stones or clusters of large stones. Hand placing may be necessary to achieve the required grades and a good distribution of stone sizes. Ensure the final thickness of the riprap blanket is within plus or minus 0.25 of the specified thickness.

### Maintenance

Inspected periodically to determine if high flows have caused scour beneath the riprap or filter blanket or dislodged any of the riprap or filter blanket materials. Once a riprap installation has been completed, it should require very little maintenance. Periodic removal of large trees may be required to ensure the integrity of the riprap.

## Gabion

### Definition

Flexible wire mesh baskets composed of rectangular cells filled with riprap or other selected (hard, durable) rock.

## Purpose

- To protect soils from the erosive forces of concentrated runoff or wave action.
- To slow the velocity of concentrated runoff.
- To stabilize slopes.

## Applicability

For use as grade control structures, revetments, retaining walls, abutments, and similar installations. Under some circumstances, gabions can be used for bank stabilization near flowing water or as stone check dams.

## Planning Considerations

Gabions are used where erosion potential is high. Therefore, construction must be sequenced so that the gabions are constructed with the minimum possible delay. In applications to stabilize stream banks or near flowing water (i.e., as stone check dams), failure due to undermining, abrasion and corrosion potential is high. Therefore, a pH below 5 for the soil and water may determine whether an additional protective coating is required for the wire or if gabions are feasible. The sediment load and velocity of the stream or channel must also considered. Gabions should not be exposed to abrasion due to sand or gravel in moving water. Special consideration should be given to prevent undermining at the ends of the gabions and geotextile should be used to prevent the migration of sediment through the gabions.

*Table 5. 11 Gabion Thickness and Max Velocity*

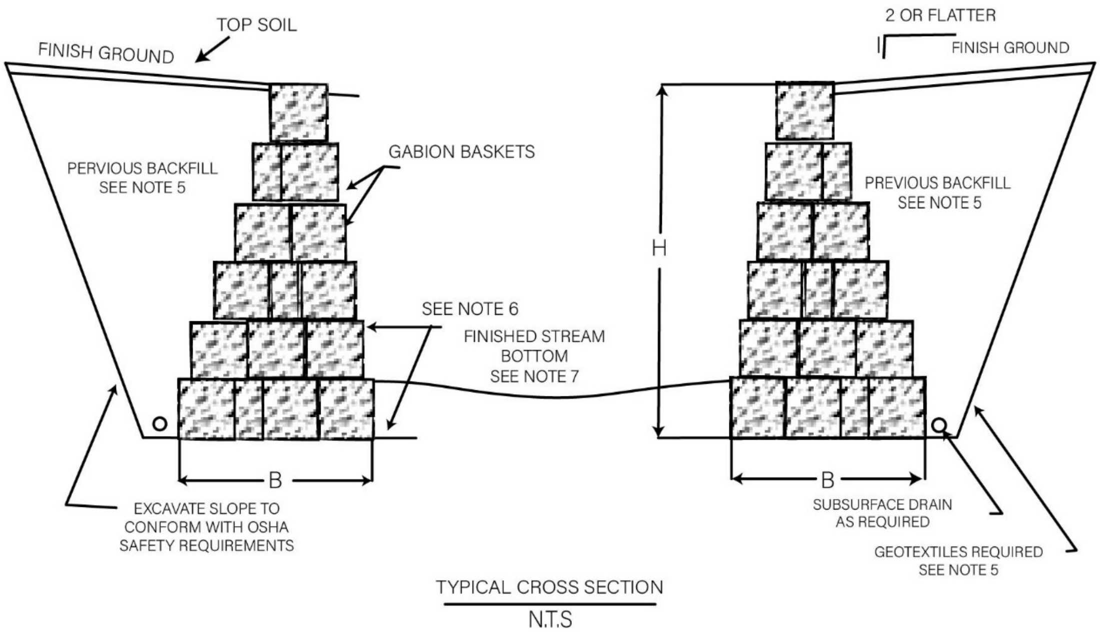
| Gabion Thickness (inch) | Maximum Velocity of Flowing Water (ft/sec) |
|---|---|
| 6 | 6 |
| 8 | 11 |
| 12 | 14 |

## Design Criteria

### General

The design shall be in accordance with accepted engineering practices. Where water has the potential to wash out underlying subgrade materials, gabions shall have a filter blanket (geotextile and/or gravel filter) between the system and subgrade to protect against soil loss in the subgrade. Geotextiles and filter blankets used with the gabions shall be designed for specific soil conditions and rockfill sizes. See Riprap measure for geotextile, bedding, and filter blanket requirements. Figure 5- 22 and Figure 5- 23 show the use of gabions for retaining walls and revetments, respectively.

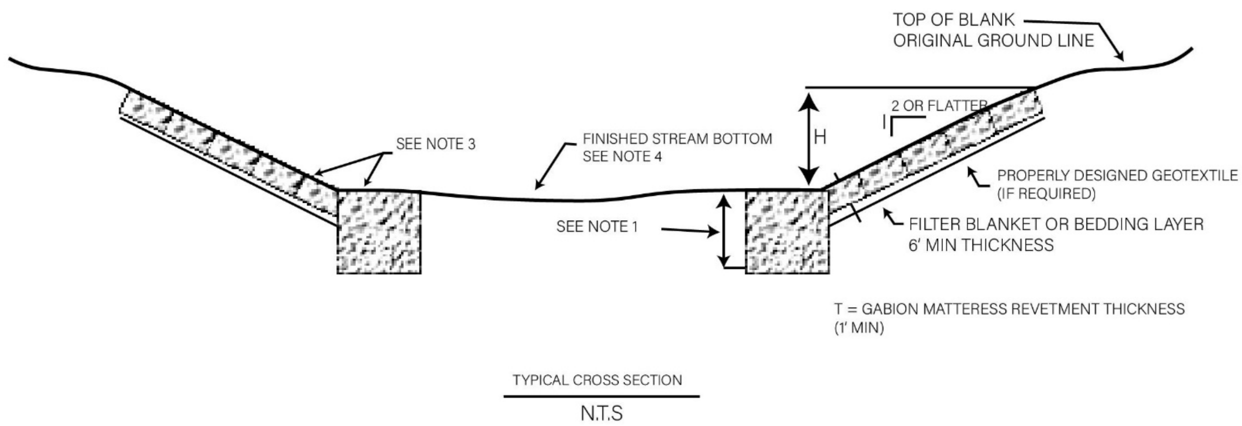
*Figure 5- 22 Gabion Use for Streambank Protection and Retaining Walls*




NOTES:

1. SIZES OF INDIVIDUAL GABION BASKETS TO BE DETERMINED ON A CASE BY CASE BASIS
2. "H" AND "B" BIMENSIONS INDIVIDUALLY EDESIGNED BASED UPON EARTH AND HYDROTSTATIC LOADINGS.T
3. FOUNDATION BEARING CAPACITY TO BE CONFIRMED IN THE DESIGN PROCESS
4. WERE BASKETS SHALL CONFORM WITH CT DOT SPECFICATIONS SECTION 704 OR USDA NRCS SPECIFICATION 64.
5. PROPERLY DESIGNED PERVIOUS BACKFILL AND GEOTEXTILE MAY BE REQUIRED TO RELIEVE HYDROSTATIC PRESSURES AND PREVENT PIPING OF FINE SOIL PARTICLES.
6. THE BOTTOM OF THE BASE BASKET SHALL BE AT LEAST THE DEPTH OF ANTICAPTED SCOUR, THE FACE OF BOTTOM BASKETS MAY REQURED GROUT OR GUNTIE PROTECTION TO PREVENT ABRASION AND INCREASE GABIONWIRE LONGEVITY.
7. STREAM BOTTOM MAY REQURE RIPRAP OR GABION MATTRESS FOR STABILITY
8. PROVIDE SAFETY BARRIERS IF REUIRED BY CODE

*Figure 5- 23 Gabion Revetment*




NOTES

1. SIZE OF ANCHOR OR TOE BASKET TO BE DETERMINED ON A CASE BY CASE BASIS. THE BOTTOM OF THE BASKET SHALL BE AT LEAST THE DEPTH OF ANTICIPATED SCOUR.
2. THE TOTAL HEIGHT OF GABION REVETMENT IS DIPEDENT UPON THE DESIGN FLOW DEPTH PLUS FREEBOARD.
3. FACE OF ANCHOR BASKET AND LOWER REVETMENT BASKETS MAY REQUIRE GROUT OR GUNITE PROTECTION TO PREVENT ABRASION AND ICREASE GABION WIRE LONGEVITY
4. STREAM BOTTOM MAY REUQIRE RIPRAP OR GABION MATTRESS FOR STABILITY
5. WIRE BASKET SHALL CONFORM WITH CT DOT SPECFICATIONS SECTION 7.04 OR USDA SEPCFICATION 64.

## Materials

Minimum material specifications shall meet the requirements of CTDOT Standard Specifications Section 7.04, entitled “Gabions” and of the manufacturer. Materials may alternately conform to the most recent version of the USDA Natural Resources Conservation Service (NRCS) Construction Specification 64 (Wire Mesh Gabions and Mattresses). For aesthetic purposes facing stone may be rounded or otherwise shaped, providing it is larger than the largest gabion mesh opening or gabions can be vegetated. Where gabions are used for streambank stabilization, incorporate vegetation such as with living shoreline techniques.

## Installation Requirements

Installation shall be in accordance with either CTDOT Standard Specifications Section 7.04, or the USDA Natural Resources Conservation Service Construction Specification 64.

## Maintenance

Periodic inspection for signs of corrosion of wire, undercutting, or excessive erosion at transition areas is essential and repair must be carried out promptly.

## Cellular Confinement System

### Definition

Cellular confinement systems, also known as "geocells," are three-dimensional honeycomb-shaped sheets, mats, or interlocking geosynthetic structures filled with soil, gravel, or other fill material. The structure of the matrix retains a large volume, which provides weight and shear resistance.

### Purpose

- Permanent erosion control practices intended to stabilize infill materials for slope and channel protection, load support, and earth retention applications.
- To stabilize the surface of cut and fill slopes, streambanks, or natural slopes.
- Can be used as a type of vegetated retaining wall.
- To increase the load-bearing capacity of roads, driveways, or parking lots or to create a permeable pavement system (non-erosion control application).

### Applicability

- On a range of slopes ranging from flat surfaces to slopes as steep as 1:1, while still maintaining vegetation. Can be used in place of riprap, gabions, and other structural measures.
- The honeycomb-shaped cells encapsulate and prevent erosion of the infill material, making it an appropriate method of stabilizing high-volume or high-velocity channels.
- Cellular confinements systems should not be used where site conditions prevent the installation of anchoring pins (e.g., rocky slopes, exposed bedrock).

### Planning Considerations

Manufacturer's recommendations should be followed to determine suitability of application. Seeding and mulch is usually required unless used as reinforcement for gravel surfaces (e.g., gravel parking lot, boat launch).

Where manufacturer's recommendations allow, cellular confinement systems can be used to stabilize streambanks. Vegetation is required when used near streams or wetland habitat, as appropriate given water depth and velocity.

### Design and Installation Considerations

Cellular confinement systems shall be designed by a CT licensed professional engineer and manufacturer's recommendations should be followed regarding application, slope limits, site preparation, installation procedure, and appropriate fill material. It is important that the cells be properly anchored in order to prevent deformation or sliding of the panel. Therefore, cellular confinement systems should not be used where soil or rock conditions prevent installation of the anchoring pins in the required pattern. When filling the cells, care should be taken to avoid damaging them. Limit drop heights to 3 feet or less.

If plantable soils are used, soils shall be planted with native vegetation selected for the particular site and application. Plantings shall be placed in accordance with the standards in these guidelines.

Where water has the potential to wash out underlying subgrade materials, cellular confinement systems shall have a filter blanket between the system and subgrade in order to protect against soil loss in the subgrade.

### Maintenance

Inspect at least annually to confirm system is performing as planned. Periodic removal of woody vegetation/tree growth (e.g., annual) may be required to ensure the integrity of the cellular confinement system.

## Articulating Concrete Block

### Definition

Articulating Concrete Block (ACB) revetment systems are manufactured systems consisting of preformed concrete blocks that are interconnected to form open cells and that can be filled with plantable soil, sand, aggregate, and other materials. The blocks are able to "articulate" to some degree along their adjoining faces, allowing the system to conform to changes in the subgrade while maintaining the protective cover. Several varieties of ACB systems are available: interlocking, cable-tied and noncable-tied matrices, and open cell and closed cell varieties. Open cell units contain open voids within individual units that facilitate the placement of aggregate and/or vegetated soil. Closed cell units are solid, concrete elements that are capable of allowing vegetation growth between adjacent units.

### Purpose

- Permanent erosion protection to underlying soil from the hydraulic forces of moving water.

### Applicability

- Armoring for installations generating high velocities such as pipe/culvert outlets, channels, and spillways.
- Streambed grade stabilization.
- Scour protection around bridge piers.
- ACBs do not provide strength to a slope; therefore, a protected slope must be geotechnically stable prior to placement of the ACB revetment system. ACB systems should not be placed on slopes that are geotechnically unstable or exhibit bedslope angles steeper than that used during hydraulic performance testing.

### Planning and Design Considerations

ACB systems shall be designed in accordance with the intended application and manufacturer's specifications, as well as applicable design guidance including the U.S. Army Corps of Engineers

Technical Supplement 14L (bank protection), the Federal Highway Administration HEC-23 Design Guide 16 (scour protection for bridge piers), and other application-specific design manuals.

A suitable filter and/or drainage layer are considered essential to the proper design of an ACB system to prevent soil loss in the subgrade and failure resulting from loss of contact between the revetment and the subgrade it protects. The filter layer requires a geotextile and may include a granular transition layer. In some cases, a highly permeable drainage layer, either granular or synthetic, may be included in the system to provide sub-block pressure relief, particularly in turbulent flows or high energy wave environments.

### Maintenance

Inspect at least annually to confirm system is performing as planned. Periodic removal of excessive vegetation growth or woody vegetation/tree growth (e.g., annual) may be required to ensure the integrity of the cellular confinement system. Sediment removal may be necessary from the surface of the concrete blocks. Damage to concrete blocks may need to be repaired through concrete pours, or blocks may need to be removed and replaced with new blocks. Replacement or repairs may require re-connection with existing pieces, doweling into existing concrete pours, or other methods of re-connection.

## Permanent Slope Drain

### Definition

A permanent open or enclosed structure or series of structures consisting of pipe(s), culvert(s), and/or manhole(s) used to convey water from a higher elevation to a lower elevation.

### Purpose

- To convey water through excessive grade changes.
- To convey stormwater runoff down a slope without causing erosion problems within the slope.

### Applicability

Within and upon cut and fill slopes where the soil and existing or planned vegetative cover will not handle concentrated runoff flows without erosion.

### Planning Considerations

Consider potential problems caused by frost heaving and ice affecting the function of the permanent slope drain. Also consider existing downstream erosion and hydraulic conditions to ensure that problems are neither created nor made worse.

When coordinating with other construction activities remember the construction sequence for a permanent slope drain must begin from the outlet and proceed to the inlet, installing outlet protection first.

### Design Criteria

Design the permanent slope drain according to generally accepted engineering standards (e.g., the USDA-NRCS National Engineering Handbook, Part 650 (Engineering Field Handbook), Chapter 6 Structures; CTDOT Drainage Manual).

Unstable conditions downstream shall not be created by the permanent slope drain. Outlet energy dissipation structures shall be provided to prevent downstream erosion (see Outlet Protection measure).

Assess downstream tailwater conditions to ensure adequate capacity at the outlet of the permanent slope drain.

When designing a permanent slope drain to correct an existing slope failure, a water handling plan is necessary. It may include the installation of a temporary pipe slope drain (see Temporary Pipe Slope Drain measure) or temporary lined chute (see Temporary Lined Chute measure), dewatering measures, and the installation of other temporary soil erosion and sediment controls.

### Installation Requirements

- Install and maintain temporary soil erosion and sediment controls. Implement a water handling plan as site conditions may dictate.
- Begin construction at the outlet installing outlet protection and placing the structure on or within undisturbed soil or on well-compacted fill, according to generally accepted engineering standards. Continue construction to the inlet.
- Stabilize all disturbed areas upon completion of construction of the permanent slope drain.

### Maintenance

During construction of the permanent slope drain inspect associated temporary erosion and sediment controls at least once a week and within 24 hours of the end of a storm that generates a discharge[42]

for failure. Make repairs and adjustment to erosion controls as needed.

Inspect the completed permanent slope drain annually and after each major storm for damage and deterioration. Repair damages immediately. Ongoing maintenance should include removal of debris around the inlet and outlet to the structure, and periodic removal of road sands, sediment, and debris.

## Channel Grade Stabilization Structures

### Definition

A permanent open structure used to control the grade and head-cutting in natural or artificial channels. Head-cutting is a condition of soil erosion represented by a sudden change in the bed elevation within a gully or stream forming an obvious downward step (in the direction of flow). The erosion of the gully or stream primarily results from this ‘step’ migrating up the gully line or stream channel.

[42] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

## Purpose

- To stabilize the grade and control erosion in natural or artificial channels.
- To prevent the formation or advance of gullies.

## Applicability

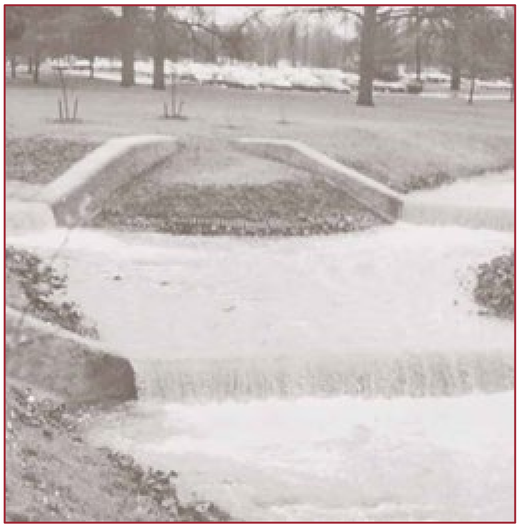
- In areas where the concentration and flow velocity of water requires a structure or series of structures to stabilize the grade in channels or to control gully erosion.
- For channel side-inlet structures needed to lower the water from a higher elevation, a surface drain, or a waterway to a lower outlet channel.
- Does not apply to structures designed to control the rate of flow or to regulate the water level in channels.

## Planning Considerations

The nature of existing and future fisheries resources should be considered and may dictate design criteria. For example, to provide fish passage, a series of smaller structures that do not prevent fish passage may be needed in place of one larger structure. Alternately, the design of the structure may include a rock ramp (a nature-like fishway providing fish passage and aquatic habitat through a simulated natural stream environment that contains pools, runs, riffles and rapids), fish ladder, or other type of fishway.

In urban and developing areas, safety concerns should be addressed. These may involve the installation of fencing, trash racks, or other appropriate barriers to protect the public.

*Figure 5- 24 Example of a Grade Stabilization Structure*



In highly visible public areas and those associated with recreation, careful consideration should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points. See Figure 5- 24 for an example of a grade stabilization structure.

## Design Criteria

Permanent channel grade stabilization structures shall be designed in accordance with accepted engineering practice, consideration of fluvial geomorphic principles, and principles set forth in applicable engineering design guidance including but not limited to the USDA-NRCS National

Engineering Handbook, Part 654 (Stream Restoration Design) and Part 650 (Engineering Field Handbook).

Grade stabilization structures may be constructed of concrete, metal, rock riprap, timber, or other suitable material. The choice of material is dependent on the proposed life of the structure, availability of materials, site specification, and soil conditions where the structure will be installed.

Generally, concrete structures are more expensive and more complicated to build but are more durable. Prefabricated metal structures are available at a slightly lower cost and are not as complicated to install. Rock riprap is a less expensive alternative where an adequate supply of durable rock is available but requires more maintenance. Timber structures are not as easily installed as rock riprap, nor are they as durable.

Additional design considerations for drop structures include:

- Spillway stability shall consider bearing capacity and resistance to flotation, sliding, and overturning.
- Structures which are designed to operate in conjunction with other erosion control practices should have as a minimum sufficient capacity to handle the bankfull capacity of the channel delivering water to the structure.
- The minimum design capacity for grade control structures that are not designed to perform in conjunction with other practices should be that required to handle a 25-year frequency 24-hour duration storm. Local and state highway facilities may require a higher design storm. If pre-development flooding problems exist, or if the consequences of flooding are severe, or if drainage systems which convey larger storms converge with the channel drained by the drop spillway, consideration should be given to increasing the capacity beyond the 10-year frequency.
- Structures shall not create unstable conditions upstream or downstream.
- Toe wall drop structures can be used if the vertical drop is 4 feet or less, flows are intermittent, downstream grades are stable, and tailwater depth at design flow is less than one-third the vertical drop.
- The capacity of the structure in relation to existing road culverts falls within the jurisdiction of responsible road authority.

### Installation Requirements

1. Prior to construction, develop a water handling plan and obtain necessary local, state, and federal permits or approvals.
2. Implement the water handling during construction.
3. Construct the structure in accordance with the approved design.
4. Stabilize all areas disturbed during construction as necessary to prevent erosion.

### Maintenance

Inspect the structure daily during construction for adequacy of the water handling plan and erosion and sediment controls. Inspect the completed structure annually and after each major rainfall for damage and deterioration. Repair damage immediately. Ongoing maintenance should include removal of debris around the structure.

## Temporary Lined Chute

### Definition

A temporary channel constructed with a non-erosive material, such as concrete, bituminous concrete, riprap, sacked concrete, gabions, half round pipes, revetment erosion control mats with cement grout, or similar materials used to carry concentrated runoff down a slope.

### Purpose

To temporarily convey concentrated stormwater runoff down a slope without causing erosion problems on or below the slope.

### Applicability

- For drainage areas less than or equal to 36 acres.
- Where the intended use is less than one year.
- For protection of disturbed cut or fill slopes where planned vegetative cover is not established and/or permanent drainage controls have not been completed.
- On slopes no steeper than 1.5:1 and no flatter than 5:1. For slopes flatter than 5:1 use Temporary Lined Channel, Vegetated Waterway, or Permanent Lined Waterway where appropriate.

### Planning Considerations

Temporary lined chutes should be planned and installed along with, or as part of, other erosion control practices in an overall surface water control plan. If the chute is anticipated to be needed for more than 1 year, use Permanent Lined Waterway measure, Permanent Slope Drain measure, or consider revising the sequence of construction to eliminate the need for a temporary lined chute. For drainage areas less than 5 acres the Temporary Pipe Slope Drain measure may be used as an alternative to a temporary lined chute. If the drainage area exceeds 36 acres, then either split the drainage area or use alternate measures such as Permanent Lined Waterway measure.

### Design Criteria

#### Slope Limitations

Temporary lined chutes shall be designed for placement on undisturbed or well-compacted slopes that are not steeper than 1:1.5 and not less than 5:1.

#### Sizing Limitations

Design criteria are divided into two groups depending on the size of the drainage area. Group A is limited to a maximum area of 18 acres, and Group B may be used for drainage areas between 14 and 36 acres. Within each group the height of the lining at the entrance, depth of the chute down the slope, and length of the inlet and outlet sections are constant (See Table 5. 12). These are determined by the selection of a bottom width. The bottom width of the chute is dependent upon the size of the drainage area involved.

Use Table 5. 12 to determine the sizing requirements for the chute and associated group based on drainage area and proposed bottom width. The selected size shall be identified in the E&S plan. For dimensions, grades, and construction details of concrete chutes see Figure 5- 25.

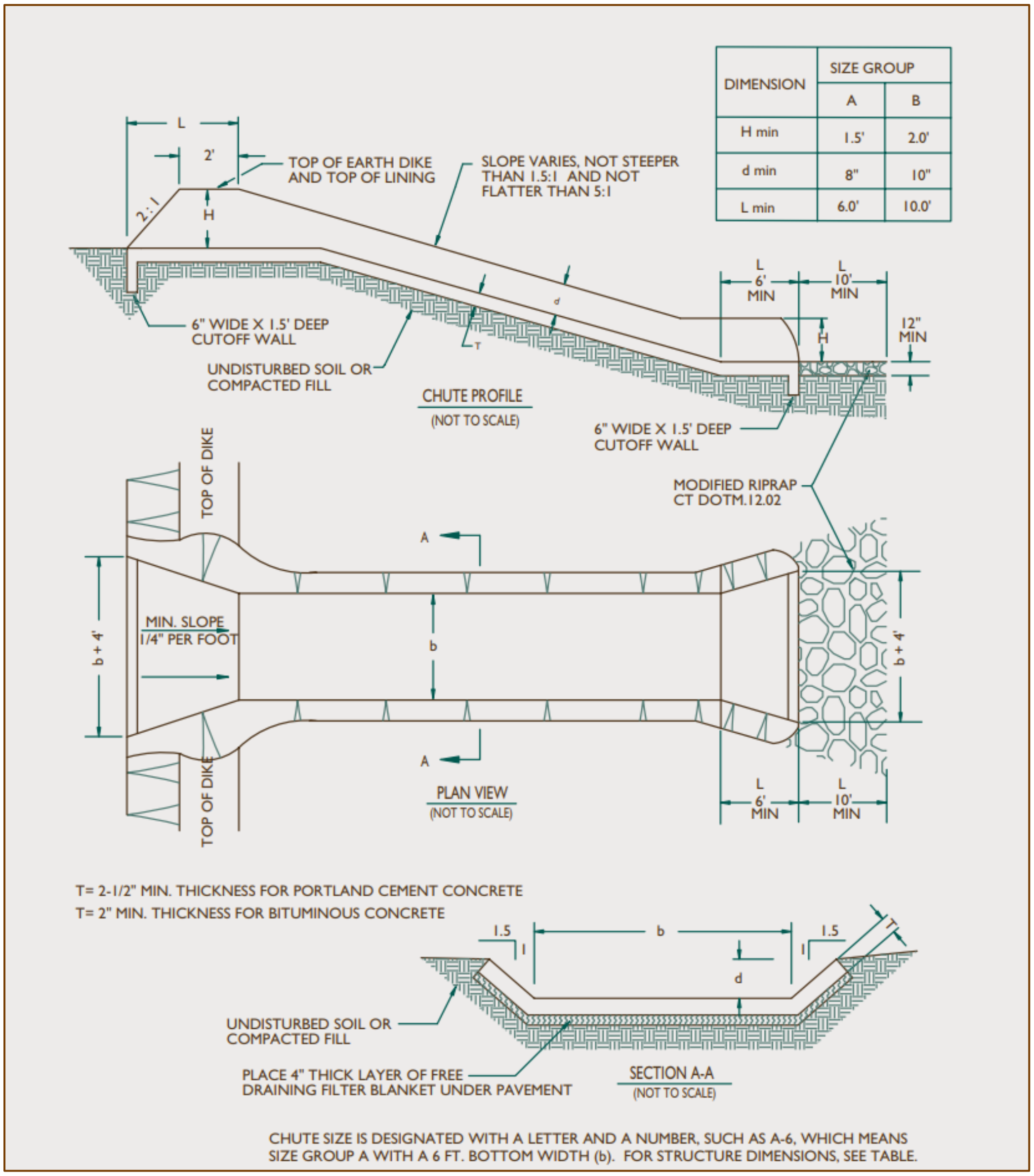
*Table 5. 12 Chute Size Determination*

| Group A | | | Group B | | |
|---|---|---|---|---|---|
| **Size** | Bottom Width b (ft) | Maximum Drainage Area[43] (acres) | Size | Bottom Width b (ft) | Maximum Drainage Area[39] (acres) |
| **A-2** | 2 | 5 | B-4 | 4 | 14 |
| **A-4** | 4 | 8 | B-6 | 6 | 20 |
| **A-6** | 6 | 11 | B-8 | 8 | 25 |
| **A-8** | 8 | 14 | B-10 | 10 | 31 |
| **A-10** | 10 | 18 | B-12 | 12 | 36 |
| **Height at entrance (h) = 1.5 feet**<br>**Depth of Chute (d) = 8 inches**<br>**Length of inlet & outlet section (L) = 6 feet** | | | Height at entrance (h) = 2 feet<br>Depth of Chute (d) = 10 inches<br>Length of inlet & outlet section (L) = 10 feet | | |

[43] 1 Criteria for extending the maximum allowable drainage area listed above:

- If good mulch cover (equivalent to landscape mulch or temporary soil protection) is maintained over a minimum of 75% of the drainage area throughout the life of the structure, then the drainage areas listed above may be increased by 25%, providing the 36 acres drainage area limit is not exceeded.
- If good grass cover (i.e. well established turf) or woodland cover is maintained over a minimum of 75% of the drainage area throughout the life of the structure, then the drainage areas listed above may be increased by 50%, providing the 26 acre drainage area limit is not exceeded.

*Figure 5- 25 Temporary Paved Chute Plan and Profile*




## Channel Linings

The lining shall consist of riprap, bituminous concrete, or other comparable non-erodible material as described below. Design temporary chute linings with inlet and outlet protection to prevent erosion, to withstand the loading imposed by site conditions, and to meet durability requirements for the proposed maintenance program. Provide for adequate filter blankets, geotextile, or both, for these types of channel linings.

- Riprap shall be designed in accordance with the Riprap measure.
- Bituminous concrete linings shall be designed with a minimum thickness of 2 inches and in accordance with accepted engineering practices for structural adequacy.

- Portland Cement Concrete shall be 2500 PSI minimum with 2.5 inches minimum thickness.
- Sacked concrete shall be designed for both structural and hydraulic stability.
- Gabions shall be designed in accordance with the Gabion measure.

### Inlet Design

- The top of the earth lining at the entrance to the chute shall not be lower at any point than the top of the lining at the entrance of the chute ("H" as shown in Figure 5- 25).
- The lining of the side slopes at the chute entrance shall extend the distance H above the lining invert as shown in Figure 5- 25.
- The entrance floor at the upper end of the chute shall have a minimum slope toward the outlet of 0.25 inch per foot.
- Design the cutoff wall at the entrance so that it is continuous with the lining.

### Outlet Design

The minimum requirements for outlet protection are shown in Figure 5- 25. Verify adequacy of outlet stabilization using Outlet Protection measure. Design the cutoff wall at end of the discharge aprons so that it is continuous with the lining.

### Installation Requirements

- Install the chute on undisturbed soil, if possible, or if not possible, on well-compacted fill.
- Begin construction of the chute at its lower end. Compact or place the lining so that it is free of voids and reasonably smooth
- Construct the cutoff walls at the entrance and at the end of the discharge aprons so that they are continuous with the lining.
- Stabilize all areas disturbed by construction immediately after work is completed.

### Maintenance

- Inspect the temporary lined chute at least once a week and within 24 hours of the end of a storm that generates a discharge44 for erosion damage. Repair as needed. If repeated failure occurs, check design limitations and installation requirements. Correct deficiencies as needed.
- Prevent construction traffic across the chute and avoid the placement of any material on the chute.

[44] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

# Temporary Pipe Slope Drain

## Definition

A temporary structure, typically a flexible or rigid pipe, used to convey water from the top of a slope to the toe of the slope.

## Purpose

- To convey water over excessive grade changes.
- To convey concentrated stormwater runoff flows down the face of a slope without causing erosion problems either on or at the toe of the slope.

## Applicability

- On cut or fill slopes where the soil or existing vegetative cover will not withstand concentrated runoff flows.
- For use less than 6 months.
- Where the contributing drainage area is 5 acres or less.

## Planning Considerations

Temporary pipe slope drains should be planned and installed along with, or as part of, other erosion control measures in an overall surface water management system. This measure should be used only for the temporary conveyance of water and consideration should be given to the final stabilization of the area during the initial planning stages. Temporary pipe slope drains are commonly used in conjunction with temporary diversions (see Diversion Functional Group) which direct water to the drain.

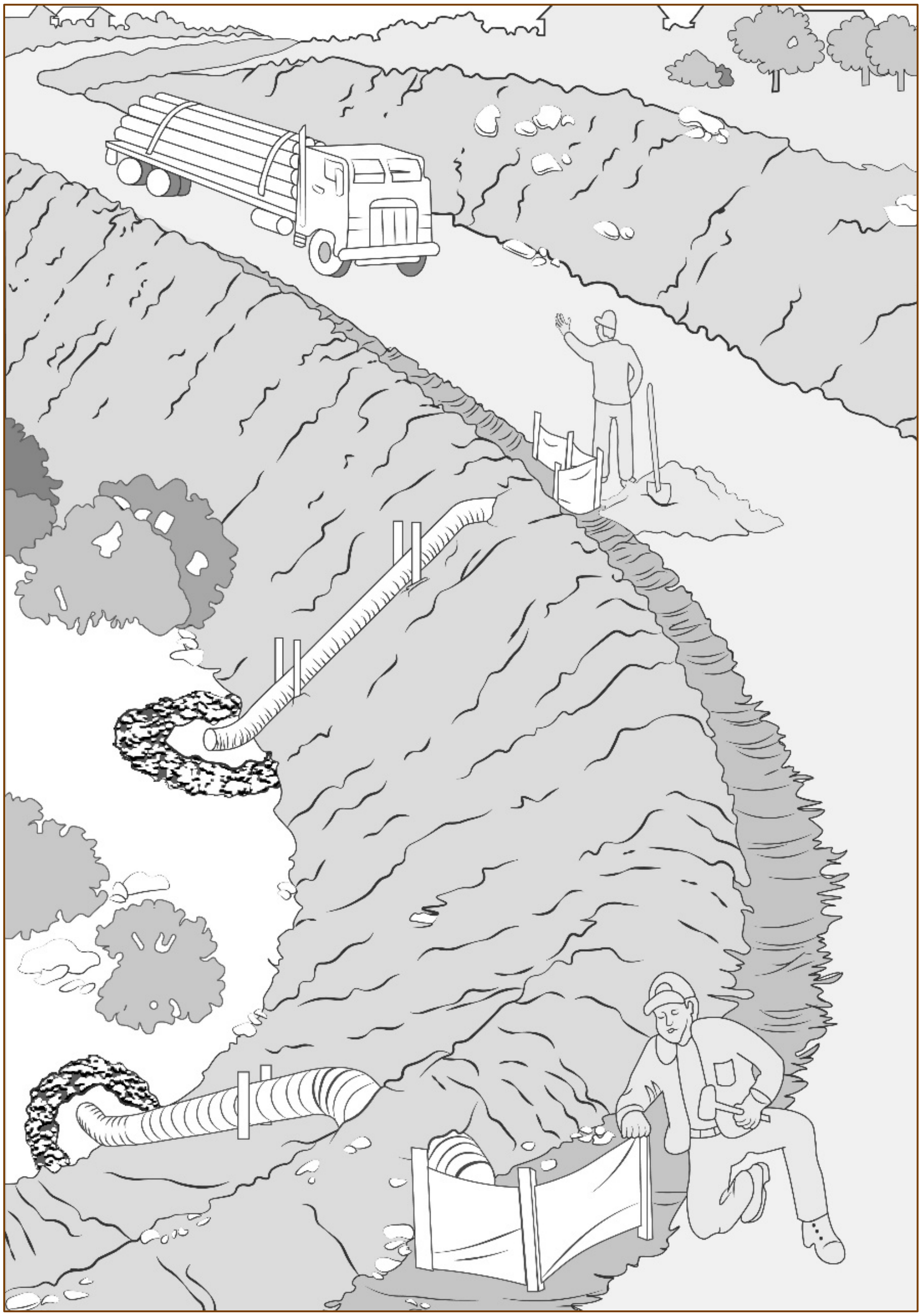
## Design Criteria

The maximum allowable drainage area per drain is 5 acres.

Material used in the temporary pipe slope drain shall be heavy duty flexible (see Figure 5- 26) or rigid conduit (see Figure 5-27) designed for specifically for this purpose, with hold down grommets or rigid pipe supplied with anchors. Additionally, use only one size pipe for any single installation.

The bottom of the pipe slope drain shall be flush with the toe of the diversion berm (see Figure 5-27).

*Figure 5- 26 Example of Temporary Pipe Slope Drain*



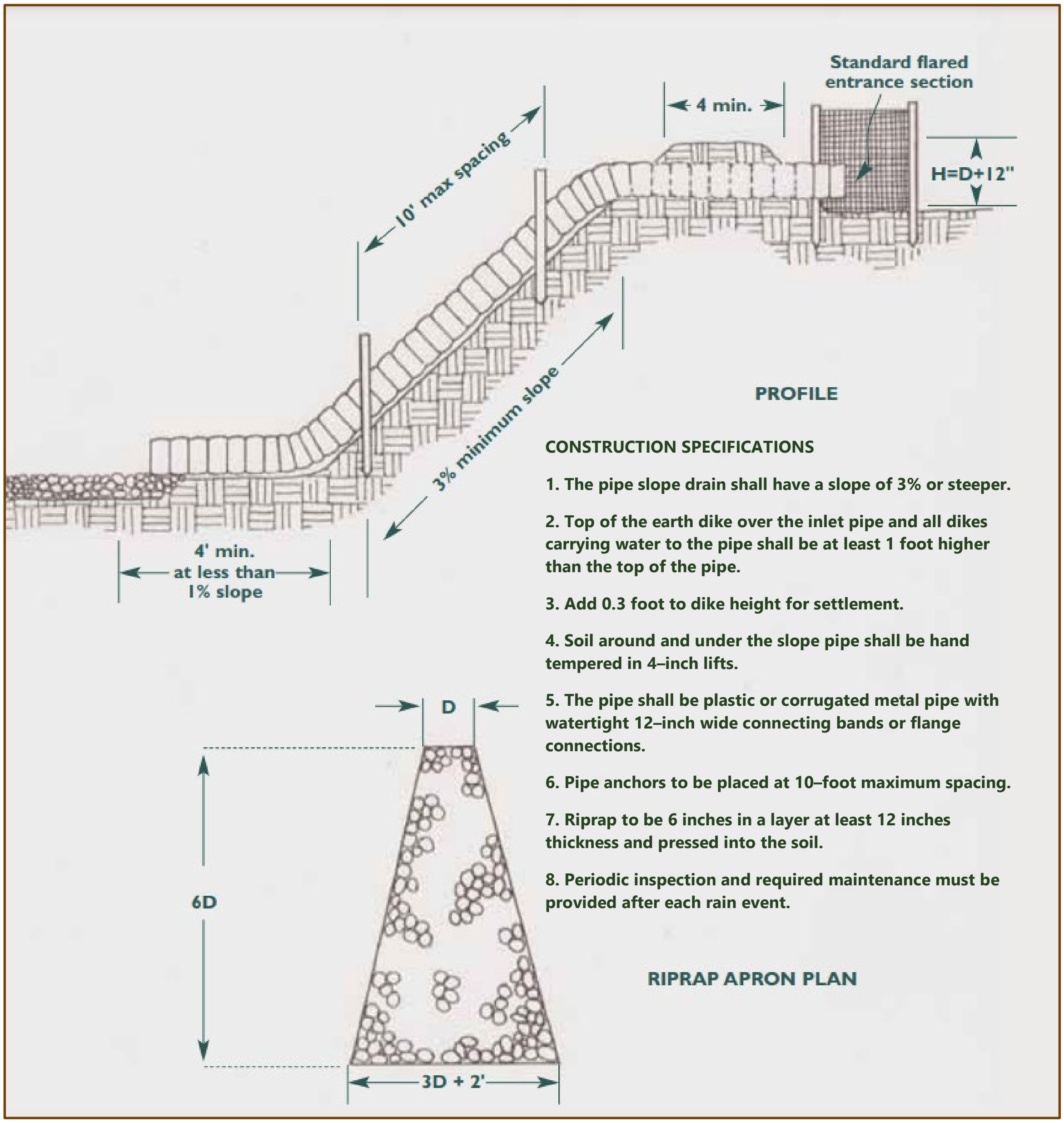



*Figure 5-27 Example of Temporary Pipe Slope Drain*

The pipe slope drain shall be sized according to Table 5. 13 and shall be provided with watertight fittings. Water directed into the temporary slope drain shall be in accordance with temporary diversion measures found in the Diversion Functional Group, where applicable. However, at a minimum, the height of the berm at the centerline of the inlet shall be equal to the diameter of the pipe (D) plus 12 inches. Where the berm height is greater than 18 inches at the inlet, it shall be sloped 3:1 or flatter.

The area immediately below the outlet of the pipe slope drain shall be protected from erosive discharges with appropriate energy dissipators. For drainage areas greater than 1 acre, straw/hay bale check dams and geotextile silt fences are not appropriate.

*Table 5. 13 Size of Slope Drain*

| Maximum drainage area (acres) | Pipe Diameter (inches) |
|---|---|
| 0.5 | 12 |
| 2.5 | 18 |
| 5.0 | 24 |

### Installation Requirements

1. Install a temporary pipe slope drain on a cut or a stable fill slope during or immediately after construction of diversion berms.
2. Stabilize the area from the top of the berm, around and under the entrance section of the drain to prevent erosion and piping failure at the inlet.
3. Anchor the pipe slope drain securely. Space anchors a maximum of 10 feet on center.
4. Securely fasten the sections of pipe together with watertight fittings.

### Maintenance

Inspect the temporary pipe slope drain at least once a week and within 24 hours of the end of a storm that generates a discharge[45] to determine maintenance needs. Repair damage as necessary. Avoid the placement of any material on top of the pipe and prevent vehicular traffic from crossing the slope drain.

# Drainageways and Watercourses

## Planning Considerations

The measures included in this group are Vegetated Waterway, Temporary Lined Channel, Permanent Lined Waterway, and Temporary Stream Crossing.

Vegetated Waterways are limited to drainage areas of 50 acres or less and are used where they can carry the peak flow from a 10-yr frequency, 24-hr duration storm without erosion. They not intended for waterways with perennial flow. They may be used with Permanent Turf Reinforcement Mat for added protection.

[45] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

Temporary Lined Channels are limited to drainage areas no greater than 100 acres when the flow line of the channel is 2% or greater. If the flow line is less than 2%, then the contributing area can be increased to 1 square mile. The measure requires performing a risk assessment in accordance with the design procedure for temporary facilities in the Connecticut Department of Transportation (CTDOT) Drainage Manual to determine the design storm for the channel. It requires a minimum design standard of a 2-year frequency, 24-hour duration storm. It is limited to a maximum of 2 years intended use.

The Permanent Lined Waterway is used when the limitations of the Vegetated Waterway and Temporary Lined Channel are exceeded. However, its application is also limited to a maximum design discharge of 200 cubic feet per second (cfs). It requires a minimum design standard of a 10-year frequency, 24-hour duration storm, although higher design standards may be required by regulating agencies.

The Temporary Stream Crossing is similar to the Temporary Lined Channel in that it also requires performing a risk assessment to establish the design standard and has a drainage limitation of 1 square mile. It also requires a minimum design standard of a 2-year frequency, 24-hour duration storm. However, its intended use is up to 3 years rather than 2 years.

Plan to avoid constructing the measure when the local weather forecast predicts rainfall to occur during the time of construction. Local forecasts may be obtained by listening of local radio and television stations, the National Weather Service broadcasts (162.400 MHZ for CT generally, 162.475 MHZ for northeastern CT., 162-550 MHZ for Southeastern and Southwestern CT) or from the NOAA website.

## Vegetated Waterway

### Definition

A permanent constructed channel or swale shaped or graded in earth materials and stabilized with non-woody vegetation for the non-erosive conveyance of water. Vegetated waterways are not natural stream channels.

### Purpose

To provide for the conveyance of water while preventing damage by erosion or flooding.

### Applicability

- Where the contributing drainage area does not exceed 50 acres.
- Where the design discharge does not exceed 100 cfs.
- For man-made channels such as roadside ditches and drainageways.
- Not for use in perennial streams or natural stream channels.

### Planning Considerations

Sequence and schedule construction to ensure the vegetation within the waterway is established before it is used to convey flow. Also, the drainage area contributing to the waterway must be stabilized with proper erosion and sediment controls installed to prevent sedimentation of the waterway. Repeated erosional failures of the waterway can be expected if these two conditions are not addressed. Consider using other measures such as Sodding, Temporary Diversion, Permanent Turf Reinforcement Mat (including a three-dimensional geosynthetic turf reinforcement), Subsurface Drain (to permit the growth of suitable vegetation and to eliminate wet spots), Channel Grade Stabilization structure, Filter Socks (such as Fiber Rolls) and other management practices (e.g., irrigation) to hasten the establishment of the grass cover.

Consider channel width, side slopes, and depth as they affect the use of maintenance equipment. For areas to be mowed, the steepest recommended slope is 3:1.

## Design Criteria

### Peak Runoff

Design the vegetated waterway according to generally accepted engineering standards (e.g., the USDA-NRCS National Engineering Handbook, Part 650 (Engineering Field Handbook) and the CTDOT Drainage Manual).

Design the minimum runoff to safely carry the peak flow expected from a 10-year frequency, 24-hour duration storm or lesser duration storm where the storm duration exceeds the time of concentration. If a contributing drainage system is designed to a design standard greater than the 10-year frequency storm, then design the vegetated waterway to that higher standard. If pre-development flooding problems exist or if the consequences of flooding are severe, then consider increasing the capacity beyond the 10-year frequency storm. If drainage systems which convey larger frequency storms converge with the waterway, design the waterway to the same design frequency as the contributing drainage system.

Compute the velocity and capacity using Manning's formula and the Continuity Equation consistent with the design references cited above.

### Velocity

Design the waterway so that the peak velocity from the design frequency storm shall not exceed the maximum permissible velocity for a vegetative lining given in Table 5. 14. Determine the maximum permissible velocity for design flow by the most erodible soil texture exposed and the type of vegetation expected and maintained in the channel.

Determine the minimum capacity and maximum velocity by using the appropriate vegetative retardant factors listed in Table 5. 15.

*Table 5. 14 Maximum Permissible Velocity (ft./sec.)*

| Soil Texture | Channel Vegetation Condition[46] | | | |
|---|---|---|---|---|
| | Poor | Fair | Good | Stone Center |
| Sand, silt loam, sandy loam, loamy sand, loam, and muck | 2.0 | 2.5 | 3.5 | 8.0 |
| Silty clay loam, sandy clay loam, clay, clay loam, sandy clay, silty clay | 3.0 | 4.0 | 5.0 | 8.0 |

### Dimensions

To select channel dimensions, use Figure 5- 28 through Figure 5- 40.

Base the dimensions of the channel on: the minimum capacity, the channel slope, the maximum permissible velocity, the vegetation, the soil; ease of crossing and maintenance; and site conditions such as water table, depth to rock, or possible sinkholes.

The minimum top width shall be 5 feet. The maximum bottom width of a vegetated waterway channel is 15 feet unless multiple or divided channels, stone center, or other means are provided to control the meandering of low flows.

[46] For channels with geosynthetic turf reinforcement, permissible velocities shall be designed on a product-specific basis and for long duration flows (>24 hours).

*Figure 5- 28 Solution of the Manning Formula for Retardant B (High Vegetative Retardant), Source: USDA-NRCS*

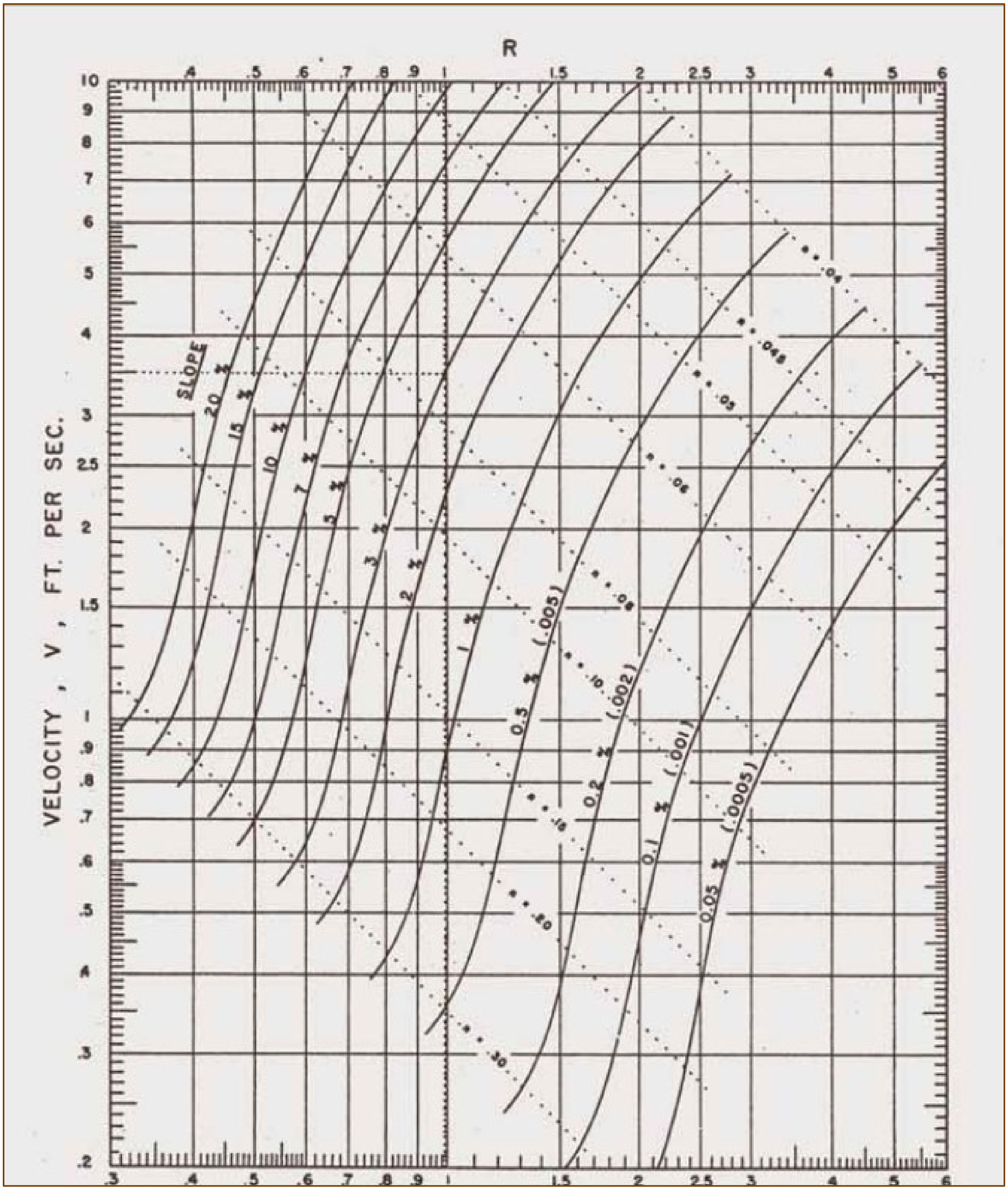


*Figure 5- 29  Solution of the Manning Formula for Retardant C (Moderate Vegetative Retardant), Source: USDA-NRCS*

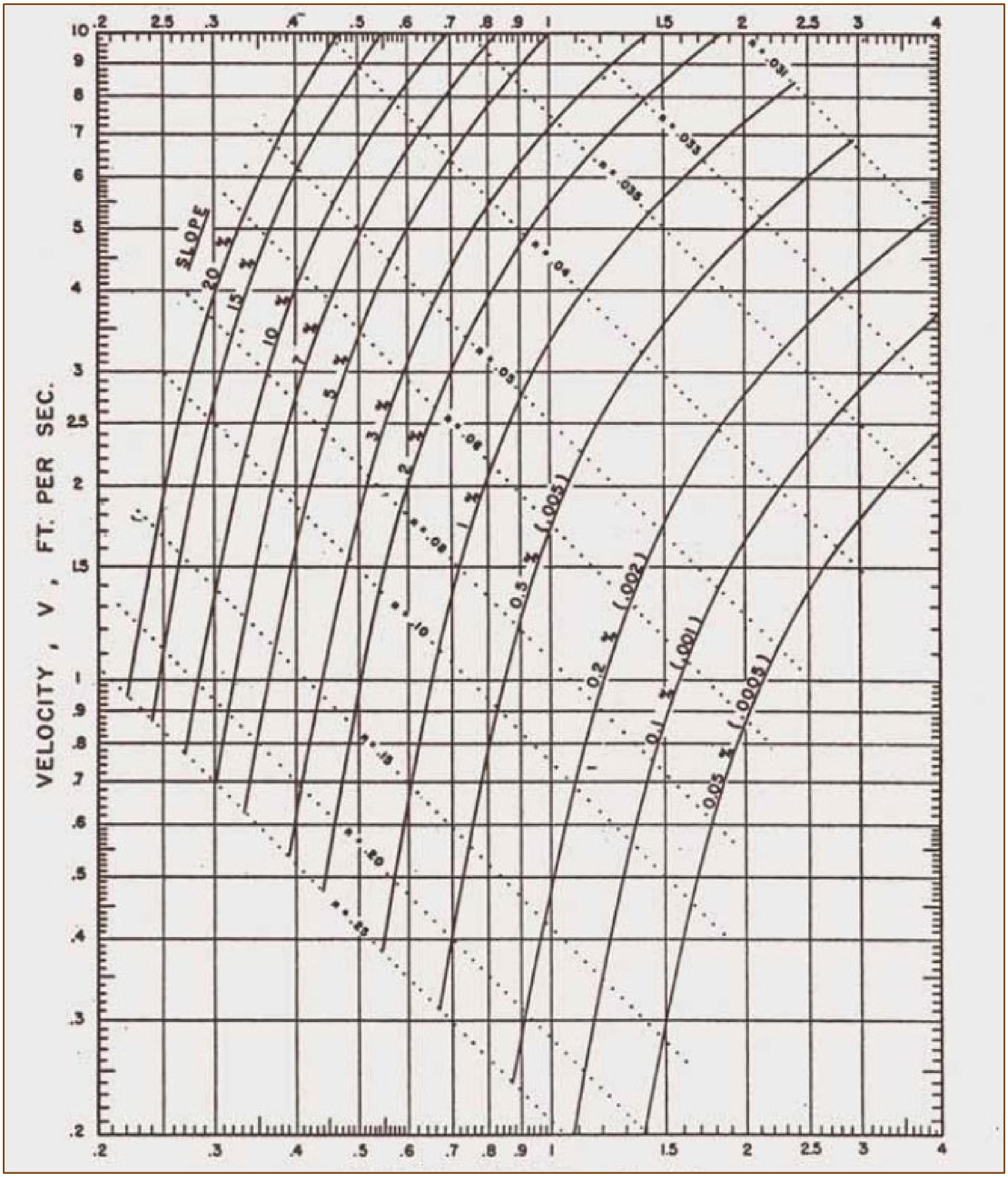


*Figure 5- 30 Solution of the Manning Formula for Retardant D (Low Vegetative Retardant) Source: USDA-NRCS*

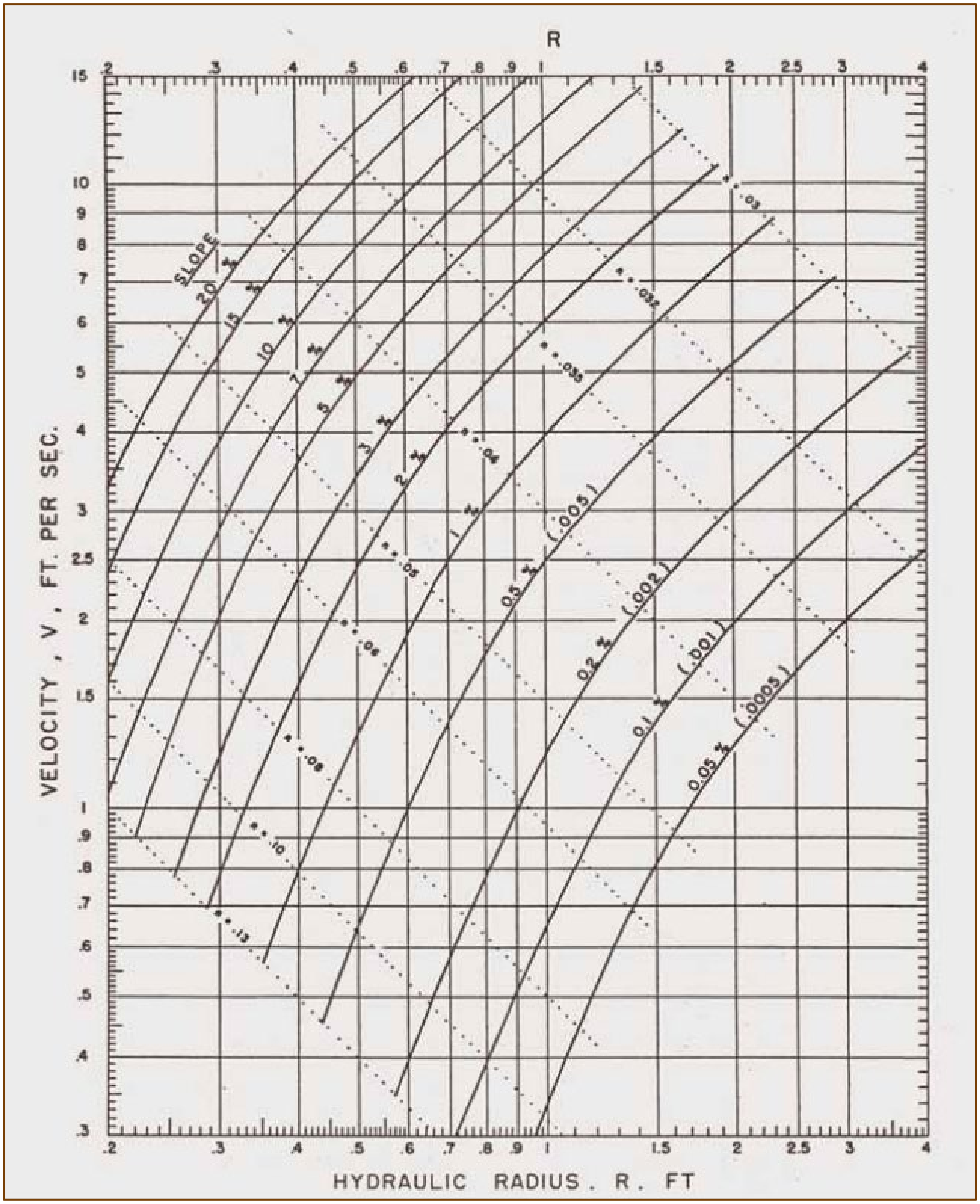


*Figure 5- 31 Solution of the Manning Formula for Retardant E (Very Low Vegetative Retardant), Source USDA-NRCS*

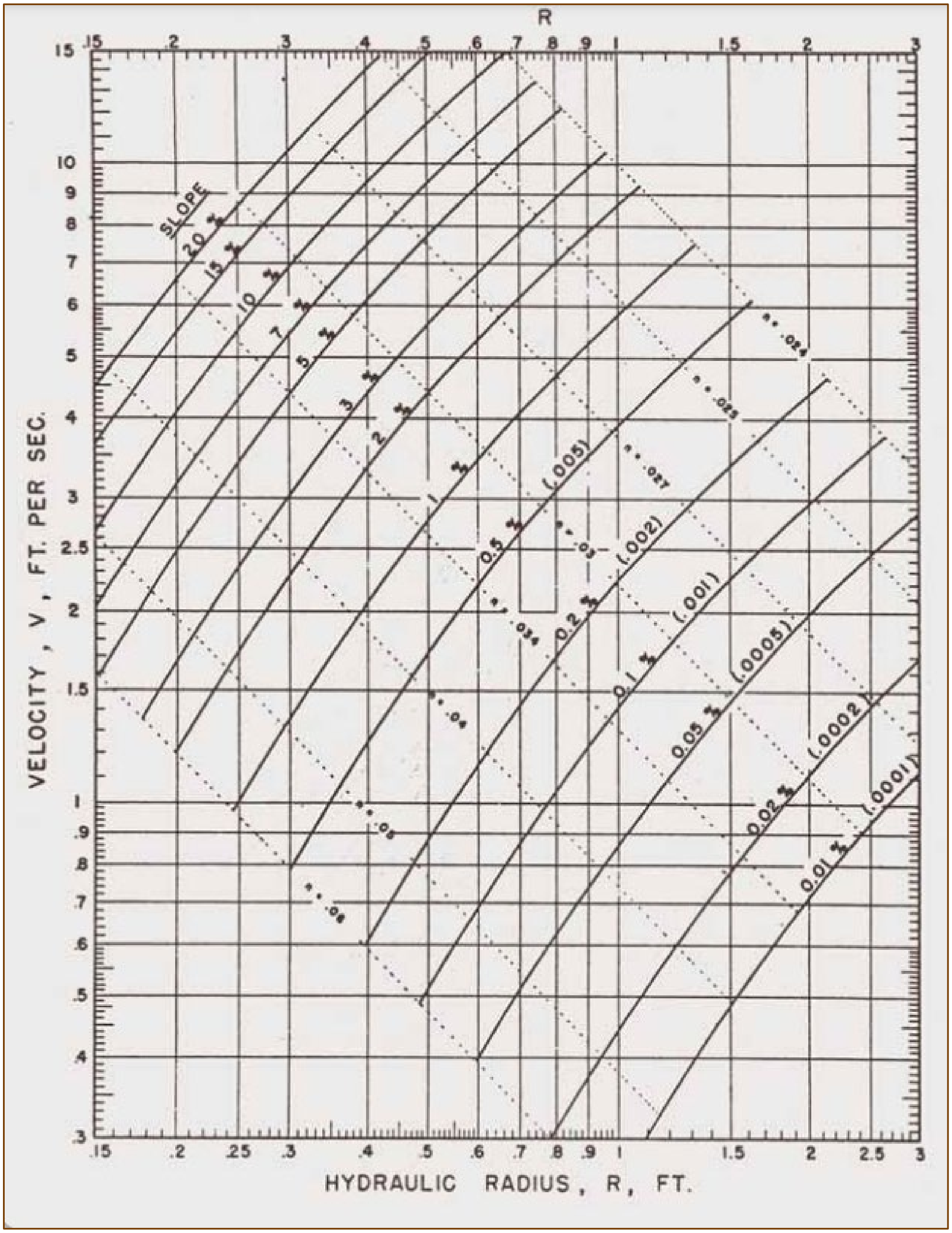


*Figure 5- 32 Dimensions of Trapezoidal Channels with 6 to 1 Side Slopes, Source: USDA- NRSC*

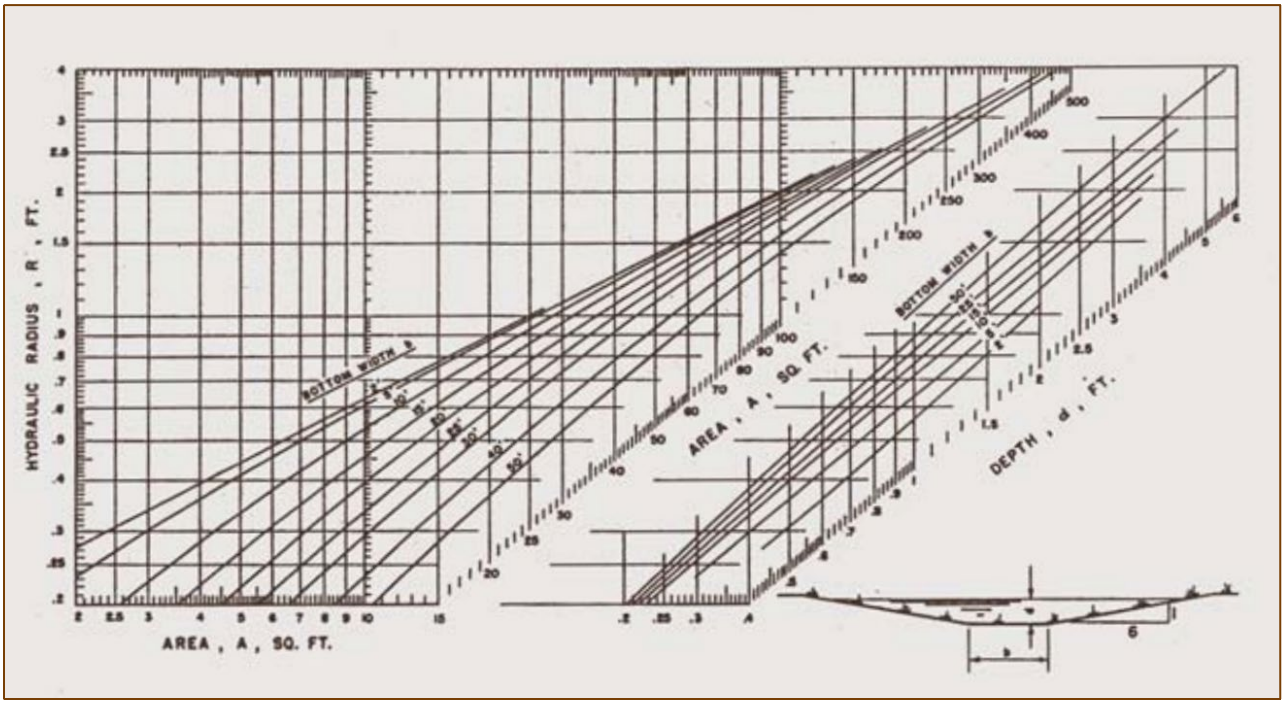



*Figure 5- 33 Dimensions of Trapezoidal Channels with 5 to 1 Side Slopes, Source: USDA-NRCS*

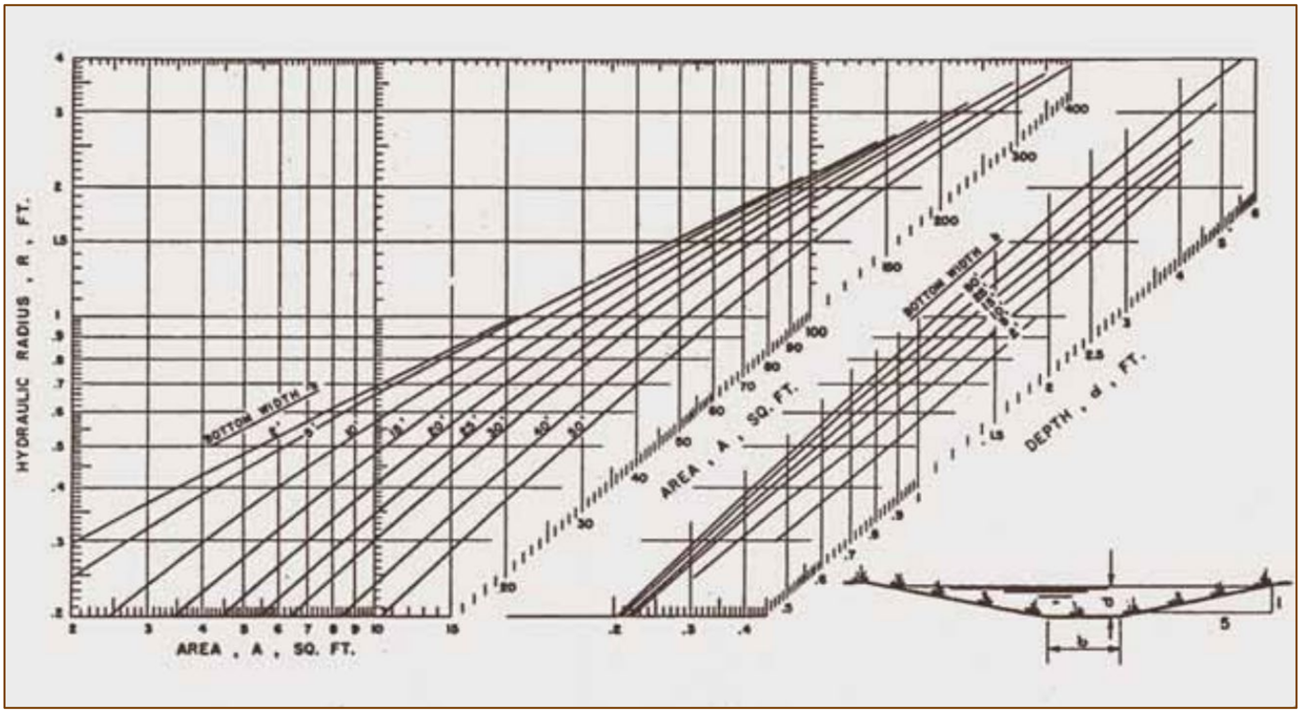


*Figure 5- 34 Dimensions of Trapezoidal Channels with 3 to 1 Side Slopes, Source: USDA-NRCS*

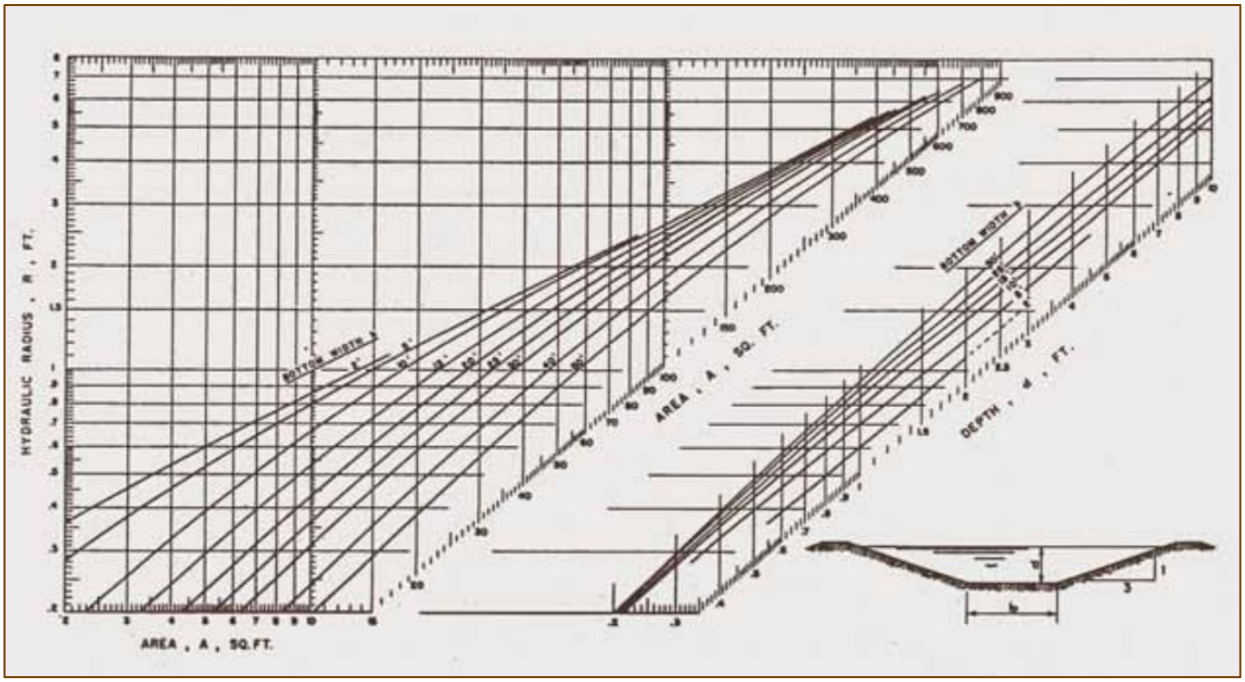



*Figure 5- 35 Dimensions of Trapezoidal Channels with 2-1/2 to 1 Side Slopes, Source: USDA-NRCS*

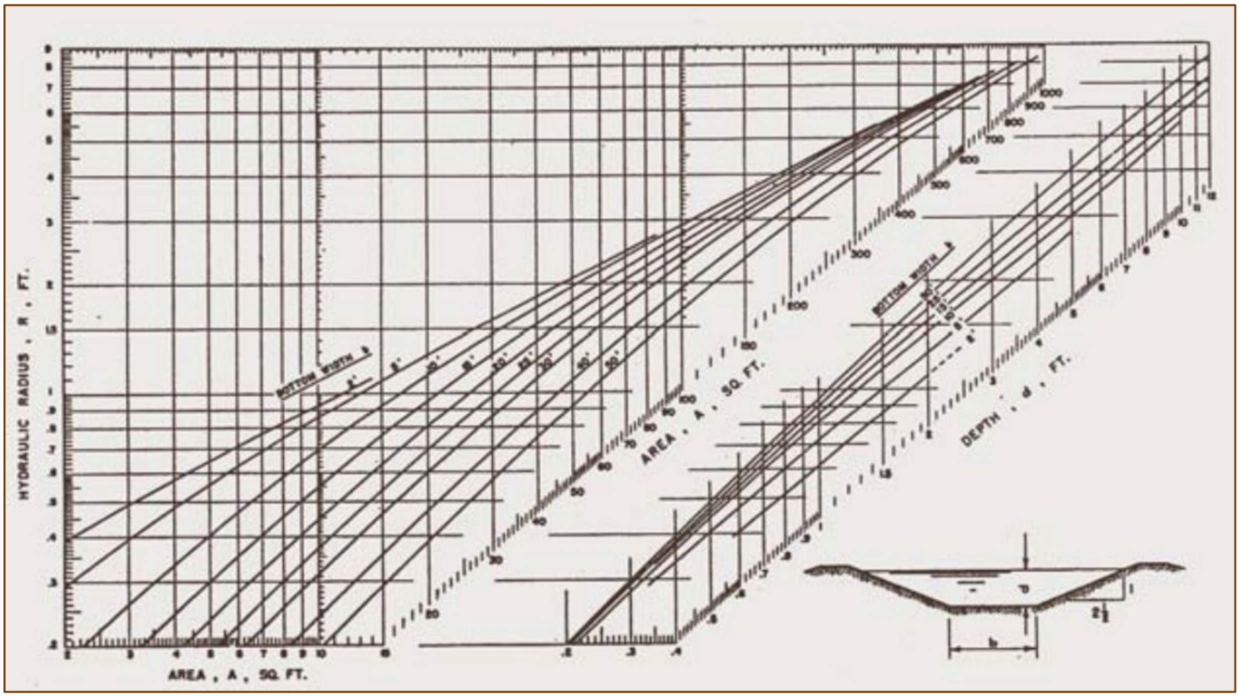


*Figure 5- 36 Dimensions of Trapezoidal Channels with 2 to 1 Side Slopes, Source: USDA-NRCS*

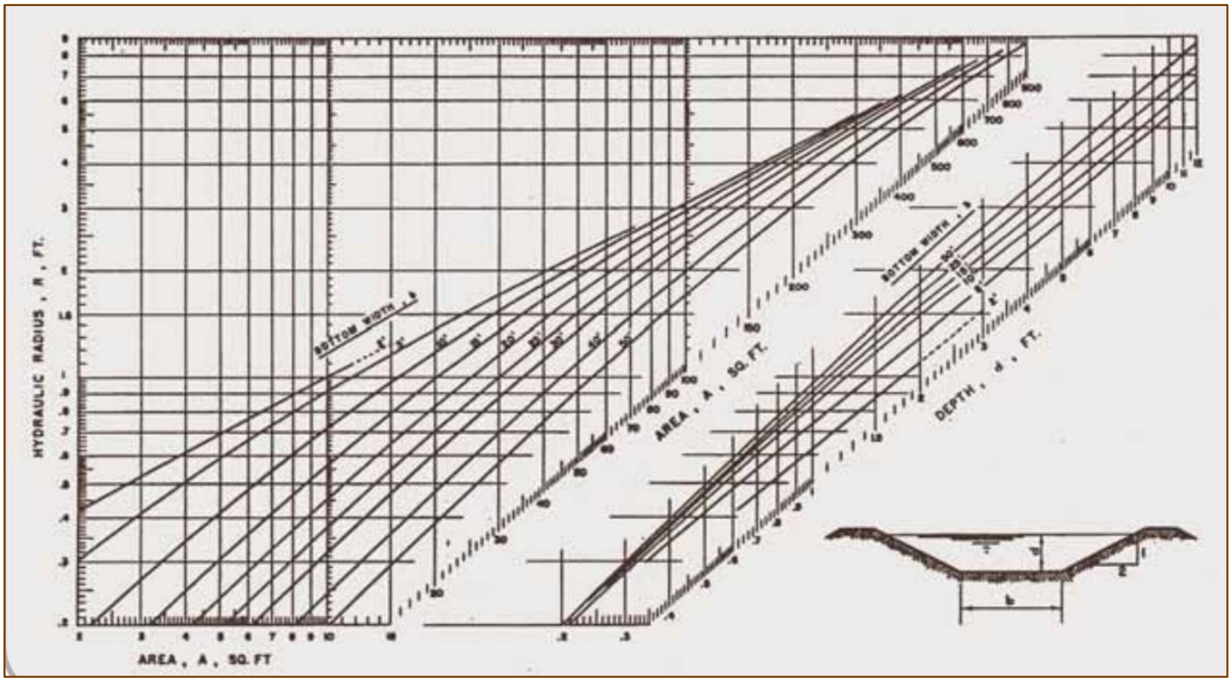



*Figure 5- 37 Dimensions of Trapezoidal Channels with 1-1/2 to 1 Side Slopes, Source: USDA-NRCS*

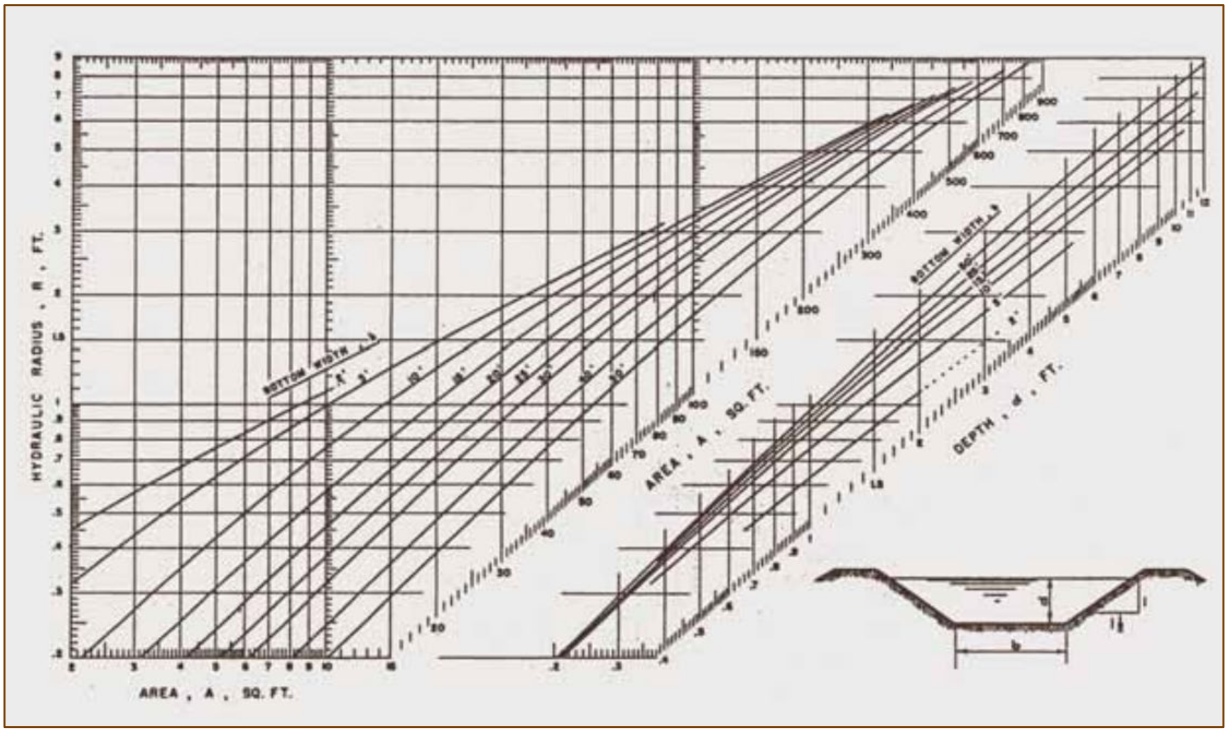


*Figure 5- 38 Dimensions of Triangular Channels*

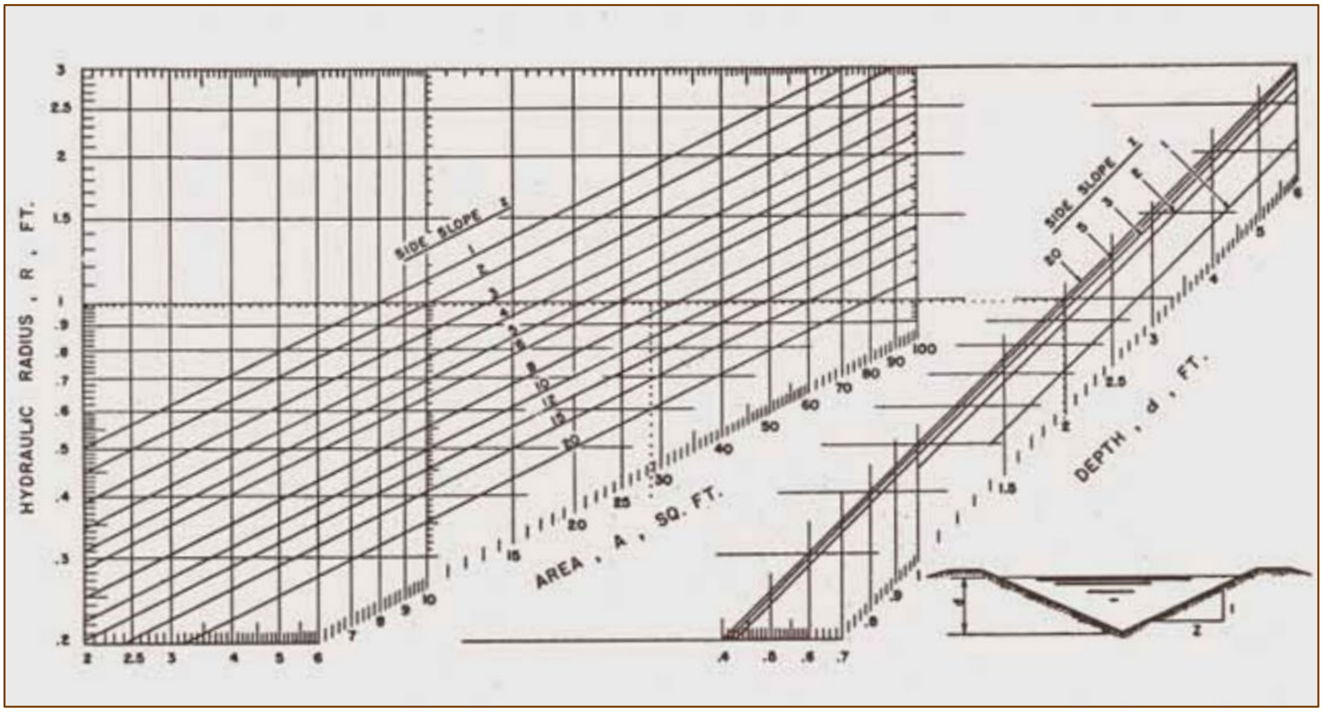



*Figure 5- 39 Dimensions of Parabolic Channels, Source : USDA- NRCS*

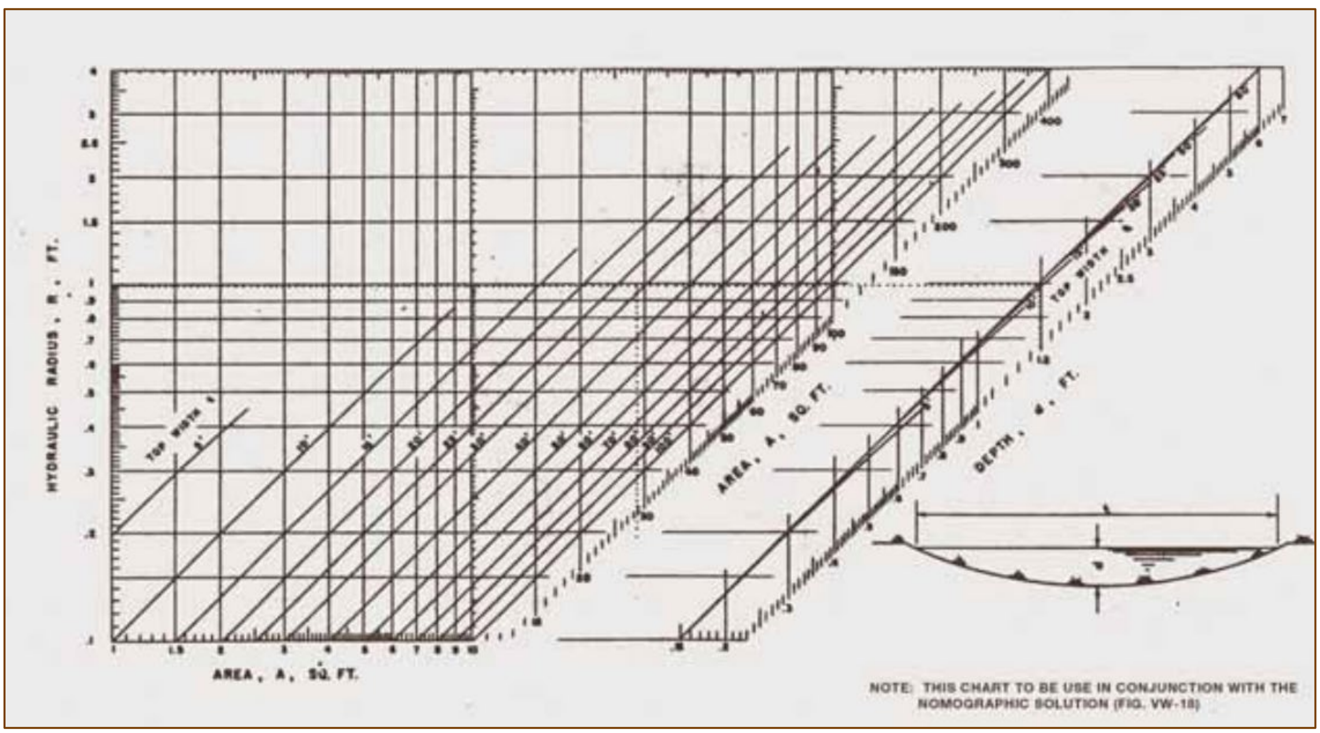
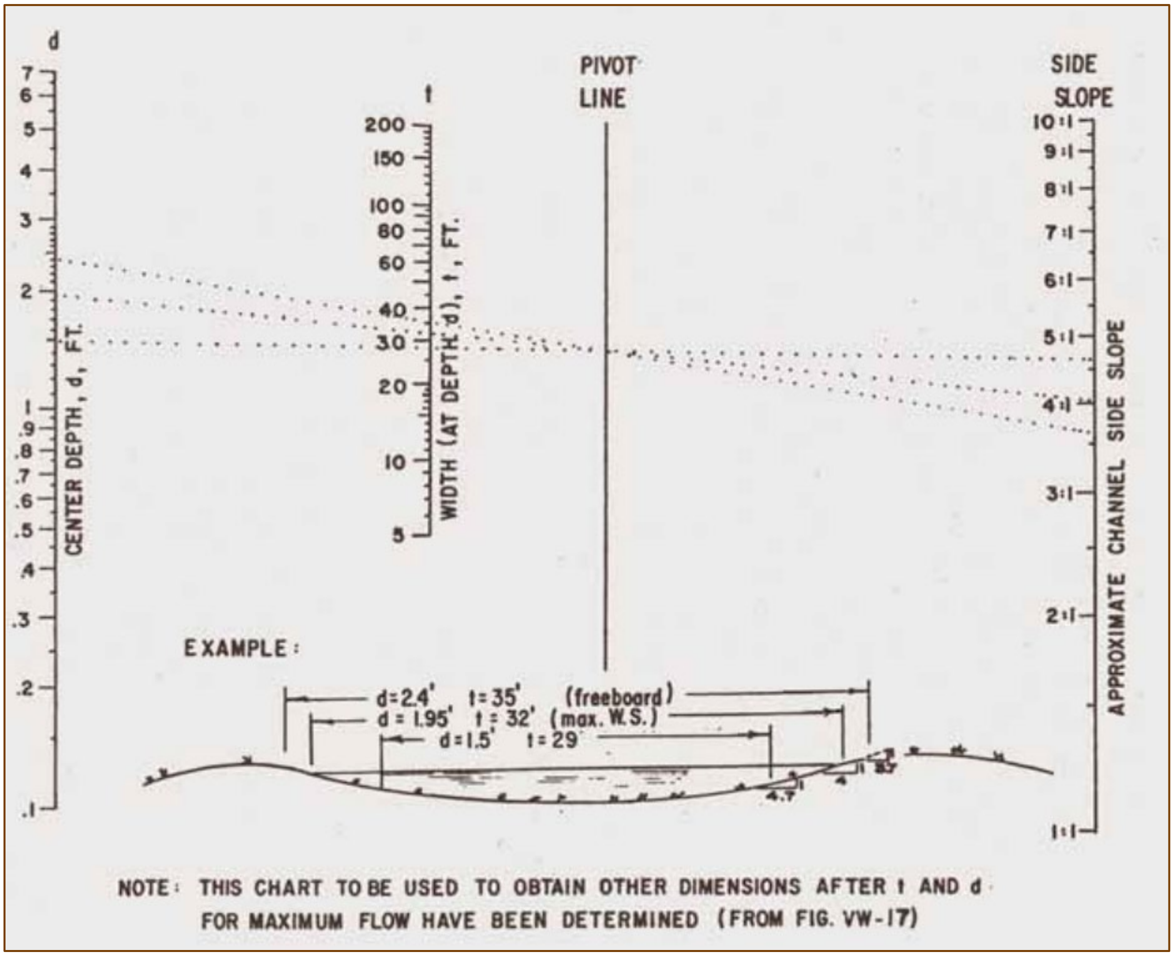


*Figure 5- 40 Solution for Dimensions of Parabolic Channels, Source: USDA-NRCS*



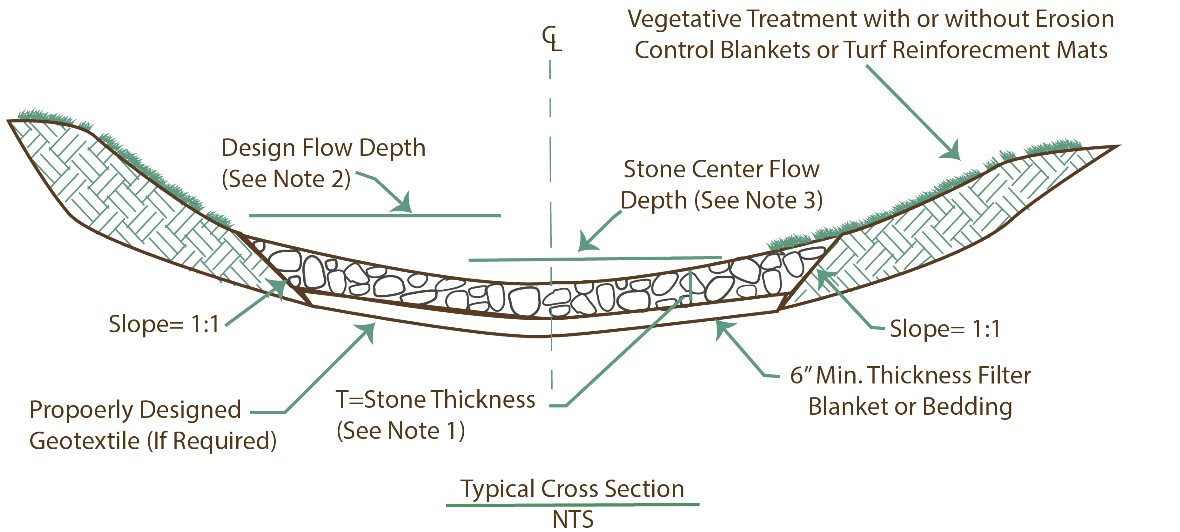
### Cross Section Design

Trapezoidal and "V-shaped" waterways are often used where space is limited.

Parabolic waterways are often used where space is available for a wide, shallow channel with low velocity flow. Stone center waterways should be used where higher velocities or persistent flows are expected.

Vegetated waterways with stone centers (see Figure 5-41) are useful where there is a persistent but not permanent low flow in the channel. For a channel designed to a 10-year frequency storm, the stone center shall be wide enough to safely pass a 2-year frequency storm. For a channel designed to a 25-year frequency storm, the stone center shall be wide enough to safely pass a 10-year frequency storm. The stone center shall have 6 inches of gravel bedding or a properly designed geotextile under the stone. If the d75 of the stone is 8 inches or greater, then a bedding over the geotextile shall be considered in the design to protect the geotextile from puncture during stone placement. The d75 of the stone shall be determined from HEC-15. The minimum d75 size shall be 3 inches. The d100 size shall be 1.5 times the d75 size. The d15 size shall be 3 inches or one third the d75 size, whichever is larger. The stone center shall have a minimum thickness of 12 inches or the d100 size, whichever is larger. The stone shall be hard and durable.

*Figure 5-41 Diagram of Vegetated Waterway with Stone Center*




Notes:
1. Minimum stone layer thickness is 1.5 times $D_{75}$, but not less than 12".

2. The total waterway depth is dependent upon the design depth of flow plus runup due to the channel curvature plus freeboard.

3. For a 10 yr. capacity waterway, the stone center shall contain a 2 yr. runoff event;
For a 25 yr. capacity waterway, the stone center shall contain a 10 yr. runoff event.

### Grading

Grade all areas adjacent to the waterways to drain toward the waterway.

### Outlet

The outlet shall be stable for the design storm discharge without erosion or flood damage.

### Permanent Cover

Establish a permanent vegetative cover on all vegetated waterways in accordance with the measure for Permanent Seeding or Sodding. Where the permanent vegetative cover is established by seeding, extend the seeding to at least the design top width and include any other areas disturbed by construction activities. For seeded channels with no stone centers use Temporary Erosion Control Blanket measure to hold seed in place and protect root bases from scour during the establishment period.

### Installation Requirements

Check weather forecasts to ensure a storm is not predicted during the time of construction. Delay construction until after the threat of rainfall has passed.

### Site Preparation

Remove all trees, brush, stumps, and other unsuitable materials and dispose of properly so as not to interfere with construction or proper functioning of the waterway.

Begin construction at the outlet installing outlet protection and continue construction to the inlet.

Excavate or shape the channel to the design grade and cross-section.

Compact any fills and rills to prevent unequal settlement.

Remove any excess soil.

For a waterway stabilized with permanent seedings, prepare the seedbed in accordance with the requirement of the Permanent Seeding measure. For a waterway stabilized with sod, prepare the soil surface in accordance with the requirement of the Sodding measure.

*Table 5. 15 Vegetative Retardant Factors and Manning's "n" Value*

| Range of Vegetation Height During Different Periods of the Year | Vegetative Retardant Factors | |
|---|---|---|
| | For Determining Minimum Capacity | For Determining Maximum Allowable Velocity |
| **Good Stand** | | |
| Between 6"and 1" | D | E |
| Between 10" and 2" | C | D |
| Between 24" and 2" | B | D |
| **Fair and Poor Stand** | | |
| Between 10" and 1" | D | E |
| Between 24" and 2" | C | D |
| Between 30" and 2" | B | D |

## Temporary Lined Channel

### Definition

A channel designed to convey flows on a short-term basis and lined with a flexible impermeable geomembrane or other erosion resistant covering.

### Purpose

To provide temporary conveyance of water through a stable channel either until a stable permanent channel is established or until site construction that required the temporary relocation has been completed.

### Applicability

- For drainage areas less than 100 acres (0.16 square miles) where the gradient of the flow line of the channel is greater than 2%.
- For drainage areas less than 1 square mile where the gradient of the flow line of the channel is less than 2%.
- Where the temporary relocation of a drainageway is needed to complete other construction work or to allow for the establishment of vegetation in a permanent channel.
- Use limited to 60 days when lined with flexible impermeable geomembrane.
- Use limited to 2 years when lined with a permanent channel lining as referenced in Permanent Lined Waterway measure.

## Planning Considerations

Temporary lined channels differ from temporary diversions in that temporary diversions are intended only to convey stormwater collected from areas no greater than 5 acres, while temporary lined channels are intended to convey watercourses from substantially larger areas. Like temporary diversions, they assist in isolating off-site flows from construction activities.

Choosing a flexible impermeable geomembrane, such as a plastic sheeting, over other linings is generally dependent upon watershed size, length of use, and flow characteristics. When geomembrane applicability limitations are exceeded, use permanent channel linings. While the same channel linings used in the Permanent Lined Waterway measure may be used in this measure, these linings are sufficiently expensive to consider alternate construction methodologies or construction sequences that avoid the need for a temporary lined channel.

No matter the channel lining used, a risk assessment is required to determine proper channel size. The risk assessment used in the Design Criteria provides for a smaller sized channel over that normally required because the time of exposure is limited when using a temporary lined channel. If the time of use for this measure is at all questionable, opt for a more conservative approach. The best approach is to plan construction schedules and sequences so that the need for temporary lined channels is as short as possible to reduce the exposure to storms that exceed the design storm provided by the risk assessment. In any event, if the intended use exceeds 2 years, the channel is no longer considered temporary, and a permanent measure must be utilized.

## Design Criteria

### Determining the Temporary Design Storm Frequency and Discharge

The design storm frequency is determined by using the risk assessment procedures outlined in Section 6.15 (Hydrology for Temporary Facilities) and Appendix F (Design Procedure: Hydrology for Temporary Facilities) of the CT DOT Drainage Manual.

1. Using the “Impact Rating Table” in Appendix F of the CT DOT Drainage Manual, assign a value of 1 to each of the factors in the Impact Rating Table except “Property Damage”. Property damage is assessed by predicting the areas that can be damaged should the channel capacity be exceeded or the channel lining fail. This includes an evaluation of potential flood damage upstream or adjacent to the channel and damage downstream to properties and water resources that might receive sediment should the channel fail. The Property Damage value shall be chosen as follows:
    - **5 points:** cropland, parking lots, recreational areas, undeveloped land, forest land
    - **10 points:** private or public structures, appurtenances such as sewage treatment systems and water supply areas (public and private well heads and reservoirs), utility structures either above or below ground, trout management areas, streams stocked by CTDEEP, ponds located immediately downstream before the confluence with other watercourses, wetlands

When the assigned risk falls between two design frequency delineations, choose the higher of the two design frequencies. For example, a design risk of 30% for 18 months falls between the 3-year and 5-year frequency event.

2. Once the temporary design storm is chosen, determine the temporary design discharge corresponding to the temporary design storm frequency using hydrologic calculation methods described in the CTDOT Drainage Manual.

3. Design the temporary lined channel according to generally accepted engineering standards (e.g., the USDA-NRCS National Engineering Handbook, Part 650 (Engineering Field Handbook) and the CTDOT Drainage Manual).

4. Design the minimum runoff to carry the peak flow expected from a 2-year frequency, 24-hour duration storm without erosion.

### Lining Selection

Lining is required to protect the channel from erosion and shall be in conformance with the manufacture's recommendations for use in flow conditions.

- **Impermeable Geomembranes:** made of plastic sheeting or similar material at least 6 mils thick.
- **Permanent Channel Linings:** an erosion resistant lining of concrete, stone, or other permanent material. Required when use exceeds 60 days, or the watershed exceeds 100 acres. See Permanent Lined Waterway measure for design requirements.

## Installation Requirements

Check weather forecasts to ensure a storm is not predicted during the time of construction. Delay construction until after the threat of rainfall has passed.

### Impermeable Channel Linings

Shape and prepare the channel to receive the lining.

Remove all rocks, stones, debris, sticks, or any other material exposed that could puncture the lining.

Bury the upper end of the lining in a trench at least 6 inches deep. At least every 40 feet of channel length a fold of the plastic lining shall be buried in a trench at least 6 inches deep. The edges of the lining shall be buried in a 6-inch trench or at least 6 inches of soil mounded over the edges of the plastic.

### Permanent Channel Linings

See Permanent Lined Waterway measure for installation requirements.

## Maintenance

For temporary channels containing impermeable geomembranes, inspect daily for undercutting of and damage to the lining. Repair and patch as needed. For temporary channels containing permanent channel linings, inspect at least once a week and within 24 hours of the end of a storm that generates a discharge.[47] Repair as needed.

## Permanent Lined Waterway

### Definition

A permanent waterway, including chutes and flumes, with an erosion resistant lining composed of turf reinforcement mat, riprap, gabions, or other appropriate durable material.

### Purpose

- To provide for the safe non-erosive conveyance of concentrated surface water runoff to an appropriate receiving channel, without damage by erosion or flooding.
- To safely convey concentrated stormwater runoff down the slope by use of a lined chute, flume, or waterway.

### Applicability

- Where the contributing drainage area does not exceed 200 acres.
- Where the design discharge does not exceed 200 cfs.
- Where vegetative stabilization is inadequate because the velocity of concentrated runoff is of such magnitude that a lining is needed to prevent erosion of the channel and/or where excessive grades, channel wetness, prolonged base flow, seepage, or soil piping would cause erosion.
- Where vegetative slopes will not prevent erosion caused by people, animals, or vehicles.
- Where property values or adjacent facilities warrant additional protection.
- Not for use within natural stream channels.

### Planning Considerations

The Permanent Lined Waterway is used when the limitations of the Vegetated Waterway and Temporary Lined Channel are exceeded. This measure should be planned and installed along with, or as part of, other measures in an overall surface water conveyance system. These systems require detailed design by a CT licensed professional engineer. The measure should be installed and stabilized prior to the introduction of flows.

The design of the waterway is based upon the peak volume and velocity of flow expected in the channel. If conditions are appropriate, vegetation, turf reinforcement mat, riprap, gabions, or combinations thereof may be used. While concrete channels are efficient and easy to maintain, they remove runoff so quickly that channel erosion and flooding may result downstream. Vegetation, turf reinforcement mat, riprap, and gabions and various combinations of these materials reduce this problem by more closely duplicating a natural system. See the Vegetated Waterway measure for further discussion of vegetated waterways.

In addition to the primary design considerations of capacity and velocity, a number of other important factors should be taken into account when selecting a cross section and lining. These

[47] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

factors include land availability, compatibility with land use and surrounding environment, safety, maintenance requirements, outlet conditions, soil erodibility factor, and tailwater conditions. If a riprap design is chosen, a geotextile or graded filter may be used to act as a separator and stabilizer between the riprap and the subbase.

On stream bank erosion sites, there are many different structural stabilization techniques which can be used successfully. Good site planning normally requires staying away from streams. Properly designed and installed bank toe protection can provide excellent stabilization for stream banks if bank failure is a problem and site constraints prevent vegetative treatments.

A primary cause of stream channel erosion is the increased frequency of bank-full flows. When designing for stream bank stabilization, consider preserving or developing viable aquatic habitats using soil bioengineering and other vegetative techniques.

When this measure is intended to function as a paved chute or flume then it should be planned and installed along with, or as part of, other conservation practices in an overall surface water conveyance system. Consideration must be given to protecting structures against buoyancy failures. The potential for buoyancy failure due to hydrostatic uplift forces exists in channels constructed in periodically saturated areas (basically all channels will experience saturation of the subgrade by virtue of the function of the channel) and especially if a submerged outfall condition exists.

Lined chutes or flumes should be utilized and constructed carefully. Field experience has shown a significant number of post-construction problems with these controls. If the subbase contains unsuitable material, the chute or flume may be subject to undermining and fracturing. If high outlet velocities are expected, it may be appropriate to install a system of pipe slope drains to slow the exit velocity of the measure to reduce erosion potential.

## Design Criteria

### Discharge

Design the permanent waterway according to generally accepted engineering standards (e.g., the USDA-NRCS National Engineering Handbook, Part 650 (Engineering Field Handbook) and the CTDOT Drainage Manual).

The minimum waterway capacity shall be adequate to carry the peak rate of runoff from a 10-year frequency 24-hour duration storm. Local and state highway facilities may require a higher design standard. If pre-development flooding problems exist, or if the consequences of flooding are severe, or if drainage systems which convey larger storms converge with the channel in question, consideration should be given to increasing the capacity beyond the 10-year frequency.

Waterway capacity shall be computed using Manning's formula and the Continuity Equation consistent with the design references cited above. Note: For help in using these formulas and in choosing Manning's "n" values see Design Example.

### Velocity

Channels should be designed so that the velocity of flow from a 10-year frequency storm shall not exceed the permissible velocity for the type of lining used.

- **Riprap-lined channels** can be designed to withstand most flow velocities by choosing a stable stone size. The procedures for selecting a stable stone size for channels and installation is contained in the Riprap measure. All ripraps shall be placed on a geotextile or gravel blanket (see Riprap measure for details). Transition from a riprap lining to vegetative lining must be carefully designed to meet the allowable velocities of each type of lining.
- **Turf Reinforcement Matting** shall be designed in accordance with the manufacturer's recommendations and the Permanent Turf Reinforcement Mat measure.
- **Gabions** shall be designed in accordance with the manufacturer's recommendations and the Gabion measure.
- **Articulated Concrete Block** shall be designed in accordance with the manufacturer's recommendations and the Articulating Concrete Block measure.
- Other flexible lined channels should be designed based on accepted engineering practice, applicable design guidance, and manufacturers' recommendations for any manufactured products that are used. FHWA HEC-15 Other flexible lined channels should be designed based on accepted engineering practice, applicable design guidance, and manufacturers' recommendations for any manufactured products that are used.

Design flow depth and maximum velocities should be consistent with Table 5. 16. See Figure 5-44 for an example of a permanent lined chute or flume.

*Table 5. 16 Maximum Velocity*

| Design Flow Depth | Maximum Velocity (fps) |
|---|---|
| 0.0-0.5′ | 25 |
| 0.5-1.0′ | 15 |
| >1.0′ | 10 |

Source: USDA-NRCS

### Critical Slope

A critical slope is the slope of the channel bottom required to produce a water surface equal to critical depth. Except for short transition sections, slopes in the range of 0.7 to 1.3 of the critical slopes shall be avoided. Lined waterways with velocities exceeding those found at critical depth shall discharge into an energy dissipator to safely reduce velocity to less than the velocity found at critical depth.

### Cross Section Design

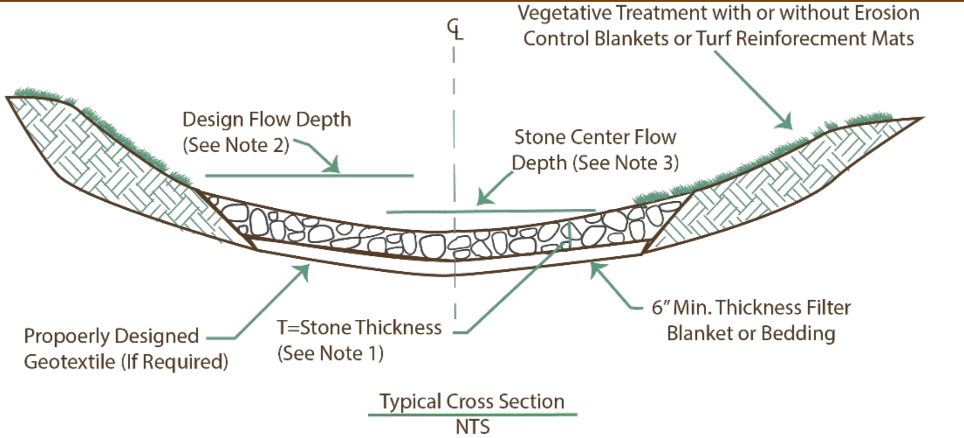
**"V" shaped** channels are generally used where the quantity of water to be handled is relatively small, such as drainageways and roadside ditches. A vegetative lining may suffice where velocities in the ditch are low. For steeper slopes where high velocities are encountered, a riprap, concrete or bituminous concrete lining may be appropriate.

**Parabolic** channels are often used where the quantity of water to be handled is larger and where space is avail- able for a wide, shallow channel with low velocity flow. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of vegetation and riprap (a.k.a. vegetated channel with stone center) are also useful where there is a continuous low flow in the channel (see Vegetated Waterway measure).

**Trapezoidal and rectangular** channels are often used where the quantity of water to be carried is large and conditions require that it be carried at a relatively high velocity (trapezoidal and rectangular channels are generally lined with riprap or other hard armoring.)

Refer to Figure Figure 5- 42 and Figure 5- 43 for typical cross sections of various channel shapes.

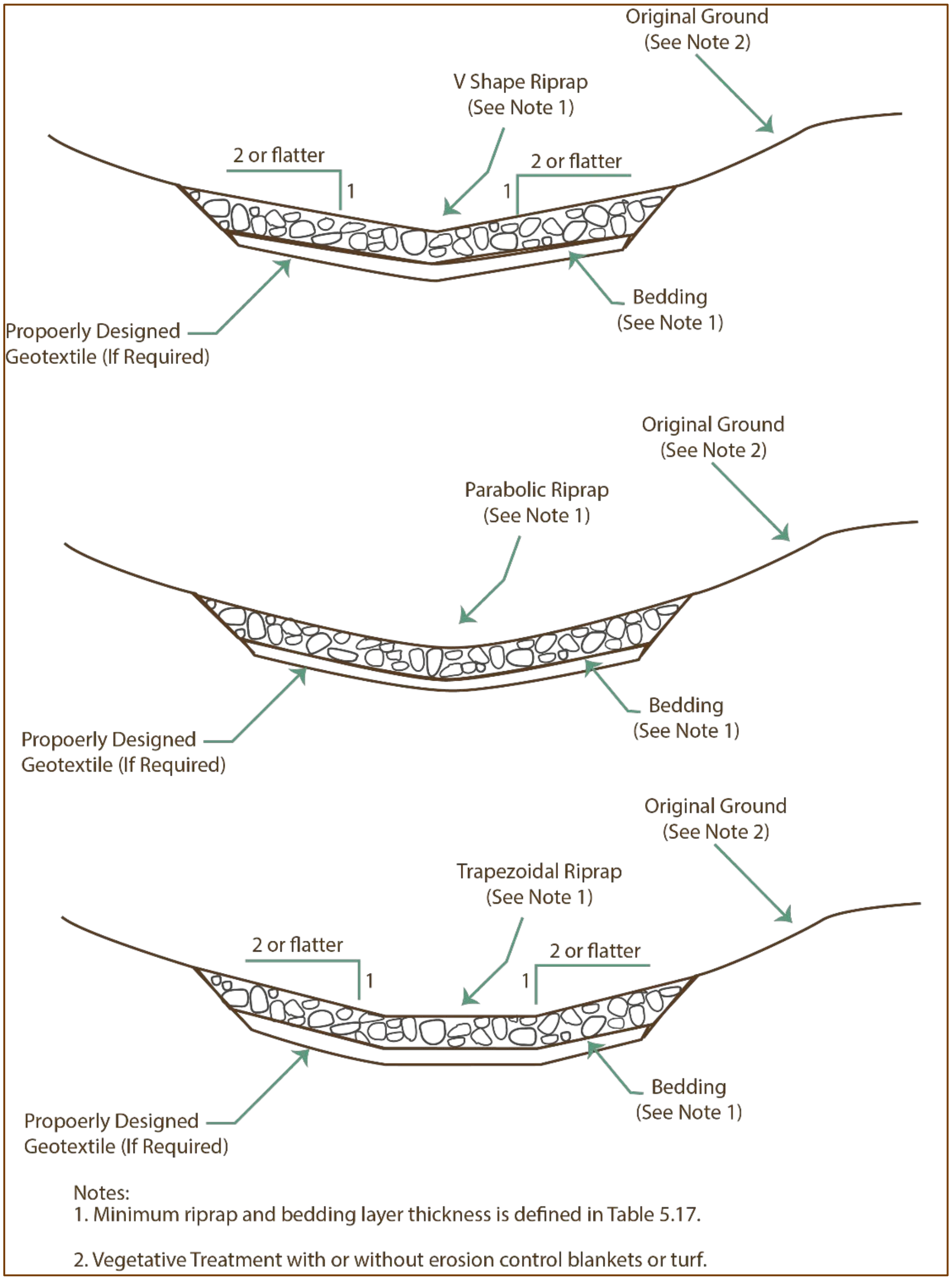
*Figure 5- 42 Waterways with Stone Centers*




Notes:

1. Minimum stone layer thickness is defined in Table 5.17.
2. The total waterway depth is dependent upon the design depth of flow plus runup due to the channel curvature plus freeboard.
3. For a 10 yr. capacity waterway, the stone center shall contain a 2 yr. runoff event; For a 25 yr. capacity waterway, the stone center shall contain a 10 yr. runoff event.

*Figure 5- 43 Typical Waterway Cross Sections*



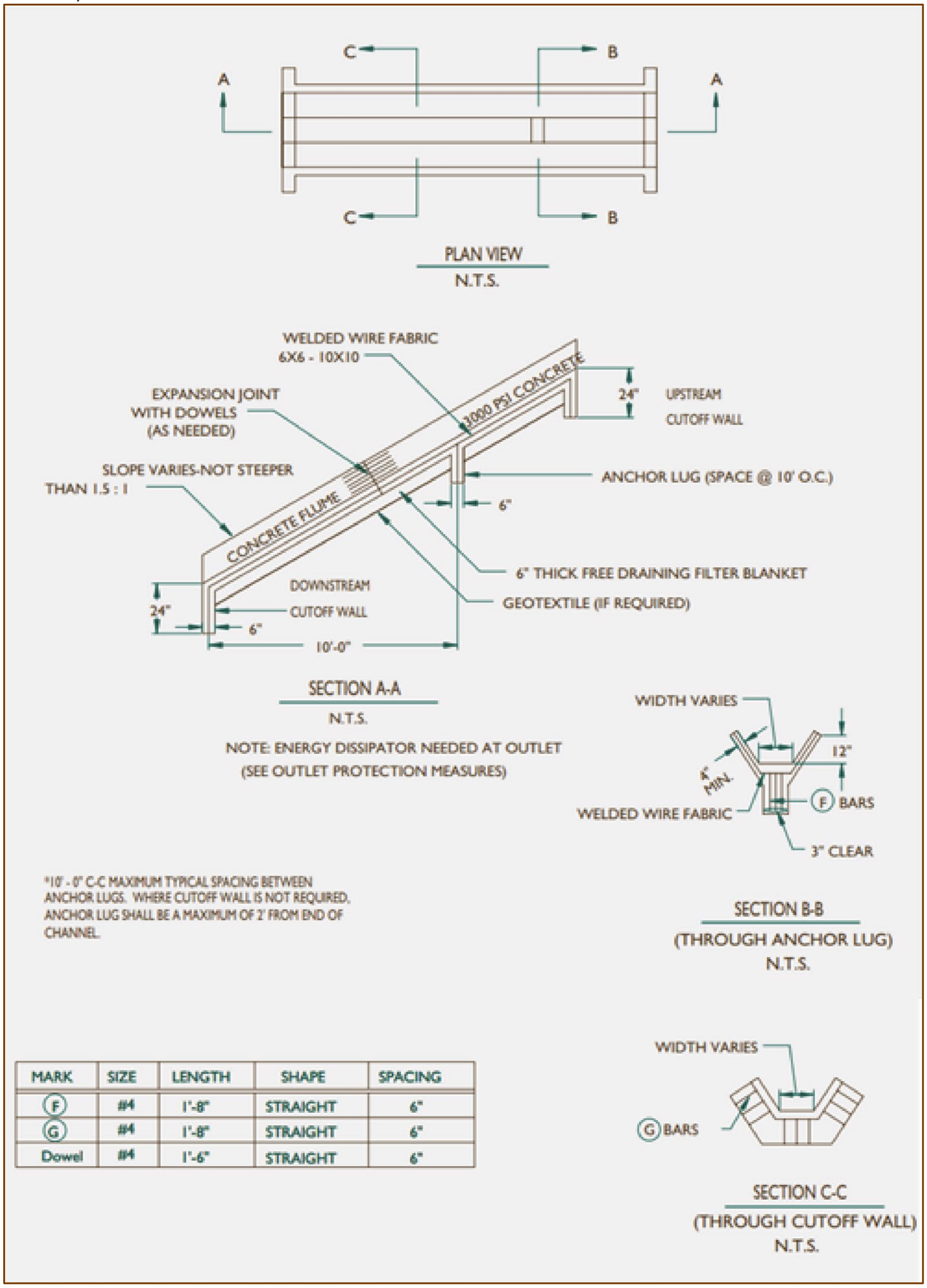

## Freeboard

Use a minimum freeboard of 0.5 ft. if no out-of-bank damage would be expected. Increase freeboard in areas where high damage can be expected from out-of-bank flow

## Side Slopes

For lined channels, the steepest recommended side slopes are shown Table 5. 17.

*Figure 5-44 Example of Permanent Lined Chute or Flume*




| MARK | SIZE | LENGTH | SHAPE | SPACING |
|---|---|---|---|---|
| F | #4 | 1'-8" | STRAIGHT | 6" |
| G | #4 | 1'-8" | STRAIGHT | 6" |
| Dowel | #4 | 1'-6" | STRAIGHT | 6" |

*Table 5. 17 Channel Lining Recommended Side Slopes*

| | Lining | Steepest Recommended Side Slope (horizontal to vertical) |
|---|---|---|
| Increasing Slope ↓ | Riprap | 2 to 1 |
| | Turf reinforcement matting | 2 to 1 |
| | Gabions | 2 to 1 |
| | Hand-placed, screened concrete or mortared in-place flagstone<br>Height of lining more than 2 feet | 2 to 1 |
| | Articulating concrete block | 2 to 1<br>(no steeper than the<br>side slope used in the hydraulic stability test of the product) |
| | Hand-placed, screened concrete or mortared in-place flagstone Height of lining less than 2 feet | 1 to 1 |
| | Reinforced slip form concrete -<br>Height of lining less than 3 feet | 1 to 1 |
| | Non-Reinforced Concrete - Hand placed, formed concrete Height of lining 1.5 feet or less | Vertical |

### Lining Thickness

**Riprap –** maximum stone size + thickness of filter or bedding layer (see Table 5. 18)

**Concrete –** 4 inches plus 6 bedding.

**Turf reinforcement matting –** per manufacturer's recommendations, can be flat or three-dimensional matrices, laid either on top of or within the soil surface layer.

**Gabions –** per manufacturer's recommendations plus thickness of filter or bedding layer

**Articulating concrete block –** blocks are typically 4 to 9 inches thick plus 6 inches minimum of filter or bedding layer

*Table 5. 18 Riprap Lining Specifications*

| Riprap Specification | Maximum Stone Size (inches) | Minimum Thickness (inches) | Minimum Bedding Thickness (inches) |
|---|---|---|---|
| Standard | 30 | 36 | 12 |
| Intermediate | 18 | 18 | 6 |
| Modified | 10 | 12 | 6 |

Source: CTDOT Standards and Specifications Section M.12.02 and CTDOT Drainage Manual

### Contraction Joints

Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet. Provide for uniform support to the joint to prevent unequal settlement.

### Filters or Bedding

Filters, bedding, and/or geotextiles shall be used to prevent piping. Subsurface drains may be used, as required, to reduce uplift pressure and to collect water. Filters, bedding, geotextiles, and drains shall be designed according to the measure-specific criteria contained in these Guidelines. Subsurface weep holes shall be used with impervious linings.

### Materials

Riprap shall be of a stone that is dense and hard and durable enough to withstand exposure to air, water, freezing and thawing and be chemically stable (see Riprap measure for further riprap materials requirements).

Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required. Specify a mix that can be certified as suitable to produce a minimum strength of at least 3,000 lb./in$^3$. The concrete mix shall contain air entrainment. Cement used shall be Portland Types I, II, or if required Types IV or V. See Figure 5-44 for example of a permanent concrete lined chute or flume.

### Outlet

The outlet must handle the design flow without flooding or erosion. The outlet shall be stable for the 10-year, 24-hour storm discharge. Outlets of all channels shall be protected from erosion. Transition from a man-made lining, such as gabions and riprap, to a vegetated or non-vegetated lining shall be taken into consideration. Appropriate measures shall be taken to dissipate the energy of the flow to prevent scour of the receiving channels. See Outlet Protection measure.

### Related Structures

Side inlets, permanent slope drains, and energy dissipators shall meet the hydraulic and structural requirements for the site.

### Installation Requirements

1. Remove and properly dispose of all trees, brush, stumps, roots, obstructions, and other unsuitable materials so as not to interfere with construction or proper functioning of the permanent lined waterway.
2. Install temporary erosion and sediment controls to protect the site of the permanent lined waterway from sediment deposition while the contributing drainage area is unstable.
3. Excavate or shape the channel to the proper grade and cross-section. Consider phasing of channel construction in order to minimize time of exposure in lengthy projects.
4. Compact any fills to prevent excessive settlement.
5. Remove and dispose of any excess soil properly.

### Channels Lined with Riprap, Turf Reinforcement Matting, Gabions, and Articulating Concrete Blocks

Install these lining materials in accordance with the guidance provided in these Guidelines for each respective measure.

### Concrete-lined Channels

Construct concrete-lined channels in accordance with all applicable CTDOT specifications. The following items highlight those specifications:

1. Place concrete only when the subgrade is moist.
2. Provide transverse joints for crack control at approximately 10–15-foot intervals and when more than 45 minutes elapse between times of consecutive concrete placements. Make all sections at least 6 feet long. Crack control joints may be formed by using a 0.125-inch-thick removable template, by sawing to a depth of at least 0.75 inch, or by an approved “leave in” type insert.
3. Install expansion joints every 100 feet.

### Maintenance

Until the contributing drainage area is stabilized, inspect at least once a week and within 24 hours of the end of a storm that generates a discharge.[48] Repair as needed.

[48] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

## Design Procedure Open Channel Flow (from FHWA HEC-15)

To calculate the flow in an open channel, assume that the quantity of flow in the channel does not change with time and that the cross-sectional area and slope of the channel remain constant.

1. Determine design discharge (Qd) based on hydraulic computations. Use a 10-year frequency discharge.
2. Determine Maximum Permissible Velocity (V max). See Table 5. 19.
3. Select channel shape and slope. (So).
4. Determine dmax for the selected lining and slope (use HEC-15 Maximum Permissible Depth (MPD) charts). Note: dmax does not apply to concrete lined channels.
5. Calculate area (A) and hydraulic radius (R) for the selected channel geometry and dmax.
6. Determine Manning's "n". Manning's roughness coefficient, "n", is determined by the type of channel lining selected. Ranges of "n" factors for various structural linings are listed in Appendix A of "Design Charts for Open-Channel Flow, Hydraulic Design Series No. 3" published by the U.S. Department of Transportation. Generally, for a given lining the lower values should be used to calculate velocity and the higher values should be used to calculate capacity of the channel. See the equation below for determining Manning's "n".
7. Calculate design velocity (Vd) from R and So using Manning's equation or nomographs widely available.

$$V = \frac{1.49}{n} R^{2/3} \times S^{1/2} \quad \text{(Manning's Equation)}$$

Where.

V = the average velocity in the channel (ft./sec.)

n = Manning's roughness coefficient, based upon the lining of the channel.

R = the hydraulic radius (feet) = A ÷ wp

Where.

A= cross sectional area

Wp= wetted perimeter.

S = the slope of the channel (ft/ft)

8. Calculate allowable discharge (Qa) using the Continuity Equation:

$$Qa = VA$$

Where

Qa =the allowable discharge

V = the average velocity in the channel (ft./sec.)

A = cross sectional area of flow

9. Check Vd against Vmax. If Vd > Vmax, select larger channel or use more stable lining.
10. Compare allowable discharge (Qa) with design discharge (Qd). If Qa >> Qd the channel is over designed. If Qa < Qd. the channel is inadequate.

*Table 5. 19 Maximum Velocity (ft/sec)*

| Riprap Type[49] | Size | Maximum Permissible Velocity (ft/sec) |
|---|---|---|
| Modified | $d_{50}$ <0.42 feet | 8 |
| Intermediate | 0.42 feet<$d_{50}$<0.67 feet | 10 |
| Standard | 0.67 fee<$d_{50}$ | 14 |

Source: CTDOT Drainage Manual

[49] Riprap types as defined in CTDOT Standard Specifications. Other gradations may be designed which also met the d50 criteria.

## Design Example

**Given:** Qd = 100cfs
Sa (slope) = 1%
Channel shape = Trapezoidal w/ 2:1 side slope
Z = 2 (see Figure 5- 36 )
Type of Lining = Concrete w/ float finish
'n' = 0.013 - 0.017 (see Table 5. 20)

**Find:** Channel Size and Depth of Flow

**Solution:** Solve by trial and error. Using the Continuity Equation (Q = AV), Manning's equation ( V = (1.49/n) x R 2\3 x S 1\2) and the formulas in Figure 5- 45.

***Try:*** Bottom Width = 6 ft. Depth of Flow = 1.4 ft. Area A = bd + zd2 = 6 x 1.4 + 2 x 1.42 = 12.32 sq. ft.

Hydraulic Radius R = A /wp where wp = wetted perimeter

R =( bd + zd2 ) / (b +2d (z2+1)1\2) = 12.32 / 12.26 = 1.004 use 1.0

Vd = (1.49 / 0.017) x 1.0 x 0.1 = 8.8 ft./sec.

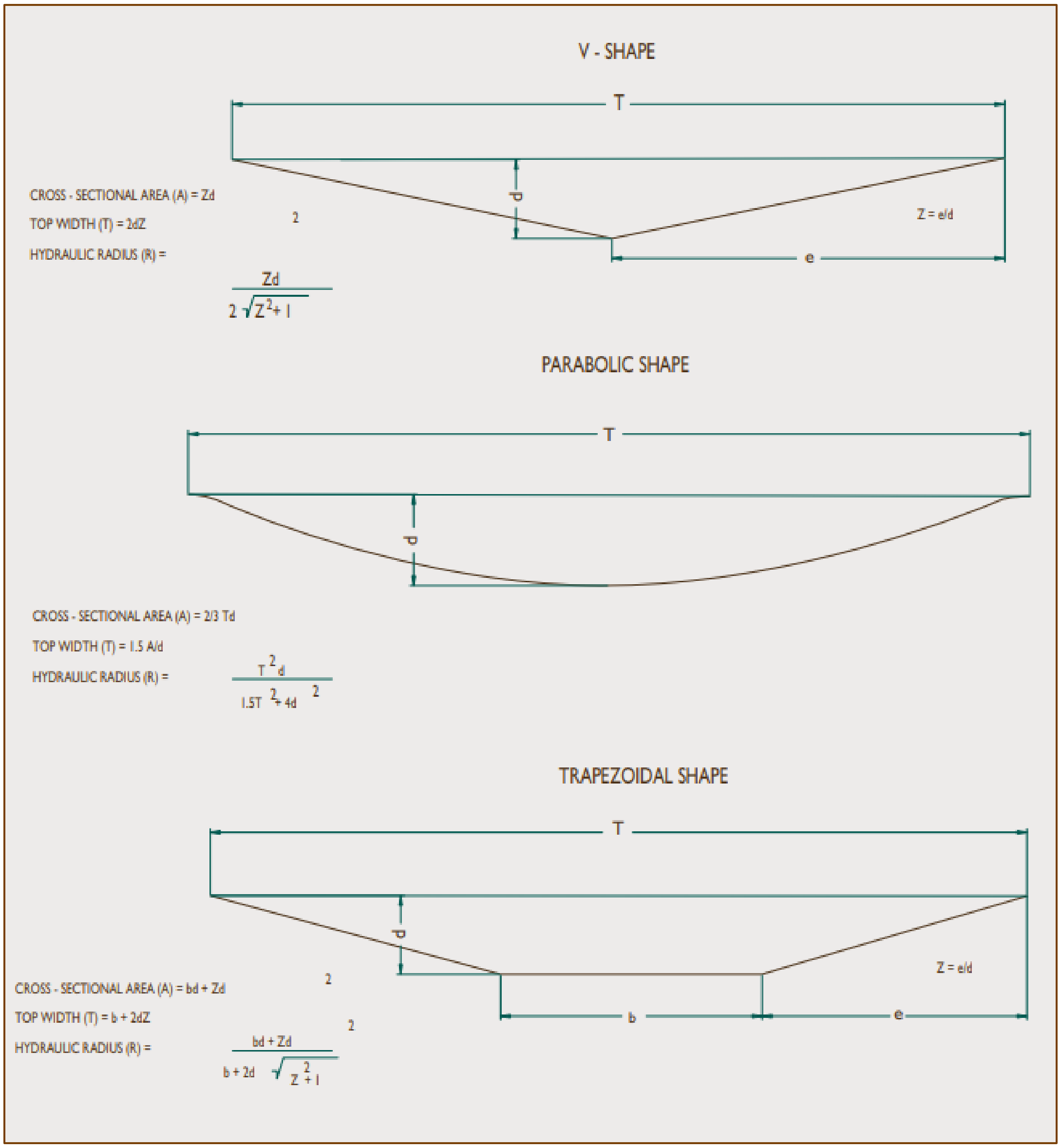
Qa = VA = 8.8 x 12.32 = 108.4 cfs > Qd of 100 cfs, OK.

Use a minimum freeboard of 0.25 ft. if not out of bank damage would be expected. Increase freeboard in areas where high damage can be expected from out of bank flow.

Construction Dimensions:

Side slopes = 2:1; Bottom Width = 6 ft.; Depth = 1.65 feet; Lining thickness = 4 inches. Concrete = 3000 psi (air entrained); Cement = Portland Type 1; Aggregate maximum size = 1-1/2 inches; Use contraction joints every 15 feet; use 6 inches gravel bedding under all concrete.
Note: For a riprap lined waterway, see Riprap measure

*Figure 5- 45 Channel Geometry Equations*




## Manning's "n" Roughness Coefficients

For riprap-lined channels, Manning's "n can be determined from the following equation:

*Equation 5. 3 Mannings Coefficient Formula*

$$n = 0.0395 d_{50}^{1/6}$$

The following table identifies Manning's "n" roughness coefficients for specific linings derived from the USDA-NRCS National Engineering Handbook guidance the CTDOT Standard Specifications M.12.02 (riprap). Ranges of n values reflects different materials, construction methods, relative roughness, and initial versus vegetated conditions.

*Table 5. 20 Mannings Coefficients for Specific Lining Types*

| Lining type | Manning's "n" |
|---|---|
| **Concrete** | |
| Trowel Finish | 0.012 to 0.014 |
| Float Finish | 0.013 to 0.017 |
| Gunite | 0.016 to 0.022 |
| **Riprap** | |
| Modified (d50=0.42)<br>Intermediate (d50=0.67)<br>Standard (d50=1.25) | 0.034<br>0.037<br>0.041 |
| Turf Reinforcement Mat | 0.024 to 0.036 |
| Gabions | d50 of the basket rock |
| Articulating Concrete Block | 0.010 to 0.015 |
| Cellular Confinement System | 0.013 to 0.024 |

## Temporary Stream Crossing (TSC)

### Definition

A temporary bridge, culvert, or ford across a watercourse for use by construction traffic.

### Purpose

- To provide a safe, stable way for construction vehicle traffic to cross a watercourse.
- To provide streambank stabilization, reduce the risk of damage to the streambed or channel, and minimize sediment loading from construction traffic.

### Applicability

- Because of the potential for stream degradation, flooding, and safety hazards, avoid stream crossings whenever possible.
- Temporary stream crossings are appropriate where heavy construction equipment must be moved from one side of a stream channel to the other.
- They can also be used where lighter construction vehicles will cross the stream repeatedly during construction.
- A bridge or culvert is the best choice for most temporary stream crossings because each

can support heavy loads.

- Fords should be used only where flash flooding might occur, where normal flow is intermittent, where stream crossings are expected to be infrequent, or in seasonally dry streambeds.
- Where crossings are unavoidable, design crossings to cross the narrowest possible section of the stream and/or bordering wetlands.
- Use or upgrade existing paths or roads to avoid previously undisturbed areas.
- Avoid crossing through or bisecting wetland life breeding areas such as vernal pools.
- Consider using precast bridges, especially for longer spans, allowing installation to occur with minimal contact to the wetland.
- Generally applicable to streams with drainage areas less than one square mile.

For drainage areas exceeding one square mile, use generally accepted engineering standards including the USDA-NRCS National Engineering Handbook and the CTDOT Drainage Manual, which more accurately define the actual hydrologic and hydraulic parameters which will affect the functioning of the structure. Consider incorporating principles of the CT DEEP Stream Crossing Guidelines to minimize the impacts of channel constrictions on flows and aquatic organism passage during construction.

### Planning Considerations

Temporary stream crossings are necessary to prevent construction vehicles from damaging stream banks and continually tracking sediment and other pollutants into the stream. However, these structures are also undesirable in that they represent a channel constriction which can cause flow backups or washouts during periods of high flow and impede the passage of aquatic organisms. Temporary stream crossings can also cause risk to fish habitat by destabilizing embankments, compacting stream beds, and releasing sediment, and from vehicle fluid leaks, changes in channel morphology, and alteration of flows. For this reason, the temporary nature of stream crossings is stressed. They should be in place for the shortest practical period of time and be removed as soon as their function is completed.

Consider alternative routes to accessing a site before planning to erect a temporary stream crossing. If a stream crossing is necessary, select an area where the potential for erosion is low. If possible, select the stream crossing structure during a dry period to reduce sediment transport into the stream.

The specifications contained in this measure pertain primarily to flow capacity and resistance to washout of the structure. From a safety and utility standpoint, the designer must also be sure that the crossing can withstand the expected loads from heavy construction equipment. Additionally, the design plans and installation shall comply with applicable federal, state, and local laws and regulations.

A temporary bridge crossing is a structure made of wood, metal, or other materials which provides access across a stream or waterway. A temporary culvert crossing is a structure consisting of stone and a section(s) of circular pipe, pipe arches, or oval pipes of reinforced concrete, corrugated metal, or structural plate, which is used to convey flowing water through the crossings. A ford is a place along a river or stream that may be crossed by a vehicle. A ford may occur naturally or be constructed.

Bridges are preferred over culvert installations. Normally, bridge construction causes the least amount of disturbance to the stream bed and banks when compared to the other types of crossings. They can also be quickly removed and reused. In addition, temporary bridges pose the least chance for interference with fish migration when compared to the other temporary access waterway crossings. If bridges are used, construct them only under the supervision and approval of a qualified engineer.

Multiple smaller culverts may be used in place of a single larger culvert if the hydraulic capacity is equivalent or greater. However, smaller multiple culverts are more susceptible to being obstructed with debris during flooding events. They can increase the risk of blockage resulting in overtopping and erosion of the roadway creating damages that may exceed the difference in costs between multiple small culvert and one large culvert.

Stream fords are the least desirable option. When fords are the only option, the following key conditions must be met:

- The work must not include diverting flow or realigning the channel or stream bank.
- Crossing sites must avoid known fish spawning sites (pools, etc.).
- The crossing must not result in erosion or sedimentation of the stream or blockage of fish passage.
- Fording should only be employed when culverts or temporary bridges are impractical or impossible to utilize.
- Grading of stream banks for approaches is not permitted.
- Fords should be employed only where water depth is sufficiently shallow to allow passage of vehicles at very low speeds.
- Effective erosion and sediment control measures must be installed prior to starting work. These measures must be inspected regularly and maintained properly.

Water bars are required for the crossing and other erosion and sediment controls may be needed.

## Design Criteria

Temporary stream crossings may be bridges, culverts, or fords and associated rock fill. For temporary culvert crossings that will remain in place for 90 days or less, in lieu of a formal hydraulic design, the structure shall have the ability to convey without erosion the flow from a 2-year frequency storm or to replicate the cross-sectional area of the natural channel. The minimum culvert size is 18 inches.

### Minimum Design Flows

If the structure will remain in place 90 days to 3 years, the design storm is determined by using the risk assessment procedures outlined in Section 6.15 (Hydrology for Temporary Facilities) and Appendix F (Design Procedure: Hydrology for Temporary Facilities) of the CT DOT Drainage Manual. Using the "Impact Rating Table" in Appendix F of the CT DOT Drainage Manual, determine all factors in the Impact Rating Table as described except "Property Damage." Property damage is assessed by predicting the areas that can be damaged should the crossing capacity be exceeded. This includes an evaluation of potential flood damage upstream or adjacent to the channel and damage downstream to properties and infrastructure that might receive sediment should the stream crossing fail. The Property Damage value shall be chosen as follows:

- **5 points** cropland, parking lots, recreational areas, undeveloped land, forest land
- **10 points:** private or public structures, appurtenances such as sewage treatment systems and water supply areas (public and private well heads and reservoirs), utility structures either above or below ground, trout management areas, streams stocked by CTDEEP, ponds located immediately downstream before the confluence with other watercourses, wetlands greater than 5 acres in size.

When the assigned risk falls between two design frequency delineations, choose the higher of the two design frequencies. For example, a design risk of 30% for 18 months falls between the 3-year and 5-year frequency event. Therefore, choose the 5-year design frequency.

The structure shall be designed to pass the design storm without erosion. If the structure must remain in place over 3 years, it must be designed as a permanent stream crossing in accordance with accepted engineering standards and practices for culvert and bridge design, including the CT DEEP Stream Crossing Guidelines. The installation of the temporary stream crossing shall not impact structures near the crossing by causing a rise in the water surface elevation for the chosen design storm.

### Crossing Load Limitations

The materials used to construct the crossing must be able to withstand the anticipated loading of the construction traffic.

### Crossing Width

The crossing shall be designed for single lane traffic only, with a minimum width of 12 feet and a maximum of 20 feet. For culvert crossings the length of the culvert(s) shall include the width needed for single lane traffic plus the side slopes.

### Crossing Alignment

The temporary stream crossing shall be at right angles to the stream. Where approach conditions dictate, the centerline of the stream crossing may be aligned so that it is no greater than 15% from a line drawn perpendicular to the stream flow.

### Crossing Approaches

The centerline of both roadway approaches shall coincide with the centerline of the crossing with sufficient length to accommodate the equipment to be used on the crossing. All fill materials associated with the roadway approach shall be limited to a maximum height of 2 feet above the existing grade.

The approaches to the structure shall consist of a minimum thickness of 6 inches of well graded, free draining gravel or crushed stone equal to the width of the travel way.

### Temporary Bridge Crossing Criteria

Design the elevation of the temporary bridge structure at or above top of bank elevation to prevent the entrapment of floating materials and debris. Additionally, the abutment shall be parallel to and tied into stable banks. Design the bridge to span the entire channel. If the channel width exceeds 8 feet (as measured from top of bank to top of bank), then a footing, pier or bridge support within the waterway may be included in the design. One additional footing, pier or bridge support is permitted for each additional 8-foot width of channel. No footing, pier or bridge support is allowed within the channel for waterways which are less than 8 feet wide.

Provide specifications for decking materials, bridge stringers and a bridge anchor of sufficient strength to support the anticipated load. Identify if run planking and curbs or fenders along the outer sides of the deck are required. Materials may include logs, sawn timber, pre-stressed concrete beams, metal beams, or other approved materials.

### Temporary Culvert Crossing Criteria

Culvert Size: Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert diameter that may be used is 18 inches.

Culvert Length: In no case shall the culvert exceed 40 feet in length. If the crossing approach grades require extensive fills, then consider using a bridge rather than a culvert for the crossing structure.

Culvert Slope: The slope of the culvert shall match the existing channel bottom slope.

Culvert Backfill: Culvert backfill requires the use of well graded, free draining gravel or crushed stone to form the crossing and a geotextile, if necessary, specifically intended for road stabilization between the fill and the native soil. Provide specifications for the geotextile such that it can adequately distribute loads, retain fines, and provide separation between the backfill and the native soil. See Entrance measure for required physical qualities of the geotextile. The depth of cover over the culvert shall be a minimum of 24 inches and may be increased if anticipated loads require designed fill depths to be greater. For culvert(s) on a temporary stream crossing expected to be used in excess of 14 days, the backfill shall be protected from erosion with riprap designed in accordance with the Riprap measure.

### Temporary Stream Ford Crossing Criteria

Seasonally dry stream fords must be protected from erosion and possible sedimentation caused by significant rainfall events. Appropriate technology must be employed. In these areas, or in areas where minor rutting is likely to occur, logs, swamp pads or rubber mats may be used. One proven design method involves installation of three-dimensional cellular confinement grid over a non-woven geotexile base. The cellular confinement grid is then filled with clean stone. So as not to alter seasonal flows, it is important that these installations match the contours of the existing stream bed.

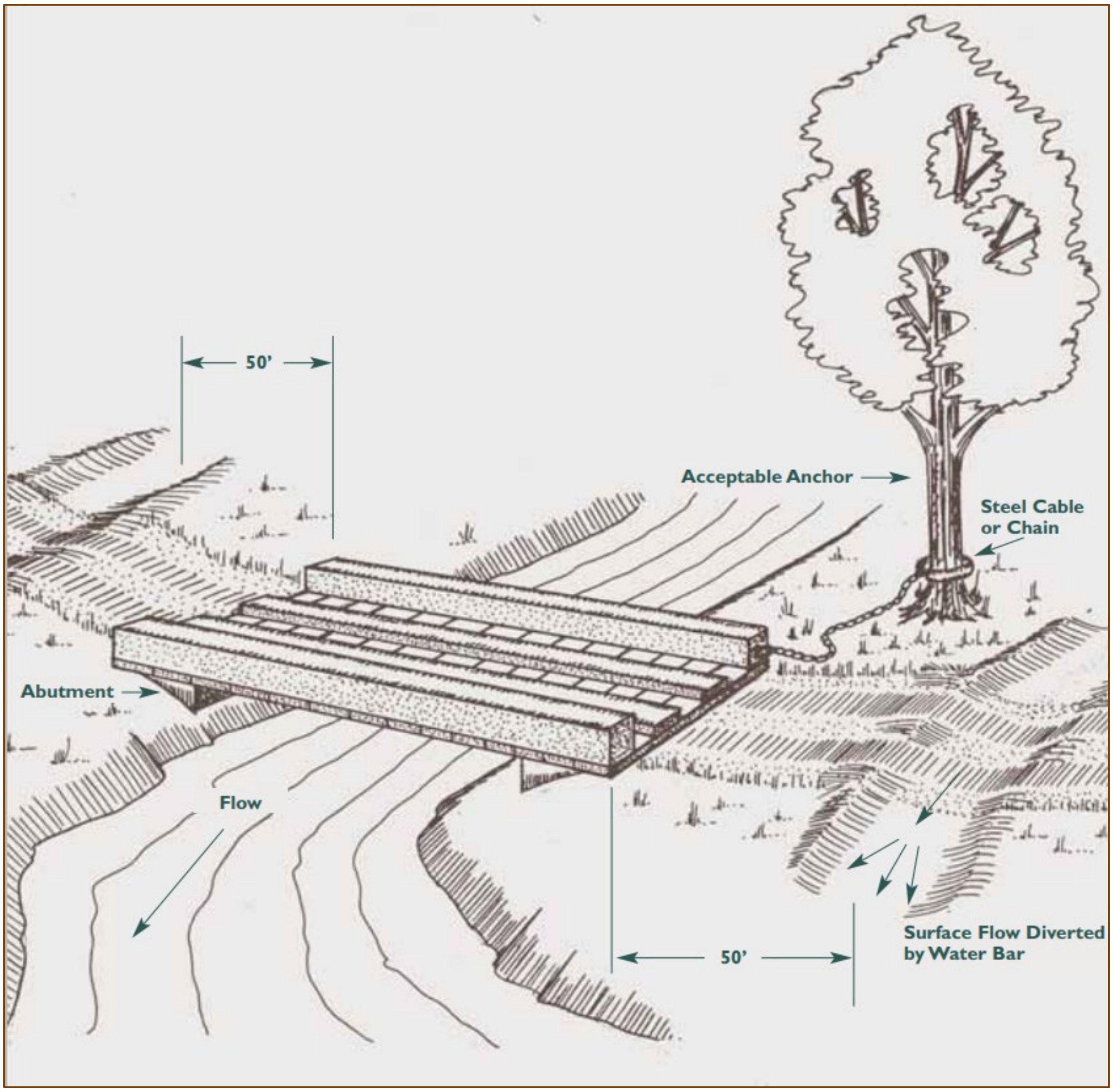
## Installation Requirements

Check weather forecasts to ensure a storm is not predicted during the time of construction. Delay construction until after the threat of rainfall has passed. Construct, use, and disassemble the temporary crossing structure during periods of low flow and frozen ground conditions whenever possible.

Temporary Bridge Crossing (see Figure 5- 46).

1. Keep clearing and excavation of the stream bed and banks to a minimum.
2. Place abutments parallel to and tied into stable banks.
3. Place all decking members perpendicular to the stringers, butted tightly, and securely fastened to the stringers. Butt decking materials tightly to prevent any soil material tracked onto the bridge from falling into the waterway below.
4. If required, secure run planking by fastening to the length of the span. Provide one run plank for each track of the equipment wheels. Run planks are sometimes needed to properly distribute loads.
5. If required, install curbs or fenders along the outer sides of the deck. Curbs or fenders provide additional safety.
6. Anchor bridges securely at only one end using steel cable or chain. Anchoring at only one end will pre- vent channel obstruction if flood waters float the bridge. Acceptable anchors are large trees, large boulders, or driven steel anchors. Anchoring shall be sufficient to prevent the bridge from floating downstream and possibly causing an obstruction to the flow.
7. Install stone for bridge approaches, construct water bars at the beginning of each approach and associated controls (see Water Bar Measure).
8. For bridges that are to remain in place more than 30 days apply measures that protect disturbed soils from erosion. The choice of measure used is in part dependent upon the length of time the crossing will be used.
9. For manufactured bridges follow manufacturer's recommendations.

*Figure 5- 46 Temporary Bridge Crossing*

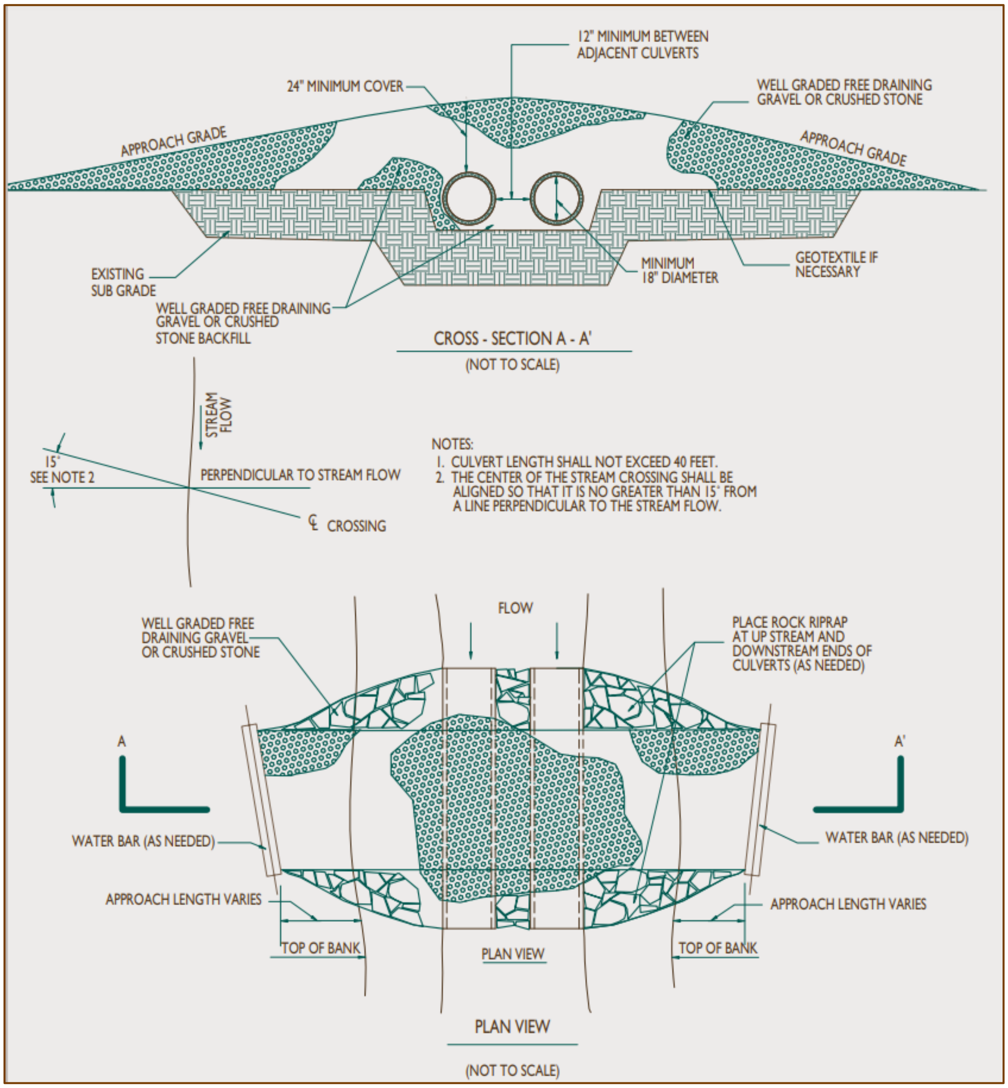



Temporary Culvert Crossing (see Figure 5- 47)

1. Keep clearing and excavation of the stream bed and banks to a minimum.
2. When a geotextile is to be used, place it on the stream bed and stream banks prior to placement of the pipe culvert(s) and fill. Cover the geotextile in the stream bed and extend a minimum of six inches and a maximum of one foot beyond the end of the culvert and bedding material
3. Install the culvert on the natural stream bed.
4. Extend the culvert(s) a minimum of one foot beyond the upstream and downstream toe of the backfill placed around the culvert.

5. Cover the culvert(s) with a minimum of 24 inches of backfill. If multiple culverts are used, separate them by at least 12 inches of compacted fill.

*Figure 5- 47 Temporary Culvert Crossing*




## Maintenance

Inspect and perform any repair work at the end of each day that the temporary stream crossing and approaches are exposed to vehicular traffic. When the crossing is not used for a week or more, inspect at least once a week and within 24 hours of the end of a storm that generates a discharge.[50] Check for washouts at culverts, crossing approaches, and failing associated controls. Immediately repair all damage. Where structural damage or repeated washouts of the

[50] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

temporary stream crossing occur, an engineering review is required to determine the cause of the failures and adjustments made to the structure or erosion and sediment controls as needed to prevent future failures.

When the temporary stream crossing is no longer needed, immediately remove all structures, associated fill materials, and geotextiles keeping in-stream work to a minimum. Upon removal of the structure, immediately shape the stream to its original cross-section, protect the banks from erosion, remove of all construction materials, and apply soil protection measures to unstable soils.

# Diversions

## Planning Considerations

The diversion measures are Temporary Fill Berm, Water Bar, Temporary Diversion, and Permanent Diversion. These measures serve the common function of redirecting and controlling the direction of water flow.

Diversions are used to direct runoff away from or around sensitive construction areas and to fragment drainage areas to reduce the need for a Temporary Sediment Basin.

Diversions are preferable to other types of man-made stormwater conveyance systems because they more closely simulate natural flow patterns and characteristics. Flow velocities are generally kept to a minimum.

The Temporary Fill Berm is a non-engineered measure that is a very temporary berm used at the top of active fill slopes whose drainage area at the point of discharge is less than 3 acres. Its intended use is less than 5 days for any specific fill berm. The use of a berm starts when it is constructed and ends when new fill is placed.  When filling is complete, and it is determined that a diversion is needed at the top of fill to protect the fill until it is stabilized then a Temporary Diversion is needed.

The Water Bar is a non-engineered measure consisting of a channel with a supporting earthen ridge used on access and construction roads to intercept flows in the roadway that have a drainage area less than 1 acre and to force these flows off the roadway. When the drainage area is greater than 1 acre or the diversion is needed for more than 1 year, plan on using a Temporary Stream Crossing, Permanent Diversion and/or Permanent Lined Waterway.

The Temporary Diversion measure is a channel and associated berm used anywhere in and around the construction site where control of water flow is needed. It is limited to 1 year or less for use and a contributing drainage area of 5 acres or less. When the drainage area exceeds 1 acre, an engineered design is required. When the use exceeds 1 year, or the drainage area exceeds 5 acres a Permanent Diversion is used.

The Permanent Diversion is an engineered measure that is used when a permanent installation is needed or when the implementation criteria are exceeded for a Temporary Diversion.

Diversion needs should be identified during the development of the erosion and sediment control plan. When used for keeping clean waters segregated from construction waters, grading and stabilization of diversions should be placed early in the construction sequence before other grading work occurs. For example, a Temporary Fill Berm may need to be replaced with a Temporary Diversion and Temporary Pipe Slope Drains after final grades are reached, to be maintained until the slope is stabilized and then removed.

As with any earthen structure, it is very important to establish adequate vegetation as soon as possible after installation. It is equally important to stabilize the drainage area above the diversion so that sediment will not enter and accumulate in the diversion channel.

All diversions require a stable discharge point. Temporary diversions installed internally to the construction area generally require a sediment barrier or trap at their point of discharge.

Diversions installed around the perimeter may also require such controls if the diversion channel or berm is not stabilized before use. Temporary diversions used to protect unstable slopes may need Temporary Pipe Slope Drains to ensure drainage drainage areas to the diversion remain below the design requirements.

## Temporary Fill Berm

### Definition

A very temporary berm of soil placed at the top of an unprotected fill slope.

### Purpose

To divert runoff from unprotected fill slopes during construction to a stabilized outlet or sediment-trapping facility.

### Applicability

- On active earth fill slopes where the drainage area at the top of fill drains toward the exposed slope and where ongoing fill operations make the use of a Permanent Diversion unfeasible.
- Where the intended use is 5 days or less. For use longer than 5 days, use Temporary Diversion or other measure.
- Where the drainage area at the point of discharge is less than 3 acres.

### Planning Considerations

Good timing is essential to fill construction. The filling operation should be completed as quickly as possible and the permanent slope stabilization measures installed. With prompt and proper construction, the landowner or contractor will save both time and money in building, repairing, and stabilizing the fill area. The longer the time period for construction and stabilization, the more prone the fill will be to being damaged by erosion. Repairing the damage adds additional time and expense to the project. At times, the erosion on these slopes can be difficult to reach with standard equipment.

The temporary fill berm is intended to provide some slope protection on a daily basis until final elevations are reached and a more permanent measure can be constructed. By directing runoff water to a predetermined point of discharge, problems can be reduced at the discharge point and steps taken to minimize potential damage. This measure can also reduce time and money spent repairing slopes by reducing their exposure to rilling during fill slope construction. A stable outlet is critical to the proper function of the temporary fill berm. If the runoff is diverted over the fill itself, the practice will cause erosion by concentrating water at a single point.

Points of discharge must be directed to a sediment impoundment or barrier. Clean off-site water should be diverted around or culverted through the construction site. If a Temporary Pipe Slope Drain is used, the drainage area at the point of discharge can sometimes be kept below 1 acre, which allows for a geotextile silt fence, filter sock, or straw bale barrier as the sediment control.

However, if the drainage area exceeds 1 acre, sediment traps and/or sediment basins must be used.

Once the slope is brought to a final grade, the Temporary Fill Berm may need to be replaced with a Temporary Diversion, and associated water control measures such as Temporary Pipe Slope Drain, or Temporary Lined Chute may be needed until the slope is stabilized.

## Specifications

### Limitations

Use the following criteria for installing the measure:

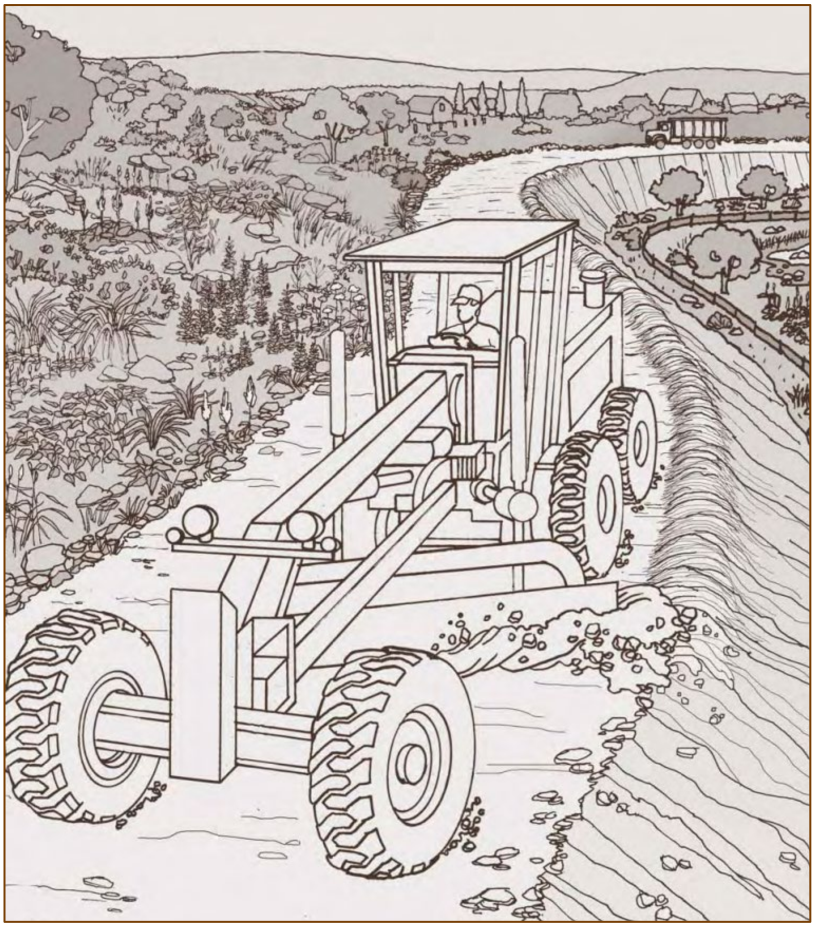
- The drainage area at the point of discharge is 3 acres or less. (Drainage area at the point of discharge can be controlled by using the Temporary Pipe Slope Drain measure.)
- The berm is at least 9 inches high with a base width of at least 3.0 feet.
- The upslope side of the berm slope is no steeper than 3:1, the downslope side of the berm slope is no steeper than 1:1, and the downslope toe of the berm is not closer than 2 feet from the top of the fill slope.
- The flow line controlled by the berm has a positive grade no steeper than 2%.

### Construction

Construct and shape the temporary fill berm following the completion of fill placement on any given day. A grader or dozer with its blade tilted may be run near the top of the fill slope, creating a berm along the top of the fill slope as depicted in Figure TFB-1.

Install erosion controls at the point of discharge as conditions dictate. Associated erosion control measures may include a Temporary Pipe Slope Drain to carry runoff down an unstable slope, and a Geotextile Silt Fence, Filter Sock, Straw Bale Barrier, or Temporary Sediment Trap to filter runoff and detain sediments.

*Figure 5- 48 Illustration of Temporary Fill Berm*



### Maintenance

Inspect the temporary fill berm and associated controls at the end of each workday to ensure the criteria for installing the measure have been met. Determine if repair or modification of the berm and associated measures are needed. Make modification and/or repair as needed.

This measure is temporary and under most situations will be covered the next workday. The maintenance required should be minimal. The contractor should avoid the placement of any material over the structure while it is in use. Construction traffic should not be permitted to cross the temporary fill berm.

## Water Bar

### Definition

A channel with a supporting berm on the downslope side constructed across a construction access road, driveway, log road, or other access way.

### Purpose

- To minimize the concentration of sheet flow across and down sloping roadways and access ways, or similar sloping and unstable areas.

- To shorten the continuous flow length within a sloping right-of-way.

## Applicability

- On construction access road, driveway, log road, or other access way.
- Where the drainage area to each separate water bar is less than 1 acre. For drainage areas greater than 1 acre, use Permanent Diversion measure or Permanent Lined Waterway measure modified to remain stable during vehicular traffic or Temporary Stream Crossing measure.

## Planning Considerations

The construction of utility lines, construction roads, access ways or roadways often requires the clearing of long strips of ground over sloping terrain. The volume and velocity of stormwater runoff tend to increase on these cleared strips of ground, increasing the potential for erosion. To compensate for this loss of vegetation, it is usually a good practice to break up the flow length within the cleared strips so that runoff does not have a chance to concentrate and therefore cause erosion.

At proper intervals, water bars can significantly reduce the amount of erosion which can occur before the area is permanently stabilized. If the slope is composed of highly erodible soils, it may be appropriate to space the water bars closer than stated in the following measure.

Plan to construct the water bar to ensure there is sufficient clearance for the vehicles that will use the access road. Consider the height of the vehicle clearance in relation to the distance between the vehicle axles.

Unless the water bar discharges into a heavily vegetated area of sufficient length to adequately filter runoff, plan to settle or filter runoff water through a Geotextile Silt Fence, Filter Sock, Straw Bale Barrier, or Temporary Sediment Trap. Since many access ways or roadways are constructed through heavily vegetated areas, runoff can often be diverted into a vegetated filter or buffer strip (see Vegetated Filter measure).

## Specifications

### Materials

For access ways or roadways where little or no construction traffic is expected, the water bars may be constructed of earth fill, gravel, or graded stone.

### Height

From the bottom of the channel to the crest of the berm the minimum vertical distance is 9 inches, and the maximum is 18 inches (see Figure 5- 49).

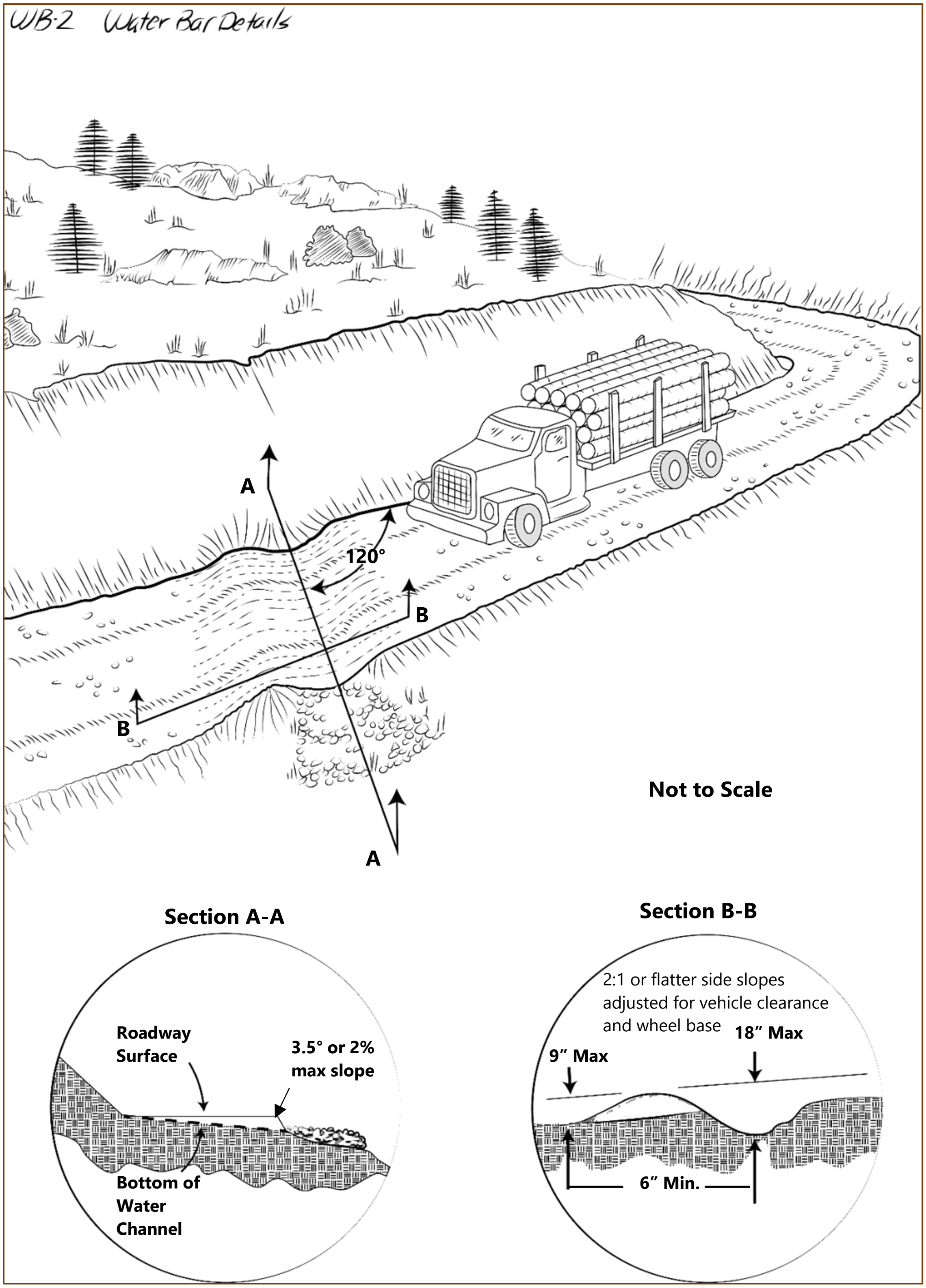
### Side Slopes

Side slopes are 2:1 or flatter. Adjust the side slopes to accommodate vehicle clearance and wheelbase requirements.

### Base

Minimum base width of the berm is 6 feet (see Figure WB-2).

*Figure 5- 49 Water Bar Details*



### Length

Span the water bar completely across the access way or roadway.

### Spacing

Table 5. 21is used to determine the maximum spacing of the water bar.

*Table 5. 21 Spacing of Water Bars*

| % Slope of Access Way or Roadway | Spacing (feet) |
| --- | --- |
| 1 | 400 |
| 2 | 245 |
| 5 | 125 |
| 10 | 78 |
| 15 | 58 |

### Grade

Provide positive drainage with 2% or less slope along the upslope side of the water bar (see Figure 5- 49).

### Outlet

Discharge the water bar to a stabilized outlet, sediment-trapping facility, or a vegetated filter of adequate size.

### Construction

1. Install the water bar as soon as the access way or roadway has been cleared and/or graded.
2. Tamp or compact all earthen berm portions of the water bar.
3. When slopes vary between water bars, space the water bars using the maximum spacing given for the steepest gradient found between the water bars.
4. Adjust the field location of the outlet as needed to utilize a stabilized outlet area, without violating the spacing restrictions.

## Maintenance

For water bars receiving drainage from disturbed areas, inspect and perform any repair work at the end of each day during which the water bar is exposed to vehicular traffic and within 24 hours of the end of a storm that generates a discharge.[51] For water bars receiving drainage from stable areas inspect and perform any repair work at the end of each day that the water bar is exposed to vehicular traffic or annually, whichever comes first. If sediment deposits reach approximately one-half the height of the water bar, remove the accumulated sediments.

When the water bars have served their usefulness, they may be removed.

## Temporary Diversions

### Definition

A temporary channel with a berm of tamped or compacted soil placed in such a manner so as to divert flows.

### Purposes

- To divert sediment-laden runoff from a disturbed area to a sediment-trapping facility such as a temporary sediment trap, sediment basin, or vegetative filter.
- To direct water originating from undisturbed areas away from areas where construction activities are taking place.
- To fragment disturbed areas thereby reducing the velocity and concentration of runoff.

### Applicability

- Where the drainage area at the point of discharge is 5 acres or less. For drainage areas greater than 5 acres, use Permanent Diversion measure.
- Where the intended duration of use is 1 year or less. For durations greater than 1 year, use Permanent Diversion measure.

### Planning Considerations

A temporary diversion is used to divert sheet flow to a stabilized outlet or a sediment-trapping facility. It is also used during the establishment of permanent vegetative cover on sloping disturbed areas. When used at the top of a slope, the structure protects exposed slopes by directing runoff away from the disturbed areas. When used at the base of a disturbed slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

Temporary diversions must be installed as a first step in the land-disturbing activity and must be functional prior to disturbing the land they are intended to protect.

Where channel grades within the temporary diversion exceed 2%, stabilization of the channel is necessary to prevent erosion of the temporary diversion itself (e.g., temporary seeding, temporary erosion control blankets, riprap, etc.). The channel and berm must have a positive grade to ensure drainage, but if the gradient is too great, precautions must be taken to prevent channel erosion due to high-velocity flows behind the berm. The cross- section of the channel

[51] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

should be of a parabolic or trapezoidal shape to prevent high velocity flows which could arise in the bottom of a "V" shaped ditch.

This practice is economical because it uses materials available on the site and can usually be constructed with equipment needed for site grading. The useful life of the practice can be extended by stabilizing the berm with vegetation. Temporary diversions are durable, inexpensive, and require little maintenance when constructed properly. When used in conjunction with a Temporary Sediment Trap, temporary diversions become a logical choice for a control measure when the control limits for silt fences, filter socks, or straw bale barriers have been exceeded.

Temporary diversions are often used as a perimeter control in association with a sediment trap or a sediment basin, or a series of sediment-trapping facilities, on moderate to large construction sites. If installed properly and in the first phase of grading, maintenance costs are very low. Often, cleaning of sediment-trapping facilities is the only associated maintenance requirement.

## Design Criteria

No engineered design is required for a temporary diversion if the contributing drainage area is 1 acre or less.

If the contributing drainage area exceeds 1 acre and is 5 acres or less, design the temporary diversion to the Permanent Diversion measure standards using the 2-year frequency, 24-hour duration storm as the design storm.

## Specifications

For engineered temporary diversions, construct the temporary diversion in accordance with the design standards and specifications. For all non-engineered temporary diversions, comply with the following specifications.

### Height

The minimum height from the bottom of the channel to the top of the berm shall be at least 18 inches and the berm constructed of compacted material.

### Side Slopes and Top Width

Side slopes shall be 3:1 or flatter inside and 1:1 or flatter outside. The top width of the berm shall be 1 foot.

### Grade and Stabilization

The flow line behind the berm shall have a positive grade. Channel grades flatter than 2% require no stabilization. Channels with grades steeper than 2% require stabilization in accordance with stabilization specifications found in the Permanent Diversion measure. Temporary diversions shall be stabilized according to the duration of their intended use (see Short Term Non-Living Soil Protection Functional Group).

### Outlets

Regardless of design, release the diverted runoff to a stable outlet or channel. Where diverted runoff is expected to carry a sediment load, the runoff shall be released to a sediment impoundment (see Sediment Impoundments and Barriers Functional Group).

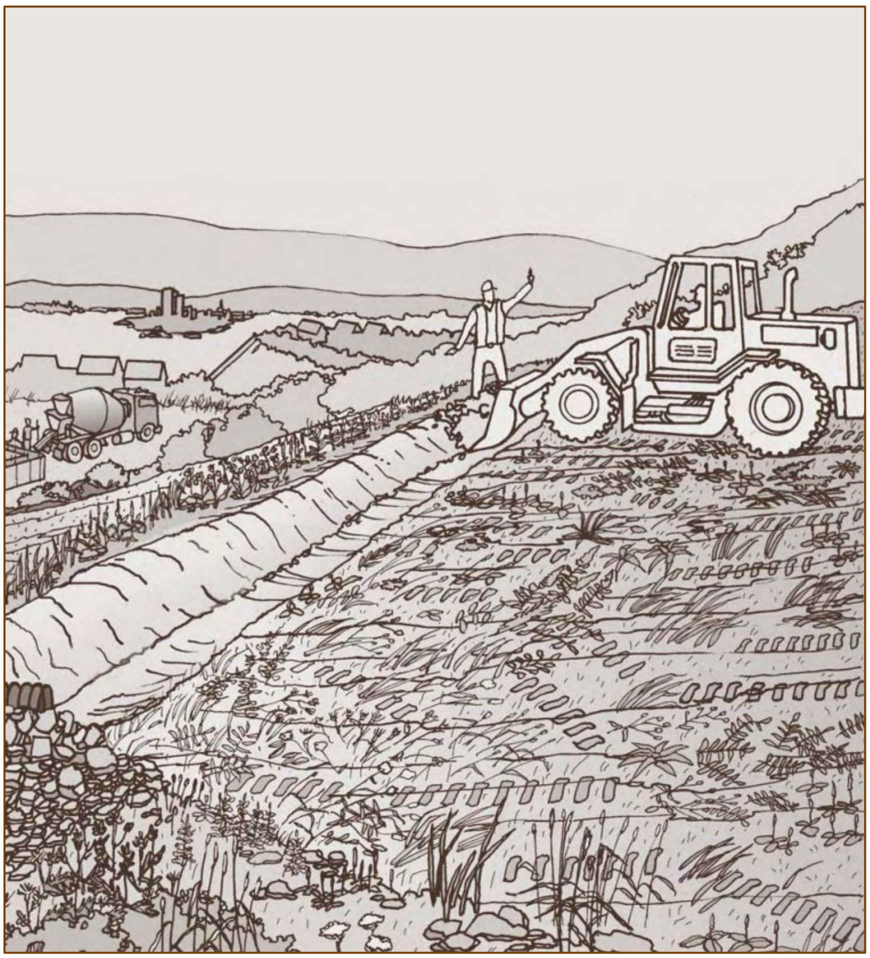
### Construction

Install erosion controls at the outlet where sediment laden runoff is expected.

Construct the temporary diversion (see Figure 5- 50). After grading the berm, tamp or compact it to prevent failure.

Apply stabilization measures (may include temporary or permanent seed and mulch) immediately following construction.

*Figure 5- 50 Requirements for Non-Engineered Temporary Diversions*



## Maintenance

When the temporary diversion is located within close proximity to ongoing construction activities, inspect the temporary diversion at the end of each workday and immediately repair damages caused by construction equipment. Otherwise inspect the temporary diversion and within 24 hours of the end of a storm that generates a discharge[52] to determine maintenance needs.

Repair the temporary diversion and any associated measures within 24 hours of observed failure. Failure of the temporary diversion has occurred when the diversion had been damaged by either construction equipment, erosion, or siltation such that it no longer meets the criteria established under the Specifications section or provided in the engineered design (if any).

When repetitive failures occur at the same location, review conditions and limitation for use and determine if additional measures are needed to reduce failure rates or if alternate measures are indicated to replace the temporary diversion.

## Permanent Diversion

### Definition

A channel constructed across a slope with a supporting earthen ridge on the lower side.

### Purpose

- To increase slope length and reduce erosive velocities.
- To intercept and divert stormwater runoff to a stabilized outlet.
- To protect downgradient areas from erosion and sedimentation.

### Applicability

- Where the contributing watershed is 25 acres or less. For watersheds with a drainage area greater than 25 acres, either use Permanent Lined Waterway or Vegetated Waterway.
- Where the diversion is to be included as an integral part of a permanent water management system.
- Where runoff from areas of higher elevation may damage property, cause erosion, or interfere with the establishment of vegetation on lower areas.
- Where surface and/or shallow subsurface flow is damaging sloping uplands.
- Where the slope length needs to be reduced to control excessive overland flow velocities and minimize soil loss.

### Planning Considerations

Diversions are useful tools for managing surface water flows and preventing soil erosion. On moderately sloping areas, they may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion. They may be placed at the top of cut or fill slopes to keep runoff from upland drainage areas off the slope. They can also be used to protect structures, parking lots, adjacent properties, and other special areas from flooding.

[52] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

When properly coordinated into the landscape design of a site, permanent diversions can be visually pleasing as well as functional (see Figure 5- 52).

The supporting ridge of the permanent diversion may be constructed from soil excavated from the channel if the soil excavated meets the installation requirements for ridge construction. If it is known at the planning stage that the soil will not meet the installation requirements, then plan on importing soil which is adequate to meet the installation requirements.

Should permanent seeding (as opposed to stabilizing with stone) of the top and outside of the ridge be planned for ridge stabilization, then plan on requiring the use of topsoil and seed bed preparation in accordance with the Topsoiling and Permanent Seeding measure.

Maintenance requirements should be planned in accordance with the intended use.

## Design Criteria

Design the permanent diversion according to generally accepted engineering standards ((e.g.,., the USDA-NRCS National Engineering Handbook, Part 650 (Engineering Field Handbook) and the CTDOT Drainage Manual).

### Location

Determine the permanent diversion location by considering outlet conditions, topography, land use, soil type, length of slope, seepage planes (i.e., seepage breakout locations where seepage is expected to be a problem) and the development layout.

### Capacity

Design the minimum capacity to safely carry the peak flow expected from a 10-year frequency, 24-hour duration storm with a freeboard of at least 0.3 feet (see Figure 5- 51).

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots, and comparable high-risk areas, and those designed to function in connection with other stormwater management systems, shall be designed at a minimum to safely carry the peak flow from a 25- year frequency, 24-hour duration storm with a freeboard of at least 0.3 feet.

If a contributing or receiving drainage system is designed to a standard greater than the 10-year frequency storm, then design the permanent diversion to that higher standard. If pre-development flooding problems exist or if the consequences of flooding are severe, then consider increasing the capacity beyond the 10-year frequency storm. If drainage systems which convey larger storms converge with the diversion in question, design the diversion to the same design storm as the contributing drainage system.

### Channel Design

The diversion channel may be parabolic, trapezoidal, or "V" shaped and shall be designed in accordance with the Vegetated Waterway measure or Permanent Lined Waterway measure.

### Ridge Design

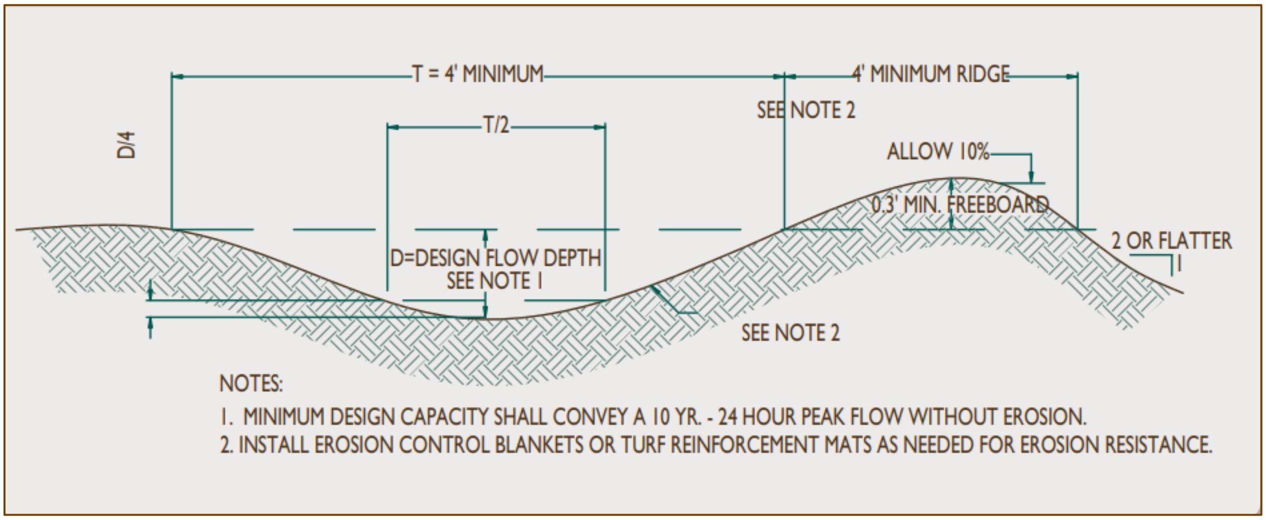
The supporting ridge cross-section shall meet the following criteria (see Figure 5- 51):

1. The side slopes shall be no steeper than 2:1.
2. The width at the design water elevation shall be a minimum of 4 feet.

3. The minimum freeboard shall be 0.3 feet.
4. The design shall include a 10% settlement factor.

Provide for soil stabilization of the top and outside portions of the ridge in accordance with the intended use.

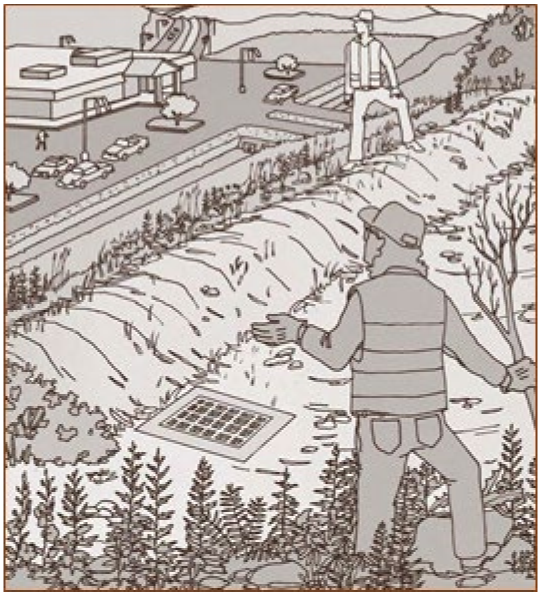
*Figure 5- 51 Permanent Diversion*




### Outlet

Provide the permanent diversion with a stable outlet which will reduce the energy of concentrated discharge so as not to cause downstream erosion.

*Figure 5- 52. Illustration of Permanent Diversion Intercepting Overland Flow*



## Installation Requirements

### Site Preparation

Remove and dispose of all trees, stumps, obstructions, and other objectionable material so as not to interfere with the proper functioning of the diversion.

Excavate or shape the diversion to line, grade, and cross-section as required to meet the criteria specified herein. Ensure the diversion profile is free of irregularities which will impede flow and cause scouring and/or sediment deposition. Place, grade, and compact fill to prevent unequal settlement. Fill shall be composed of soil which is free from excessive organics, debris, large rocks (over 3-inch diameter) or other objectionable materials.

Spread or dispose of all earth removed and not needed in construction.

### Stabilize Diversion

Stabilize the diversion in accordance with the design plans.

#### Install Sediment Controls for Contributing Areas

Install sediment controls to trap sediment before it enters the diversion. Field experience has demonstrated that many newly constructed vegetated channels become damaged from sediment deposition and require costly repairs as a result of improper upslope protection and control measures.

## Maintenance

Inspect the permanent diversion at least once a week and within 24 hours of the end of a storm that generates a discharge[53] during construction of the site and until the diversion is permanently stabilized. For seeded and mulched channels, see Permanent Seeding measure Maintenance Section for initial establishment and first mowing requirements. Check for seed and mulch movement and/or rill erosion. For sodded channels, see Sodding measure Maintenance Section.

Repair damage to vegetated channels immediately. Remove sediment from the channel and make repairs as necessary.

After construction is complete and the diversion is stable, inspect the permanent diversion annually and after each major rainfall for damage and deterioration. Repair damages immediately. Ongoing maintenance should include the removal of accumulated sediment

[53] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

# Subsurface Drain

### Planning Considerations

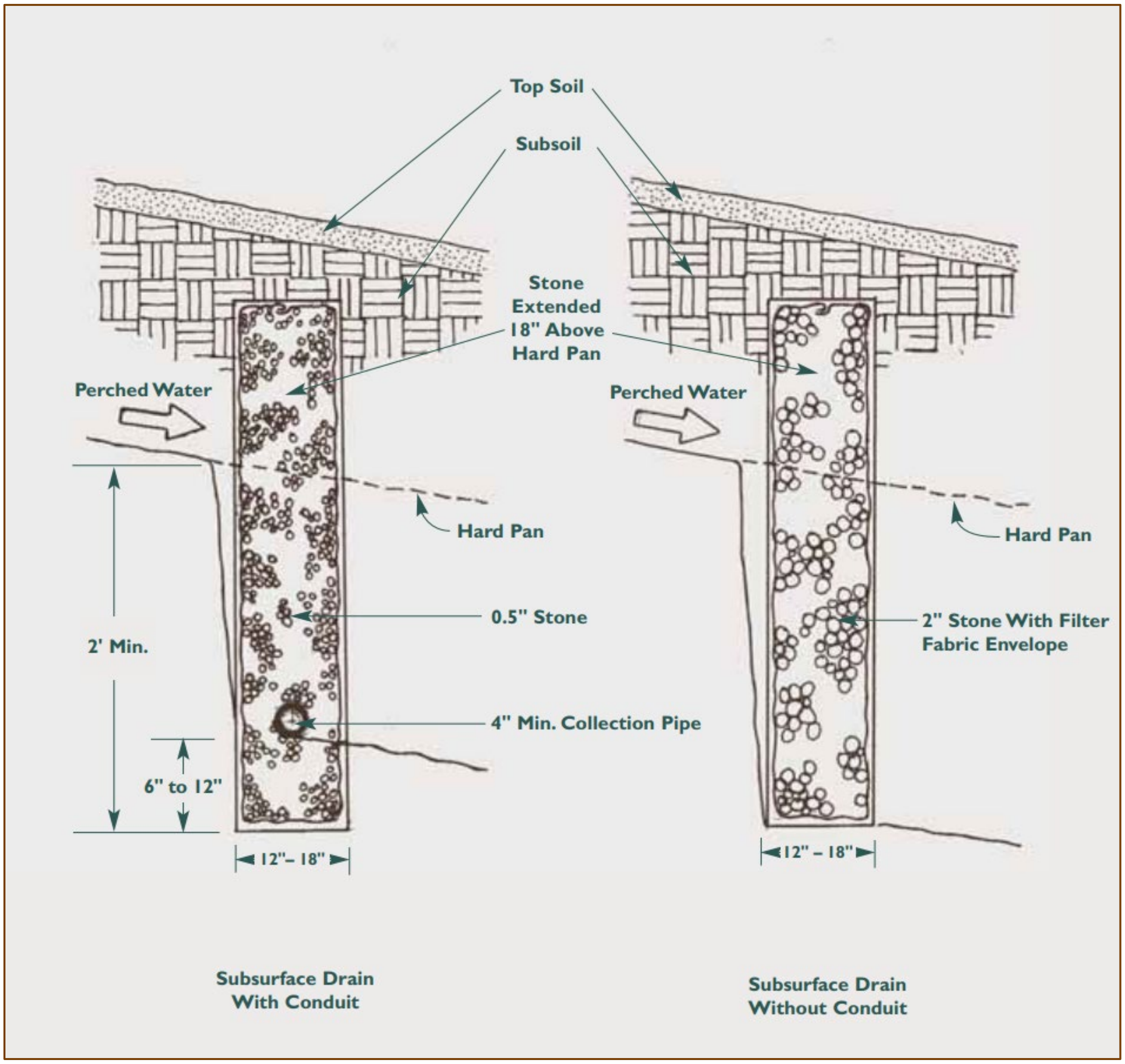
The only measure included in this group is Subsurface Drain. See the measure for planning considerations.

## Subsurface Drain

### Definition

An underground water conveyance system consisting of a perforated conduit, such as pipe, tubing, tile, or a stone-filled trench installed beneath the ground to intercept and convey groundwater (see Figure 5- 53).

*Figure 5- 53 Subsurface Drains With and Without a Conduit*




### Purpose

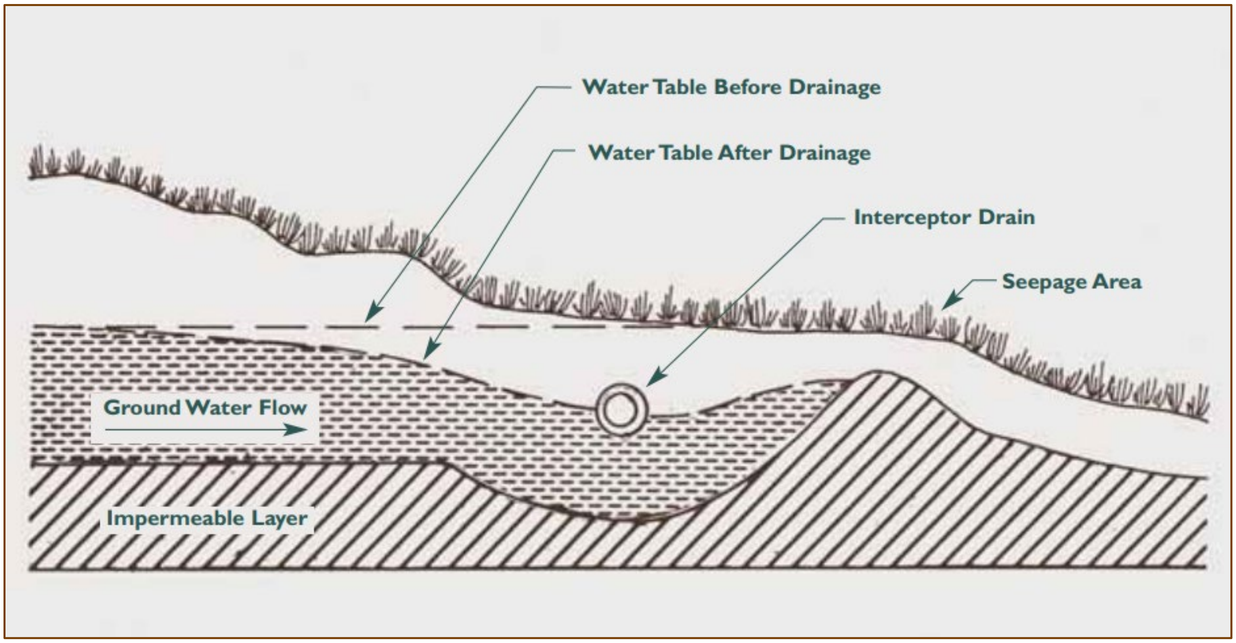
- To prevent sloping soils from becoming excessively wet causing sloughing.
- To improve the bearing capacity of soils.

- To reduce frost heaving of fine-grained soils.
- To prevent hydrostatic pressures from developing behind retaining walls, foundations, or floor slabs and to reduce cracking and heaving of pavement.
- To relieve artesian pressures.
- To lower water tables in vegetated waterways and diversions to maintain stable vegetative conditions.
- To drain stormwater detention areas or structures.

## Planning Considerations

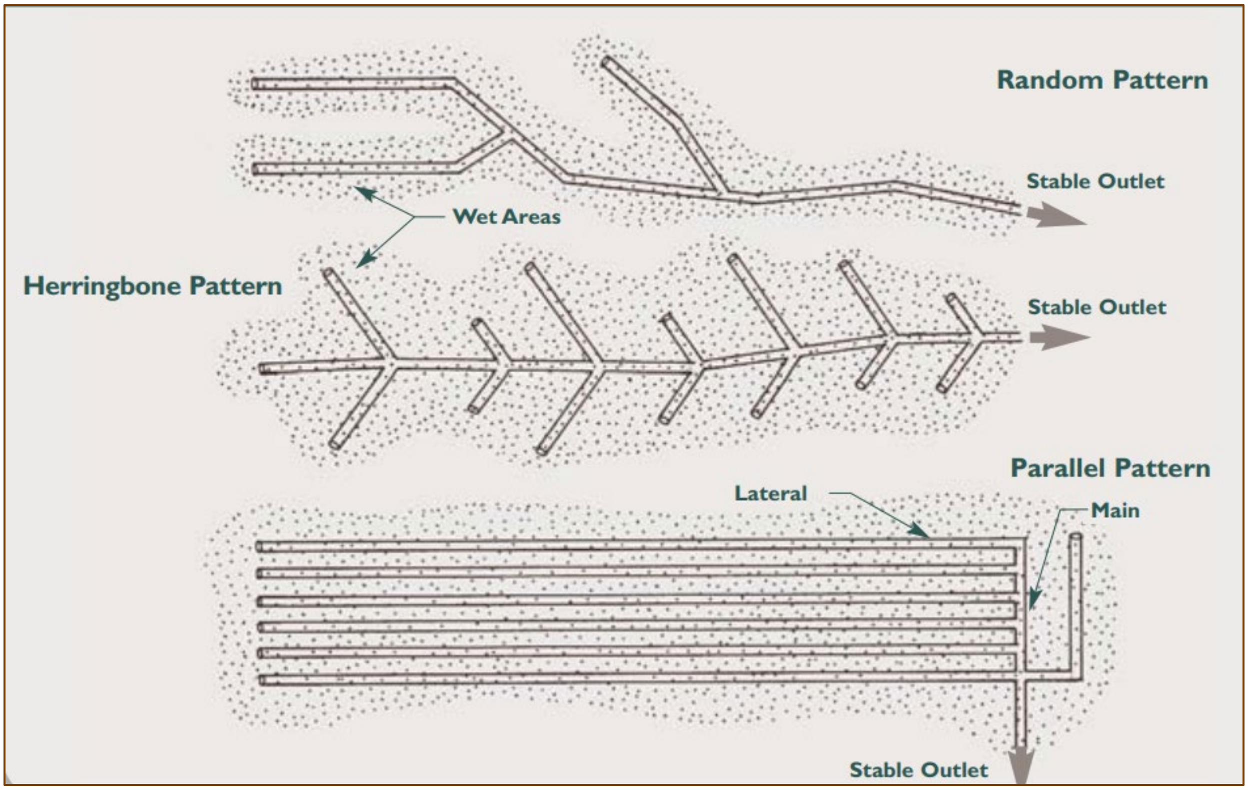
Subsurface drains are generally installed within a slope to lower the water table (see Figure 5-54).

*Figure 5- 54 Effect of Subsurface Drainage on the Water Table*




Subsurface drainage systems are either relief drains or interceptor drains (sometimes called curtain drains) or a combination of both. Relief drains are used either to lower the water table to keep structures (e.g., basements) dry or to improve the growth of vegetation. They are generally installed along a slope, draining in the direction of the slope, and are provided with a stable outlet. They can be installed in a parallel pattern, a herringbone pattern, or a random pattern (see Figure 5- 55).

*Figure 5- 55 Subsurface Drain Layouts*




Interceptors are used to remove water as it seeps down a slope, to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and are provided with a stable outlet.

A lowering of the groundwater table through the installation of a subsurface drain may have legal implications in that it may dewater adjacent wetlands as well as affect the property rights of adjacent owners. Damage may also occur at or near the point of discharge. Also, consolidation of soils and settlement of the soils and the structures they support can occur in some cases.

The design drawings and installation shall comply with applicable federal, state, and local laws and regulations. The landowner or developer is responsible for obtaining required permits. Drains shall comply with septic system setback and setbacks established for known groundwater pollution.

## Design Criteria

The design and installation of subsurface drains shall be based on detailed surveys and investigations. Where failure could cause damage to structures such as roadways, buildings, or utilities a more detailed engineering design may be required than that provided below.

### Capacity

The required capacity for interceptor drains shall be determined by Table 5. 22.

### Size of Drain

If a pipe is used in the drain installation, the minimum size shall be 4” diameter. If a stone filled trench is used without a conduit, the minimum size of the voids in the stone of the drain shall be equivalent to a 4” diameter conduit. The designer should check with the reviewing and approving authorities for differing minimum and maximum sizes of conduit. Manning’s formula may be used to size the drain when the hydraulic grade line is parallel to the bottom grade of the drain (see Equation 5. 4).

*Equation 5. 4 Manning’s Equation*

$$Q = AxV = A\frac{1.49}{n}R^{2/3} \times S^{1/2} \quad \textit{(Manning's Equation)}$$

**Where.**

**Q=** volume of flow

**V =** the average velocity in the channel (ft./sec.)

**n =** Manning’s roughness coefficient, based upon the lining of the channel.

(n=0.011 for PVC pipe, n=0.015 for corrugated plastic pipe, n=0.025 for corrugated metal pipe)

**R =** the hydraulic radius (feet)

**A=** cross sectional area of flow in the pipe

**S =** the slope of the channel (ft/ft)

Simple interceptor drains or random drains may be designed without calculating a discharge “Q”, if the total length of drains does not exceed the maximum lengths in Table 5. 23, provided surface flow or unusually heavy spring flows are not added to the drain. Note: When using design grades flatter than 0.5%, a sand-aggregate envelope and/or a geotextile wrap is recommended around the pipe to prevent migration of fines into the pipe. Use Figure 5- 56, Figure 5- 57, and Figure 5- 58 for determining drainpipe diameters for various tile materials.

### Applicability

- Used in areas having a high-water table where benefits of lowering or controlling groundwater or surface runoff are desired.
- Where soil permeability is sufficient to permit installation of an effective and economically feasible system.
- Not intended for use within septic system setbacks, in areas of groundwater pollution, or to drain inland wetlands or tidal wetlands without prior authorization.

*Table 5. 22 Inflow Rates*

| Soil Texture | Unified Soil Classification[54] | Inflow rate of 1,000 ft. of line in cfs[55] |
|---|---|---|
| Coarse Sand and Gravel | GP, GW, SP, SW | 0.15-1.00 |
| Sandy Loam | SM, SC, GM, GC | 0.07-0.25 |
| Silt Loam | CL, ML | 0.04-0.01 |
| Clay and Clay Loam | CL, CH, MH | 0.02-0.20 |

Source: USDA-NRCS

*Table 5. 23 Design of Random or Interceptor Drains*

| Minimum Grade of Drain (%) | Maximum Length (feet) | |
|---|---|---|
| | 4" Drain | 6" Drain |
| 0.1 | 300' | 800' |
| 0.2 | 400' | 1200' |
| 0.3 | 500' | 1500' |
| 0.4 | 600' | 1700' |
| 0.5 | 700' | 1900' |
| 1.0 | 900' | 2700' |
| 1.5 | 1100' | 3300' |
| 2.0 | 1300' | 3800' |
| 2.5 | 1500' | 4200' |
| 3.0 | 1600' | 4600' |
| 4.0 | 1800' | 5400' |

[54] Obtain Unified Soil Classification from the County Soil Survey or perform laboratory analysis.
[55] Required inflow rates for interceptor lines on sloping land should be increased by 10% for slopes 2% to 5%, 20% for slopes 5% to 12% and 30% for slopes over 12%.

| | | |
|---|---|---|
| 5.0 | 2000' | 5800' |

*Figure 5- 56 Drainage Capacity Chart for Smooth Plastic, Clay, or Concrete Tile (n=0.011)*

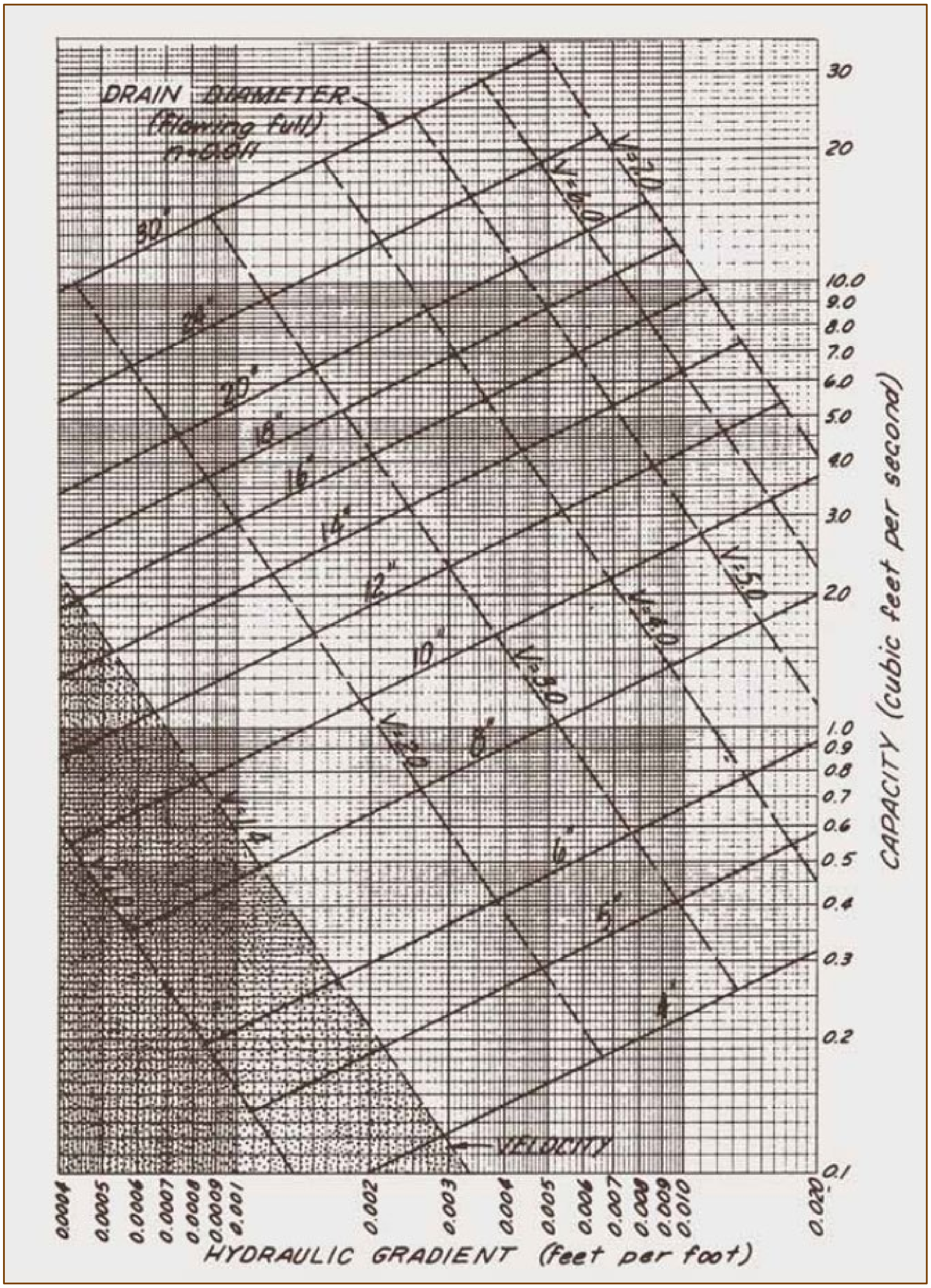


*Figure 5- 57 Drainage Capacity Chart for Corrugated Plastic Pipe (n=0.015)*

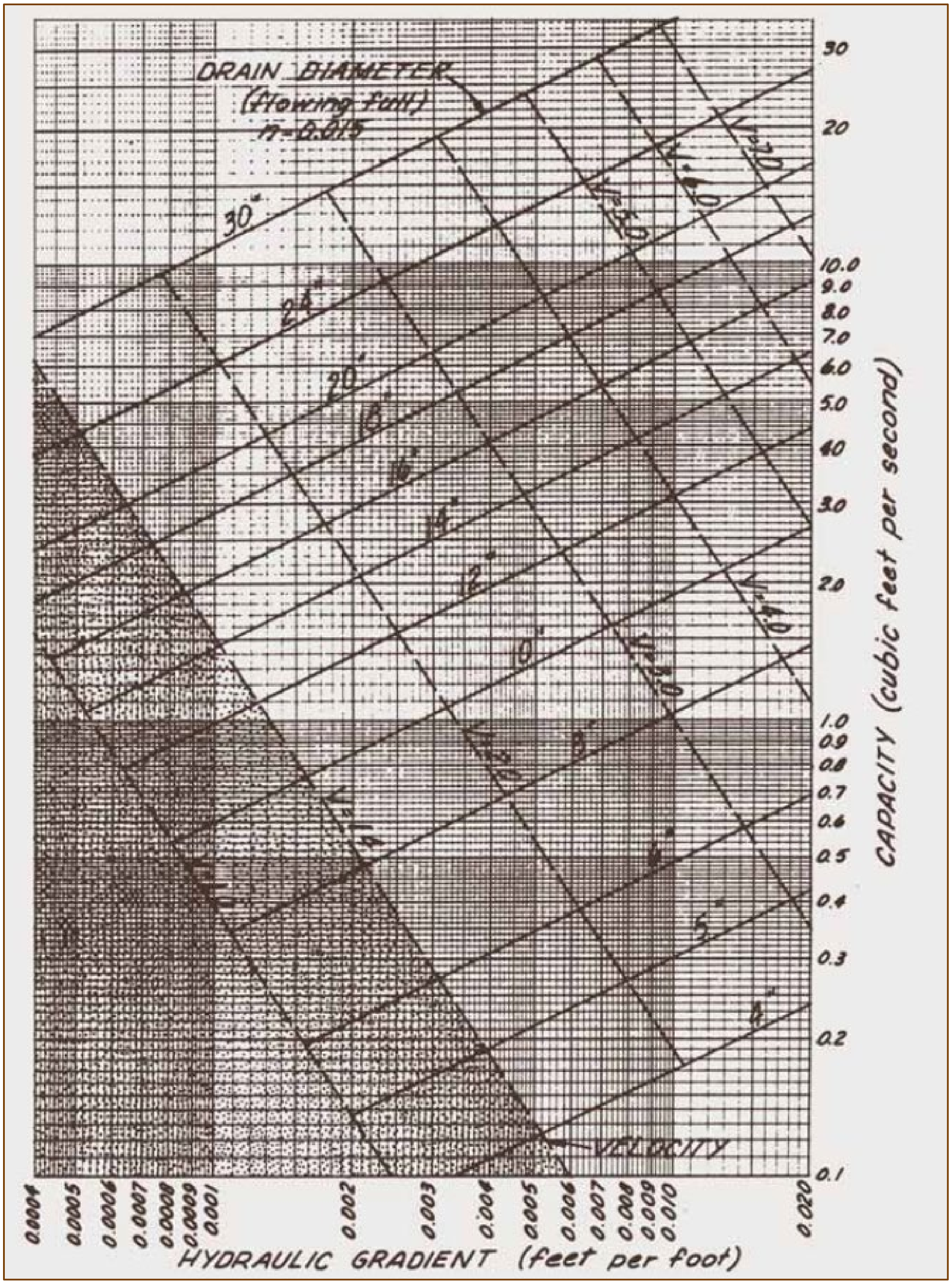
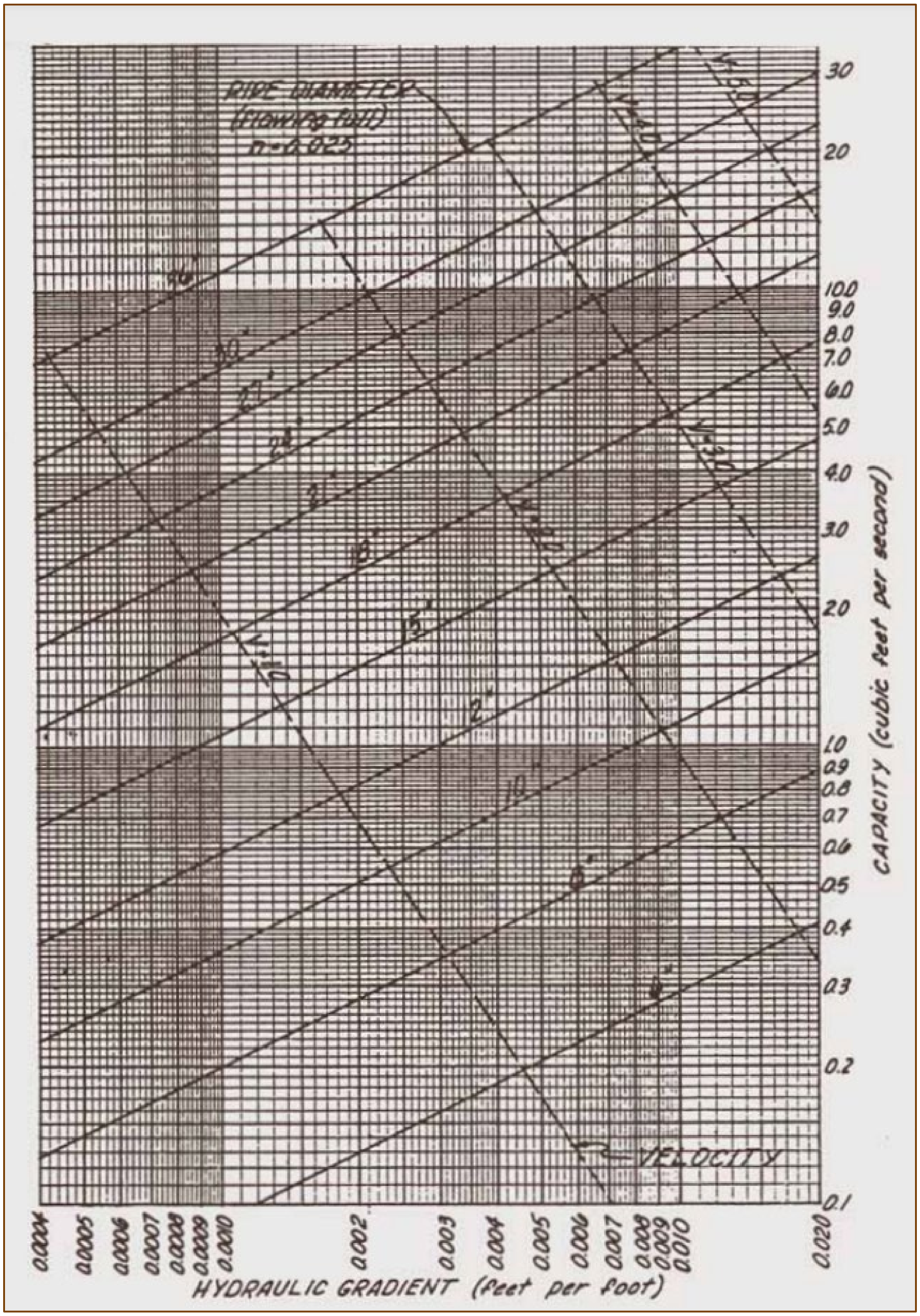


*Figure 5- 58 Drainage Capacity Chart for Corrugated Metal Pipe (n=0.025)*



### Location

Subsurface drains shall not be installed in areas where there is danger of pollutants entering the line. Refer to state health code for minimum distance between subsurface drains and septic drain fields.

Note: Do not install drains where contaminated and/or hazardous soils may exist.

Relief drains: Relief drains should be located through the center of wet areas. They should drain in the same direction as the slope.

Interceptor drains: Interceptor drains should be located on the uphill side of wet areas. They should be installed across the slope and drain to the side of the slope.

### Depth

The minimum depth of cover over conduits shall be 24 inches. This minimum depth shall apply to normal ground levels and may exclude sections of line near the outlet, or sections laid through minor depressions. The minimum depth of cover may be reduced if stronger load resistant pipe is used or if a sleeve is installed around the drain. This may also be used where heavy vehicle crossings are expected. A relief drain will need to be installed deep enough to lower the groundwater surface to the levels desired. An interceptor drain will need to be installed deep enough to intercept and remove the water as intended.

### Spacing

Relief drains – Design relief drains in a uniform pattern having equal spacing between drains at a uniform depth. Spacing between drains is dependent on soil permeability and the depth of the drain. (NAVFAC DM-7.1, Soil Mechanics and geotechnical engineering design guidance can be consulted as a reference.)

Interceptor drains – Interceptor drains may be either singular or multiple. If multiple drains are used, the required spacing is dependent upon the site condition and desired results. The best approach is to install the first drain, then if seepage or high-water table problems occur downslope, install an additional drain an appropriate distance downslope.

### Minimum Velocity and Grade

For systems whose drainage velocity is less than 1.4 feet per second, the design should incorporate filters or sediment clean outs. Relief wells or breather pipes should be installed at abrupt changes in grade to equalize pressures and facilitate clearing of the pipe.

On sites where topographic conditions require that drain lines or the discharge conduits from the drain lines need to be placed on steep grades and the design velocities will be greater than indicated in Table 5. 24, special measures shall be used to protect against soils surrounding the pipe from entering the pipe, thus creating a "piping" failure in the soils around the pipe. The protective measures may include one or more of the following:

1. sealing joints and using a watertight pipe or non-perforated continuous pipe, or
2. enclosing continuous perforated pipe or pipe with geotextile material and/or properly graded sand and gravel.

*Table 5. 24 Maximum Recommended Velocities by Soil Texture Without Piping Protection*

| Soil Texture | Velocity (ft/sec) |
|---|---|
| Sand and Sandy Loam | 3.5 |
| Silt and Silt Loam | 5.0 |
| Silt Clay Loam | 6.0 |
| Clay and Clay Loam | 7.0 |
| Coarse Sand or Gravel | 9.0 |

### Envelopes and Filters

Envelopes shall be used around subsurface drains where required for proper bedding of the conduit, piping protection, or where necessary to improve the flow characteristics of groundwater into the conduit. Filters for drains are used to facilitate passage of water to the drain and to prevent movement of fine particles of silt and sand into the drain. The engineer determines if conditions warrant the designing and installation of a filter. Materials used for envelopes do not always need to meet the gradation requirements of filters, but they shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for bedding of the conduit. Envelopes shall at a minimum consist of sand-gravel materials, all of which shall pass a 1.5-inch sieve, 90% to 100% shall pass a 0.75-inch sieve, and not more than 10% shall pass a No. 60 sieve. The thickness of the envelope shall be at least 4 inches.

A good filter should be well-graded from coarse to fine and within a limited size range of particles. Concrete sand, as specified by the American Association of State Highway Officials (AASHO), has been found to meet the requirements of an adequate filter for most soil conditions encountered. This mate- rial is essentially a mixture of medium and coarse sand with fine and medium gravel, in which the particles are well graded from a minimum size of about 1/6 mm (grains held on a No. 100 sieve) to a maximum of about 9.5 mm. If proposed, locally available gravel should be checked for the gradations as specified in the design. A sand-gravel filter, in addition to its filtering action, provides excellent bedding material for cushioning tile and pipe when laid in the stony soils frequently encountered.

Geotextiles may be used provided opening sizes, strength, durability, and permeability are adequate to provide filtering and capacity requirements throughout the expected life of the system.

Filter material, other than the manufactured types, shall completely encase the pipe with a thickness of at least 4 inches. The trench in which the drain is to be placed shall be a minimum of 12 inches wide and shall be excavated below grade a depth equal to the thickness of filter. The trench shall then be filled to the grade of the pipe with the filter material before laying the pipe. After the pipe is laid, the trench shall be filled with filter material to the required depth. Place filter material over the drain to within 1 foot of the ground surface when interception through heavy soil is desired and found practical. If surface water interception is desired, the filter material shall extend to the finished ground line.

For typical sections of subsurface drains refer to Figure 5- 59, Figure 5- 60, and Figure 5- 61.

*Figure 5- 59 Typical Section of One-Zone Subsurface Drain, Source: USDA-NRCS*

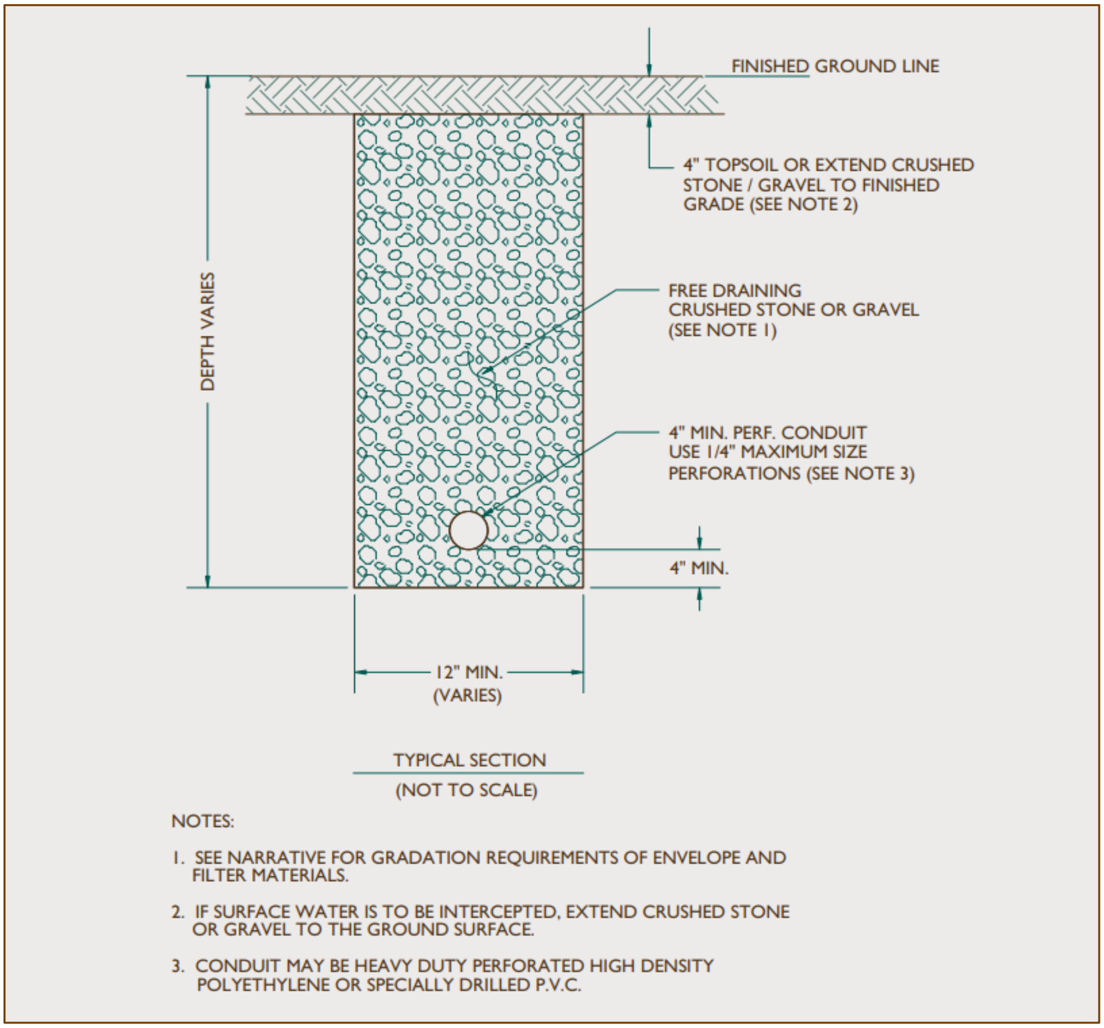


*Figure 5- 60 Typical Section of Two-Zone Subsurface Drain, Source: USDA-NRCS*

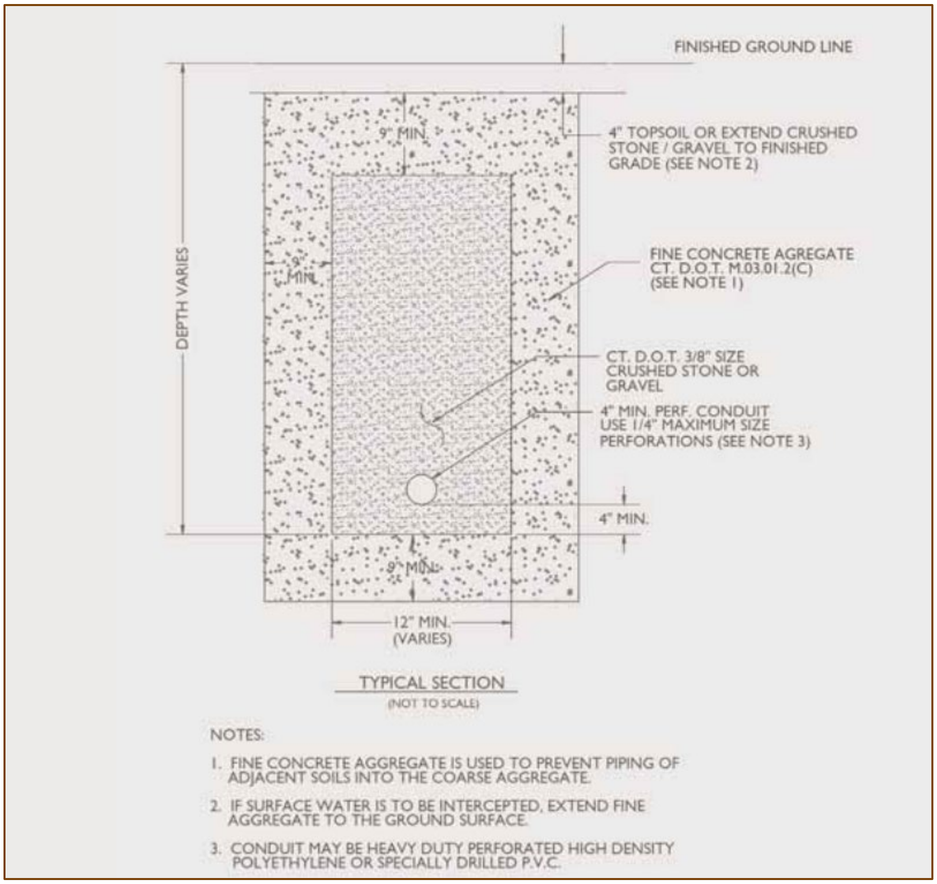
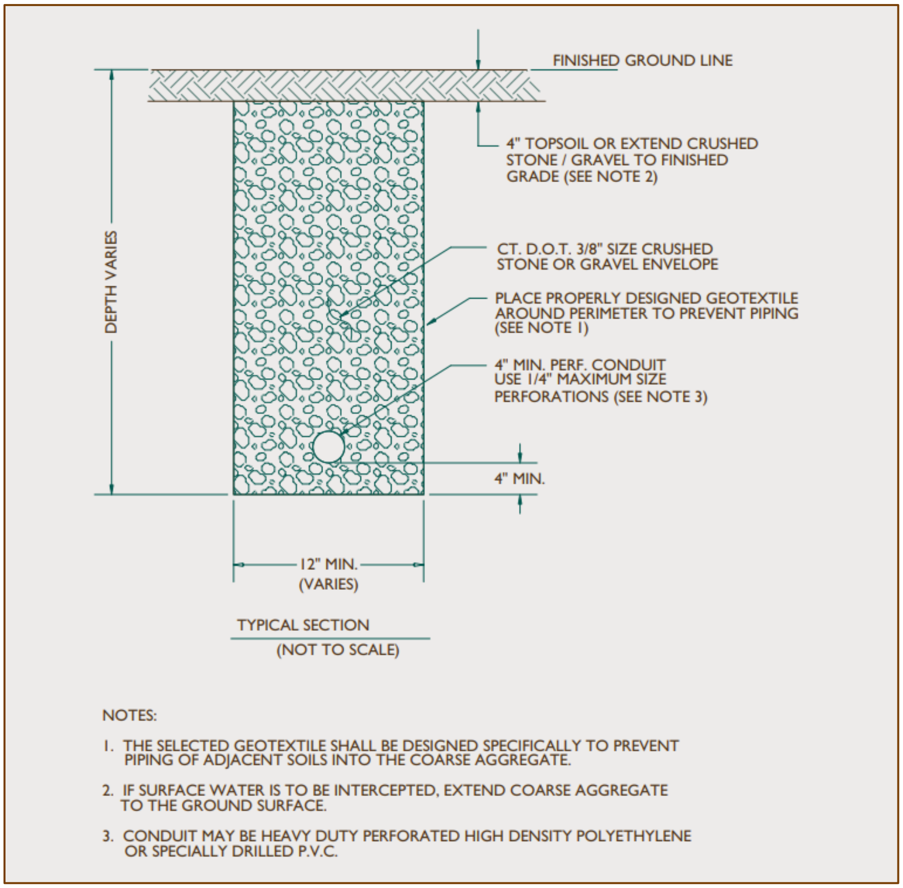


*Figure 5- 61 Subsurface Drain with Geotextile, Source: USDA-NRCS*




### Outlet

An outlet for the drainage system shall be made available, either by gravity flow or by pumping.

The outlet shall be protected against erosion and undermining of the conduit, against damage during adverse weather conditions such as sunlight, submergence, or ice, and against entry of rodents or other animals into the subsurface drain system.

A section of pipe without open joints or perforations shall be used at the outlet end of the drain. The minimum length of outlet pipe shall be 8 feet. Non-perforated corrugated polyethylene drainage piping is not structurally strong enough nor weather resistant for use as the outlet pipe. Only rigid pipe or flexible pipe that can withstand anticipated loading and is resistant to damage from ultraviolet light, fire, weathering, and vandals shall be used.

Exposed PVC outlets shall be protected against damage using headwalls, shading from the sun's rays, or painting with a dark colored latex paint. PVC outlet pipe shall have a minimum wall thickness of 0.24 inch for 4-inch, 0.28 inch for 6 inch, and 0.32 inch for 8 inch. The outlet pipe shall be cantilevered over the outlet ditch at least one foot above the normal elevation of low flow in the outlet channel. At least two-thirds of the pipe length shall be encased in backfill. No envelope material shall be used around the outlet pipe.

If ice or floating debris is a threat, the outlet shall be recessed to protect the cantilevered portion from the current in the ditch.

Headwalls used for draining outlets shall be designed to minimize washouts and undermining.

Animal guards shall have openings that are at a minimum 1.5 inches in both directions, with a maximum opening of 2 inches in one direction. Horizontal bars are preferred. Free swinging animal guards are also an accept- able alternative.

### Prefabricated Curtain Drains

Several types of prefabricated curtain drains exist. Materials shall be selected as appropriate for the specific site conditions in accordance with manufacturer's recommendations.

## Installation Requirements

1. Install perimeter erosion and sediment control measures as required.
2. Construct the trench starting at the outlet end working up the grade continuous with no reverse grades or low spots.
3. Install animal guards on the outlet pipe to prevent animals from entering the drain.
4. Stabilize soft or yielding soils under the drain with gravel or other bedding material.
5. Lay pipe to design grade and install relief wells and breather pipes as designed.
6. Do not use deformed, warped, or otherwise unsuitable pipe.
7. Place envelopes and filter material as specified with at least 4 inches of material on all sides of the pipe.
8. Immediately backfill after placement of the pipe. Hand labor is usually required to prevent crushing the pipe during backfilling operations. No sections of pipe shall remain uncovered overnight or during a rainstorm. Places backfill material in the trench in such a manner that the drainpipe is not displaced or damaged. Do not use backfill containing any stones larger than 2-inch diameter within 2 feet of the pipe.
9. Stabilize all areas disturbed by construction.

## Maintenance

Inspect the outlets to subsurface drains annually to ensure that they are free flowing, not clogged with sediment, and the animal guards are in place. Keep the outlet clean and free of debris. Keep any surface inlets open and free of sediment and other debris. Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain, or remove the trees.

## Subsurface Drain: Design Examples

### Example 1

*A permanent diversion is to be constructed upslope of a house to divert runoff away from the house and to protect the house from surface water flooding. The diversion will outlet into a stone center waterway. The area upslope of the diversion location is in woods and is to remain in woods and will not be disturbed. The diversion will be constructed on Paxton fine sandy loam. The diversion will be seeded with a lawn grass* *mixture. The diversion will be a part of the backyard of the house and is expected to be mowed with the yard. The diversion will have a grade of 1%.*

*The Paxton soil has a fragipan (hard, relatively impervious layer) at a depth of about 2 feet and it is anticipated that a seep line will develop where the back yard is excavated into original ground. To intercept this seepage, perforated corrugated plastic pipe is planned. The pipe will extend the width of the lot (200 feet) plus an additional 200 feet to a suitable outlet.*

Example solution: Determine the size of the piping from Table 5. 23. Using slope = 1%, length 400 feet, is less than 900 feet, select 4″ size pipe.

### Example 2

*This problem is the same situation as above except that a large spring is present near the property line and the beginning of the drain. The flow from this spring is measured to be about 10 gallons per minute. The slope of the land uphill from the drain line is about 4%.*

Example solution: Use Table 5. 22

Soil = fine sandy loam, therefore, use an average inflow rate of 0.16 cfs/1,000 feet. Increase by 10% because of 4% land slope uphill from drain.

Calculate inflow rate:

*Equation 5. 5 Inflow Rate*

Inflow Rate = Average Inflow Rate x Pipe Length (ft) x Increase

1,000 ft = 0.16 cfs x 400 ft x 1.10

1,000 ft = 0.07 cfs

Convert inflow rate from spring 10 gal/min. to cfs.

10 gal x1.0 ft3 x 1.0 min = .022 cfs min 7.44-gal 60 sec

Select pipe size from Figure SD-8 (n= 0.015 for corrugated plastic pipe).

Slope = 1%, discharge = 0.07 cfs. + 0.022 cfs. = 0.092 cfs

Find 4″ corrugated plastic pipe is adequate. Note that velocity in the pipe will be about 1.7 feet per second.

*Source: USDA-NRCS*

# Energy Dissipators

## Planning Considerations

The energy dissipator measures are Level Spreader, Outlet Protection, and Check Dam. These measures serve the common function of dissipating the energy of runoff waters for the specific purpose of reducing erosion potential. Although these measures may be installed for either permanent or temporary use, the design guidance in this section is applicable to temporary installations during construction. Level spreaders, outlet protection, and check dams used for post-construction stormwater management purposes, including as components of post-construction stormwater Best Management Practices (BMPs), should be designed in accordance with guidance contained in the Connecticut Stormwater Quality Manual, as amended.

The Level Spreader measure includes a depression or apron at the outfall of a channel or pipe with a broad stable discharge area used for the purpose of de-energizing and dispersing runoff to stable ground. It is commonly used with measures found in the Diversions Functional Group. When used at the outfall of a conduit, care should be given to ensure that the exit velocities from the measure do not exceed the receiving area's capability to remain stable.

The Outlet Protection measure is also used at the outfall of a channel or culvert but uses structures or riprap to serve the multiple purpose of preventing scour and reducing runoff velocities to the receiving channels or watercourses. If a conduit outlet discharges into a channel (ditch or swale), outlet protection is required. Where a pipe discharges onto a naturally level and vegetated area, an energy dissipator such as a level spreader should be provided (see Figure LS-4 in Level Spreader measure which combines a level spreader with outlet protection).

The Check Dam measure uses a dam constructed of stone or fiber rolls across a drainageway to reduce the potential for channel erosion. Check dams are useful during the establishment of vegetative linings in channels. They can sometimes trap sediment particles by virtue of their ability to pond runoff but are not a substitute for a Temporary Sediment Trap or Temporary Sediment Basin.

# Level Spreader

## Definition

A temporary discharge outlet to disperse or spread runoff as sheet flow over a vegetated area to promote infiltration and to prevent channelization and erosion. Level spreaders consist of a long linear shallow trench or low berm and a broad stable discharge structure constructed at zero grade (i.e., level lip) over which water flows as sheet flow across a stabilized, well-vegetated flat or gently sloped area without causing erosion.

## Purpose

To reduce the depth and velocity of concentrated runoff and release it uniformly as sheet flow onto a stable area.

## Applicability

- Any location where concentrated flows generate velocity and energy than could potentially destabilize existing soils such as storm drain outfalls, culverts, chutes and flumes, and outlets of channels.
- Where other outlet protection measures (e.g., riprap apron) alone is insufficient to prevent erosion resulting from concentrated flows.
- Where there is a need to carry stormwater away from disturbed areas and to avoid stressing erosion control measures.
- Where sediment reduced runoff can be released as sheet flow over a stabilized slope without causing erosion.
- Where the spreader can be constructed on undisturbed soil.
- Where the area below the level spreader lip has a maximum slope of 4% to 6%, is stabilized by vegetation, and is clear of obstacles that may result in concentrated flow..

## Planning Considerations

- The level spreader is a relatively low-cost structure to convert relatively small volumes of concentrated flow to sheet flow across stabilized areas where site conditions are suitable. Concentrated flow may enter the level spreader at a single or multiple points, with appropriate energy dissipation, and leave as uniformly distributed sheet flow. The maximum contributing drainage area for a level spreader should be 2.5 acres for maximum efficiency.
- Level spreaders should be designed in combination with other outlet protection devices just upstream of the level spreader to ensure that velocities entering the level spreader are low enough to avoid short-circuiting.
- Check the proposed location of the level spreader to ensure it can be constructed on level, stable, and undisturbed ground. Any depressions in the outlet lip of the spreader could concentrate flow and result in erosion. Check conditions downslope from the spreader to ensure the runoff water will not reconcentrate after release unless it occurs during interception by another measure located below the level spreader. Sheet flow discharge from the level spreader will typically reconcentrate within 300 feet.
- Level spreaders should not be constructed in newly deposited fill as these areas are most susceptible to erosion. Undisturbed earth is more resistant to erosion than fill.
- Special care should be taken when designing level spreaders on terrace escarpments located in the Connecticut River valley. These areas are very susceptible to erosion by the concentration flows. Consider using alternative methods to discharge runoff through the escarpment area.

## Design Criteria

Criteria provided below are for flows from a 10-year, 24-hour storm that is equal to or less than 20 cubic feet per second (cfs) ($Q_{10} \leq 20$ cfs). For higher flows use other standard engineering practices that will result in a diffuse non-erosive discharge.

### Spreader Dimensions

- Determine the size of the level spreader by estimating the peak flow expected from a 10-year storm (Q10). Calculate the required length of the level spreader so that the flow velocity over the level spreader is equal to or less than the permissible velocity of the soils in the area immediately downgradient of the level spreader (see Table 5. 26).
- As a general rule of thumb, the length of the level spreader should be selected to convey 0.25 cfs per linear foot of spreader[56] during the peak flow of a 10-year, 24-hour storm event. This equates to 4 feet of length for every 1 cfs of flow for the 10-year, 24-hour storm. For example, if the peak flow associated with the 10-year, 24-hour storm event is 5 cfs, the level spreader would need to be 20 feet long. The minimum length for a level spreader shall be 6 feet.
- The depth of the level spreader, as measured from the lip to the bottom of the trench behind the level lip, should be at least 6 inches. The depth may be increased to increase temporary storage capacity, improve trapping of sediment and debris, and to enhance settling of any suspended solids.
- The most commonly used devices for temporary outlet protection at outfalls that discharge into level spreaders are a riprap-lined apron and/or a stilling basin (also referred to as a plunge pool). Temporary riprap-lined aprons and stilling basins should be designed in accordance with the Outlet Protection measure.
- For level spreaders used at outfalls, avoid orienting any outfalls into the spreader in a manner that causes short-circuiting over the top of the spreader. For example, the flows discharging from the outfall to the spreader could short-circuit through the spreader and "skip" over the level weir so that concentrated flow is still discharged. This is more common when level spreaders are oriented perpendicular to the outfall. An alternative approach with less risk of short-circuiting is if the level spreader is oriented parallel with the outfall. Use of a stone stilling basin between the outfall and spreader can mitigate the potential for water to short-circuit across the level spreader. The stilling basin reduces flow velocity and energy to a point that allows water to be redistributed across the spreader.
- For level spreaders used at the discharge end of a channel, the grade of the channel for the last 20 feet of the channel entering the level spreader shall be no steeper than 1% to

[56] Reference: Maine Erosion and Sediment Control BMPs (10/2016); 0.25 cfs per linear foot of spreader corresponds to a depth of approximately 1 inch flowing over the lip of the level spreader at a velocity of 3 feet per second (i.e., silt loam soil).

ensure a low approach velocity, unless a stilling basin is used to slow velocities and dissipate energy.

### Spreader Lip

- Flow Flow should be uniformly distributed and crest over the lip of the spreader along its entire length. The downgradient edge over which flow is distributed must be level. Small variations in height (of more than 0.25 inch) will result in concentrated flow and erosion.
- The level lip of the spreader shall be of uniform height and at the same elevation (i.e., zero grade) over the length of the spreader, with its discharge to an undisturbed well-vegetated area having a maximum slope of 4% without temporary erosion control blanket and 6% with temporary erosion control blanket. Slopes shall be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.
- The level spreader lip may be constructed of stabilized grass for low flows (0-4 cfs) or a rigid non-erodible material for higher flows (5-20 cfs) (see Table 5. 25). A grass level lip shall be constructed with a temporary erosion control blanket to inhibit erosion and allow vegetation to become established. For higher design flows (5 cfs and greater), a rigid lip of non-erodible material, such as concrete, concrete curbing, pressure-treated wood timbers, or 6 to 12 inches of crushed stone shall be used.

*Table 5. 25 Discharge Limitation*

| Spreader Lip | Design Flow (cfs) |
|---|---|
| Vegetated (grass with temporary erosion control blanket) | 0-4 |
| Rigid (concrete, concrete curbing, pressure-treated wood timbers, crushed stone) | 5-20 |

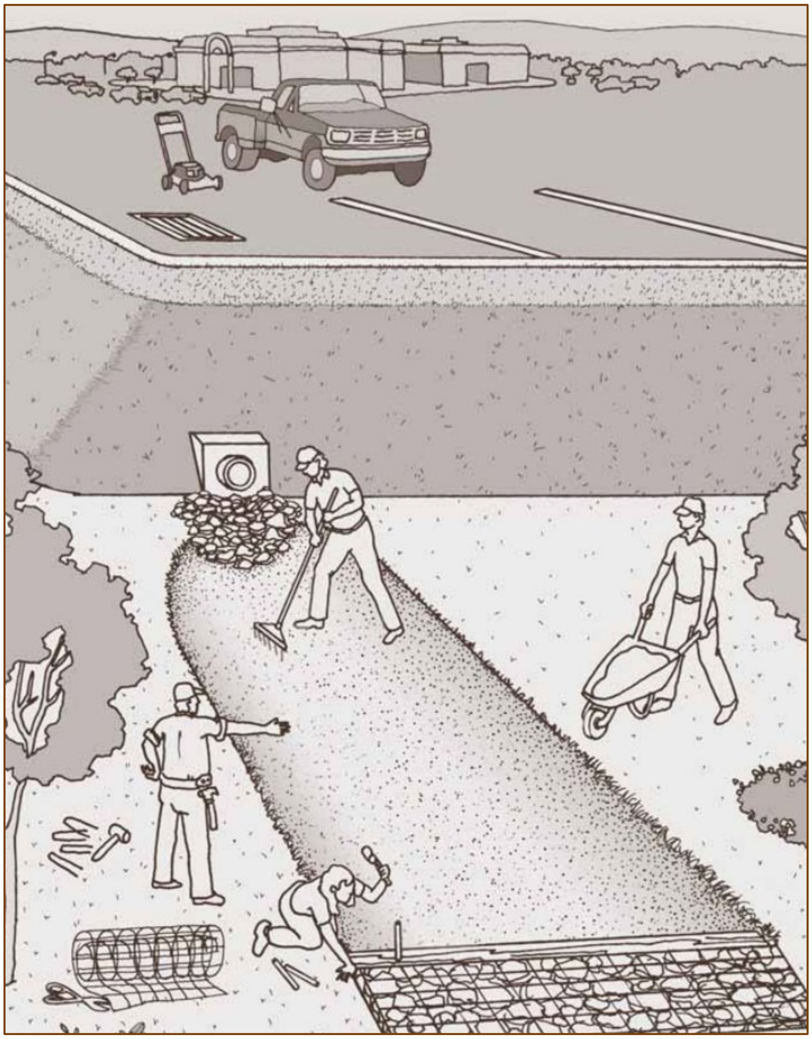
### Installation Requirements (see Figure 5- 62)

1. Construct the level spreader on undisturbed soil (not fill material).
2. Shape the entrance to the spreader in such a manner as to ensure that runoff enters and is conveyed over the level spreader.
3. Construct the level lip at 0.0% slope to ensure uniform spreading of stormwater flow.
4. The protective covering for a vegetated lip shall be a minimum of 4 feet wide extending 6 inches over the lip and buried 6 inches deep in a vertical trench on the lower edge. Butt the upper edge smoothly cut sod, and securely hold in place with closely spaced heavy duty wire staples.
5. Entrench the rigid level lip at least 2 inches below existing ground and securely anchor to prevent displacement. Place an apron of CTDOT #3 stone or modified

riprap at the top of the level lip and extended down slope at least 3 feet. Place geotextile under the stone. Galvanized mesh may be used to hold stone securely in place.

6. Stabilize the disturbed area around the spreader immediately after its construction (see Permanent Seed, Mulch for Seed and/or Stone Slope Protection measures).

*Figure 5- 62 Illustration of a Level Spreader with a Rigid Lip*



## Maintenance

- During construction activity, inspect level spreaders at least once a week and within 24 hours of the end of a storm that generates a discharge[57] to determine maintenance needs

[57] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

- Maintain the level spreader lip at 0.0% slope to allow for proper functioning of the measure. Avoid the placement of any material on and prevent construction traffic across the structure. If the measure is damaged by construction traffic, repair it immediately.

## Outlet Protection

### Definition

Structurally lined aprons or other acceptable energy dissipating devices placed between the outlets of pipes or paved channel sections and a stable downstream channel.

### Purpose

To prevent scour at storm drain, culvert, or drainageway outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

### Applicability

At the outfall of storm drain outlets, road culverts, paved channel outlets, new channels constructed as outlets for culverts and conduits, etc. discharging into natural or constructed channels, which in turn discharge into existing streams or drainage systems.

### Planning Considerations

Analysis and appropriate treatment shall be done along the entire length of the flow path from the end of the conduit, channel, or structure to the point of entry into an existing stream or drainage system. Where flow is excessive for the economical use of an apron, excavated stilling basins may be used.

### Design Criteria

#### Determination of Needs

The need for conduit outlet protection shall be determined by comparing the allowable velocity which the soil will withstand to the exit velocity of the flow from the conduit. The allowable velocity for water over the soil shall be that given in Table 5. 26. The exit velocity of the water in the conduit shall be calculated using the greater of the conduit design storm or the 25-year, 24-hour storm. When the exit velocity of the water in the conduit exceeds the allowable velocity for the soil, outlet protection is required.

*Table 5. 26 Allowable Velocities for Various Soil Textures*

| Soil Texture | Allowable Velocity (ft./sec.) |
|---|---|
| **Sand and sandy loam** | 2.5 |
| **Silt Loam** | 3.0 |
| **Sandy clay loam** | 3.5 |
| **Clay loam** | 4.0 |
| **Clay, fine gravel, graded loam to gravel** | 5.0 |
| **Cobbles** | 5.5 |
| **Shale** | 6.0 |

### Riprap Aprons (Figure 5- 63 and Figure 5- 64)

**Design Limitations:** No bends or curves at the intersection of the conduit and the apron protection will be permitted. There shall be no vertical drop from the end of the pipe to the apron or from the end of the apron to the receiving channel.

**Apron Dimensions:** If an apron is used for energy dissipation, the following criteria apply[58]:

1. The length of the apron, La, shall be determined from the formula:

*Equation 5. 6 Apron Length*

$$L_a = \frac{1.7Q}{D_0^{3/2}} + 8D_0$$

**where:**

**Do** is the maximum inside pipe width in feet, and

[58] Note these are recommendations for temporary installation, for permanent installations we recommend following the CT DOT Drainage Manual.

**Q** is the pipe discharge in cubic feet per second (cfs) for the conduit design storm or the 25-year storm, whichever is greater.

2. The width of the apron, W, shall be determined as follows:
   - Where there is a well-defined channel downstream of the apron, the bottom width of the apron shall be at least equal to the bottom width of the channel. The structural lining shall extend at least one foot above the tailwater elevation but no lower than two-thirds of the vertical conduit dimension above the conduit invert.
   - Where there is no well-defined channel immediately downstream of the apron, the width, W, of the outlet end of the apron shall be as follows:

For tailwater elevation greater than or equal to the elevation of the center of the pipe,

$$W = 3\,D_o + 0.4\,L_a$$

For tailwater elevation less than the elevation of the center of the pipe,

$$W = 3\,D_o + L_a$$

where:

La is the length of the apron determined from the length formula and Do is the culvert width.

The width of the apron at the pipe outlet shall be at least three times the pipe width.

3. The side slopes shall be 2:1 or flatter.
4. The bottom grade shall be 0.0% (level).
5. There shall be no vertical drop at the end of the apron or at the end of the pipe.

*Figure 5- 63 Outlet Protection Utilizing Riprap Apron*

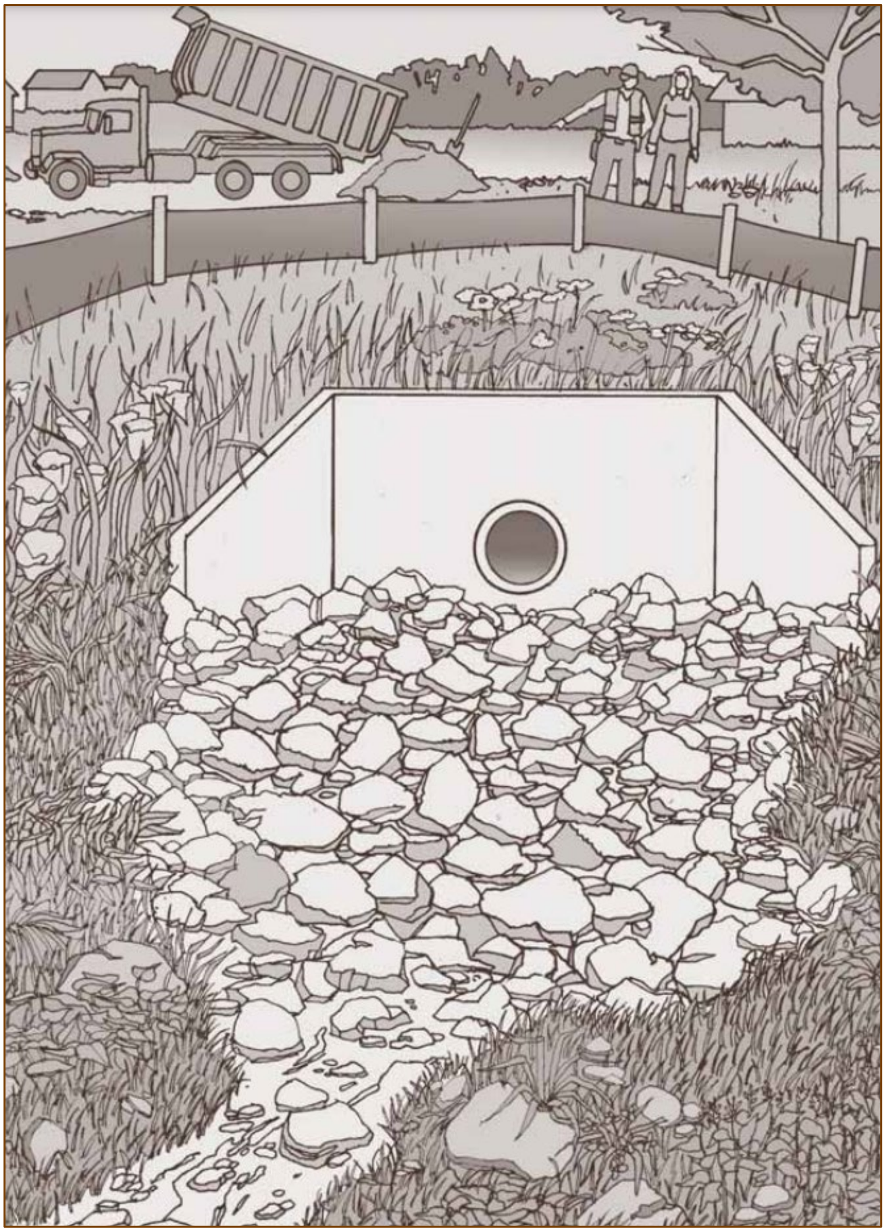
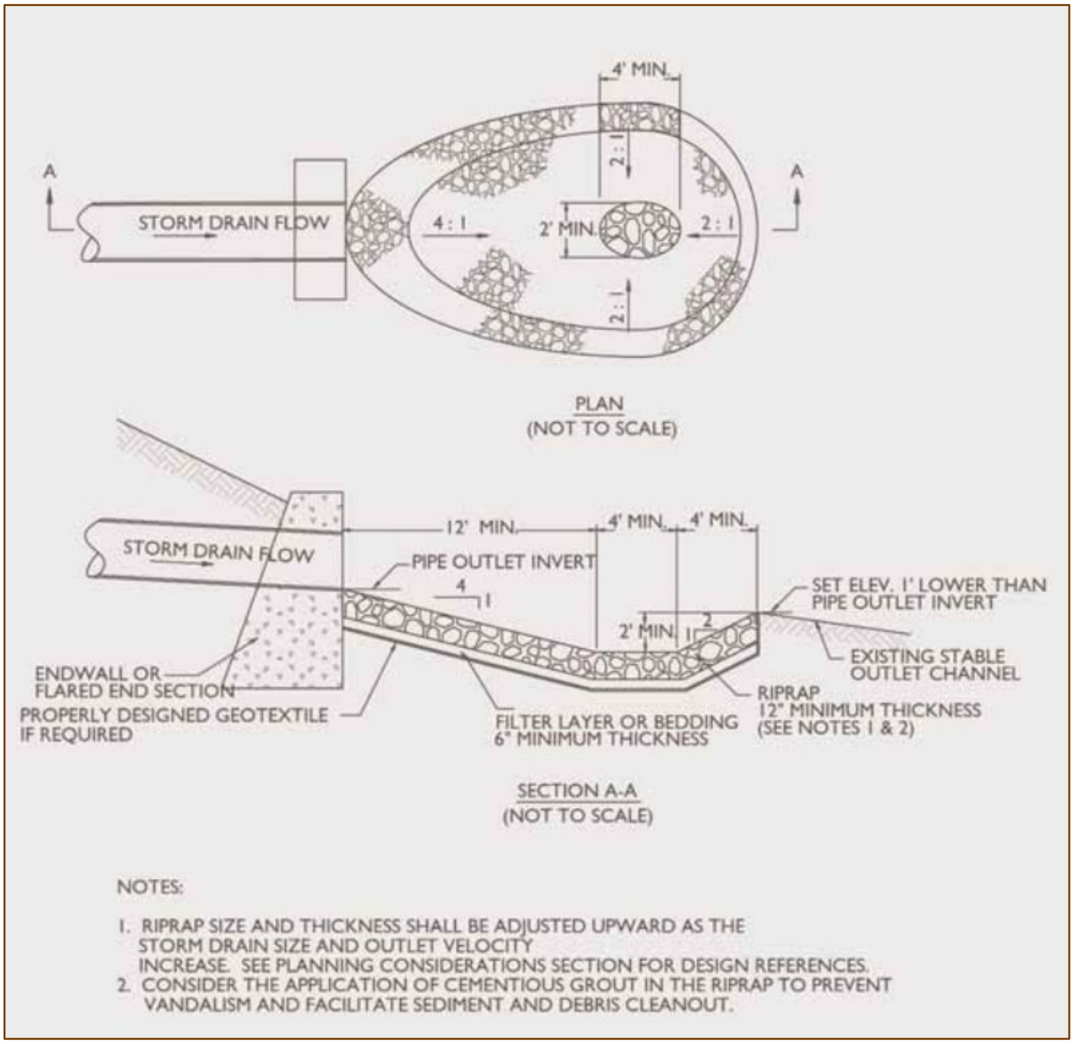


*Figure 5- 64 Configuration of Outlet Protection using a Riprap Stilling Basin*




### Stilling Basin (See Figure 5- 64)

An excavated riprap stilling basin (also referred to as a plunge pool) may also be used as outlet protection. Figure 5- 64 shows a common configuration of a riprap stilling basin used for outlet protection. Acceptable guidance for the design of stilling basins may be found in the following sources:

- Hydraulic Design of Energy Dissipators for Culverts and Channels, Hydraulic Engineering Circular No. 14, U.S. Department of Transportation, Federal Highway Administration
- Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, U.S. Department of the Interior, Bureau of Reclamation
- Scour at Cantilevered Pipe Outlets – Plunge Pool Energy Dissipator Design Criteria, Agricultural Service Research Publication ARS-76
- Plunge Pool Design at Submerged Pipe Spillway Outlets, American Society of Agricultural Engineers, Volume 37(4):1167-1173, 1994.

### Riprap Requirements

1. The median stone diameter, $d_{50}$ in feet is determined using the formula for $d_{50}$ found in the Outlet Protection Design Example Problem where

   Q and Do are as defined under apron dimensions and

   TW is tailwater depth above the invert of the culvert in feet.

2. At least 50% by weight of the riprap mixture shall be larger than the median size stone designated as $d_{50}$. The largest stone size in the mixture shall be 1.5 times the $d_{50}$ size. The riprap shall be reasonably well graded.
3. The riprap and filter layer or bedding shall meet the requirements of the Riprap measure.
4. Gabions or precast cellular blocks may be substituted for riprap if the $d_{50}$ size calculated above is less than or equal to the thickness of the gabions or concrete revetment blocks.

*See Example Design Problem on for Outlet Protection*

### Installation Requirements

- Place outlet protection either on native soils or well compacted fill.
- Place designed filter blanket under rock outlet protection. Rock shall be placed in a manner that does not damage the filter blanket.
- Avoid disturbance to the area immediately downstream of the outlet protection.

### Maintenance

Once a riprap outlet has been installed, the maintenance needs are very low. It should be inspected after high flows for evidence of scour beneath the riprap or for dislodged stones. Repairs should be made immediately.

### *Outlet Protection Design Example Problem*

*Given: $D_o$ = 1.5 ft, Q = 14.5 cfs, TW = 0.7 ft.*

*Find: $L_a$, W, d50*

*Solution:*

For $L_a$ (apron length):

$$L_a = \frac{1.7Q}{D_0^{3/2}} + 8D_0 = \frac{1.7 \times 14.5cfs}{1.5^{3/2}} + 8 \times 1.5ft = 25.4$$

*For W (apron width):*

$$W = 3D_o + L_a = 3(1.5) + 29.9 \text{ ft}$$

*For $d_{50}$ (median stone diameter):*

$$d_{50} = \left(\frac{0.02}{TW}\right) \times \left(\frac{Q}{D_o}\right)^{4/3} = \left(\frac{0.02}{0.70}\right) \times \left(\frac{14.5}{1.5}\right)^{4/3} = 0.58\text{ft}$$

## Check Dam

### Definition

A small temporary dam placed across a drainageway. Check dams can be constructed of stone or fiber rolls. Fiber rolls are coconut fiber (coir logs), straw, or excelsior woven roll (wood excelsior fibers) encased in netting of jute, nylon, or burlap. Temporary check dams can be constructed using other materials and products, although these are not addressed in this section.

### Purpose

- To reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the drainageway.
- To temporarily pond stormwater runoff to allow sediments to settle out.
- To trap small amounts of sediment generated in the drainageway.

### Applicability

- Where concentrated flows are expected to cause erosion or where longitudinal channel slope is greater than 6%.
- For temporary drainageways which, because of their short length of service, will not receive a non-erodible lining but still need protection to reduce erosion.
- For temporary or permanent drainageways which need protection prior to stabilization.
- Permanent ditches or swales that will receive significant sediment loads during construction.

### Limitations

- This measure is not a sediment trapping measure and is not a substitute for a Temporary Sediment Trap or a Temporary Sediment Basin. However, check dams may be used in conjunction with those measures.
- Only stone check dams should be considered for permanent applications.
- This measure is limited to use in small open channels.
- This measure should not be installed in natural streams or watercourses.

### Planning Considerations

A check dam is considered to be temporary if it is used less than 1 year. It is considered to be permanent if it is used more than 1 year. Its length of use and the size of the watershed determine if an engineered design is required (see Table 5. 1).

When planning the location of the check dam(s) consider the tailwater effects, duration of ponding, stone size (for stone check dams), and the contributing watershed. Also assess if the final use of the area will require the check dam(s) to be removed. Give consideration to mowing requirements and aesthetics.

Check dams should never be placed in wetlands or natural waterways unless specifically permitted by a regulatory agency.

*Table 5. 27 Check Dam Design Requirements*

| Design Requirements | Drainage Area | Length of Use |
|---|---|---|
| no engineered design | 0-2 acres | <6 months |
| 2-yr, 24-hour storm | 1-2 acres | >6 months, <1 year |
| 2-yr, 24-hour storm | >2 acres | >6 months, <1 year |
| 25-yr, 24-hour storm | any drainage size | >1 year |

## Design Criteria

### Small or Temporary Check Dams (Non-Engineered)

No engineered design is required for a check dam if the contributing drainage area is 2 acres or less and its intended use is shorter than 6 months. However, the following criteria apply when specifying check dams

- The drainage area of the ditch or swale being protected should not exceed 2 acres.
- The maximum height of the check dam should be 2 feet.
- The center of the check dam should be at least 6 inches lower than the outer edges.
- The maximum spacing between the dams should be such that the toe at the upstream dam is at the same elevation as the top of the downstream dam.

### Larger or More Permanent Check Dams (Engineered)

- If the contributing drainage area is greater than 2 acres or its intended use is longer than 6 months, design the check dam according to generally accepted engineering standards (e.g., the USDA-NRCS National Engineering Handbook, Part 650 (Engineering Field Handbook); CTDOT Drainage Manual).
- For use of a check dam less than 1 year, design the check dam to safely pass the peak flow expected from a 2-year, 24-hour storm without structural failure and adverse tailwater effects.

- For use of a check dam exceeding 1 year, design the check dam to safely pass the peak flow expected from a 25-year, 24-hour storm without structural failure of the check dam and adverse tailwater effects.
- Stone: Shall meet the requirements of CTDOT Standard Specifications Section M.01.01, #3 aggregate. Stone shall be appropriately sized to manage the design storm flow without failure. The stone shall be sound, tough, durable, angular, not subject to disintegration on exposure to water or weathering, be chemically stable, and shall be suitable in all other respects for the purpose intended. Larger stone can be used on the outside surface of the check dam in order to stabilize it during larger flows.
- Fiber Rolls: Shall be specified and installed in accordance with the manufacturer's recommendations for the intended use.

## Application

### Type of Check Dams

Stone Check Dams: Place the stone by hand or machine, making side slopes no steeper than 1:1 (i.e., the angle of repose) with a maximum height of 3 feet at the center of the check dam. A geotextile shall be placed below permanent check dams and keyed into the upstream and downstream channel bottom and sides at a depth of at least 6 inches.

Fiber Roll Check Dams: Follow manufacturer's instructions regarding product applications, limitations, and installation. Fiber rolls should be placed lengthwise, oriented perpendicular to the flow lines of the channel, with ends of adjacent rolls tightly abutting one another. Rolls shall be secured in a manner that is consistent with manufacturer's recommendations for this application so that the rolls are not washed downstream. When staking down, ensure good soil contact for the full length of the fiber roll, following manufacturer's recommendations for this application.

### Types of Applications

In Drainageways: Shall not exceed 3 feet in height at the center. Extend the check dam to the full width of the drainageway, plus 18 inches on each side leaving the height of the center of the check dam approximately 6 inches lower than the height of the outer edges (see Figure 5- 65).

The maximum spacing between check dams shall be such that the toe of the upstream check dam is at the same elevation as the top of the center of the downstream check dam (see Figure 5- 65).

Catch Basins in Drainageways on Slopes and at Culvert Inlets: Where catch basins in drainageways are located on slopes or at culvert inlets, locate the check dam across the drainageway no farther than 6 feet above the catch basin or culvert (see Figure 5- 66).

Catch Basins in Depressions or low spots (yard drains): Encircle the entire catch basin with a check dam not to exceed 18 inches in height and 3 feet out from the outside edge of the top of the frame (see Figure 5- 67).

**Culvert Inlets:** Locate the check dam approximately 6 feet from the culvert in the direction of the incoming flow (see Figure 5- 68).

**Special Case Combinations for Added Filtration & Frozen Ground Conditions:** These are non-engineered check dams modified for use in critical watersheds (e.g., public water supply, cold water fisheries) when the drainage area is 2 acres or less or when a sediment barrier needs to be installed during frozen ground conditions.

- Stone Check Dam/Geotextile (Figure 5- 69) Stone check dams that are installed with an internal core of geotextile. The geotextile encourages ponding while the stone check dam provides stability. The geotextile must meet the minimum standards set forth in Geotextile Silt Fence measure. Partially construct the stone check dam to at least half its height. Place the geotextile over the partially built dam with sufficient material on the upstream side to allow for it to make complete contact with the ground. Complete the placement of stone by burying the geotextile within the check dam. Useful life of the measure is limited by the life of the geotextile used and maintenance.

- Stone Check Dam/Straw Bales or Fiber Roll (Figure 5- 69 and Figure 5-44): Stone check dams that are installed with a core of straw bales or fiber rolls. The straw bales or fiber rolls provide filtering capacity, while the stone check dam provides stability.  Place straw bales or fiber rolls with the ends of adjacent bales/rolls tightly abutting one another. Bury straw bales or fiber rolls with stone and complete the construction of the stone check dam as indicated in the Application paragraphs above. Useful life of the measure is limited by the life of the straw bales or fiber rolls and maintenance.

*Figure 5- 65 Check Dam Installation in Drainageways, Source: USDA-NRCS*

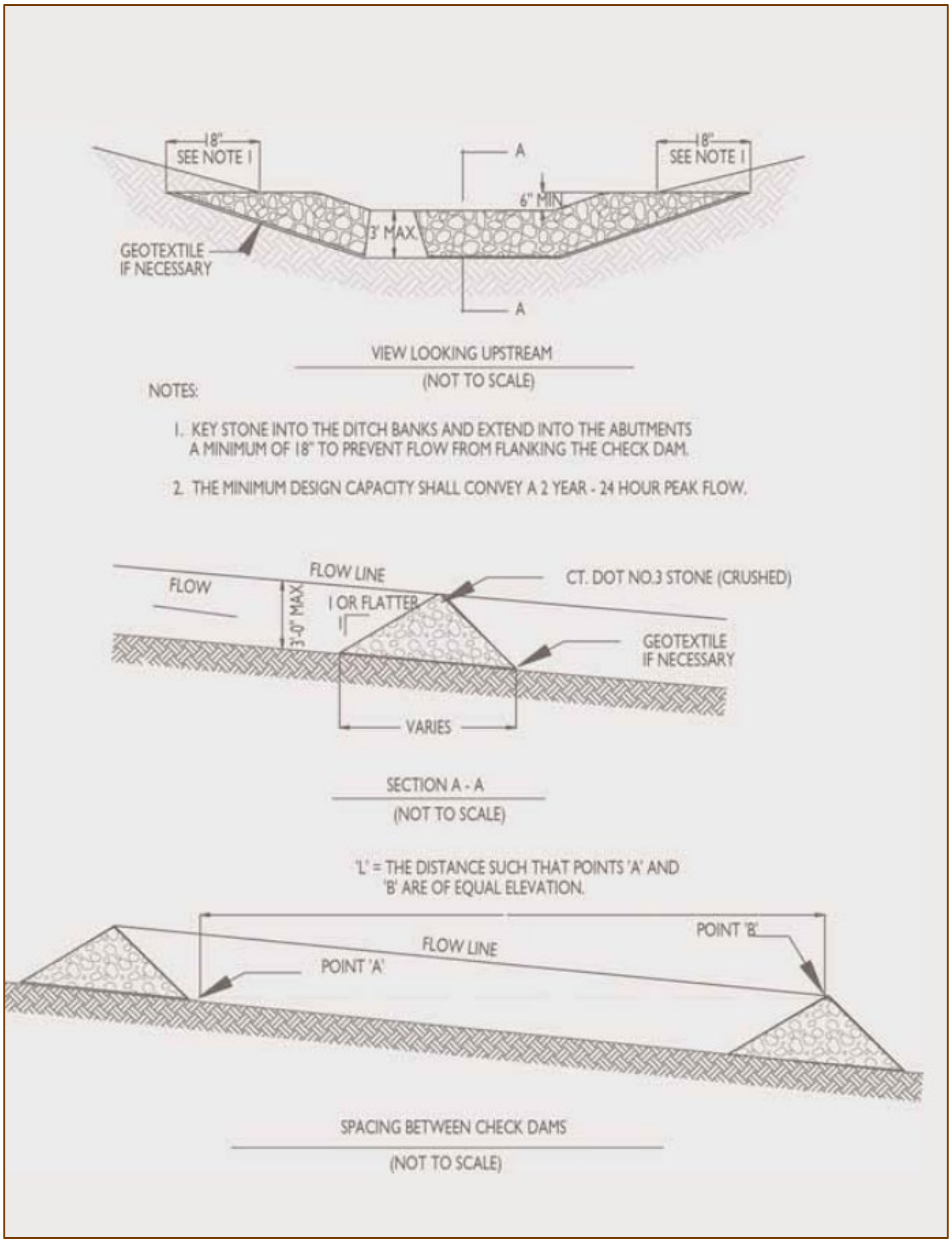


*Figure 5- 66 Check Dam Above Catch Basin in Drainageway on Slope*

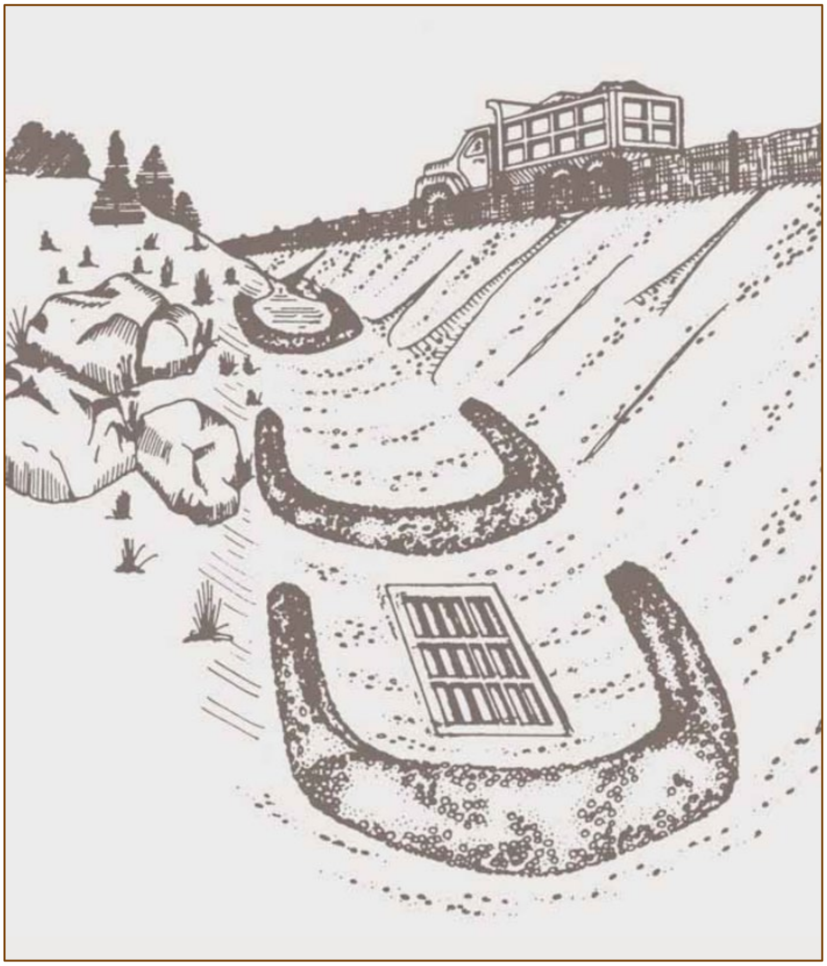


*Figure 5- 67 Check Dam at Catch Basin in Depression*

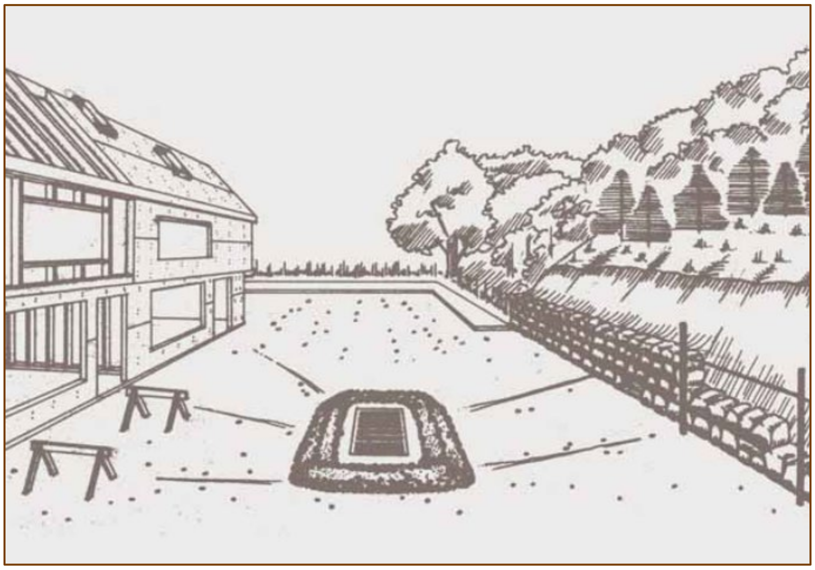


*Figure 5- 68 Check Dam at Culvert Inlet on Slope*

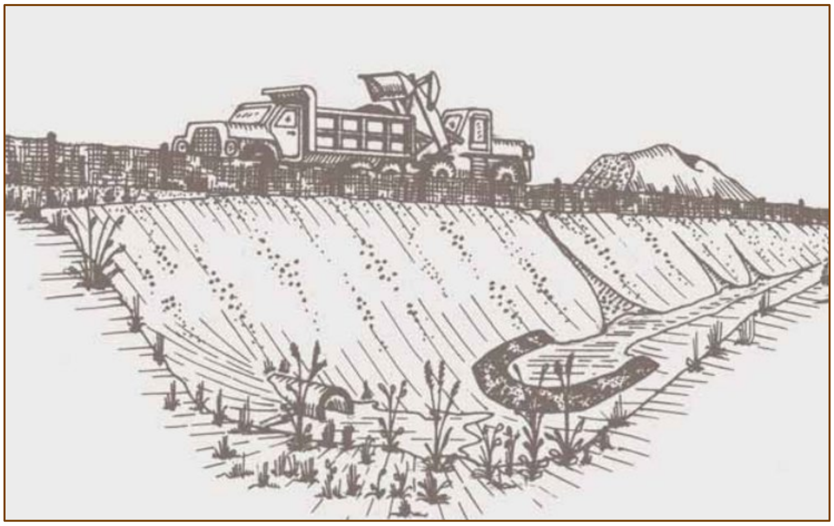
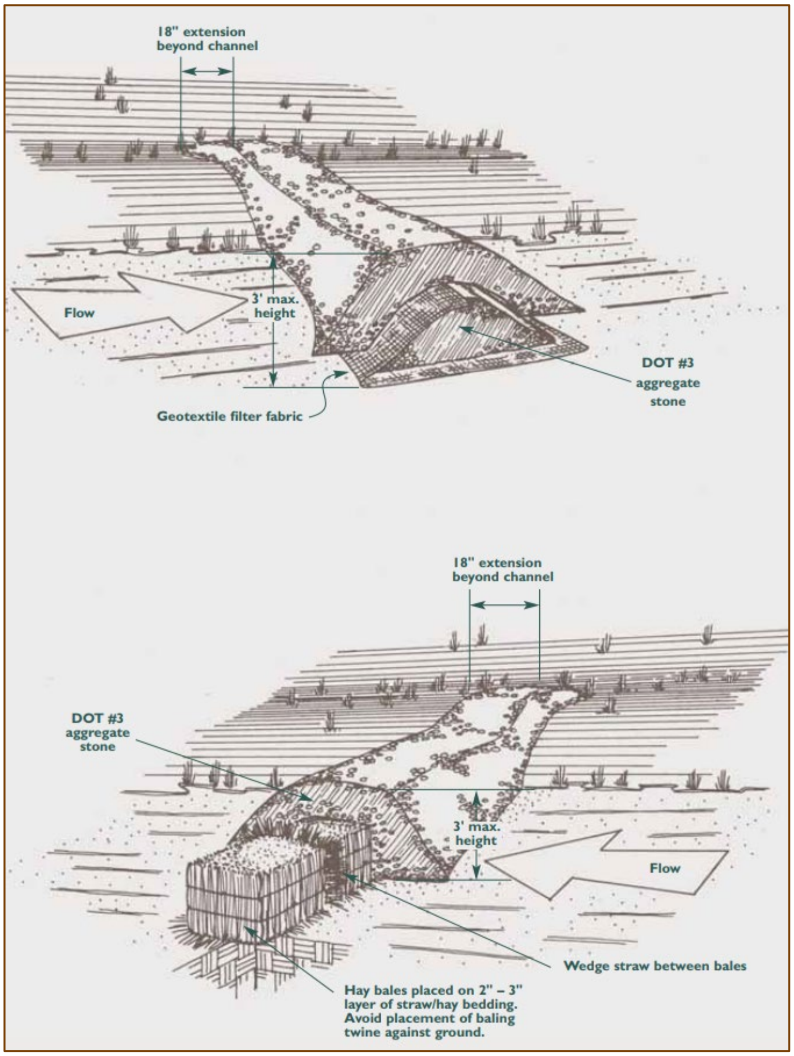


*Figure 5- 69 Combination Stone Check Dams*



## Maintenance

- Temporary check dams shall be maintained in proper working condition by the contractor as long as the structure is in place
- For permanent check dams, inspect and maintain the check dam in accordance with the standards and specifications provided in the design.
- For temporary check dams, inspect check dams at least once a week and within 24 hours of the end of a storm that generates a discharge[59] to determine maintenance needs.
- Remove the sediment deposits when deposits reach approximately half the height of the check dam.
- Replace or repair the check dam within 24 hours of observed failure. Failure of the check dam has occurred when sediment fails to be retained because:
  - stone or fiber rolls have moved
  - soil has eroded around or under the check dam reducing its functional capacity, or
  - trapped sediments are overtopping the check dam.
- When repetitive failures occur at the same location, review conditions and limitations for use and determine if additional controls (e.g., temporary stabilization of contributing area, diversions, check dams) are needed to reduce failure rate.
- Maintain the check dam until the contributing area is stabilized.
- After the contributing area is stabilized, remove accumulated sediment.
- Stone check dams must be removed or graded into the flow line of the channel over the area left disturbed by sediment removal. Grade so there are no obstructions to water flow. If stone check dams are used in grass-lined channels which will be mowed, remove all the stone, or carefully grade out the stone to ensure it does not interfere with mowing.
- Decomposable fiber logs typically do not require removal since they can be left in the channel to deteriorate and add organic matter to further support vegetation establishment.
- Stabilize any disturbed soil that remains from check dam removal operations.
- The area beneath the check dams should be seeded and mulched immediately after they are removed.

[59] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

# Sediment Impoundments, Barriers, and Filters

## Planning Considerations

The measures included in the sediment impoundments, barriers functional group include Temporary Sediment Basin, Temporary Sediment Trap, Inlet Protection, Filter Sock, Straw Bale Barrier, Geotextile Silt Fence, Turbidity Curtain, and Vegetated Filter. The primary function of these measures is to slow the velocity of sediment laden waters enough to allow suspended sediments to drop out of solution. Secondary functions can include the filtering of sediment laden waters and the creation of a physical barrier that prevents the sediment laden water from mixing with clean waters.

Sediment impoundments (Temporary Sediment Basin and Temporary Sediment Trap) are excavated and/or diked areas which impound water long enough to allow sediment to settle out of the water column. They are intended to provide a high degree of sediment removal (75%–90% trap efficiency)[60] for a 10-year, 2-hour storm.

These measures are different from each other by their design requirements. Temporary sediment basins:

- Require an engineered design.
- Are limited to a maximum of 100 acres contributing drainage area.
- Can be used for more than 2 years, but not for post-construction stormwater management.
- Have an outlet control structure that includes an emergency spillway.
- Have an initial minimum storage of 134 cubic yards per acre of contributing drainage area (which may be adjusted based on the engineering analysis).

Temporary sediment traps:

- Do not require an engineered design.
- Are limited to a maximum of 5 acres contributing drainage area.
- Are appropriate only where the intended use is less than 2 years.
- Have an aboveground outlet.
- have a minimum storage of 134 cubic yards per acre of contributing drainage area without adjustment.

Sediment barriers (Inlet Protection, Filter Sock, Straw Bale Barrier, Geotextile Silt Fence, and Turbidity Curtain) are temporary barriers consisting of either natural or manmade materials installed and maintained within or at the edge of disturbed areas to control the movement of

[60] Temporary sediment basins and traps are not intended for use as post-construction stormwater management controls. Post-construction stormwater management controls should be designed in accordance with the Connecticut Stormwater Quality Manual, as amended.

sediments. Additionally, straw bale barriers may be used to redirect small volumes of water away from sensitive areas or highly erodible slopes.

The design criteria for sediment barriers are not based upon any specific storm. As a rule, their installation is limited to 1 acre or less of contributing drainage area. Filter socks, straw bale barriers, and geotextile silt fences are useful in toe-of-slope and catch basin (inlet) protection as well as in some pumping settling basins. In drainage channels, geotextile silt fences may be used to a limited extent. However, a geotextile silt fence and straw bales may be used in a channel within a non-engineered check dam. Fiber rolls, a type of filter sock, may be used as temporary check dams in drainage channels (see Energy Dissipators Functional Group) and for bank stabilization near flowing water or along the toe of slopes (see Stabilization Structures Functional Group).

On land, temporary sediment barriers may be used separately or in combination with each other, such as for catch basin protection, culvert inlet protection, and dewatering facilities. When added protection is needed for work in critical watersheds (e.g., adjacent to wetlands, public water supply, nearby cold water fisheries) or when the ground is frozen, use a combination of approaches with stone. This special application is described in the Check Dam measure found in the Energy Dissipators Functional Group.

Where site disturbance occurs within 50 feet upgradient of a wetland, wetlands, or waterbodies, a double row of sediment barrier shall be installed between the disturbed area and any such downgradient wetland, wetlands, or waterbodies.

Two rows of sediment barriers shall also be installed and maintained on sites with slopes equal to or greater than eight percent (8%) within the contributing drainage area to such barrier, except to accommodate animal crossing or animal movement, when the E&S Plan includes an equivalent erosion control system, or for linear projects when two rows of sediment barriers will cause greater adverse impacts to wetlands, waters, or other sensitive resources.

More than one sediment barrier measure may be used for the same situation. However, each measure has performance characteristics that tend to make its application more appropriate. In choosing which type to use, it is important to consider both the length of time that the barrier must remain effective, and the sediment retention capacity needed.

A Turbidity Curtain can be used as a sediment barrier in tidal waters or water deeper than 2 feet. Its design and installation are determined by water fluctuation, depth, velocity, wave conditions, and manufacturer's recommendations.

In non-tidal water of standing water less than 2 feet deep, fiber rolls, geotextile silt fence, or other similar barriers, such as sandbags, may be used to isolate construction waters from non-construction waters.

When locating a sediment impoundment or barrier, anticipate the possible need to have equipment access the area for the removal of accumulated sediments.

A Vegetated Filter is more limited in its application the other measures in this group. A vegetated filter can only be used where slopes of both the contributing area and filtering area are less than 10%, where the contributing area is less than one acre, and where there is a sufficient length of flow through the filter to meet filtering needs. Frequently, a vegetated filter cannot be used either due to the steepness of slope or the lack of a large enough filtering area to meet the minimum flow lengths through the filter.

Table 5. 28 identifies the limitations for each sediment barrier and filter measure. Temporary check dams (non-engineered) are included only for reference when they are combined with straw bales or geotextile silt fence.

*Table 5. 28 Sediment Barrier and Filter Limitations*

| Limitation | Straw Bale | Geotextile Silt Fence | Turbidity Curtain | Vegetated Filter | Check Dam (non-engineered) | Filter Sock (Straw Wattle and Compost Filter Sock) | Filter Sock (Fiber Roll) |
|---|---|---|---|---|---|---|---|
| site conditions | on land | on land or standing water < 2 ft. deep | in water > 2 ft. deep | on land | on land | on land | on land or standing water < 2 ft. deep |
| max. slope gradient | 50% (2:1) | 50% (2:1) | NA | 10% (10:1) | 50% (2:1) | 50% (2:1) | 50% (2:1) |
| max. slope length<br>toe of slope application | 100 ft. | 100 ft. | NA | NA | NA | 100 ft. | 100 ft. |
| swale application | NA | depends on contributing slope gradient | NA | NA | depends on contributing slope gradient | N/A | Yes |
| max. drainage area | 1 acre | 1 acre | NA | 1 acre | 2 acres | 1 acre | 1 acre |
| expected life of control | < 3 months | 1-3 years | per manufacturers specifications | until silted in | 1 year | typically, < 3 months; > 3 months or permanently per manufacturer's specifications | Up to 5 years (per manufacturer's specifications) |

| Limitation | Straw Bale | Geotextile Silt Fence | Turbidity Curtain | Vegetated Filter | Check Dam (non-engineered) | Filter Sock (Straw Wattle and Compost Filter Sock) | Filter Sock (Fiber Roll) |
|---|---|---|---|---|---|---|---|
| time of year to install | before ground freezes[61] | | non-frozen water conditions | must be established before initial use | year round | year round | year round (per manufacturer's specifications) |
| location on landscape | not on pavement, bedrock or other hard surface that prevents proper entrenching or anchoring | | in water > 2 ft. depth | slope in filter area not steeper than 10% | on land | on land or pavement | on land or in water > 2 feet (when vegetated or used in coastal applications), on impervious surface or frozen ground per manufacturer's specifications |
| in still water < 2 ft. deep | no | by special design only | no | no | no | No | Yes |
| in water > 2 ft. deep | no | no | yes | no | no | No | Yes |
| sheet flows - toe of slope | on the contour 5-10 away from toe of slope | on the contour 0-10 away from toe of slope | NA | only where vegetation is adequate to filter runoff water | not advised | on the contour 5-10 away from toe of slope | Yes |
| drainageways | not advised | "U" shaped across drainageway | NA | NA | across drainageway | not advised | "U" shaped across drainageway |
| catch basins | ring basin | | NA | NA | ring basin | | |

[61] Special case – see Check Dam measure when stone barrier and straw bale, fiber roll, or geotextile silt fence are combined during frozen ground conditions.

| Limitation | Straw Bale | Geotextile Silt Fence | Turbidity Curtain | Vegetated Filter | Check Dam (non-engineered) | Filter Sock (Straw Wattle and Compost Filter Sock) | Filter Sock (Fiber Roll) |
|---|---|---|---|---|---|---|---|
| in hollows | | | | | | | |
| on slopes | twin "U" shaped up- and down-slope of basin | | NA | NA | twin barriers, one up- and down-slope of basin | twin "U" shaped up- and down-slope of basin | |
| culver inlets | no | "U" shaped at least 6 ft. from inlet | Yes | no | "U" shaped at least 6 ft. from inlet | no | "U" shaped at least 6 ft. from inlet |
| culvert outlets | no | "U" shaped at least 6 ft. from inlet | yes | no | "U" shaped at least 6 ft. from inlet | no | "U" shaped at least 6 ft. from inlet |

# Temporary Sediment Basin

## Definition

A temporary dammed impoundment, excavated pit, or dugout pond constructed across a waterway or at other suitable locations with a controlled outlet(s), creating a combination of wet and dry storage areas.

A basin that is created by the construction of a dam is classified as an embankment sediment basin, and a basin that is constructed by excavation is an excavated sediment basin. A basin that is created by a combination of dam construction and excavation is classified as an embankment sediment basin when the depth of water impounded against the embankment at emergency spillway elevation is three feet or more.

## Purpose

- To intercept and retain sediment during construction.
- To reduce or abate water pollution by preventing undesirable deposition of sediment in wetlands and waterbodies.
- To preserve the capacity of reservoirs, ditches, canals, diversions, storm sewers, waterways, and streams.

## Applicability

- Below disturbed areas with a contributing drainage areas less than 100 acres. For drainage areas less than 5 acres, a Temporary Sediment Trap may be used.
- Only for locations where failure of the temporary sediment basin will not, within reasonable expectations, result in loss of life or damage to buildings, roads, railroads, utilities, or other infrastructure.
- Not for use as a post-construction stormwater management system.
- Planning Considerations

The preferred method of sediment control is to prevent erosion and control it near the source, rather than constructing sediment basins which only trap a portion of the sediments. However, where physical conditions, land ownership, or construction operations preclude the treatment of the sediment source by the installation of erosion control measures to keep soil and other material in place, a temporary sediment basin may offer the most practical solution.

Sequence construction so that the basin is located in an area that won't be developed until after the contributing watershed is stabilized and where it won't interfere with other construction activities and construction of utilities.

Locate the basin outside of wetlands and in such a way that maximum storage benefit is obtained from the existing surrounding terrain to minimize disturbance from the construction of the dam.

Regardless of the construction sequence and location, provide and maintain construction equipment access for the removal of accumulated sediment.

To minimize the size of the temporary sediment basin, divert clean waters around the basin and intercept only runoff from disturbed areas.

#### Peak Flow Attenuation

Temporary sediment basins should not be located in the proposed locations of permanent, post-construction stormwater BMPs (i.e., retention/infiltration, treatment, or stormwater quantity control BMP). Fine soil particles in the sediment trapped by the temporary sediment basin will seal the underlying soils of the sediment basin and the future infiltration capacity of the soils may be significantly reduced. If no other options exist, and a post-construction stormwater BMP must be sited in the location of a temporary sediment basin, the temporary sediment basin must be modified to prepare it for long-term use including, at a minimum, removal of any accumulated sediments, restoration of the pre-construction infiltration capacity of the underlying soils (including field infiltration testing of the soils for infiltration-based BMPs), and other structural modifications in accordance with the BMP-specific design guidance in the Connecticut Stormwater Quality Manual, as amended.

In most cases, the combination of measures that control erosion, control runoff, and control sediment will be adequate to control temporary increases in volume and peak flows during the construction phase of a project. However, the designer must evaluate if conditions warrant the use of detention measures for peak flow control during construction. The evaluation must include a description of site conditions and proposed onsite controls and conveyances for all discharge points. For those projects proposing a common drainage location that serve an area with greater than five (5) acres disturbed at one time, the permitting agency may require peak flow control on a case-by-case basis. The designer must ensure that the proposed combination of measures is adequate to protect the receiving waters and downstream conveyances from the excessive velocities created as a result of land disturbance activities.

For projects that require peak flow control during construction, the temporary sediment basin should be sized to meet the minimum requirements of both sedimentation and peak flow attenuation (i.e., detention) during the construction period. The temporary peak flow attenuation requirements during the construction phase differ from the long-term peak flow attenuation requirements of the development site following construction, which should be addressed through the use of Low Impact Development (LID) site planning and design techniques and post-construction stormwater quantity controls designed in accordance with the Connecticut Stormwater Quality Manual, as amended.

### Permitting

The CT DEEP regulates all dam construction in the State of Connecticut. Temporary sediment basins classified as dams under the CT DEEP dam safety program should be constructed, inspected, and maintained in accordance with applicable CT DEEP dam safety regulations and guidance. Contact the CT DEEP dam safety program early in the planning process to determine the potential need for a dam safety permit and/or water diversion permit. A local or state inland wetlands permit may be required if the temporary sediment basin is proposed adjacent to a wetland and/or watercourse area. Additional local permits may be required for work within floodplain and wetland upland review areas.

## Design Criteria

### Overall

Locate temporary sediment basins where:

1. Failure of the sediment basin would not, within reasonable expectations, result in loss of life; damage roads, railroads, homes, commercial and industrial properties; or interrupt the use or service of utilities. (Dams which might fail and endanger life or property are regulated by the Commissioner of the CT by the Commissioner of the CT DEEP under the CGS §§22a-401 through 22a-411.).

2. The effective height of the dam for an embankment sediment basin should be 15 feet or less. The effective height of the dam is defined as the difference in elevation in feet between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam becomes the upper limit.

3. The product of the storage times the effective height of the dam should be less than 3,000. Storage is the volume in acre-feet in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is as defined above.

Sediment basins that exceed any one of the above conditions shall be designed to meet the criteria in USDA-NRCS Earth Dams and Reservoirs, Technical Release 60 (TR-60).

### Drainage Area

The maximum allowable drainage area into a sediment basin shall be 100 acres. An emergency spillway shall be provided on all embankment sediment basins with a contributing drainage area equal to or greater than 20 acres.

### Basin Capacity

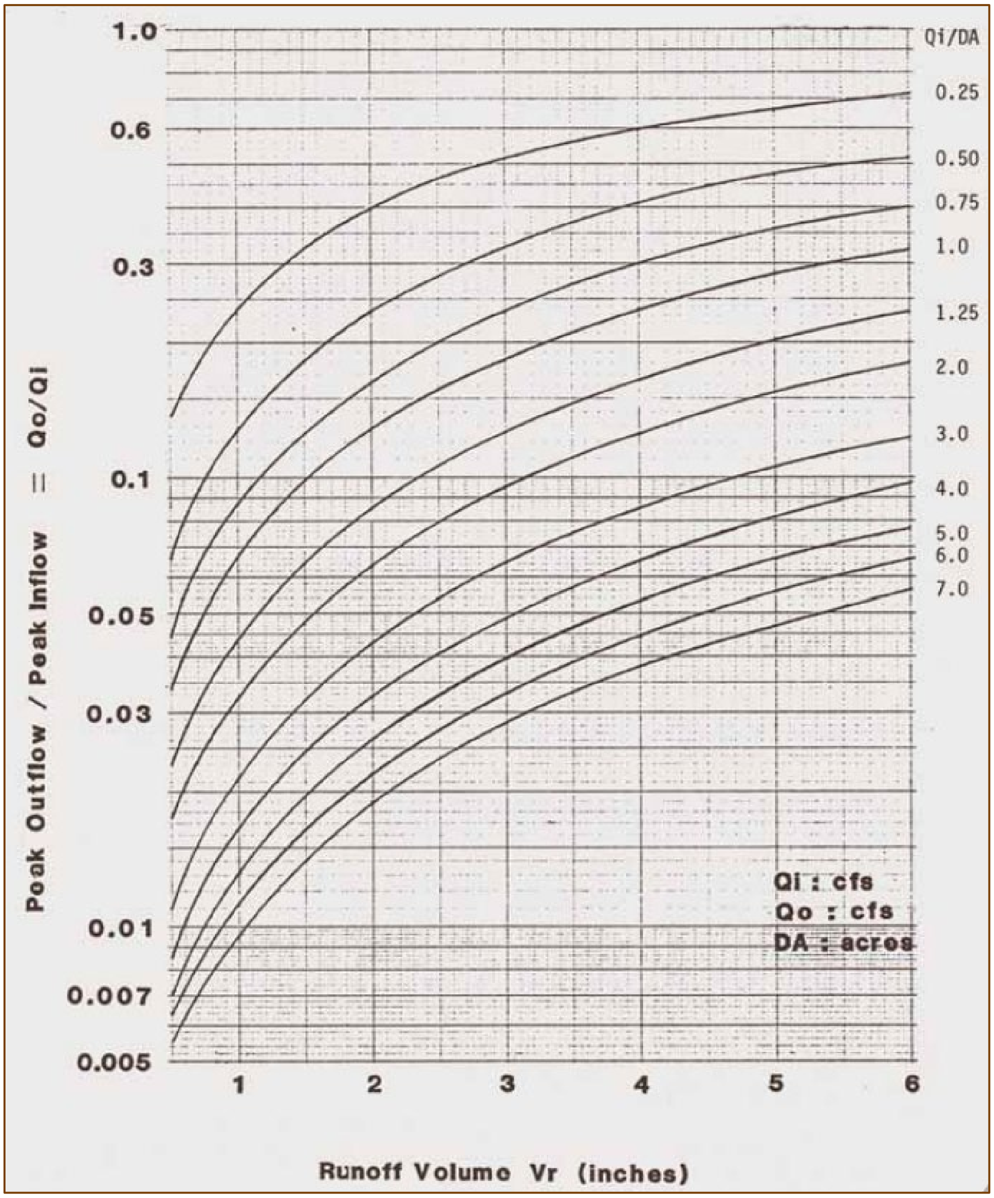
The volume in the sediment basin below the crest elevation of the emergency spillway shall be at least that required for wet storage (which includes sediment storage) plus that required for residence storage.

**Residence Storage Time and Volume:** Residence time is defined as the volume weighted average time that an amount of flow will reside in a reservoir.

The sediment basin shall provide, in addition to sediment storage volume and wet storage volume, adequate volume to provide a minimum of 10 hours residence time for a 10-year frequency, 24-hour duration storm.

Flood routing is required to determine residence storage time. Figure 5- 70, along with flood routing using the methods in TR-20, TR-55, or other generally accepted flood routing methods, will provide the minimum required residence storage volume and the maximum allowable principal spillway discharge.

*Figure 5- 70 Maximum Peak Outflow for Detention Time Graph, Source: USDA-NRCS*




Sediment Storage Volume: At least 1 year of predicted sediment load must be provided regardless of the planned frequency of sediment removal. Where it is determined that periodic removal of sediment is practical, the sediment storage volume may be proportionately reduced.

For the purpose of determining the sediment storage volume, use 80% trap efficiency. The USDA-NRCS National Engineering Handbook, Section 3 Sedimentation and USDA-NRCS Earth

Dams and Reservoirs, Technical Release 60 (TR-60) may be used to provide a more refined estimate of the actual trap efficiency[62] of a specific sediment basin.

Sediment volume is calculated from the following formula:

$$V = \frac{(DA)(A)(DR)(TE)(\frac{2000lbs}{ton})}{(\gamma)(43{,}560\ sq\frac{ft}{acre})}$$

Where:

V = the volume of sediment trapped in ac. ft./yr.

DA = the total drainage area in acres

A = the average annual erosion in tons per acre per year using either values from the Universal Soil Loss Equation, the Revised Universal Soil Loss Equation, or the values in Table 5. 29 for the listed land use.

DR = the delivery ratio determined from Figure 5- 71.

TE = the trap efficiency as given above. (Use 0.8)

γ= the estimated sediment density in the sediment basin in lbs./cu. ft. (from Table 5. 30).

**Wet Storage Volume:** The volume of the wet storage shall be at least twice the volume of the sediment storage volume (see above) and shall be designed to a minimum depth of 2 feet.

Wet storage volume is the volume in the basin that is located below the invert of the lowest outlet structure for the basin. The wet storage may not provide permanent ponding of water depending on site conditions but will create a permanent pool for settling suspended sediment during a runoff event. The wet storage is intended to minimize the re-suspension of existing trapped sediments during a runoff event. To reduce sediment removal frequency, increase the volume of wet storage which will increase the sediment storage volume.

### Basin Shape and Depth

The length, width, and depth of the basin are measured from the emergency spillway crest elevation.

**Depth:** The average depth shall be 4 feet or greater.

**Width:** The minimum width shall be:

$$W = 10\sqrt{Q_5}$$

where:

[62] Trap efficiency is the amount (expressed as a percent) of the total sediment delivered to the basin that will remain in the sediment basin. It is a function of residence time, characteristics of the sediment, nature and properties of inflow, and other factors.

W=width in feet

$Q_5$=peak discharge from a 5-year frequency storm in cfs.

When the downstream area is highly sensitive to sediment impacts, the minimum width shall be:

$$W = 10\sqrt{Q_{25}}$$

where:

W= width in feet

$Q_{25}$ = peak discharge from a 25-year frequency storm in cfs.

*Figure 5- 71 Sediment Delivery Ratio Vs. Drainage Area Graph, Source: USDA-NRCS*

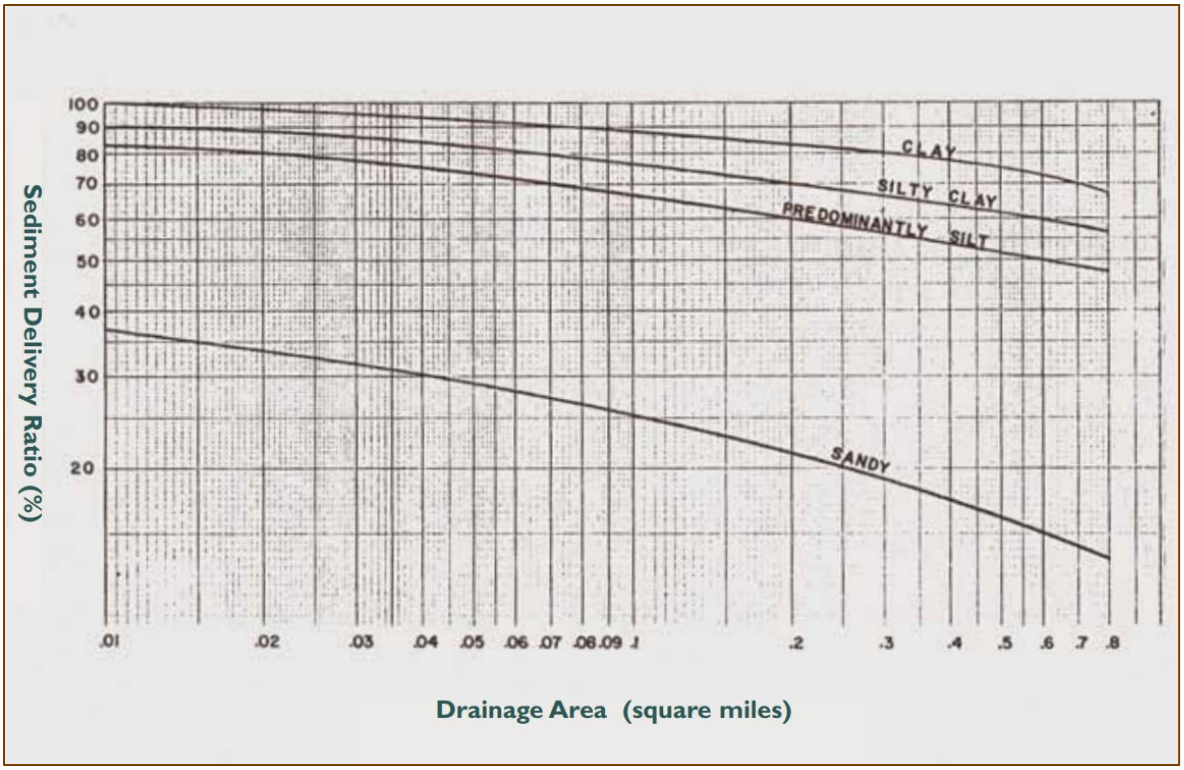


*Table 5. 29 Determining Erosion Rates*

| Land Use | Average Annual Erosion (tons/acre/yr.) |
|---|---|
| Wooded Area | 0.2 |
| Developed urban areas, grassed areas, pastures, hay fields, abandoned with good cover | 1.0 |
| Clean tilled cropland (corn, vegetables, etc.) | 10.0 |
| Construction Areas | 50.0 |

Source: USDA-NRCS

*Table 5. 30 Estimated Sediment Density*

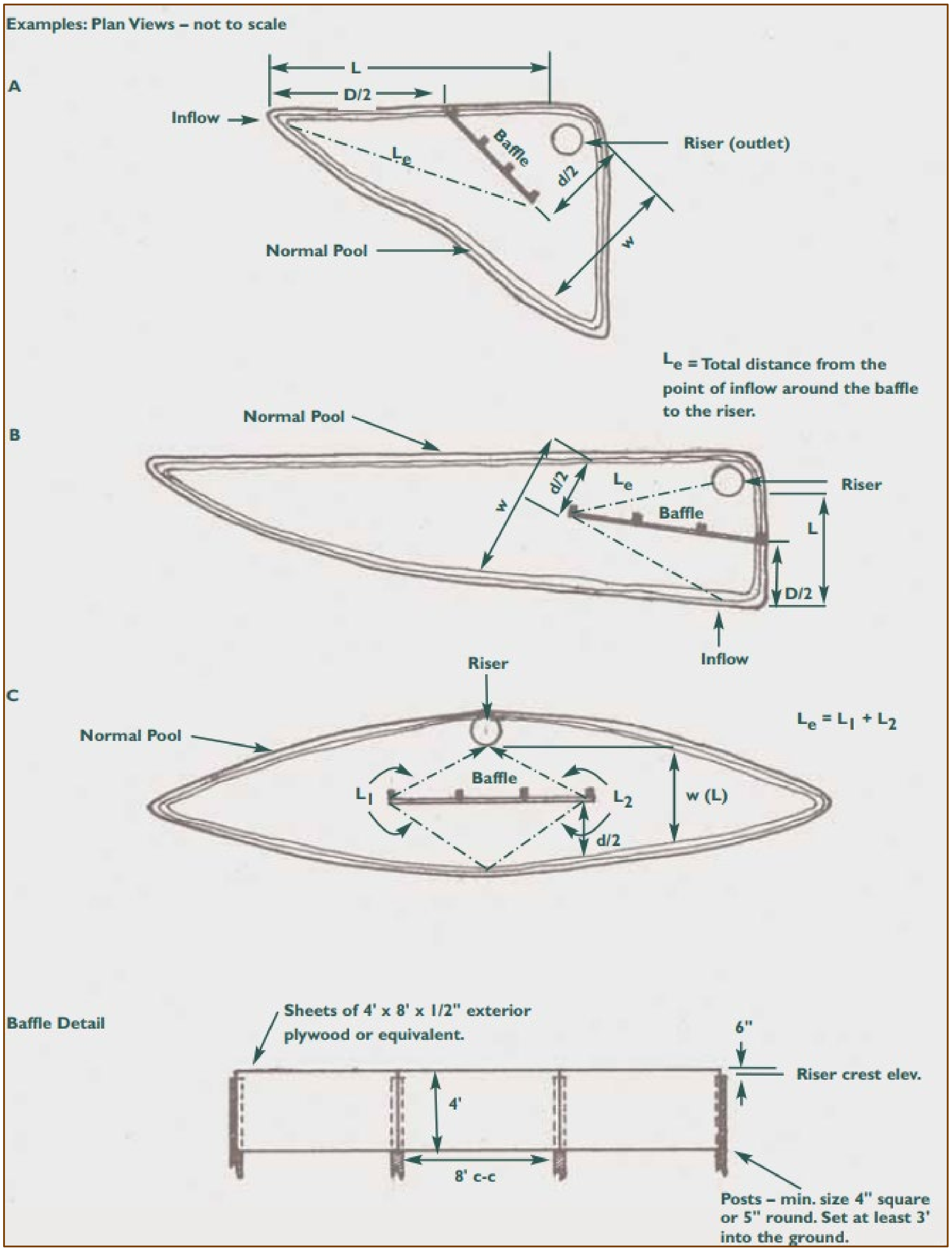
| Soil Texture* | γ Submerged (lbs./ft$^3$) |
|---|---|
| Clay | 40-60 |
| Silt | 55-75 |
| Clay Silt Mixture (equal parts) | 40-65 |
| Sand Silt Mixture (equal parts) | 75-95 |
| Clay Silt Sand Mixture (equal parts) | 50-80 |
| Sand | 85-100 |
| Gravel | 85-125 |
| Poorly Sorted and Gravel | 95-130 |

* Use USDA soil data from county soil surveys or sieve analysis to determine soil texture.

Source: USDA-NRCS

Length: The effective flow length shall be equal to at least two times the effective flow width. When site constraints prohibit the design of an adequate length, baffles are required to provide for the creation of an adequate flow length (see Figure 5- 72).

*Figure 5- 72 Sediment Basin Baffle Details*




## Spillway Design

The outlets for the basin shall consist of a combination of principal and emergency spillways. These outlets must pass the peak runoff from the contributing drainage area for the design storm (see Table 5. 33). If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the design storm. However, an attempt to provide a separate emergency spillway should always be made (refer to “Emergency Spillway”, Figure 5- 75). Runoff computations shall be based upon the soil cover conditions which are expected to prevail during the life of the basin. Refer to standard engineering practices for calculations of the peak rate of runoff. Notably, the flow through the dewatering orifice cannot be utilized when calculating the design storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway crest.

The spillways designed by the procedures contained in this manual will not necessarily result in any reduction in the peak rate of runoff. If a reduction in peak runoff is desired, the appropriate hydrographs and storm routings shall be generated to choose the basin and spillway sizes.

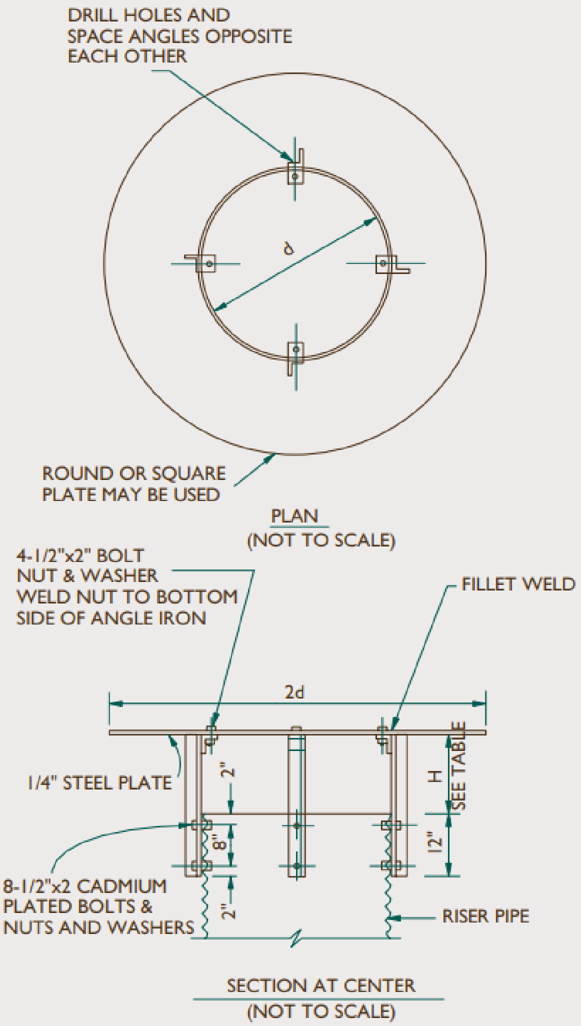
### Principal Spillway

For maximum effectiveness, the principal spillway should consist of a vertical pipe or box of corrugated metal or reinforced concrete, with a minimum diameter of 15 inches, joined by a watertight connection to a horizontal pipe (barrel) extending through the embankment and out letting beyond the downstream toe of the fill. If the principal spillway is used in conjunction with a separate emergency spillway, then the principal spillway shall be designed to pass at least the peak flow expected from a 2-year storm. If no emergency spillway is used, the principal spillway shall be designed to pass the entire peak flow expected from the design storm.

**Design Elevations:** The crest of the principal spillway shall be set at the elevation corresponding to the storage volume required. If a principal spillway is used in conjunction with an emergency spillway, the principal spillway crest shall be a minimum of 1.0 foot below the crest of the emergency spillway. In addition, a minimum freeboard of 1.0 foot shall be provided between the design high water elevation (design depth through the emergency spillway) and the top of the embankment. If no emergency spillway is used, the crest of the principal spillway shall be a minimum of 3 feet below the top of the embankment; in addition, a minimum freeboard of 2.0 feet shall be provided between the design high water and the top of the embankment.

**Anti-Vortex Device and Trash Rack:** If a riser-type principal spillway is used, an anti-vortex device and trash rack shall be attached to the top of the riser to improve the flow characteristics and prevent blockage due to floating debris. (See Figure 5- 73 and Figure 5- 74 for examples of the anti-vortex device and trash rack.)

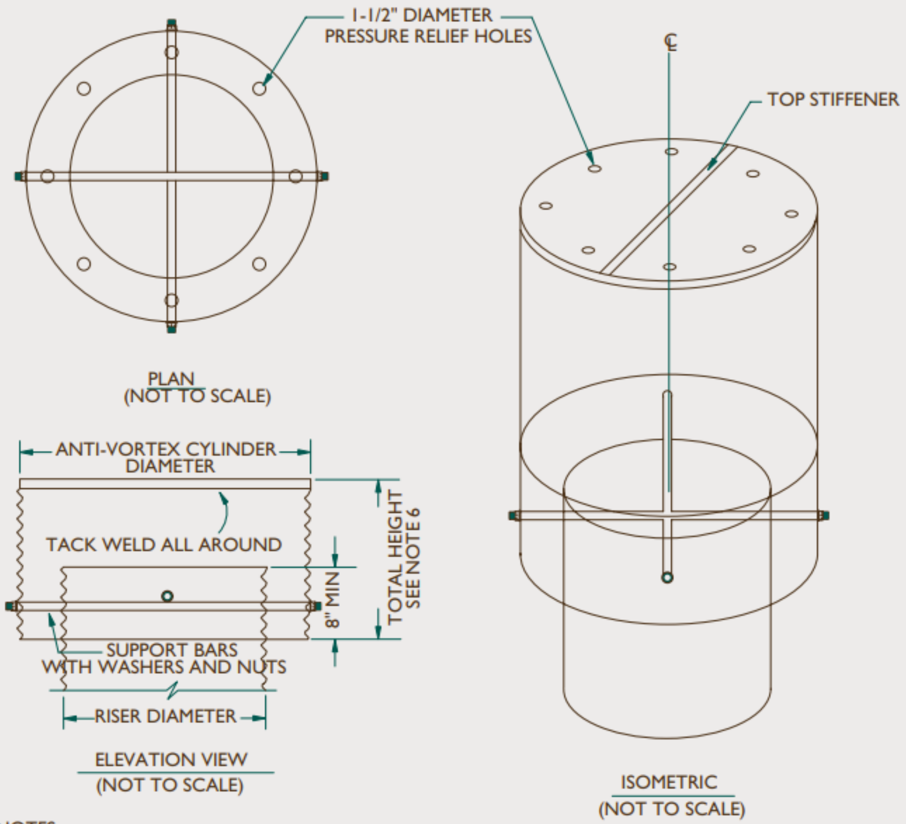
*Figure 5- 73 Anti-Vortex - Trash and Safety Guard Diagram, Source: USDA-NRCS*




| INLET d DIA. INCHES | BARREL DIA. INCHES | H INCHES |
|---|---|---|
| 12 | 6 | 6 |
| 12 | 8 | 6 |
| 15 | 10 | 6 |
| 15 | 12 | 7 |
| 18 | 12 | 6 |
| 24 | 15 | 7 1/2 |
| 24 | 18 | 10 |
| * 30 | 18 | 8 1/2 |
| * 30 | 24 | 13 1/2 |
| * 36 | 24 | 12 |

* USE ANGLE IRON STIFFENERS ON PLATE AS SPECIFIED.

*Figure 5- 74 Concentric Trash Rack and Anti-Vortex Device, Source: USDA-NRCS*




NOTES:

1. TOP STIFFENER (IF REQUIRED) IS 2" X 2" X 1/4" ANGLE WELDED TO TOP AND ORIENTED PERPENDICULAR TO CORRUGATIONS.
2. TOP IS 12 GAGE CORRUGATED METAL OR 1/8" STEEL PLATE. PRESSURE RELIEF HOLES MAY BE OMITTED IF ENDS OF CORRUGATIONS ARE LEFT FULLY OPEN WHEN CORRUGATED TOP IS WELDED TO CYLINDER.
3. CYLINDER IS 12 GAGE CORRUGATED METAL PIPE OR FABRICATED FROM STEEL PIPE WITH A MINIMUM 1/8" WALL THICKNESS.
4. SUPPORT BARS ARE 1/2" DIAM. (MIN).
5. TRASH RACK DIAMETER SHALL BE SIZED SO THE VELOCITY THROUGH THE BOTTOM OF THE RACK IS LESS THAN 2.5 FEET/SECOND.
6. THE TOP OF THE CONCENTRIC TRASH RACK SHALL BE SET AT OR ABOVE THE ELEVATION AT WHICH THE PRINCIPAL SPILLWAY BARREL FLOWS FULL (PRIMES).

Base: The base of the principal spillway shall be firmly anchored to prevent floatation. If the riser height of the spillway is greater than 10 feet, computations shall be made to determine the anchoring requirements. A minimum factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces).

For risers 10 feet or less in height, the anchoring may be done in one of the two following ways:

1. A concrete base 18 inches thick and twice the width of the riser diameter shall be used, and the riser shall be embedded 6 inches into the concrete.

2. A square steel plate securely attached or welded to the base of the riser, a minimum of 0.25 inch thick and having a width equal to twice the diameter of the riser shall be used; it shall be covered with stone, gravel, or compacted soil to prevent flotation.

Note: If a steel base is used, special attention should be given to compaction so that 95% standard proctor compaction is achieved over the plate. Also, added precautions should be taken to ensure that material over the plate is not removed accidently during removal of sediment from the basin.

Barrel: The barrel of the principal spillway, which extends through the embankment, shall be designed to carry the flow provided by the riser of the principal spillway with the water level at the crest of the emergency spillway. The connection between the riser and the barrel shall be watertight. The outlet of the barrel shall be protected to prevent erosion or scour of downstream areas.

Seepage Control Along Principal Spillway Barrels:

Anti-Seep Collars: Anti-seep collars are designed to control seepage and piping along the barrel by increasing the flow length and thus making any flow along the barrel travel a longer distance.

Anti-seep collars shall be used along the barrel of the principal spillway within the normal saturation zone of the embankment to increase the seepage length by at least 10%, if either of the following two conditions is met:

1. The settled height of the embankment exceeds 10 feet.
2. The embankment has a low silt-clay content (Unified Soil Classes SM or GM based on sieve analysis. See Appendix E for classification specifications) and the barrel is greater than 10 inches in diameter.

Anti-seep collars shall be installed within the saturated zone. The maximum spacing between collars shall be 14 times the projection of the collars above the barrel and in no case shall exceed 25 feet. Collars shall not be closer than 2 feet from a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure 95% standard proctor compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight.

Filter Diaphragms: Due to the constraints that collars impose on embankment fill placement and compaction, collars may sometimes be ineffective or actually result in an increase in seepage and piping.

Alternative measures to anti-seep collars have been developed and incorporated into embankment designs. These measures include a structure known as a “filter or drainage diaphragm.” A filter diaphragm consists of a layer of sand and fine gravel which runs through the dam embankment perpendicular to the barrel. Typically, the structure is 4 to 5 inches in width, approximately 1 foot in height, and is located at the barrel elevation at its intersection with the upper bounds of the seepage zone. The measure controls the transport of embankment fines, which is the major concern with piping and seepage. The diaphragm channels any undesirable flow through the fine-graded material, which traps any embankment material being transported. The flow is then conveyed out of the embankment through a drain.

The critical design element of the filter diaphragm is the grain-size distribution (gradation) of the filter material which is determined by the gradation of the adjacent embankment fill material. The use and design of these measures shall be based on site-specific geotechnical information and be supervised by a qualified professional.

**Principal Spillway - Construction Specifications:** The riser of the principal spillway shall be securely attached to the barrel by a watertight connection. The barrel and riser shall be placed on a firmly compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent its floating. With the exception of filter diaphragms, pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the barrel or anti-seep collars (compact by hand if necessary). Fill material shall be placed around the pipe in 6-inch layers and compacted until 95% standard proctor compaction is achieved. A minimum of two feet of fill shall be hand-compacted over the barrel before crossing it with construction equipment.

Pipe conduits for embankment sediment basins shall meet the following requirements:

**Pipe Materials:** The pipe shall be capable of with- standing external loading without yielding, buckling, or cracking. The following pipe materials are acceptable:

1. **Corrugated Steel Pipe:** Pipe gauge is not to be less than that indicated in Table 5. 31. The maximum principal spillway barrel size shall be 48 inches. The pipe shall be helical fabrication. Flanges with gaskets or caulking may be used. Rod and lug coupling bands with gaskets or caulking may be used.
2. **Corrugated Aluminum Pipe:** Minimum pipe gauge is shown in Table 5. 31. The maximum principal spillway barrel size shall be 36 inches. The pipe shall be riveted fabrication. The embankment and water shall range between pH 4 and pH 9. Inlets, coupling bands and anti-seep collars must be made of aluminum.

*Table 5. 31 Corrugated Steel and Aluminum Pipe Requirement*

| Corrugated Steel Pipe | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Pipe Diameter | | | | | | | Risers Only | | |
| | 8 to 21 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 66 |
| Minimum Gauge | 16 | 16 | 14 | 14 | 12 | 10 | 10 | 10 | 10 |

| Corrugated Aluminum Pipe | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pipe Diameter | 8 to 21 | 24 | 30 | 36 | Risers Only | | |
| | | | | | 42 | 48 | 54 |
| Gauge (inches) | 16 (.06) | 14 (0.75) | 14 (0.75) | 14 (0.75) | 12 (.105) | 10 (.135) | 10 (.135) |

Source: Standards for Soil Erosion and Sediment Control in New Jersey. New Jersey State Soil Conservation Committee.

Fittings for aluminum pipe fabricated of metals other than aluminum or aluminized steel must be separated from the aluminum pipe at all points by at least two layers of plastic tape having a total thickness of at least 24 mils, or by other permanent insulating material that effectively prevents galvanic corrosion.

Bolts used to join aluminum and steel must be galvanized, plastic coated, or otherwise protected to prevent galvanic corrosion. Bolts used to join aluminum to aluminum, other than aluminum alloy bolts, must be galvanized, plastic coated, or otherwise protected to pre- vent galvanic corrosion.

Connections between pipe joints must be watertight. Flanges with gaskets or caulking may be used. Rod and lug coupling bands with gaskets or caulking may be used. Slip seam coupling bands with gaskets or caulking may be used.

**Plastic Pipe:** PVC pipe shall meet the requirements of Table 5. 32. Connections between pipe joints and anti-seep collar connections to the pipe must be watertight. Pipe joints shall be solvent welded, O-ring, or threaded. All fittings and couplings shall meet or exceed the same strength requirements as that of the pipe and be made of material that is recommended for use with the pipe. Connections of plastic pipe to less flexible pipe or structures shall be designed to avoid stress concentrations that could rupture the plastic. The maximum principal spillway barrel size shall be 12 inches.

*Table 5. 32 PVC* Pipe Requirements*

| Normal Pipe Size (Inches) | Strength | Maximum Depth of Fill Over Pipe (inches) |
|---|---|---|
| 6,8,10, 12 | Sched. 40 | 10 |
| | Sched. 80 | 15 |
| | SDR 26 | 10 |

*Polyvinyl chloride pipe, PVC 1120, or PVC 1220, conforming to ASTM D 1785 or ASTM D 2241

Source: Adapted from Standards for Soil Erosion and Sediment Control in New Jersey, New Jersey State Conservation Committee.

1. **Smooth Steel:** The minimum wall thickness shall be 3/16 inch. Used pipe shall be in good condition and not have deep rust pits. The maximum principal spillway barrel shall be 48 inches. Pipe joints shall be threaded or welded by a competent welder.

2. **Concrete, With Rubber Gasket Joints:** The pipe shall be laid in concrete bedding. Connections between pipe joints and anti-seep collar connections to pipe shall be watertight and remain watertight after movement caused by foundation consolidation and embankment settlement.

***Inlets for Pipe Conduits:*** The inlet shall be structurally sound and made from materials compatible with the pipe. The inlet shall be designed to prevent floatation. The inlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. The inlet materials shall be subject to the same limitations and requirements as pipe conduits.

1. **Watertight Riser:** Risers shall be completely watertight except for the inlet.
2. **Pipe Drop Inlet:** Pipe drop inlets, where designed for pressure flow, shall meet the following conditions:
   a) The weir length shall be adequate to prime the pipe below the emergency spillway elevation.
   b) For pipe on less than critical slope, the height of the drop inlet shall be at least 2 times the conduit diameter.
   c) For pipe on a critical slope or steeper, the height of the drop inlet shall be at least 5 times the conduit diameter.

**Anti-vortex Devices:** Sediment basins with the principal spillway designed for pressure flow shall have adequate anti-vortex devices. See Figure 5- 73 and Figure 5- 74.

**Trash and Safety Guards:** An appropriate guard shall be installed at the inlet. The guard shall prevent clogging of the pipe by trash and reduce the safety hazard to people. The guard shall be a type that will not plug with leaves, grass, or other debris. See Figure 5- 73 and Figure 5- 74.

**Outlets for Pipe Conduits:** The outlets shall be structurally sound and made from materials compatible with the pipe. The outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. Protection against scour at the discharge end of the spillway shall be provided. Measures may include impact basins, Saint Anthony Falls outlets, riprap, excavated plunge pools or other generally accepted energy dissipators.

**Anti-seep Collars:** Pipe conduits for embankment sediment basins shall be provided with anti-seep collars or filter diaphragms. The minimum number of anti-seep collars shall be determined by the size of the collars and the length of that part of the conduit lying in the saturated zone of earth embankment. Anti-seep collars are not required for excavated sediment basins.

The size and number of anti-seep collars is determined such that the ratio of the length of the line of seepage (L+ 2 n V) to L is to be not less than 1.15 where

V = projection of the anti-seep collar in feet

L = length in feet of the conduit within the zone of saturation, measured from the downstream side of the riser to the toe drain or point where the phreatic line intercepts the conduit, whichever is shorter

n = number of anti-seep collars

Anti-seep collars should be equally spaced along that part of the barrel within the saturated zone at distances of not more than 25 feet. See the previous discussion in this section on seepage control which may conflict.

Anti-seep collars should be equally spaced along that part of the barrel within the saturated zone at distances of not more than 25 feet. See the previous discussion in this section on seepage control which may conflict.

### Emergency Spillway

An attempt to provide a separate emergency spillway shall always be made. However, there shall be an emergency spillway on all temporary sediment basins with a contributing drainage equal to or exceeding 20 acres. The emergency spillway acts as a safety release for a sediment basin, or any impoundment-type structure, by conveying the larger, less frequent storms through or around the basin without damage to the embankment. The emergency spillway shall consist of an open channel (earthen and vegetated) constructed adjacent to the embankment over undisturbed material (not fill).

Where conditions will not allow the construction of an emergency spillway on undisturbed material, a spillway may be constructed of a non-erodible material such as riprap. The spillway shall have a control section at least 20 feet in length. The control section is a level portion of the spillway channel at the highest elevation in the channel profile.

Where conditions require the construction of an emergency spillway on the embankment, a spillway shall be constructed of a non-erodible material such as riprap. As an alternative, a structural spillway may be installed which combines the outflow requirements of a principal (primary) spillway and emergency (auxiliary) spillway.

An evaluation of site and downstream conditions must be made to determine the feasibility and justification for the incorporation of an emergency spillway. In some cases, the site topography does not allow a spillway to be constructed in undisturbed material, and the temporary nature of the facility may not warrant the cost of disturbing more acreage to construct and armor a spillway. The principal spillway should then be sized to convey all the design storms.

**Emergency Spillways for Excavated Sediment Basins:** If the downstream slope is 5:1 or flatter and has existing vegetation or is immediately protected by sod- ding, riprap, asphalt lining, concrete lining, or other equally effective protection, then excavated sediment basins may utilize the natural ground for the emergency spillway. Otherwise, the spillway shall meet the capacity requirement for embankment sediment basins given below.

**Emergency Spillway for Embankment Sediment Basins:** Emergency spillways for embankment sediment basins shall meet the following requirements:

***Capacity:*** The minimum capacity of the emergency spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 5. 33 less any reduction creditable to principal spillway discharge and detention storage.

*Table 5. 33 Design Data*

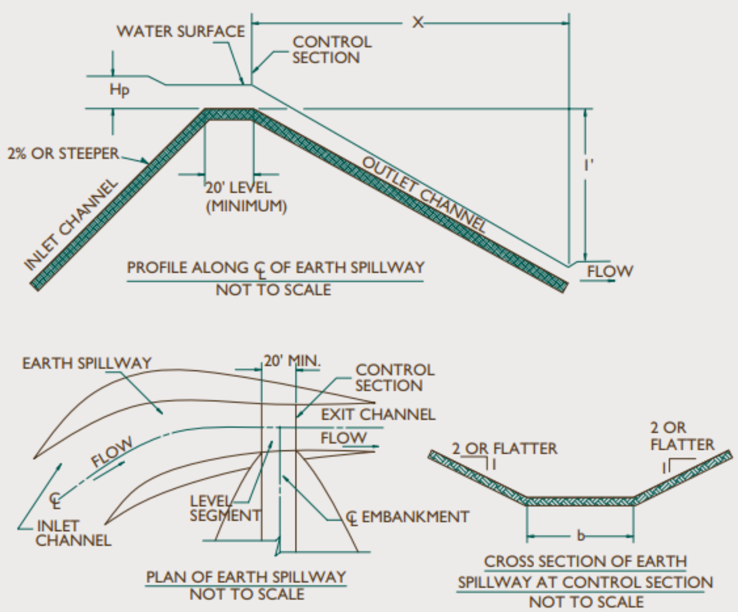
| Drainage Area (Acres) | Frequency (Years) | Minimum Duration (Hours) |
|---|---|---|
| Less than 50 | 25 | 24 |
| 50-100 | 100 | 24 |

If routed, the flood routing shall be done using the methods outlined in TR-20, TR-55, or other generally accepted methods of emergency spillway flood routing. When discharge of conduit-type principal spillway system is considered in calculating outflow through the emergency spillway, the crest elevation of the inlet shall be such that full pipe flow will be generated in the conduit before there is discharge through the emergency spillway.

*Figure 5- 75 Design Data for Earth Spillways (Emergency Spillways), Source: USDA-NRCS*

LEGEND
n = MANNING'S COEFFICIENT OF ROUGHNESS.
Hp = DIFFERENCE IN ELEVATION BETWEEN CREST OF EARTH SPILLWAY AT THE CONTROL SECTION | AND WATER SURFACE IN RESERVOIR, IN FEET.
b = BOTTOM WIDTH OF EARTH SPILLWAY AT THE CONTROL SECTION, IN FEET.
Q = TOTAL DISCHARGE, IN C.F.S.
V = VELOCITY, IN FEET PER SECOND, THAT WILL EXIST IN CHANNEL BELOW CONTROL SECTION, AT DESIGN Q, IF CONSTRUCTED TO SLOPE (S) THAT IS SHOWN.
S = FLATTEST SLOPE (S), IN % ALLOWABLE FOR CHANNEL BELOW CONTROL SECTION.
X = MINIMUM LENGTH OF CHANNEL BELOW CONTROL SECTION, IN FEET.
z = SIDE SLOPE RATIO (2:1).

NOTES:
1. FOR A GIVEN Hp A DECREASE IN THE EXIT SLOPE FROM S AS GIVEN IN THE TABLE DECREASES SPILLWAY DISCHARGE, BUT INCREASING THE EXIT SLOPE FROM S DOES NOT INCREASE DISCHARGE. IF AN EXIT SLOPE (Se) STEEPER THAN S IS USED, THEN THE VELOCITY (Ve) IN THE EXIT CHANNEL WILL INCREASE ACCORDING TO THE FOLLOWING RELATIONSHIP:
$$Ve = V\left(\frac{Se}{S}\right)^{0.3}$$
2. DATA TO RIGHT OF HEAVY VERTICAL ON FIGURE SB-11 SHOULD BE USED WITH CAUTION, AS THE RESULTING SECTIONS WILL BE EITHER POORLY PROPORTIONED OR HAVE VELOCITIES IN EXCESS OF 6 FT/SEC.




**Design Elevations:** The design storm elevation through the emergency spillway shall be at least 1.0 feet below the top of the embankment. The crest of the emergency spillway channel shall be at least 1.0 feet above the crest of the principal spillway.

**Location:** The emergency spillway channel shall be located so that it will not be constructed over fill material. The channel shall be located so as to avoid sharp turns or bends. The channel shall return the flow of water to a defined channel downstream from the embankment.

**Spillway variables** (see Figure 5- 75 and Table 5. 34): Emergency spillways are to provide for passage of the design flow at a safe velocity to a point downstream where the embankment will not be endangered. The maximum permissible velocity in the exit channel shall be 4 feet per second for vegetated channels in soils with a plasticity index of 10 or less and 6 feet per second for vegetated channels in soils with a plasticity index greater than 10 (based on laboratory analysis). For exit channels with erosion protection other than vegetation, the velocities shall be non-erosive for the type of protection used.

The emergency spillway channel shall return the flow to the receiving channel at a non-eroding velocity.

*Table 5. 34 Design Data for Earth Spillways When Used as Emergency Spillway*

| STAGE (Hp) IN FEET | SPILLWAY VARIABLES | BOTTOM WIDTH (b) IN FEET | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 |
| 0.5 | Q | 6 | 7 | 8 | 10 | 11 | 13 | 14 | 15 | 17 | 18 | 20 | 21 | 22 | 24 | 25 | 27 | 28 |
| | V | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |
| | S | 3.9 | 3.9 | 3.9 | 3.9 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| | X | 32 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| 0.6 | Q | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 35 | 37 | 39 |
| | V | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | S | 3.7 | 3.7 | 3.7 | 3.7 | 3.6 | 3.7 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| | X | 36 | 36 | 36 | 36 | 36 | 36 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 |
| 0.7 | Q | 11 | 13 | 16 | 18 | 20 | 23 | 25 | 28 | 30 | 33 | 35 | 38 | 41 | 43 | 44 | 46 | 48 |
| | V | 3.2 | 3.2 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| | S | 3.5 | 3.5 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 |
| | X | 39 | 40 | 40 | 40 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| 0.8 | Q | 13 | 16 | 19 | 22 | 26 | 29 | 32 | 35 | 38 | 42 | 45 | 46 | 48 | 51 | 54 | 57 | 60 |
| | V | 3.5 | 3.5 | 3.5 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 | 3.6 |
| | S | 3.3 | 3.3 | 3.3 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 |
| | X | 44 | 44 | 44 | 44 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| 0.9 | Q | 17 | 20 | 24 | 28 | 32 | 35 | 39 | 43 | 47 | 51 | 53 | 57 | 60 | 64 | 68 | 71 | 75 |
| | V | 3.7 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| | S | 3.2 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 |
| | X | 47 | 47 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 49 | 49 | 49 | 49 | 49 | 49 | 49 |
| 1.0 | Q | 20 | 24 | 29 | 33 | 38 | 42 | 47 | 51 | 56 | 61 | 63 | 68 | 72 | 77 | 81 | 86 | 90 |
| | V | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| | S | 3.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | X | 51 | 51 | 51 | 51 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 52 |
| 1.1 | Q | 23 | 28 | 34 | 39 | 44 | 49 | 54 | 60 | 65 | 70 | 74 | 79 | 84 | 89 | 95 | 100 | 105 |
| | V | 4.2 | 4.2 | 4.2 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 |
| | S | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| | X | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 | 56 |
| 1.2 | Q | 28 | 33 | 40 | 45 | 51 | 58 | 64 | 69 | 76 | 80 | 86 | 92 | 98 | 104 | 110 | 116 | 122 |
| | V | 4.4 | 4.4 | 4.4 | 4.4 | 4.4 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| | S | 2.9 | 2.9 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| | X | 58 | 58 | 59 | 59 | 59 | 59 | 59 | 59 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| 1.3 | Q | 32 | 38 | 46 | 53 | 58 | 65 | 73 | 80 | 86 | 91 | 99 | 106 | 112 | 119 | 125 | 133 | 140 |
| | V | 4.5 | 4.6 | 4.6 | 4.6 | 4.6 | 4.6 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 | 4.7 |
| | S | 2.8 | 2.8 | 2.8 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 |
| | X | 62 | 62 | 62 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 64 | 64 | 64 | 64 | 64 | 64 |
| 1.4 | Q | 37 | 44 | 51 | 59 | 66 | 74 | 82 | 90 | 96 | 103 | 111 | 119 | 127 | 134 | 142 | 150 | 158 |
| | V | 4.7 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.8 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 | 4.9 |
| | S | 2.8 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 |
| | X | 65 | 66 | 66 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 68 | 68 | 68 | 68 | 68 | 69 |
| 1.5 | Q | 41 | 50 | 58 | 66 | 75 | 85 | 92 | 101 | 108 | 116 | 125 | 133 | 142 | 150 | 160 | 169 | 178 |
| | V | 4.8 | 4.9 | 4.9 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.1 | 5.1 | 5.1 |
| | S | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 |
| | X | 69 | 69 | 70 | 70 | 71 | 71 | 71 | 71 | 71 | 71 | 71 | 72 | 72 | 72 | 72 | 72 | 72 |
| 1.6 | Q | 46 | 56 | 65 | 75 | 84 | 94 | 104 | 112 | 122 | 132 | 142 | 149 | 158 | 168 | 178 | 187 | 197 |
| | V | 5.0 | 5.1 | 5.1 | 5.1 | 5.1 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 | 5.2 |
| | S | 2.6 | 2.6 | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| | X | 72 | 74 | 74 | 75 | 75 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 | 76 |
| 1.7 | Q | 52 | 62 | 72 | 83 | 94 | 105 | 115 | 126 | 135 | 145 | 156 | 167 | 175 | 187 | 196 | 206 | 217 |
| | V | 5.2 | 5.2 | 5.2 | 5.3 | 5.3 | 5.3 | 5.3 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| | S | 2.6 | 2.6 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| | X | 76 | 78 | 79 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| 1.8 | Q | 58 | 69 | 81 | 93 | 104 | 116 | 127 | 138 | 150 | 160 | 171 | 182 | 194 | 204 | 214 | 226 | 233 |
| | V | 5.3 | 5.4 | 5.4 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 |
| | S | 2.5 | 2.5 | 2.5 | 2.5 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |
| | X | 80 | 82 | 83 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 | 84 |
| 1.9 | Q | 64 | 76 | 88 | 102 | 114 | 127 | 140 | 152 | 164 | 175 | 188 | 201 | 213 | 225 | 235 | 248 | 260 |
| | V | 5.5 | 5.5 | 5.5 | 5.6 | 5.6 | 5.6 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 | 5.7 |
| | S | 2.5 | 2.5 | 2.5 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |
| | X | 84 | 85 | 86 | 87 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 |
| 2.0 | Q | 71 | 83 | 97 | 111 | 125 | 138 | 153 | 164 | 178 | 193 | 204 | 218 | 232 | 245 | 256 | 269 | 283 |
| | V | 5.6 | 5.7 | 5.7 | 5.7 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 |
| | S | 2.5 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 |
| | X | 88 | 90 | 91 | 91 | 91 | 91 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 | 92 |
| 2.1 | Q | 77 | 91 | 107 | 122 | 135 | 149 | 162 | 177 | 192 | 207 | 220 | 234 | 250 | 267 | 276 | 291 | 305 |
| | V | 5.7 | 5.8 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | S | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 |
| | X | 92 | 93 | 95 | 95 | 95 | 95 | 95 | 95 | 95 | 96 | 96 | 96 | 96 | 96 | 96 | 96 | 96 |
| 2.2 | Q | 84 | 100 | 116 | 131 | 146 | 163 | 177 | 194 | 210 | 224 | 238 | 253 | 269 | 288 | 301 | 314 | 330 |
| | V | 5.9 | 5.9 | 6.0 | 6.0 | 6.0 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.1 | 6.2 | 6.2 | 6.2 | 6.2 |
| | S | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 |
| | X | 96 | 98 | 99 | 99 | 99 | 99 | 99 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 2.3 | Q | 90 | 108 | 124 | 140 | 158 | 175 | 193 | 208 | 226 | 243 | 258 | 275 | 292 | 306 | 323 | 341 | 354 |
| | V | 6.0 | 6.1 | 6.1 | 6.1 | 6.2 | 6.2 | 6.2 | 6.2 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 | 6.3 |
| | S | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| | X | 100 | 102 | 102 | 103 | 103 | 103 | 104 | 104 | 104 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 |
| 2.4 | Q | 99 | 116 | 136 | 152 | 170 | 189 | 206 | 224 | 241 | 260 | 275 | 294 | 312 | 327 | 346 | 364 | 378 |
| | V | 6.1 | 6.2 | 6.2 | 6.3 | 6.3 | 6.3 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 |
| | S | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| | X | 105 | 105 | 106 | 107 | 107 | 108 | 108 | 108 | 108 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |

**Cross Sections:** Emergency spillways shall be trapezoidal and be located in undisturbed earth. The side slopes shall be 2:1 or flatter. The bottom width shall be a minimum of 8 feet. The embankment requirements shall determine elevation differences between the crest of the emergency spillway and the settled top of dam.

**Component Parts:** Emergency spillways are open channels and consist of an inlet channel, control section, and an exit channel. The emergency spillway shall be sufficiently long to provide protection from breaching.

**Inlet Channel:** The inlet channel shall be level and straight for at least 20 feet upstream of the control section. Upstream from this level area it may be graded back towards the basin to provide drainage. The alignment of the inlet channel may be curved upstream from the straight portion.

**Exit Channel:** The grade of the exit channel of a constructed spillway shall fall within the range established by discharge requirements and permissible velocities. The exit channel shall carry the design flow downstream to a point where the flow will not discharge onto the toe of the embankment. The design flow should be contained in the exit channel without the use of dikes. However, if a dike is necessary, it shall have 2:1 or flatter side slopes, a minimum top width of 8 feet, and be high enough to contain the design flow plus 1 foot of freeboard.

**Emergency Spillway – Construction Specifications:** Do not construct vegetative emergency spillways over fill material. Design elevations, widths, and entrance and exit channel slopes are critical to the successful operation of the spillway and should be adhered to closely during construction.

### Structural Spillways Other Than Pipe

Structural spillways other than pipe systems will have structural designs based on sound engineering data with acceptable soil and hydrostatic loadings as determined on an individual site basis.

When used as a principal spillway, structural spillways shall meet the flow requirements for principal spillways and shall not be damaged by the emergency spillway design storm. When used as a combination principal emergency spillway, it shall pass the storm runoff from the appropriate storm in Table 5. 33.

### Embankment Design

**Height:** The effective height of the dam for an embankment detention basin is 15 feet or less. The effective height of the dam is defined as the difference in elevation in feet between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam becomes the upper limit. Additional design guidance can be found in the USDA-NRCS Conservation Practice Standard, Pond, Code 378. Sediment basins that exceed the above conditions shall be designed to meet the criteria in USDA-NRCS Earth Dams and Reservoirs, Technical Release 60 (TR-60).

**Embankment Cross-Section:** For embankments of less than 10 feet, the embankment must have a minimum top width of 6 feet, and the side slopes shall be 2:1 or flatter. For embankments 10 to 14 feet in height, the minimum top width shall be 8 feet and the side slopes shall be 2-1/2:1 or flatter. For 15-foot-high embankments (maximum allowed under this practice), the minimum top width shall be 10 feet with 2-1/2:1 side slopes or flatter.

**Site Preparation:** Areas under the embankment and any structural works related to the basin shall be cleared, grubbed, and stripped of topsoil to remove trees, vegetation, roots, or other unsuitable material. In order to facilitate cleanout and restoration, the area of most frequent inundation (measured from the top of the principal spillway) will be cleared of all brush and trees.

**Foundation Cutoff:** A foundation cutoff, constructed with relatively impermeable materials, shall be provided for all embankments. The cutoff trench shall be excavated along the centerline of the dam. The trench must extend at least 2 feet into undisturbed foundation soils. The cutoff trench shall extend up both abutments to the emergency spillway crest elevation. The width shall be wide enough to permit operation of compaction equipment (4 feet minimum). The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be kept free from standing water during the backfilling operations.

**Seepage Control:** Seepage control is to be included if seepage may create swamping downstream, if needed to ensure a stable embankment, or if special problems require drainage for a stable embankment. Seepage control may be accomplished by foundation, abutment or embankment drains, reservoir blanketing or a combination of these and other measures.

**Foundation:** The area on which an embankment is to be placed shall consist of material that has sufficient bearing strength to support the embankment without excessive consolidation.

### Earth Embankment Design

**Freeboard:** The minimum elevation of the top of the settled embankment shall be 1.0 foot above the water surface in the reservoir with the emergency spillway flowing at design depth.

**Materials:** The fill material for the embankment shall be from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, over- sized stones, rocks, manmade materials, or other perishable or unsuitable material. The material selected must have enough strength for the dam to remain stable and be impervious enough, when properly compacted, to prevent excessive seepage through the dam. Impervious portions of the embankment shall consist of at least 15% clay or silt. Using the Unified Soil Classification System (See Appendix E), SC (clayey sand), GC (clayey gravel) and CL (“low liquid limit” clay) are among the preferred types of embankment soils. SM, ML and GM type soils may also be used. Fill material should be selected based on laboratory analysis.

Allowance for Settlement: The design height of the embankment shall be increased by the amount needed to ensure that, after all settlement and consolidation has taken place, the height of the dam will equal or exceed the design height. This increase shall not be less than 10% when compaction is by hauling equipment or 5% if controlled compaction is used, except where detailed soil testing and laboratory analysis shows that a lesser amount is adequate.

Compaction: Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material shall contain the proper amount of moisture to ensure that at least 90% – 95% standard proctor compaction will be achieved. Fill material will be placed in 9-inch continuous layers over the entire length of the fill. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one wheel or tread track of the equipment, or by using a compactor. Special care shall be taken in compacting around the anti-seep collars and principal spillway system to avoid damage and achieve desired compaction (compact by hand, if necessary).

### Provisions for Maintenance Sediment Removal

Sediment basin designs shall include provisions for the periodic removal of accumulated sediments, including adequate access for excavating and hauling equipment, dewatering and the threshold of sediment deposition that triggers the sediment removal operation. Additionally, disposal sites for the removed sediments shall be planned. See measures found in the Dewatering Functional Group and the Stockpile Management measure.

### Sediment Storage Markers

Detail the location and installation requirements for sediment storage stakes or other means of showing the threshold elevation for sediment cleanout.

### Stabilization of Disturbed Areas

The embankment, emergency spillway, spoil and borrow areas, and other disturbed areas above normal water level shall be vegetatively stabilized in accordance with the Permanent Seeding or Sodding measures or otherwise provided with a non-erodible surface.

### Construction Specifications

Construction specifications shall be included either on the plans or contained in a supplemental document referenced by and accompanying the plans. The construction specifications identify all material and operational specifications that are required by the design. The construction specifications must include but are not limited to design requirements for site preparation, foundation cutoff, seepage control, foundation construction, materials for principal and emergency spillways, vegetation establishment, and sediment storage markers.

## Installation Requirements

Construct in accordance with the design plans and construction specifications.

### Site Preparation

Clear, grub, and strip topsoil to remove trees, vegetation, roots, or other unsuitable material from areas under the embankment or any structural works related to the basin. Clear and grub the area of most frequent inundation (measured from the top of the outlet control structure) of all brush and trees to facilitate clean out and restoration.

### Install Sediment Controls for Contributing Areas

Install sediment controls to trap sediment before it enters and leaves the detention basin construction site.

Stabilize the dam and emergency spillway in accordance with the engineered design, stabilize the spoil and borrow areas, and other disturbed areas in accordance with the Temporary Seeding or Permanent Seeding measures.

### Safety

Install safety features and devices to protect humans and animals from such accidents as falling or drowning. Temporary fencing can be used until barrier plantings are established. Use protective measures such as guardrails and fences on spillways and impoundments as needed.

## Maintenance

Inspect the temporary sediment basin at least once a week and within 24 hours of the end of a storm that generates a discharge[63] to determine conditions in the basin. Clean the sediment basin of sediments when sediment accumulation exceeds one half of the wet storage capacity of the basin or when the depth of available pool is reduced to 18 inches, whichever is achieved first. Sediment levels shall be marked within the sediment storage area by stakes or other means showing the threshold elevation for sediment cleanout.

Prior to the removal of sediments, dewater the basin through pumping or other means to the expose previously submerged sediments. Use measures found in the Dewatering Functional Group and the Stockpile Management measure. Do not allow accumulated sediment to flush into the stream or drainageway. Stockpile the sediment in such a manner that it will not erode from the site or into a wetland, watercourse, or other sensitive area.

Sediment removal, transportation and disposal shall occur as shown on the plans as limited by the design criteria.

## Temporary Sediment Basin: Design Example 1

Determining Volume in a Temporary Sediment Basin to Meet Sediment Storage Volume and Detention Storage Volume Requirements

[63] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

One-hundred acres drain into a planned temporary sediment basin. Failure of the sediment basin at the planned site will not result in loss of life or damage to buildings, roads, railroads or utilities. Ten acres are to be cleared and developed into houses. Ninety acres are in woods and will not be disturbed during the life of the sediment basin. It is estimated it will take 18 months to develop the site. The temporary sediment basin will be installed as the first item of construction and removed as the last item of construction. The owner estimates that the ten acres to be developed will be bare for 12 months and under roofs, pavement, and sod for the last six months of construction. The soils are Agawam fine sandy loam on a flat slope. The sediment pool will be normally dry. The 10-year, 24-hour rainfall is 5.0 inches.

Determine sediment storage volume using the following method:

Determine, DA - Drainage Area and A - Average Annual Erosion

1st year

Woods

(DA) (A) = 90 ac x 0.2 tons/ac/yr. = 18 tons/yr.

Construction Area

(DA) (A) = 10 ac x 50 tons = 500 tons/yr.

(DA) (A) = 518 tons for the 1st year.

2nd year

Woods

(DA) (A) = 90 ac x 0.2 tons/ac/yr. = 18 tons/yr. Urban Area

(DA) (A) = 10 ac x 1.0 tons/ac/yr. = 10 tons/yr.

(DA) (A) = (18 + 10) = 14 tons for 2nd year for six-month life

(DA) (A) = 518 + 14 = 532 tons for the life of the basin.

Determine DR - delivery ratio

100/640 = 0.16 sq mi from Figure SB-12 for a sandy soil, DR = 24%.

Determine γ - density of the sediment. From Table 5. 29 the density of submerged sand is 85-100 lbs./cu. ft., Use γ = 90 lbs./cu. ft.

Determine TE trap efficiency. The TE is 80 % from the sediment storage volume section of the Sediment Basin measure.

Determine V - minimum volume for sediment storage for the planned life of the structure using the formula:

V = (DA)(A)(DR)(TE)(2,000lbs./ton)

(γ)(43,560sq.ft./ac)

V = (532) (0.24) (0.80) (1/90) (2,000) (1/43,560)

V = 0.052 Ac. ft. for sediment storage. Determine detention storage volume.

Given that:

$Q_{10}$ = 30 cfs and

$V_r$ = 1.30 inches

Then:

Qi = 30 cfs    Vr = 1.3

$$\frac{Q_{10}}{D_A} = \frac{30}{100} = 0.30$$

$$\frac{Q_0}{Q_i} = 0.27$$

**Q10 =** 30

**DA =** 100

**Qo =** 8.1 cfs = maximum allowable principal spillway discharge.

**Qo =** (0.27) (Qi ) = (0.27) (30) = 8.1 cfs

$$Release\ Rate = \frac{(8.1\ \text{cfs})\ (640\ \text{Ac./sq. mi.})}{100\ acres} = 51.8\ csm$$

**Vr =** 1.3 inches

From the figures in the Detention Basin measure for single stage structures with release rates less than 300 csm, the minimum storage required, Vs, is 0.67 inches.

$$V_s = \frac{(0.67\ \text{in.})\ (100\ \text{Ac.})}{12in/ft} = 5.58\ acre - ft$$

Vs = 5.58 Ac. ft. for detention storage volume.

The minimum volume required below the crest of the emergency spillway is 0.052 Ac. ft. plus 5.58 Ac. ft. or 5.63 Ac. ft.

### Temporary Sediment Basin: Design Example 2

Same as Design Example 1 except the soil is Hollis fine sandy loam on a steep slope. Determine sediment storage volume using method given in Example No. 1.

(DA) (A) same as in Design Example 1

(DA) (A) = 518 tons for the 1st year

(DA) (A) = 14 tons for the 2nd year Determine, DR - delivery ratio.

The Hollis soil is a fine sandy loam. Using the Soil Survey Report, this soil would be approximately 60% sand and 40% silt. Using Figure SB-12 with 0.16 sq. mi. drainage area and a value between the sandy and silty curves, the delivery ratio is 45%.

Determine, γ- density of sediment. γ = 95 lbs./cubic ft., using Table 5. 29 with sand-silt mixture. The trap efficiency is the same as Design Example No. 1 and is 80%.

Determine minimum volume for sediment storage for the planned life structure using the formula:

$$V = \frac{(\mathrm{DA})(\mathrm{A})(\mathrm{DR})(\mathrm{TE})(2{,}000\mathrm{lbs./ton})}{(43{,}560\mathrm{sq.ft./ac})}$$

V = (518 + 14) (0.45) (0.80) (1/95) (2,000) (1/43,560)

**V =** 0.093 Ac. ft. for sediment storage

Determine detention storage volume.

Given that:

**Qi =** Q10 = 285 cfs Vr = 2.89 inches and DA = 100 acres

Then:

$$\frac{Q_i}{D_A} = \frac{285}{100} = 2.89$$

From Figure SB-13

$$\frac{Q_o}{Q_i} = 0.066$$

$$\mathrm{Qo} = (0.066)\ (\mathrm{Qi}) = (0.066)\ (285)$$

**Qo =** 0.066

**Qo =** 18.8 cfs (the maximum allowable principal spillway discharge rate)

$$Q_o = \frac{18.8\mathrm{cfs}}{100 acres}\ \frac{640\ acres}{1mi^2} = 120.3\ csm$$

when Vr = 2.89 inches V5 is 1.65 inches

**Vs =** 1.65 inches $= \frac{(1.65\ \mathrm{in.})\ (100\ \mathrm{Ac.})}{12\ in/ft}$ = 13.75 Ac. ft.

**Vs =** 13.75 Ac. ft. for detention storage volume

The minimum volume required below the crest of the emergency spillway is 0.093 Ac. ft. for sediment storage volume plus 13.75 Ac. ft. for detention storage volume or 13.84 Ac. ft.

### Conclusions From Design Examples

To have a reasonable size sediment basin that is effective, two components are critical. The total drainage area must be small, and the volume of runoff must be low. To accomplish this requires good vegetative cover and soils with high infiltration rates.

## Temporary Sediment Trap

### Definition

A temporary ponding area with a stone outlet formed by excavation and/or constructing an earthen embankment.

## Purpose

To detain sediment-laden runoff from small, disturbed areas long enough to allow a majority of the sediment to settle out.

## Applicability

Below disturbed areas where the contributing drainage area is 5 acres or less. For drainage areas greater than 5 acres use Temporary Sediment Basin measure.

- Where the intended duration of use is 2 years or less. For durations greater than 2 years, use Temporary Sediment Basin.
- When diverting sediment-laden water with temporary diversions that meet the above limitations for use.
- Avoid placing temporary sediment traps directly in the line of flow. If placed in the line of flow, peak flows must be addressed.

## Planning Considerations

Sequence the construction of temporary sediment traps, along with other perimeter erosion and sediment controls, so that they are constructed and made functional before land disturbance in the contributing drainage area takes place.

The temporary sediment trap has two storage requirements: one for wet storage and one for dry storage. Commonly, the wet storage is created by excavation within a drainageway, and the dry storage created by the construction of a pervious stone dike across the drainageway. Sometimes the trap is formed, at least in part, by the construction of an embankment. Such an embankment constitutes a dam and is therefore limited to a height of no greater than 5 feet and requires care in its construction.

E&S plans should identify the size of the contributing drainage area, wet and dry storage requirements as well as the volume of sediment accumulation that will trigger trap cleaning. Sediment is required to be removed from the trap when the sediment accumulation exceeds half of the wet storage volume of the trap. The plans should also ensure that access is provided for sediment removal and detail how excavated sediment will be disposed (such as by use in fill areas on-site or removal to an approved off-site location).

Variations in temporary sediment trap design may be considered, but plan reviewers should ensure the minimum storage requirements and structural requirements noted below are achieved.

## Specifications

### Location

Locate temporary sediment traps so that they can be installed prior to conducting any grading activities in the contributing watershed. Do not locate traps in close proximity to existing or proposed building foundations if there is any concern regarding seepage of water from the temporary sediment trap into the foundations or foundation excavation area. Locate traps to obtain maximum storage benefit from the terrain, for ease of clean out and disposal of the trapped sediment.

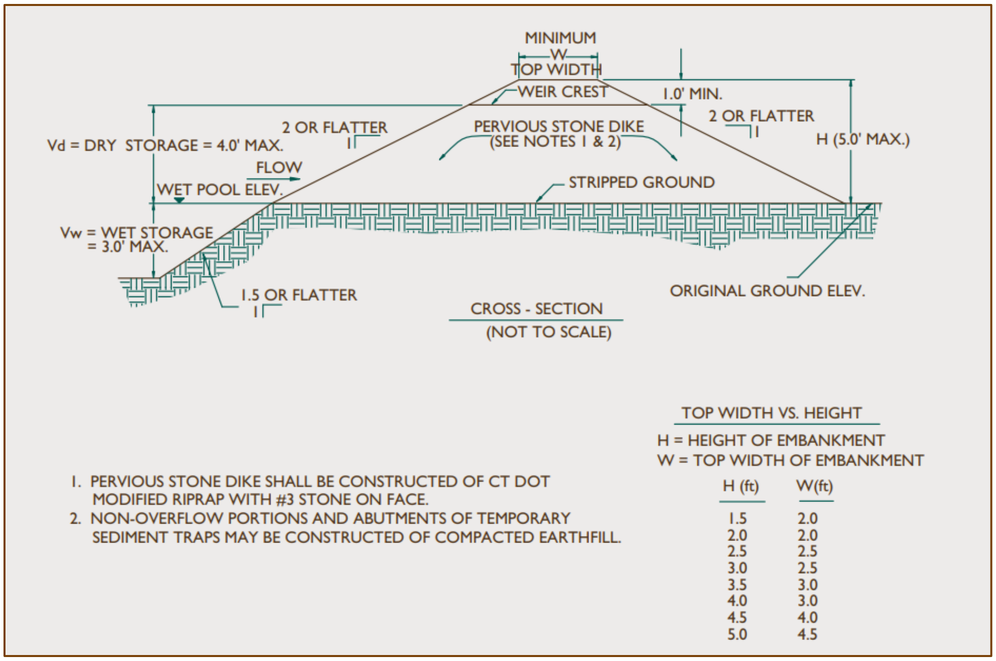
Temporary sediment traps should not be located in the proposed locations of permanent, post-construction stormwater BMPs (i.e., retention/infiltration, treatment, or stormwater quantity control BMP). Fine soil particles in sediment trapped by the temporary sediment trap will seal the underlying soils of the sediment trap and the future infiltration capacity of the soils may be significantly reduced. If no other options exist, and a post-construction stormwater BMP must be sited in the location of a temporary sediment trap, the temporary sediment trap must be modified to prepare it for long-term use including, at a minimum, removal of any accumulated sediments, restoration of the pre-construction infiltration capacity of the underlying soils (including field infiltration testing of the soils for infiltration-based BMPs), and other structural modifications in accordance with the BMP-specific design guidance in the Connecticut Stormwater Quality Manual, as amended.

### Trap Capacity

The temporary sediment trap shall have an initial storage volume of 134 cubic yards per acre of drainage area, half of which shall be in the form of wet storage to provide a stable settling medium. The remaining storage volume shall be in the form of a drawdown (dry storage) which will provide extended settling time during less frequent, larger storm events. Equation 5. 7 contains the formulas for calculating the wet storage volume and the dry storage volume. The volume of wet storage shall be measured from the low point of the excavated area to the base of the stone outlet structure (see Figure 5- 76). The volume of the dry storage shall be measured from the base of the stone outlet to the top of the stone outlet (overflow mechanism).

Try to provide a storage area which has a minimum 2:1 length to width ratio (measured from point of maximum runoff introduction to outlet).

*Figure 5- 76 Minimum Top Width (w) Required for Temporary Sediment Trap Embankments According to Height of Embankment (feet), Source: USDA-NRCS*



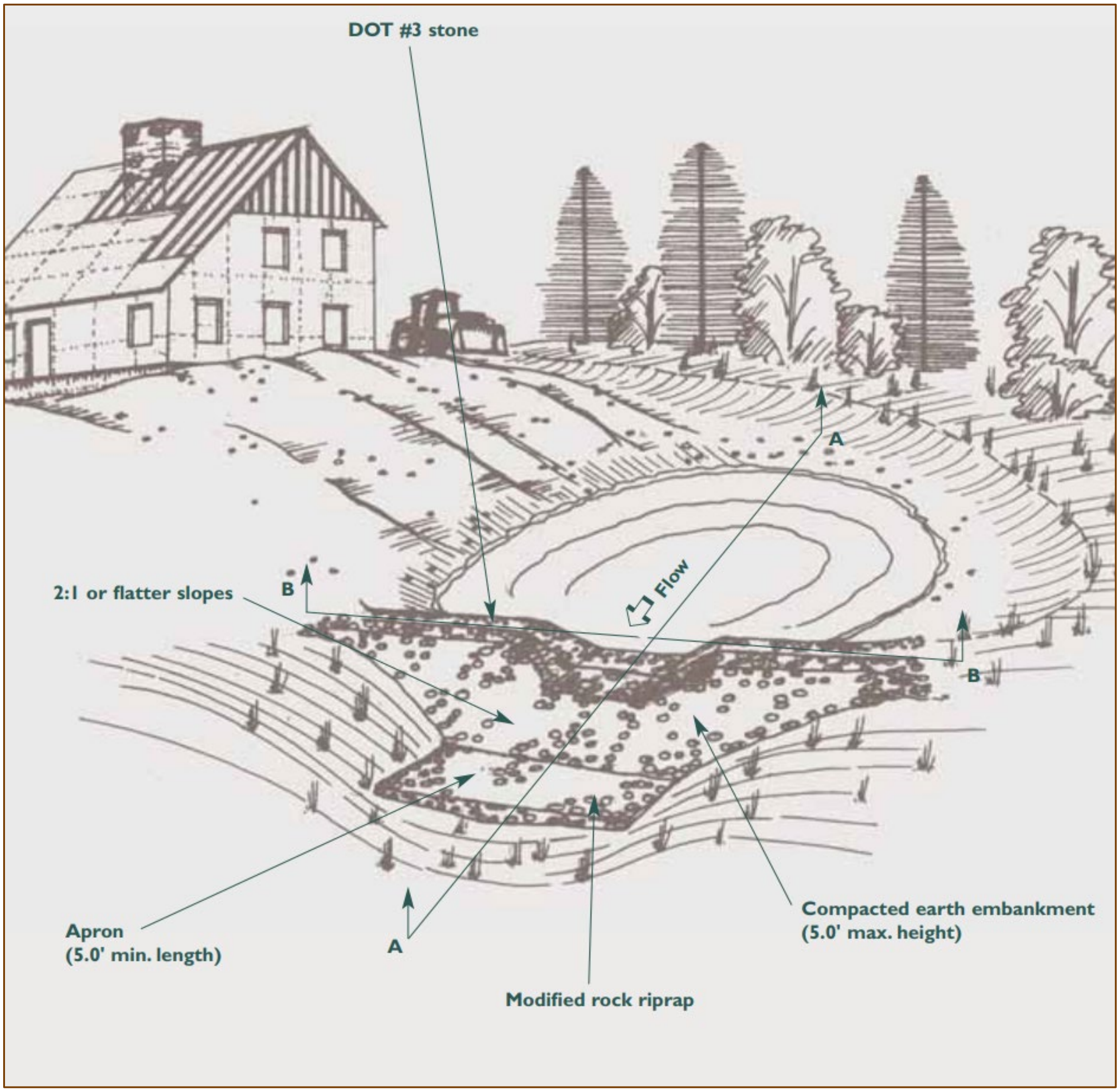

## Slope Limitations

All cut and fill slopes shall be 2:1 or flatter except for the excavated wet storage area where slopes shall not exceed 1.5:1. The maximum depth of excavation within the wet storage area should not exceed 3 feet to facilitate clean-out and for site safety considerations.

## Inlet / Outlet Configuration

The outlet shall be located at the most distant hydraulic point from the inlet. In cases where a long narrow site runs perpendicular to the direction of flow, baffles consisting of stone dikes or other structurally sufficient barriers should be added along the long axis of the trap to increase travel distance through the trap (see Figure 5- 77).

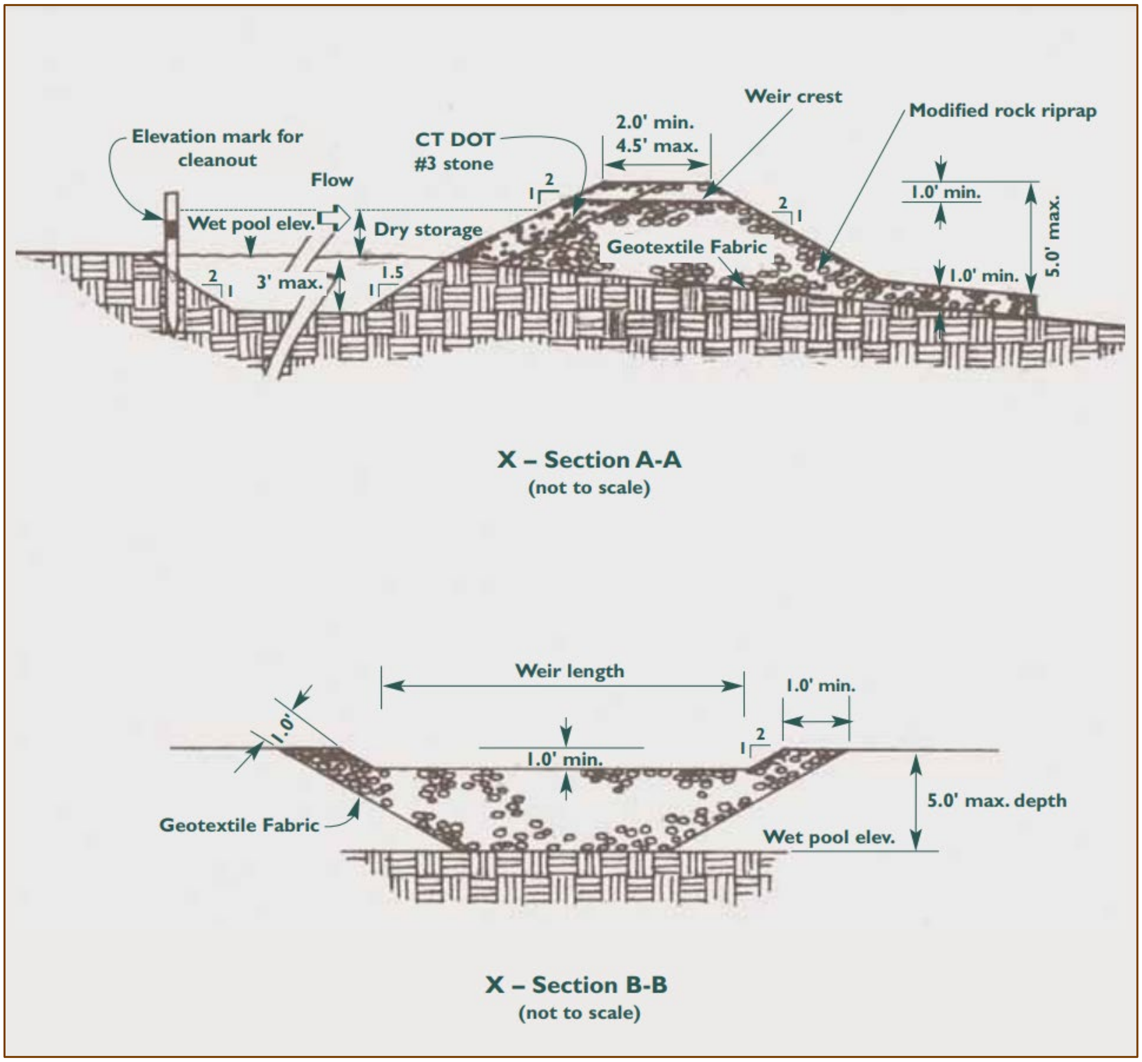
*Figure 5- 77 Example plan Views of Baffles in Temporary Sediment Traps*




## Outlet

Plan the outlet in such a manner that the minimum wet storage and dry storage volumes are created (see Trap Capacity section above) and 1 foot of freeboard between the top of the outlet and the crest of the embankment is established. The outlet consists of a pervious stone dike with a core of modified riprap and faced on the upstream side with CTDOT #3 stone. Temporary sediment traps must outlet onto stabilized (preferably undisturbed) ground, into a watercourse, stabilized channel, or into a storm drain system. Figure 5- 78 shows an example of an outlet for a temporary sediment trap.

*Figure 5- 78 Views of a Temporary Sediment Trap Outlet*




## Embankment

The maximum height of a temporary sediment trap embankment is limited to 5 feet as measured vertically from the crest of the embankment to the down slope base of the embankment or toe of the stone dike, whichever is lower. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in Figure 5- 76. Side slopes of the embankment shall be 2:1 or flatter.

## Materials

Modified Riprap: shall meet the requirements of CTDOT Standard Specifications Section M.12.02.

CTDOT #3 Stone: shall meet the requirements of CTDOT Standard Specifications Section M.01.01 for #3 Aggregate.

### Construction

Clear, grub, and strip any vegetation and root mat from any proposed embankment and outlet area. Remove stones and rocks whose diameter is greater than 3 inches and other debris.

Excavate wet storage and construct the embankment and/or outlet as needed to attain the necessary storage requirements. Use only fill material for the embankment that is free from excessive organics, debris, large rocks (over 6 inches) or other unsuitable materials. Compact the embankment in 9-inch layers by traversing with equipment while it is being constructed.

Stabilize the earthen embankment using any of the following measures: Temporary Seeding, Permanent Seeding, or Stone Slope Protection immediately after installation.

Carry out construction operations in such a manner that erosion and water pollution are minimized.

*Equation 5. 7 Formula for Determining Temporary Sediment Trap Storage Requirements*

Wet storage volume may be approximated as follows:

$$Vw = 0.85 \times Aw \times Dw$$

where,

Vw = the wet storage volume in cubic feet

Aw = the surface area of the flooded area at the base of the stone outlet in square feet

Dw = the maximum depth in feet, measured from the low point in the trap to the base of the stone outlet.

Dry storage volume may be approximated as follows:

$$Vw = \frac{A_w + A_D}{2} x D_d$$

Where,

Vd=the dry storage volume

Aw=the surface area of the flooded area at the base of the stone outlet in square feet.

Ad=the surface area of the flooded area at the top of the stone outlet (overflow mechanism), in square feet

Dd=the depth in feet, measured from the base of the stone outlet to the top of the stone outlet

Note: Conversion between cubic feet and cubic yards is cubic feet x 0.037 = cubic yards

### Maintenance

Inspect the temporary sediment trap at least once a week and within 24 hours of the end of a storm that generates a discharge.[64] Check the outlet to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be maintained at least 1 foot below the crest of the embankment. Also check for sediment accumulation and filtration performance.

When sediments have accumulated to one half the minimum required volume of the wet storage, dewater the trap as needed, remove sediments, and restore the trap to its original dimensions. Dispose of the sediment removed from the basin in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

The temporary sediment trap may be removed after the contributing drainage area is stabilized. If it is to be removed, then the plans should show how the site of the temporary sediment trap is to be graded and stabilized after removal.

## Inlet Protection[65]

### Definition

A temporary, somewhat permeable barrier, installed around storm drainage inlets in the form of a fence, berm, or excavation around an opening, trapping and filtering water and thereby reducing the sediment content of sediment laden water by settling.

- "External inlet protection" products are installed in or around storm grates. External inlet protection devices are usually fitted to the size of the manhole grate structure. These devices capture sediment before it enters the manhole.
- "Internal inlet protection" products are installed inside the manhole structure. Internal inlet filters capture sediment after it enters the manhole structure.

### Purpose

- To prevent sediment from entering storm drains and waterways.

### Applicability

- All storm drains on any active jobsite should be protected by an inlet protection device, including storm drains installed in gravel parking lots.
- This measure shall be used where the drainage area to an inlet is disturbed, it is not possible to temporarily divert the storm drain outfall into a trapping device, and watertight blocking of inlets is not advisable.
- It is not to be used in place of sediment trapping devices.

[64] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours.
[65] Guidance adapted from Rhode Island Soil Erosion and Sediment Control Handbook (Revised August 2014).

## Planning Considerations

### General

- The E&S plan should include inlet protection for all stormwater inlets on the site.
- Since there are many different types of manufactured inlet protection products, designers should match the sediment removal capabilities of the selected products with specific site and job requirements. Manufacturer's recommendations should be followed for product selection, installation, and maintenance.
- The types of inlet protection measures addressed in this section include:
    - Excavated Drop Inlet Protection
    - Geotextile Filter Fabric Drop Inlet Protection
    - Stone & Block Drop Inlet Protection
    - Curb Drop Inlet Protection
    - Manufactured external inlet protection devices
    - Manufactured internal inlet filters

## Design Criteria

### General

- The drainage area for storm drain inlets shall not exceed one acre.
- The crest elevations of these measures shall provide storage and minimize bypass flow.

### Excavated Drop Inlet Protection

- Excavated side slopes shall be no steeper than 2:1.
- The minimum depth shall be 1 foot and the maximum depth 2 feet as measured from the crest of the inlet structure.
- Shape the excavated basin to fit conditions with the longest dimension oriented toward the longest inflow area to provide maximum trap efficiency.
- The capacity of the excavated basin should be established to contain 900 cubic feet per acre of disturbed area.

### Geotextile Filter Fabric Drop Inlet Protection

- Land area slope immediately surrounding this device should not exceed 1 percent.
- The maximum height of the fabric above the inlet crest shall not exceed 1.5 feet unless reinforced.
- The top of the barrier should be maintained to allow overflow to drop into the drop inlet and not bypass the inlet to unprotected lower areas.
- Support stakes for fabric shall be a minimum of 3 feet long, spaced a maximum 3 feet apart. They should be driven close to the inlet so any overflow drops into the inlet and not on the unprotected soil.
- Improved performance and sediment storage volume can be obtained by excavating the area.
- Straw bales or filter socks can also be used instead of geotextile filter fabric.

#### Stone and Block Drop Inlet Protection

- The stone barrier should have a minimum height of 1 foot and a maximum height of 2 feet. Do not use mortar. The height should be limited to prevent excess ponding and bypass flow.
- As an optional design, the concrete blocks may be omitted and the entire structure constructed of stone, ringing the outlet ("doughnut").

#### Curb Drop Inlet Protection

- The wire mesh must be of sufficient strength to support the filter fabric and stone with the water fully impounded against it. Stone is to be 2 inches in size and clean. The filter fabric must be of a type approved for this purpose with an equivalent opening size (EOS) of 40-85. The protective structure will be constructed to extend beyond the inlet 2 feet in both directions.
- Traffic safety shall be integrated with the use of this measure.

#### Manufactured Inlet Filters

- External devices include filter bags that encase the drain grate. These devices are fitted to the specific drainage opening size. Raised or pop-up filter devices are likewise manufactured to custom fit over various drainage opening sizes.
- Internal manufactured inlet filters (also called catch basin inserts) are also fitted to the specific drain opening size. These devices are placed inside the drainage structure and under the drain grate. They can be composed of a metal frame and filter bag, while other devices are manufactured using fabric only.

## Installation Requirements

### Excavated Drop Inlet Protection

- Shape the excavated basin to fit conditions with the longest dimension oriented toward the longest inflow area to provide maximum trap efficiency.
- Weep holes, protected by fabric and stone, should be provided for draining the temporary pool.

#### Geotextile Filter Fabric Drop Inlet Protection

- If straw bales are used in lieu of filter fabric, they shall be placed tight with the cut edge adhering to the ground at least three (3) inches below the elevation of the drop inlet. Two anchor stakes per bale shall be driven flush to bale surface.
- If filter socks are used in lieu of filter fabric, they shall be placed with the ends of the socks abutting one another and shall be secured in a manner that is consistent with manufacturer's recommendations.

#### Stone and Block Drop Inlet Protection

- Recess the first course of blocks at least 2 inches below the crest opening of the storm drain for lateral support. Subsequent courses can be supported laterally if needed by placing a 2x4 inch wood stud through the block openings perpendicular to the course. The bottom row should have a few blocks oriented so flow can drain through the block to dewater the basin area.
- The stone should be placed just below the top of the blocks on slopes of 2:1 or flatter. Place hardware cloth of wire mesh with ½ inch openings over all block openings to hold stone in place.
- If concrete blocks are omitted and the entire structure constructed of stone, the stone should be kept at a 3:1 slope toward the inlet to keep it from being washed into the inlet. A level area one (1) foot wide and four (4) inches below the crest will further prevent wash. Stone on the slope toward the inlet should be at least three (3) inches in size for stability and one (1) inch or smaller away from the inlet to control flow rate. The elevation of the top of the stone crest must be maintained six (6) inches lower than the ground elevation down slope from the inlet to ensure that all storm flows pass over the stone into the storm drain and not past the structure. Temporary diking should be used as necessary to prevent bypass flow.

#### Curb Drop Inlet Protection

- Ensure that storm flow does not bypass the inlet by installing temporary dikes (such as sandbags) directing flow into the inlet.
- Make sure that the overflow weir is stable.

#### Manufactured Inlet Filters

- Install manufactured inlet filter devices in accordance with manufacturer's installation instructions.

### Maintenance

- Inspect inlet protection measures at least once a week and within 24 hours of the end of a storm that generates a discharge.[66]
- Dispose of sediment properly.
- Remove all inlet protection devices within 30 days of permanent site stabilization.

#### Excavated Drop Inlet Protection

- Inspect and clean the excavated basin after every storm.

[66] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

- Sediment should be removed when 50 percent of the storage volume is achieved. This material should be incorporated into the site in a stabilized manner.

### Geotextile Filter Fabric Drop Inlet Protection

- Inspect the fabric barrier after each rain event and make repairs as needed.
- Remove sediment from the pool area as necessary with care not to undercut or damage the filter fabric.
- Upon stabilization of the drainage area, remove all materials and unstable sediment and dispose of properly. Bring the adjacent area of the drop inlet to grade, smooth and compact and stabilize in the appropriate manner to the site.
- If straw bales are used in lieu of filter fabric, straw bales shall be replaced every 4 months until the area is stabilized.
- If filter socks are used in lieu of filter fabric, filter socks shall be replaced as needed based on condition and in accordance with the manufacturer's recommendations.

### Stone and Block Drop Inlet Protection

- The barrier should be inspected after each rain event and repairs made where needed.
- Remove sediment as necessary to provide for accurate storage volume for subsequent rains.
- Upon stabilization of contributing drainage area, remove all materials and any unstable soil and dispose of properly.
- Bring the disturbed area to proper grade, smooth, compact, and stabilized in a manner appropriate to the site.

### Curb Drop Inlet Protection

- The structure should be inspected after every storm event.
- Any sediment should be removed and disposed of on the site.
- Any stone missing should be replaced.
- Check materials for proper anchorage and secure as necessary.

### Manufactured Inlet Filters

- Inspect after each rain event.
- Inspect external devices for damage and clean as necessary.
- Lift internal inlet filters carefully from the drainage structure.
- Remove any accumulated sediment and reinsert device into the drain opening.
- Remove all accumulated sediment and dispose of properly.

# Filter Sock[67]

## Definition

A temporary sediment barrier consisting of a mulch-filled tube of flexible netting material. Common types of filter socks include:

- Straw wattles – straw-filled tubes of flexible netting materials. Commonly used filler materials include wheat and rice straw.
- Compost filter socks – Three-dimensional tubular filtration devices constructed by filling a mesh tube with a compost filter media.
- Fiber rolls – coconut fiber (coir logs), straw, or excelsior woven roll (wood excelsior fibers) encased in netting of jute, nylon, or burlap

## Purpose

- To intercept sediment laden runoff from small drainage areas of disturbed soil.
- To break up longer slopes, reduce runoff velocity, and cause deposition of transported sediment.
- To retain transported sediment on site and protect adjacent property, resource areas. and wetlands and waterways from unwanted sediment deposition.

## Applicability

- Straw wattles, compost filter socks, and fiber rolls provide alternatives to straw bales and silt fence sediment barriers. See the Applicability sections for these other measures.
- These control measures are placed perpendicular to sheet flow runoff to control erosion and retain sediment in disturbed areas.
- They are not intended for use to define property boundaries, unless designed to reduce stormwater flow coming onto the construction site.
- Wattles, socks, rolls may be biodegradable and left in place, depending upon the intent of the application and material specifications.

## Planning and Design Considerations

### General

- Identify areas within the construction site where erosion may occur.
- Determine areas where sediment has the potential to exit the property or enter an environmentally sensitive area, such as a wetland or waterway.
- Identify longer slopes where multiple barrier rows may be needed to break up the length of slope. Allowable slope lengths for sediment barriers are listed in Table 5. 29.

[67] Guidance adapted from Rhode Island Soil Erosion and Sediment Control Handbook (Revised August 2014).

- Where site disturbance occurs within fifty (50) feet upgradient of a wetland, wetlands, or waters, a double row of sediment barriers shall be installed between the disturbed area and any such downgradient wetland, wetlands, or waters.
- A sediment barrier may be used where erosion would occur in the form of sheet erosion.
- A sediment barrier may be used where there is no concentration of water flowing to the barrier.
- Design calculations are not required for installations of 1 month or less. Longer installation periods should be designed for expected runoff.
- Sensitive areas may require the use of reinforced or multiple materials.

### Straw Wattles and Fiber Rolls

- Wattles and fiber rolls can be used in areas of low shear stress.
- Wattles and fiber Rolls can be suitable in the following settings:
  - Along the toe, top, face, and at-grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow
  - At the end of a downward slope where it transitions to a steeper slope
  - Along the perimeter of a project to control runoff or run-on surface flows
  - As temporary check dams in unlined ditches
  - Downslope of exposed soil areas
  - Around temporary stockpiles.
- Straw wattles and fiber rolls have a very limited sediment capture zone.
- Straw wattles and fiber rolls should not be used on slopes subject to creep, slumping, or landslide.
- Determine the vertical spacing for slope installations on the basis of the slope gradient and soil type and in accordance with manufacturer's recommendations.
- To be effective, wattles and fiber rolls at the toe of slopes greater than 5:1 must be at least 20 inches in diameter. An equivalent installation, such as stacked smaller-diameter fiber rolls, can be used to achieve a similar level of protection.

### Compost Filter Socks

- The drainage area to a compost filter sock generally should not exceed 0.25 acre per 100 feet of device length and flow should not exceed one cubic foot per second.
- Compost filter socks may be used, subject to the slope conditions recommended by the manufacturer. Compost filter socks can be used on steeper slopes with faster flows if they are spaced more closely, stacked beside and/or on top of each other, made in larger diameters, or used in combination with other measures, in accordance with manufacturer's recommendations.
- Compost socks can be useful in protecting areas where trenching is difficult.
- Compost socks may be left in place permanently depending upon location, such as a mid-slope break. In this case they should be vegetated during installation. Compost sock

material may require design consideration. The material may be permanent, photodegradable, or biodegradable depending upon intended use and longevity.

- Compost filter sock materials and compost materials shall be in accordance with AASHTO Designation: MP 9-06 (latest revision). Compost material shall also meet all applicable Federal and State Regulations.
- Larger diameter filter socks are recommended for areas prone to high rainfall or sites with severe grades or long slopes. Coarser compost products are generally used in regions subject to high rainfall and runoff conditions.
- For compost filter socks 18 inches or less in diameter, wooden stakes shall be 1 inch by 1 inch, at 10-foot intervals on center, and of a length that shall project into the soil 1 foot leaving 3 inches to 4 inches protruding above the filter sock.
- For compost filter socks greater than 18 inches in diameter wooden stakes shall be 2 inches by 2 inches, at 10-foot intervals on center, and of a length that shall project into the soil 1 foot leaving 3 inches to 4 inches protruding above the filter sock.

## Installation Requirements

### General

- All sediment barriers shall be placed as close to the disturbed areas as possible, but at least 10 feet from the toe of a slope to allow for maintenance and roll down.
- The area beyond the fence must be undisturbed or stabilized.

### Straw Wattles and Fiber Rolls

- On slopes, install fiber rolls along the contour with a slight downward angle at the end of each row to prevent ponding at the midsection. Turn the ends of each fiber roll upslope to prevent runoff from flowing around the roll. Install fiber rolls in shallow trenches dug 3 to 5 inches deep for soft, loamy soils and 2 to 3 inches deep for hard, rocky soils.
- For soft, loamy soils, place the rows closer together. For hard, rocky soils, place the rows farther apart. Stake fiber rolls securely into the ground and orient them perpendicular to the slope. Biodegradable wood stakes or willow cuttings are recommended. Drive the stakes through the middle of the fiber roll and deep enough into the ground to anchor the roll in place. About 3 to 5 inches of the stake should stick out above the roll, and the stakes should be spaced 3 to 4 feet apart. A 24-inch stake is recommended for use on soft, loamy soils. An 18-inch stake is recommended for use on hard, rocky soils.
- The preferred anchoring method is to drive stakes through the center of the wattle or roll at regular intervals (typically staked in every three to four feet); alternatively, stakes can be placed on the downstream side of the wattle or roll.
- The ends of the wattle or roll should be directed upslope, to prevent stormwater from running around the end of the sock.
- Fiber rolls are not effective unless trenched.

- Fiber rolls can be difficult to move once saturated.
- If not properly staked and entrenched, fiber rolls can be transported by high flows. Straw wattles and fiber rolls must be set in a 2-3" furrow in the soil and staked.

### Compost Filter Socks

- Trenching is not required. Compost filter socks shall be placed over the top of ground. Wooden stakes shall be driven through the center of the filter socks at regular intervals to anchor them to the ground. alternatively, stakes can be placed on the downstream side of the sock. To ensure optimum performance, heavy vegetation shall be cut down or removed, and extremely uneven surfaces shall be graded to ensure that the compost filter sock uniformly contacts the ground surface.
- The ends of the filter sock should be directed upslope, to prevent stormwater from running around the end of the sock.
- The filter sock may be vegetated by incorporating seed into the compost when filling the filter sock. Since compost filter socks do not have to be trenched into the ground, they can be installed on frozen ground, pavement, or concrete. For placement on pavement or concrete, concrete blocks can be placed to hold the sock in place.

## *Maintenance*

### General

- Remove all filter socks once permanent erosion control practices are in place and functioning unless filter socks are designed to remain in place (i.e., compost filter socks with seed).
- Filter sock netting may be cut open and mulch spread out or used elsewhere.
- Inspect filter socks at least once a week and within 24 hours of the end of a storm that generates a discharge.[68]

### Straw Wattles and Fiber Rolls

- Straw wattles and fiber rolls are usually left along slopes and are biodegradable
- Sediment removal and disposal are still required in areas where sediment accumulates to at least one-half the distance between the top of the fiber roll or wattle and the ground surface.

### Compost Filter Socks

- If the filter sock was overtopped during a storm event, the operator should consider installing an additional filter sock on top of the original, placing an additional filter sock further up the slope, or using additional measures in conjunction with the sock(s).

[68] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

- Remove sediment that builds up behind the sock before it interferes with the functionality of the sock. Deposit the removed sediment within the project limits or dispose of legally so that the sediment is not subject to erosion by wind or by water.
- Repair or replace split, torn, or unraveling socks. Replace broken or split stakes. Sagging or slumping compost socks must be repaired with additional stakes or replaced.
- Repair or replace at locations where rills and other evidence of concentrated runoff have occurred beneath the socks

## Straw Bale Barrier

### Definition

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

Hay bales no longer appear in this section as sediment control devices. More current technical information on hay bales and other sediment barrier options reflects the limitations and problems in the use of hay bales as a sediment control measure. While hay bales were used extensively early in the evolution of construction sediment control practices, new innovation and technology, discussed thoroughly in this manual, has replaced them. Straw bales have a useful life of three months while hay bales have a useful life of one month or less. Hay bales are comprised primarily of grasses that still have grain or seeds attached. If not certified as noxious weed-free, hay bales can have undesirable impacts by spreading invasive plants. Therefore, straw bales have replaced hay bales in this manual as the preferred material for baled sediment barriers.

### Purpose

- To intercept and detain small amounts of sediment from small, disturbed areas.
- To decrease the velocity of sheet flows.
- To redirect small volumes of water away from erodible soils.
- To settle and assist in filtering waters discharged from pumping operations (see Pumping Settling Basin measure, Type I and Type II).

### Applicability

- Below small, disturbed areas where the total drainage area (disturbed and undisturbed) is less than 1 acre in size.
- Above disturbed slopes to direct surface water away from erodible areas where the total drainage area (disturbed and undisturbed) is less than 1 acre in size.
- Where protection and effectiveness are required for less than 3 months.
- Where sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas, watercourses, and other sensitive areas.
- Not for use in drainageways, except in special cases where it is applied with other measures (see Geotextile Silt Fence measure).
- Not intended for use in streams.

- Around material stockpiles (see Stockpile Management measure), for storm drain inlet protection (see Inlet Protection measure), and for pumping settling basins (see Pumping Settling Basin measure).

## Planning Considerations

See overall Planning Considerations for Sediment Impoundments, Barriers, and Filters Functional Group.

## Specifications

### Materials

**Straw Bales:** shall contain a minimum 5 cubic feet of straw, with 40 pounds minimum weight and 120 pounds maximum weight, held together by twine or wire. Straw bales should be certified as to being noxious weed-free. To be "certified" means that a product is free of any noxious weeds.

**Stakes for Anchoring:** shall be a minimum of 36 inches long and made of either hardwood with dimensions of at least 1.5 inches square or steel posts with a minimum weight of 0.5 pound per linear foot.

### Placement on the Landscape

Contributing drainage area is no greater than 1 acre. Maximum slope length is as shown in Table 5. 35. Identify longer slopes where multiple rows of straw bale barriers may be needed to break up the length of slope.

**Toe of Slope:** Locate 5-10 feet downgradient from the toe of slope (see Figure SB-2), generally on the contour. When the contour cannot be followed, stagger the bale installation, and install perpendicular wings spaced as shown in Table 5. 35 to break the velocity of water flowing behind the bales. The barrier should be located with sufficient distance from the toe of the slope to allow access by equipment for removal of accumulated sediments

**Swales:** Not recommended. See Geotextile Silt Fence or Check Dam (stone or fiber rolls) measures.

**Catch Basins in Swales on Slopes:** Not recommended. See Geotextile Silt Fence or Check Dam (stone or fiber rolls) measures.

**Catch Basins in Depressions or Low Spots (yard drains):** Encircle catch basin (see Figure SB-3).

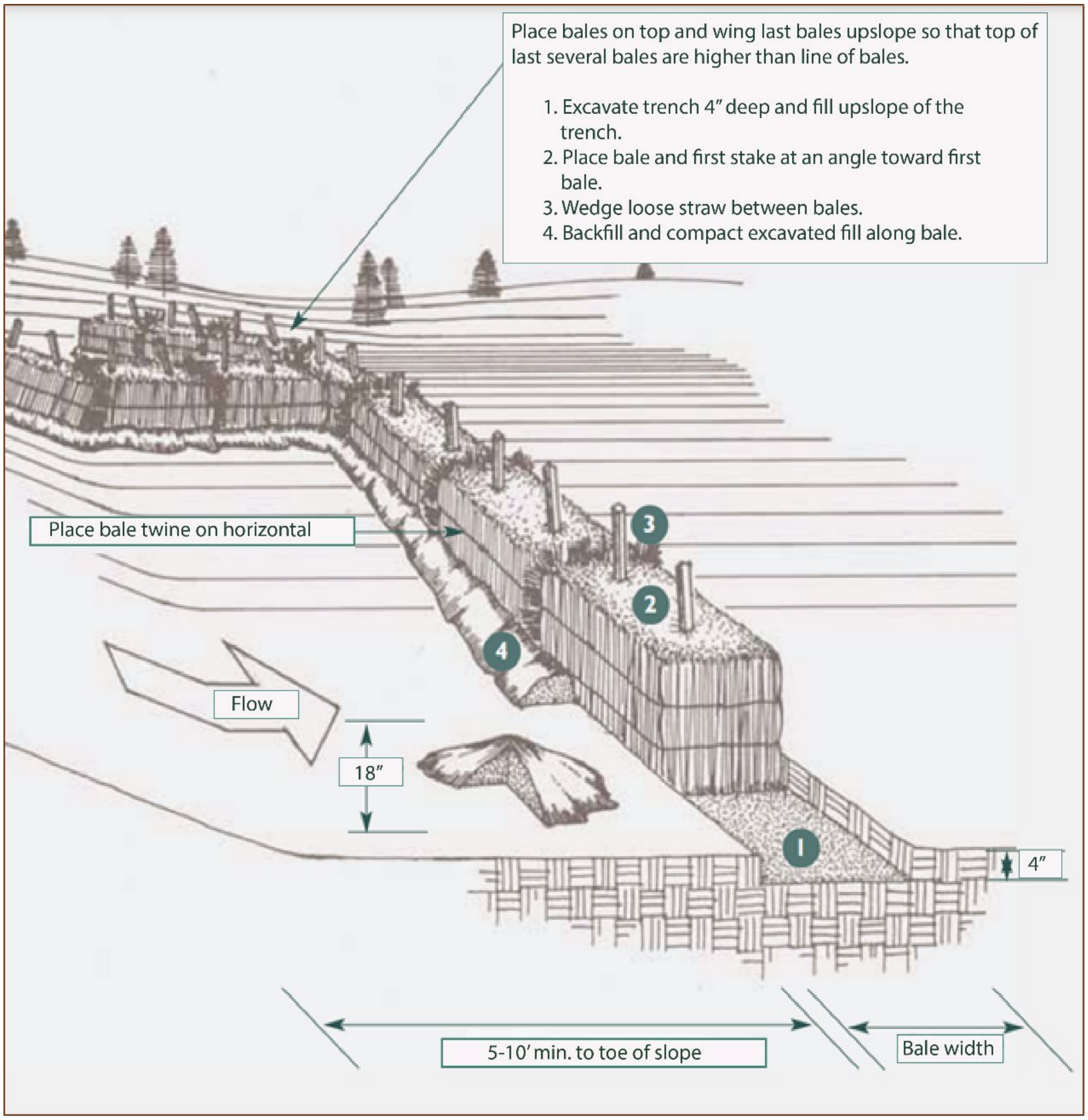
**Culvert Inlets:** Not recommended. See Geotextile Silt Fence or Check Dam (stone or fiber rolls) measures.

**Culvert Outlets:** Not recommended. Use Temporary Sediment Trap and/or Check Dam (stone or fiber rolls) measures.

**Pumping Settling Basin:** See Pumping Settling Basin measure.

## Installation (see Figure 5- 79)

*Figure 5- 79 Straw Bale Installation*




Trench Excavation: Excavate a trench as wide as the bales and at least 4 inches deep. Excavated material should be placed on the upstream side of the trench. Each end of the trench should be winged upslope so that the bottom of the last bale is higher than the top of the lowest straw bale in the barrier.

*Table 5. 35 Straw Bale Design Slope/ Length Limitations**

| Slope Steepness[69] | Slope Length and Wing Spacing |
|---|---|
| 5:1 or Shallower | 100′ |
| 3:1 - 5:1 | 75′ |
| 2:1 - 3:1 | 50′ |

*Also applies to filter socks.

Straw Bale Placement: Place bales in a single row in the trench, lengthwise, with ends of adjacent bales tightly abutting one another and the bindings oriented around the sides rather than along the tops and bottoms of the bales (to avoid premature rotting of the bindings).

Where site disturbance occurs within fifty (50) feet upgradient of a wetland, wetlands, or waters, a double row of straw bale barriers shall be installed between the disturbed area and any such downgradient wetland, wetlands, or waters.

Staking Straw Bales**:** Anchor each bale with at least 2 stakes driven through the bale into the underlying soil at a slight upstream angle, driving the first stake in each bale toward the previously laid bale to force the bales together. Fill any gaps between the bales with straw to prevent water from escaping between the bales. Stakes must be driven a minimum of 18 inches into the ground for both measures.

Backfill & Tamped: Backfill the bales with the excavated trench material to a minimum depth of 4 inches on the uphill side of the bales. Tamp by hand or machine and compact the soil. Loose straw scattered over the disturbed area immediately uphill from the straw bale barrier tends to increase barrier efficiency.

### Substitute Measures

Filter Sock and Geotextile Silt Fence may be used as substitutes. When frozen or other similar ground conditions prevent the proper trenching or anchoring of straw bales, a sediment barrier consisting of a stone check dam with a straw bale or fiber roll core may be substituted for the straw bale barrier. See Check Dam measure, "Special Case Combinations for Added Filtration & Frozen Ground Conditions" for details.

[69] Where the gradient changes through the drainage area the steepest slope section shall be used.

### Maintenance

Inspect straw bale barriers at least once a week and within 24 hours of the end of a storm that generates a discharge[70] to determine maintenance needs. For dewatering operations, inspect frequently before, during, and after pumping operations.

Remove the sediment deposits or install a secondary barrier upslope from the existing barrier when sediment deposits reach approximately one half the height of the barrier (see Figure 5-80).

The useful life span of straw bales is normally 3 months. Therefore, straw bales must be replaced, or a new barrier directly placed upslope of the old when a barrier is required for longer time periods.

Replace or repair the barrier within 24 hours of observed failure. Failure of the barrier has occurred when sediment fails to be retained by the barrier because:

a. the barrier has been overtopped, undercut, or bypassed by runoff water,
b. the barrier has been moved out of position, or
c. the barrier shows signs of deterioration or has been damaged.

When repetitive failures occur at the same location, review conditions and limitations for use and determine if additional controls (e.g., temporary stabilization of contributing area, diversions, stone barriers) are needed to reduce failure rate or replace straw bale barrier. See Table 5. 36 for trouble shooting failures.

Maintain barrier until the contributing area is stabilized.

After the upslope areas have been permanently stabilized, pull the stakes out. Unless otherwise required, no removal or regrading of accumulated sediment is necessary. The straw bales may then be left in place or broken up for ground cover.

[70] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

*Figure 5- 80. Adding Backup Straw Bale Barrier*

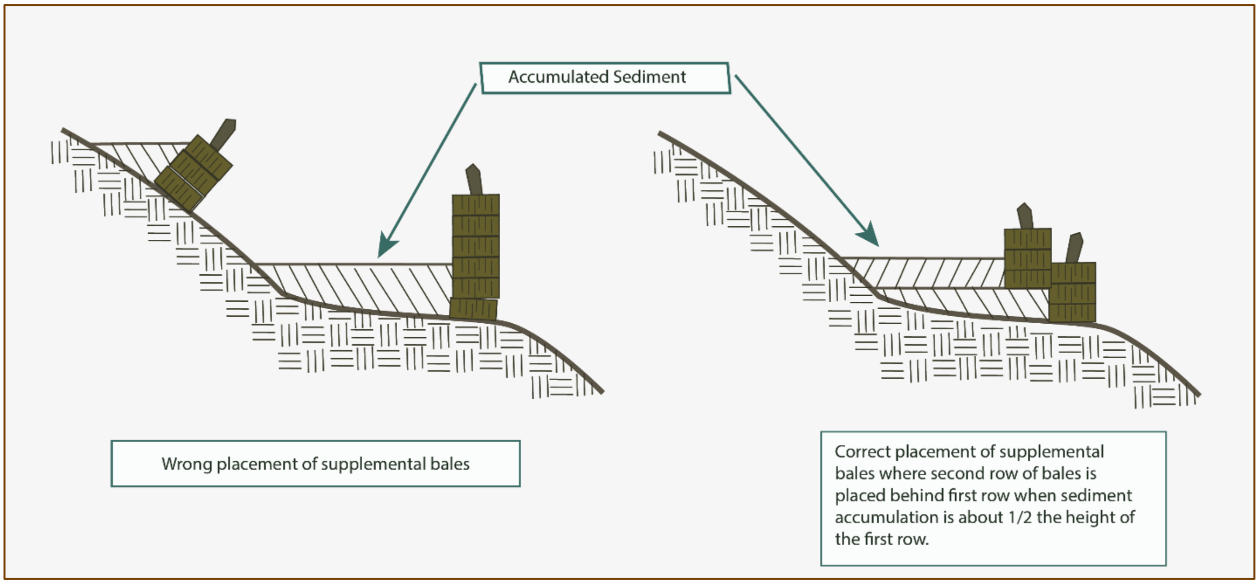


*Table 5. 36 Straw Bale Barrier Trouble Shooting Guide*

| Problem | Cause | Fix |
|---|---|---|
| undercutting | inadequate trenching | reset properly or for small failure backfill downslope rills, fill & compact under barrier, fill joints or overlap barrier at least 3' at joints, backfill up slope side of bale with 4" wedge of wood chips or compacted soil |
| | spaces between bales | |
| | barrier not on the contour, runoff flowing along upslope side of barrier | same as above, and install perpendicular wings to break flow line such that bottom<br>end of wing is higher than top of barrier |
| rilling around end | not extending end of barrier far enough upslope | extend straw bale barrier far enough upslope so that bottom of last bale or filter sock length is higher than top of lowest |
| barrier moved | watershed too large | change to stone barrier or use combination approach |
| | flows too concentrated | change to geotextile silt fence or stone barrier |
| | inadequately staked | fill and compact any rills, reinstall stakes, fill joints, backfill, and compact, increase staking depths |

## Geotextile Silt Fence

### Definition

A temporary sediment barrier consisting of a geotextile fabric pulled taut and attached to supporting posts and entrenched.

### Purpose

- To intercept and retain sediment from disturbed areas.
- To decrease the velocity of sheet flows and low volume concentrated flows.

## Applicability

- Below small, disturbed areas where the contributing drainage area (disturbed and undisturbed) is less than 1 acre in size.
- At stormwater drainage inlets and catch basins where sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas, watercourses, and other sensitive areas (see Inlet Protection measure).
- Not for use in areas where rock, frozen ground, or other hard surface prevents proper installation of the barrier (see Special Case Combinations in Check Dam measure for frozen ground conditions).
- Prohibited from use in drainageways whose flow is supported by groundwater discharge.
- Not intended for use to define property boundaries, unless designed to reduce stormwater flow coming on to the construction site.

## Planning Considerations

See Planning Considerations for Sediment Impoundments, Barriers, and Filters Functional Group.

When used at a culvert outlet, plan to install the geotextile silt fence before the start of construction and complete the installation of the required outlet protection before the culvert is made functional. It is preferable to control sediment at the inlets rather than at the outlet. Use at outlets should be limited to situations where inlet protection is not possible or to act as a backup to inlet protection.

## Specifications

### Materials

**Geotextile fabric:** shall be a pervious sheet of polypropylene, nylon, polyester, ethylene, or similar filaments and shall be certified by the manufacturer or supplier as conforming to the requirements shown in Table 5. 37. The geotextile shall be non-rotting, acid, and alkali resistant, and have sufficient strength and permeability for the purpose intended, including handling and backfilling operations. Filaments in the geotextile shall be resistant to absorption. The filament network must be dimensionally stable and resistant to de-lamination. The geotextile shall be free of any chemical treatment or coating that will reduce its permeability. The geotextile shall also be free of any flaws or defects which will alter its physical properties. Torn or punctured geotextiles shall not be used.

**Supporting posts:** shall be at least 42 inches long made of either 1.5 inch square hardwood stakes or steel posts (standard T or U section) weighing not less than 1 pound per linear foot, with projections for fastening the geotextile possessing a minimum strength of 0.5 pound per linear foot.

### Placement on the Landscape

Contributing drainage area 1 acre or less. Maximum slope length is as shown in Table 5. 38. Identify longer slopes where multiple rows of geotextile silt fence may be needed to break up the length of slope.

Where site disturbance occurs within fifty (50) feet upgradient of a wetland, wetlands, or waters, a double row of silt fence shall be installed between the disturbed area and any such downgradient wetland, wetlands, or waters.

**For toe of slope** (Figure 5- 81): Locate 5-10 feet downgradient from the toe of slope, generally on the contour with maintenance and sediment removal requirements in mind. When the contour cannot be followed, install the fence such that perpendicular wings are created to break the velocity of water flowing along the fence. See Table 5. 38 for spacing requirements.

**Swales** (see Figure 5- 82): Locate "U" shape across swale such that the bottom of both ends of the fence are higher than the top of the lowest section of the fence.

**Catch Basins in Swale on Slopes:** Locate 2 "U" shapes across swale as above: one immediately upslope from the catch basin and the other immediately downslope from the catch basin.

**Catch Basins in Depressions:** Encircle catch basin.

**Culvert Inlets:** Locate in a "U" shape approximately 6 feet from the culvert in the direction of the incoming flow.

**Culvert Outlets:** Locate across the swale at least 6 feet from the culvert outlet.

*Table 5. 37 Geotextile Silt Fencing Minimum Requirements*

| Physical Property | Test Method | Minimum Requirement |
|---|---|---|
| **filtering efficiency** | ASTM 5141 | **75% (min)** |
| **grab tensile strength (lbs.)** | ASTM D4632 | **100 lbs.** |
| **elongation @ failure** | ASTM D4632 | **15 %** |
| **Mullen burst strength** | ASTM D3786 | **250 psi** |
| **puncture strength** | ASTM 4833 | **50 lbs.** |
| **apparent opening size** | ASTM D4751 | **no greater than 0.90 mm and no less than 0.60 mm** |

| | | |
|---|---|---|
| **flow rate** | ASTM D4491 | **0.2 gal/ft2/min** |
| **permittivity** | ASTM D4491 | **0.05 sec. -1 (min)** |
| **ultraviolet radiation stability %** | **ASTM-D4355** | **70% after 500 hours of exposure (min)** |

*Table 5. 38 Geotextile Silt Fence Slope/ Length Limitations*

| Slope Steepness[71] | Slope Length and Wing Spacing |
|---|---|
| 5:1 or Shallower | 100′ |
| 3:1 - 5:1 | 75′ |
| 2:1 - 3:1 | 50′ |

[71] Where the gradient changes through the drainage area the steepest slope section shall be used.

## Installation (see Figure 5- 81)

*Figure 5- 81 Toe of Slope Installations with Wings*

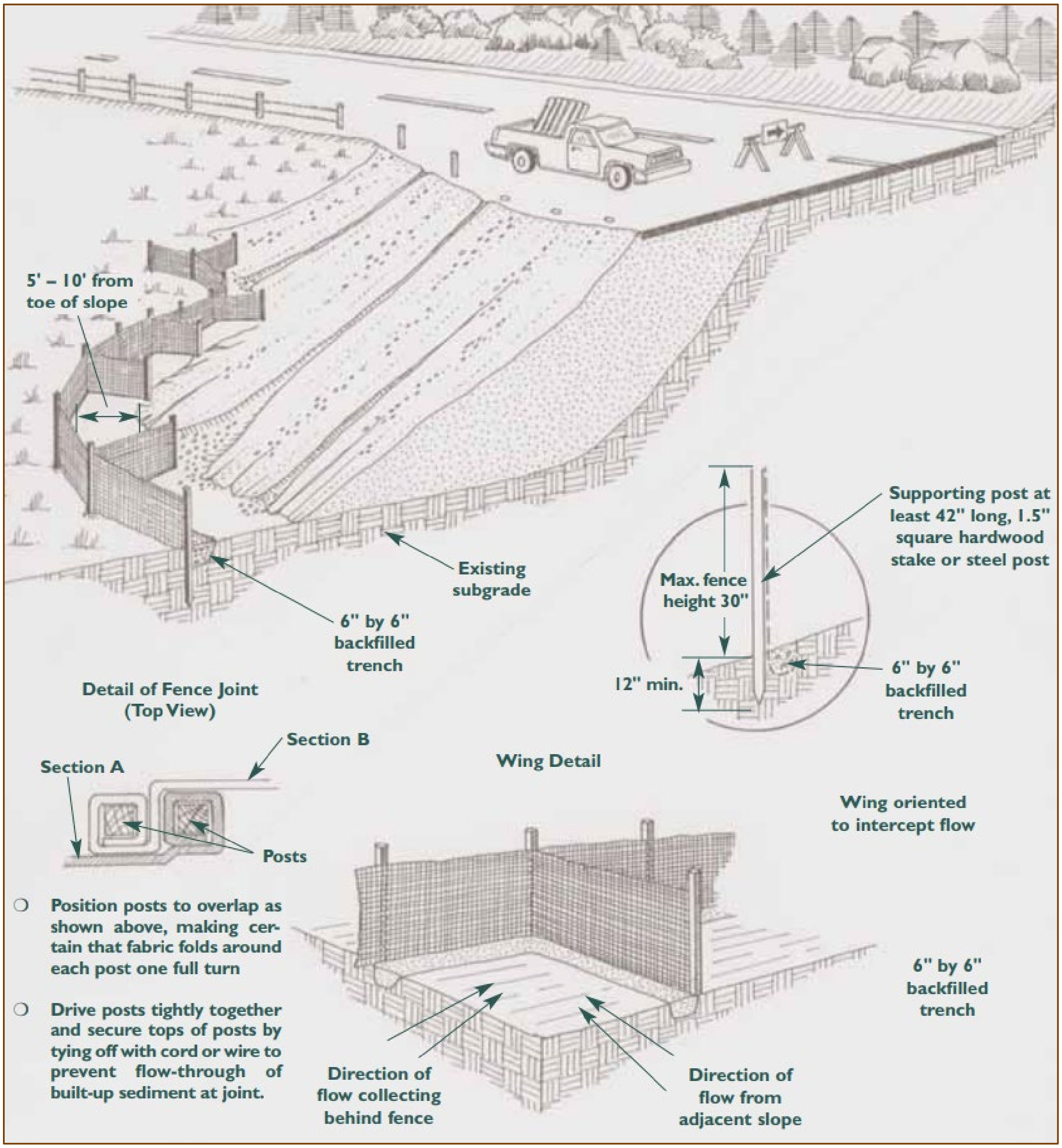
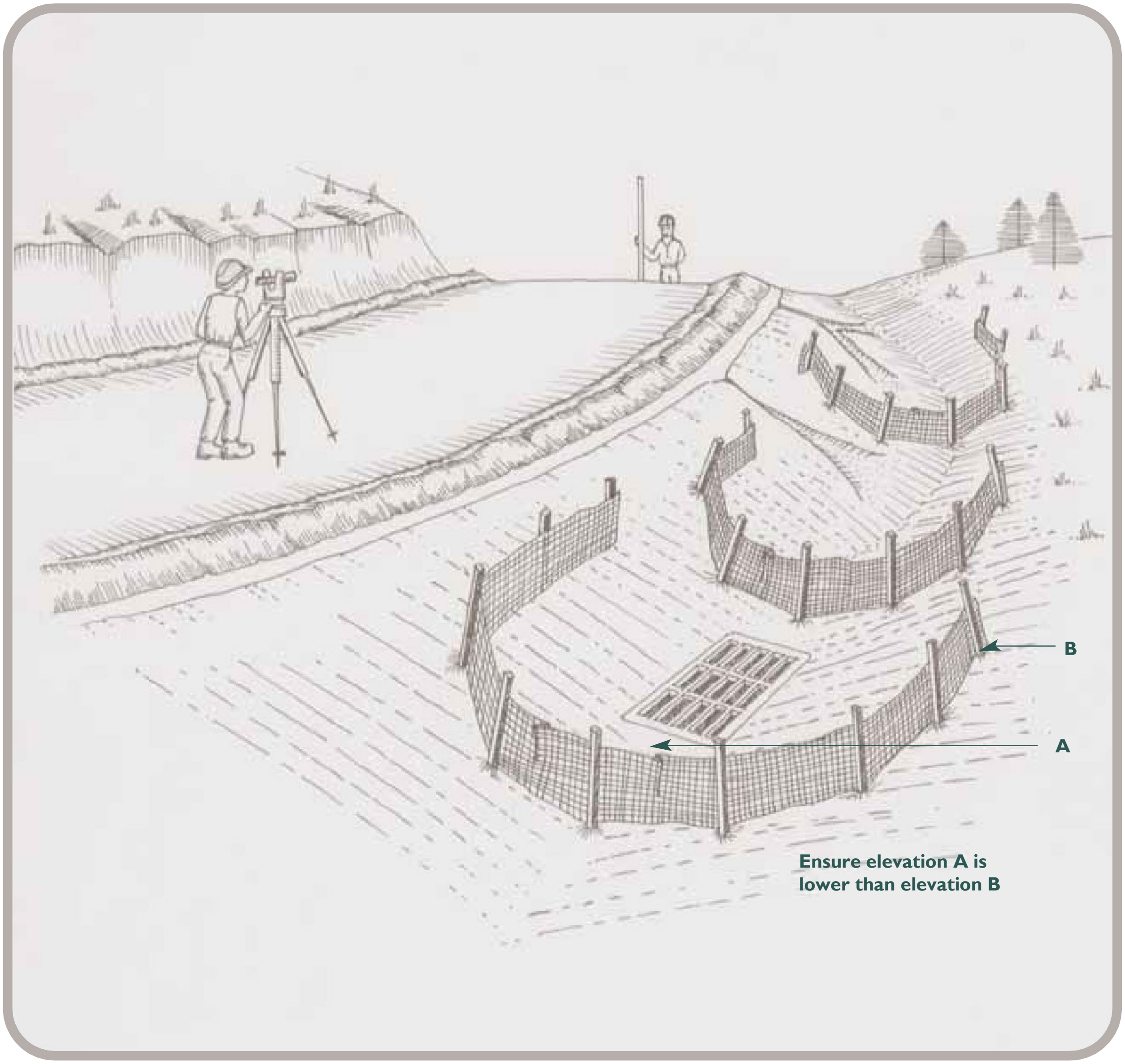


*Figure 5- 82 Swale and Catch Basin Installations*




**Trench Excavation:** Excavate a trench a minimum of 6 inches deep and 6 inches wide on the upslope side of the fence location. For slope and swale installations, extend the ends of the trench sufficiently up slope such that bottom end of the fence will be higher than the top of the lowest portion of the fence.

When the fence is not to be installed on the contour, excavate wing trenches spaced at the intervals given in Table 5. 38.

When trench excavation is obstructed by an occasional stone or tree root, provide a smooth transition between the trench bottom and the obstruction.

**Support Posts:** Drive support posts on the down slope side of the trench to a depth of at least 12 inches into original ground.

Never install support posts more than 10 feet apart. Install support posts closer than 10 feet apart when concentrated flows are anticipated or when steep contributing slopes and soil conditions are expected to generate larger volumes of sediment. For catch basins in hollows, drive posts at each corner of the catch basin. Whenever the geotextile filter fabric that is used exceeds the minimum material specifications contained in this measure, the spacing of the stakes shall be per manufacturer's recommendations.

**Geotextile Filter Fabric:**

Silt fence can be installed by hand or by machine slicing. Fabric should be buried at least six inches deep. Termination points should be extended uphill at least 6 feet. Where ends of filter cloth come together, they shall be overlapped, folded, and stapled to prevent sediment bypass.

Staple or secure the geotextile to the support posts per manufacturer's instruction such that at least 6 inches of geotextile lies within the trench, the height of the fence does not exceed 30 inches[72] and the geotextile is taut between the posts. When the trench is obstructed by stones, tree roots, etc. allow the geotextile to lay over the obstruction such that the bottom of the geotextile points up slope.

In the absence of manufacturer's instructions, space wire staples on wooden stakes at a maximum of 4 inches apart and alternate their position from parallel to the axis of the stake to perpendicular.

Do not staple the geotextile to living trees.

Provide reinforcement for the fence when it can be exposed to high winds or in sensitive areas for added support to prevent collapse.

When joints in the geotextile fabric are necessary, splice together only at a support post and securely seal (see manufacturer's recommendations).

**Backfill & Compaction:** Backfill the trench with tamped soil or aggregate over the geotextile (see Figure 5- 81). When the trench is obstructed by a stone, tree root, etc. make sure the bottom of the geotextile lies horizontal on the ground with the resulting flap on the upslope side of the geotextile and bury the flap in 6 inches of tamped soil, or aggregate.

[72] Higher barriers may impound volumes of water sufficient to push over the support posts.

## Maintenance

Inspect silt fence at least once a week and within 24 hours of the end of a storm that generates a discharge[73] to determine maintenance needs. When used for dewatering operations, inspect frequently before, during and after pumping operations.

Remove the sediment deposits or, if room allows, install a secondary silt fence upslope of the existing fence when sediment deposits reach approximately one half the height of the existing fence.

Replace or repair the fence within 24 hours of observed failure. Failure of the fence has occurred when sediment fails to be retained by the fence because:

a) the fence has been overtopped, undercut, or bypassed by runoff water,
b) the fence has been moved out of position (knocked over), or
c) the geotextile has decomposed or been damaged.

When repetitive failures occur at the same location, review conditions and limitations for use and determine if additional controls (e.g., temporary stabilization of contributing area, diversions, stone barriers) are needed to reduce failure rate or replace fence. See Table 5. 39 for trouble shooting failures.

Maintain the fence until the contributing area is stabilized.

After the contributing area is stabilized determine if sediment contained by the fence requires removal or regrading and stabilization. If the depth is greater than or equal to 6 inches, regrading or removal of the accumulated sediment is required. No sediment removal or regrading is required if sediment depth is less than 6 inches.

Once the site is stabilized, remove the fence by pulling up the support posts and cutting the geotextile at ground level. Regrade or remove sediment as needed and stabilize disturbed soils. To reduce these maintenance needs consider biodegradable options.

[73] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

*Table 5. 39 Silt Fence Trouble Shooting Guide*

| Problem | Cause | Fix |
|---|---|---|
| fence fallen over or stakes broken from pressure of water | too large drainage area | Change to stone check dams or add additional controls upslope to reduce velocities and sediment loading (see measure matrix, Chapter 4 for other measures available). |
| | flows too concentrated | Repair or replace fence, increase staking frequency, angle stake up slope, consider installing straw bale barrier on the downslope side of fence in area of concentration or adding guy wire for support. |
| | stake not driven deep enough geotextile not properly attached to stakes | Repair or replace fence, increase stake depth. Recheck manufacturer's instructions on attachment and re-attach. |
| undercutting, toe failure | poor trenching or inadequate compaction, not enough geotextile buried | Install new fence properly or retrench, fill & compact rills at fence failure, drive stakes deeper as necessary to bury enough geotextile, fill & compact trench, and downslope rills to provide support. For repeated failures consider installing straw bale barrier on the downslope side at the failure site after repair work is done. |
| | fence not on the contour, runoff eroding up slope side of barrier | Retrench, fill & compact rills at fence failure, and install perpendicular wings to break flow line such that bottom end of wing is higher than top of fence at wing joint OR install stone barriers on upslope side of fence to reduce runoff velocities. For repeated failures consider installing straw bale barrier on the downslope side at the failure site after repair work is done. |
| | poor transition from trench to obstruction at grade | Fill failed area to make smooth transition from trench to obstruction and re-bury flap of geotextile with 6 inches of tamped soil or aggregate. For repeated failures consider installing straw bale barrier on the downslope side at the failure site after repair work is done. |
| water running around ends | not extending end of fencing far enough up slope | Extend fence far enough up slope so that bottom of fence end is higher than top of lowest portion of fence, overlap joints at least 6 inches. |

## Turbidity Curtain

### Definition

A temporary, impervious barrier installed in a stream, river, lake, or tidal area which will retain silts, sediment, and turbidity within the construction area. The turbidity curtain is weighted at the bottom of the curtain while supported at the top through a flotation system.

## Purpose

- To promote the settling of suspended solids in water.
- To protect water quality and aquatic habitat in streams, rivers, lakes, and tidal areas.

## Applicability

- Where construction activities will take place immediately adjacent to or within tidal and non-tidal watercourses and sediment movement into the water is unavoidable.
- Where other sediment barriers will not be effective in preventing the movement of sediment in the water.
- Where water velocity in the area needing control will not exceed 5 feet per second (or a current of approximately 3 knots). For situations where there are greater flow velocities or currents, a qualified engineer and product manufacturer must be consulted.

## Planning Considerations

Turbidity curtains are designed to deflect and contain sediment-laden water within a limited area and/or provide enough residence time so that soil particles will fall out of suspension and not travel to other areas. Turbidity curtains should not be used as an alternative to land-based erosion and sediment control measures. However, when proximity to a watercourse or waterbody precludes the use of other types of erosion control measures, the use of a turbidity curtain during land disturbance is essential. An engineer should be consulted in determining which type of turbidity curtain should be used and when consultation with the manufacture is needed.

If waters are in the U.S. Coast Guard jurisdiction be sure to check with their local marine safety officer to be sure the curtain is not in the boat channel and if boom lights are required.

One of the most important considerations, when contemplating the use of turbidity curtains, is how the removal of the curtain and any contained sediments will impact the water quality and aquatic habitat. Determine if sediment removal will be needed and provide for the necessary disposal. In some cases, more environmental damage could be caused by sediment removal than if the curtain were not installed in the first place.

### Channel Flow Applications

Considerations must be given to the direction of water movement in channel flow situations. Turbidity curtains are not designed to act as water impoundment dams and cannot be expected to stop the flow of significant volumes of water. They are designed and installed to isolate construction waters from clean water and trap sediments within a confinement area, without halting the movement of non- construction waters. Turbidity curtains shall not be extended across flowing watercourses or channels.

### Tidal and /or High Wind and Wave Applications

In tidal or wind and wave action situations, the curtain should never touch bottom. A minimum 1-foot gap should be maintained between the curtain and the bottom. It is also seldom practical to extend a turbidity curtain deeper than 10 to 12 feet. Curtains installed deeper will be subject to very large loads which will strain the material and mooring systems.

## Specifications

### Turbidity Curtain Types

There are four turbidity curtain types. The type used must be based on the flow conditions within the water body (i.e., a flowing channel, lake, pond, or a tidal watercourse) at the proposed site of installation:

a) Type I (flatwater): An area that is calm and protected with no current, such as small lakes, ponds, canals and protected non-tidal shoreline areas. In these areas the curtain may extend to the bottom of the installation area. If the curtain is deeper than the installation area and lies freely on the bottom, it may load with silt, causing problems in curtain removal.

b) Type II (lightweight): An area that is semi-protected with current up to 2 feet/second such as moderate sized lakes, canals, and shoreline areas. Two feet/second is the velocity at which fine silts and clays can be expected to erode. In a Type II situation, the curtain may extend to within one foot or less off the bottom. This allows minimal currents in the area to pass under the curtain at a very low velocity. Keeping the velocity of current to a minimum will serve to minimize the spread of silt.

c) Type III (middleweight): An area that is exposed with currents up to 5 feet/second, such as rivers, streams, large lakes, and exposed shorelines with current in one direction. In these areas the curtain should extend to 1 foot or less off the bottom. Moderate currents will cause the curtain to lift away from the bottom allowing the current to pass. It may be necessary to reduce the depth of the curtain and/or install the curtain at an angle to the current to keep the velocity as low as possible.

d) Type IV (heavyweight): An area that is exposed and subjected to current, wind and tides such as harbors, and shorelines exposed to large expanses of water. In this situation the curtain should extend to the bottom of the installation area of high tide. The fluctuation of the tides will keep the buildup of silt on the curtain to a minimum.

### Materials

Turbidity curtains shall be fabricated from tightly woven geosynthetic or impervious reinforced thermoplastic material, brightly colored, which is stable when subjected to ultraviolet light. Woven geosynthetic material shall be of sufficient tightness such that turbidity levels are maintained at levels less than 5 NTUs over ambient conditions in waters being protected immediately adjacent to the turbidity curtain. An upper hem shall be installed to enclose a flexible flotation material. A lower hem shall be installed to contain a flexible ballast so that the curtain will hang vertically in the water. Each end or section of curtain shall be furnished with anchoring devises.

When Type I is used, external anchors of wooden or metal stakes (2x4 inch or 2.5-inch minimum diameter wood or 1.33 lbs./linear foot steel) may be used.

### Anchoring Equipment

All types of turbidity curtains require anchors. The use of proper anchoring systems is important to holding booms in their desired location.

Usually, an anchoring system consists of the following components:

- Anchor
- Anchor Chain
- Anchor Line
- Anchor Buoy
- Hardware to connect components

Anchor selection is based on anticipated loads (type of boom, current and winds) and bottom conditions. For example, a Danforth type anchor is good for sandy bottoms. The associated components, i.e., anchor chain, etc., would generally be determined by anchor size and depth of water.

The anchor line or rode should generally be 3 to 4 times the water depth to ensure the anchor will set and hold properly.

The anchor buoy placed between the anchor line and boom should be sufficiently buoyant to prevent the boom from being pulled under water.

Usually, 6 to 8 feet of anchor chain attached to the anchor stock is enough to ensure the anchor "sets" properly.

Winds, currents, and boom size will determine the number, and sizes of anchors required for a particular application. In tidal areas, the booms must be anchored from both sides to keep the boom in its desired location. Smaller anchors may be substituted for larger anchors by increasing the number of anchors used and at what interval they are attached to the boom.

### Sizing

When sizing the length of the curtain, avoid excessive joints. A minimum of 50 feet and a maximum of 100 feet between joints is recommended.

### Installation Requirements

Each turbidity curtain installation is unique because of individual site conditions and individual settings. In general, the following information is appropriate for most applications. See Figure 5-83 for an illustration of a turbidity curtain in tidal waters.

Set appropriate anchors around the perimeter of the installation. For best performance, use Danforth type anchors for sandy bottoms, or kedge type or mushroom anchors for mud bottoms. An anchor buoy should be used between the curtain and the anchor rope when working in currents. Alternative methods of anchoring might include fabricated heavy concrete weights or driven pilings. Shore anchor points are usually posts or pilings tied back to an anchor.

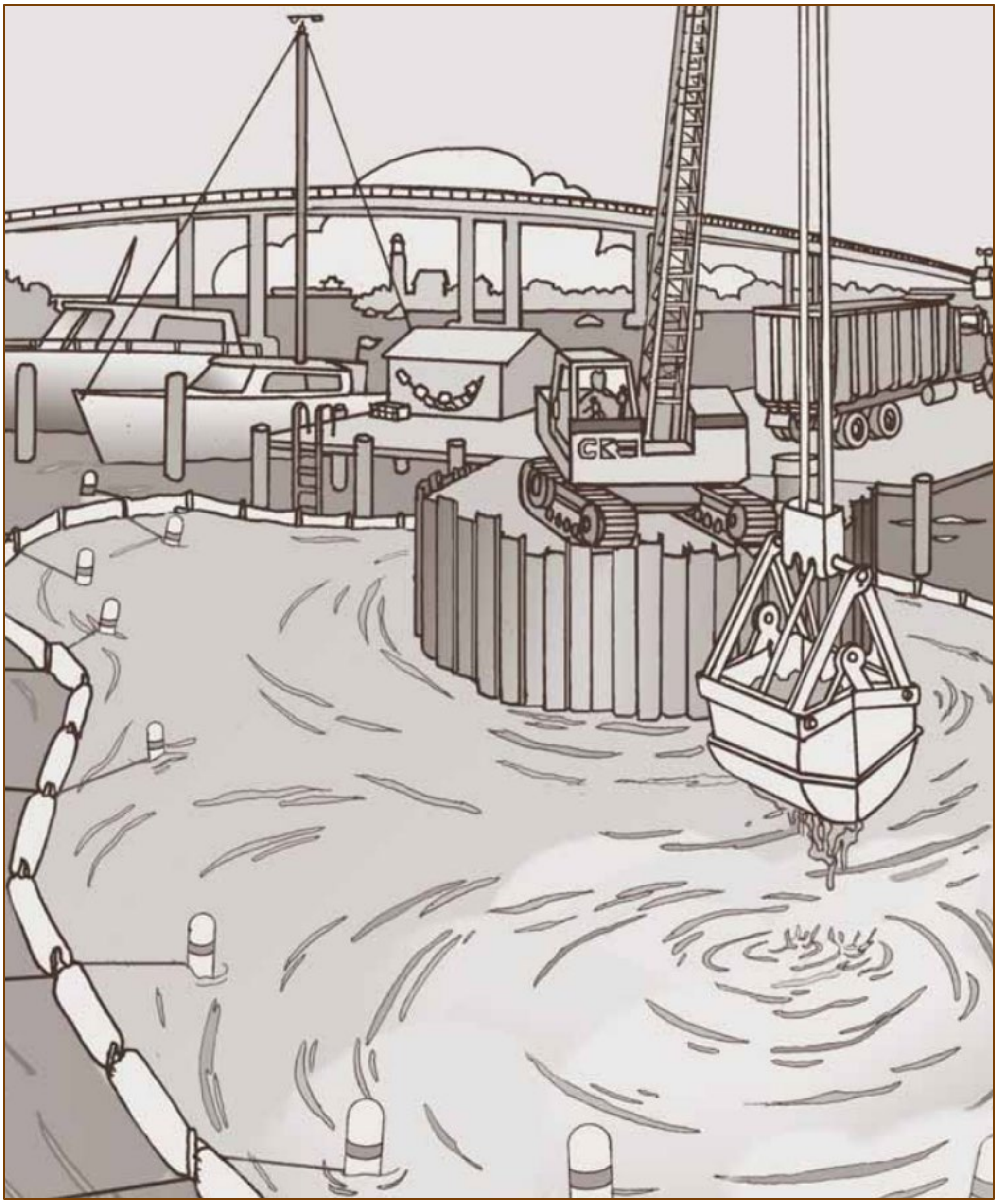
Note: Always attach anchor lines to the floatation device, not to the bottom of the curtain.

Remove the outside bundling ropes for each section. Lay the curtain out in an orderly fashion near the point of entry into the water. Inspect load line to ensure that it is not twisted around the float. If multiple lengths of curtains are involved, lay out remaining curtains and untie the furling ties nearest the section ends. Connect sections and re-tie the furling ties.

Tie one end of the curtain to the shore anchor point. Tow the curtain into position slowly either by hand or with the aid of a boat. A worker should be on shore to assist the curtain into the water. Once the curtain is in position, return and tie off the curtain at intermediate anchor points.

After the installation is complete and the curtain is properly anchored, return along the curtain and cut all the furling ties to lower the curtain skirt.

*Figure 5- 83 Illustration of a Turbidity Curtain in Tidal Waters*



## Maintenance & Removal

Inspect daily for damage. Depending on the duration and nature of the project, sediment shall be removed when its accumulation interferes with the function of the turbidity curtain. Material may be removed with construction equipment such as backhoes, draglines, mud sucking pumps or hydraulic dredges. If mud sucking pumps or hydraulic dredges are being used, then see Dewatering of Earth Materials measure. When required, removal and disposal of sediments shall be in an environmentally sound manner.

When there has been a significant change from the original depth of the watercourse due to sediment accumulation or when otherwise required, remove sediment prior to the removal of the turbidity curtain. Also remove accumulated sediment when the function of the water- course is impaired or when the accumulated sediments can be expected to be reintroduced into the water column by water flow once the turbidity curtain is removed. When sediment accumulation does not meet the conditions above, sediment may still be removed. However, its removal should be restricted to those situations where the removal will not create worse environmental conditions than if the sediment remained in place. Removal may have to be accomplished in stages since disturbance of the trapped material during removal will cause re-suspension.

Maintain the curtain for the duration of the project or for as long as the contributing area is capable of loading sediments to the body of water. Prior to the removal of the turbidity curtain, allow soil particles to settle out of the water column for a minimum of 6 to 12 hours depending on the clarity of the water and engineer's recommendation.

## Vegetated Filter

### Definition

A maintained area of well-established herbaceous or woody vegetation through which small volumes of sediment-laden water pass and are filtered.

### Purpose

- To intercept and detain small amounts of sediment from small, disturbed areas by filtering runoff waters.
- To decrease the velocity of sheet flows and allow for sediment deposition to occur before reaching sensitive areas.

### Applicability

- For contributing drainage areas of 1 acre or less in size.
- For contributing slopes are no steeper than 10%.
- Where slopes in the vegetated filter area are no steeper than 10%.
- For use only when existing vegetation is in an adequate condition to provide filtering of runoff water. If vegetated filters are to be established from permanent seedings, use is prohibited until after the grass has reached 6 inches in height, has been mowed twice, and survived one full growing season.
- Provides an aesthetic value without compromising function.
- Not for use where flows concentrate or at the outlet of diversions, drainageways, and waterways except in special cases where other measures are applied in conjunction with a vegetated filter, such as a Level Spreader, Geotextile Silt Fence, Filter Sock, or Straw Bale Barrier.
  - This is a temporary measure, only for use during construction, and is not intended for use for more than 1 year. Permanent vegetated filter strips, which are used to disconnect runoff from impervious surfaces as a type of Low Impact Development (LID) site planning

and design strategy and a type of structural post-construction stormwater Best Management Practice (BMP) commonly used with permanent level spreaders, should be designed in accordance with the Connecticut Stormwater Quality Manual, as amended.

## Planning Considerations

Vegetated filters are located in non-wetland areas and outside of riparian buffer areas. The vegetation in the filter must be sediment tolerant. The minimum flow length through the vegetated filter is determined by the steepness of the contributing slope, the soil texture of the contributing slope, the condition of vegetation within the filter, and level of human activity above the filter area. High total suspended solids (TSS) removal efficiency rates can be expected in areas where low levels of human disturbance above the filter area occur, variations in the vegetation are minimal, and flow velocity conditions are uniform throughout the filter. Lower TSS removal rates can be expected over a period of time if design conditions of the filter deteriorate.

- Use of Existing Vegetation: When planning to use existing vegetation, it must be healthy, have a vigorous growth habit, and be protected from damage by construction equipment.

- Establishing New Vegetated Filter: When planning to establish an herbaceous vegetated filter, use either Sodding or Permanent Seeding measures. Sodding is a convenient method for establishing a vegetated filter that may be used immediately after installation. Sodding around a catch basin and accompanied by geotextile silt fencing or straw bale barriers during contributing slope stabilization creates a vegetated filter that is very effective in reducing sediment loading to the storm drain system. Seeding may be done to establish a vegetated filter; however, the area cannot be used until after the first growing season and grass growth has become well established.

Due to problems with sediment accumulation, this measure is not recommended for use for more than 1 year.

## Specifications

### Size and Slope Requirements

Determine the minimum flow length through a vegetated filter based upon the slope and soil texture of the contributing drainage area, vegetative condition of the filter, and level of human activity above the filter. Use Table 5. 40 to determine filter length.

Slopes to and within the vegetated filter shall not exceed 10%.

### Condition of Vegetation in Filter Area

Herbaceous vegetation shall be a dense formed sod of fine stemmed, healthy plants. Woody vegetation shall be well established and healthy with an undisturbed layer of leaf litter or duff. Protect vegetation by prohibiting the use of construction equipment in the area.

## Maintenance

Inspect vegetated filters at least once a week and within 24 hours of the end of a storm that generates a discharge[74] to determine maintenance needs. Maintenance is required when sediment fails to be retained by the filter due to rilling, excessive deposition of sediment, vegetation failure, or other causes.

If the vegetated filter area failed due to rilling, install additional measures immediately below the filter to prevent sediment from leaving the filter area, such as a Geotextile Silt Fence, Filter Sock, or Check Dam. Rills shall then be regraded, re-seeded, or sodded.

Additionally, if the vegetated filter failed due to excessive sediment loading causing the vegetation to become buried, inspect the contributing area and install additional measures to control sediment before runoff enters the filter area. If further use of the vegetated filter is planned, consider manually removing the accumulated sediment that has buried the vegetation. Otherwise, seed or otherwise stabilize the accumulated sediments in the filter area.

[74] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

*Table 5. 40 Determining Vegetated Filter Lengths*

| Slope of contributing area (%) | Soil Texture Class[75] | | |
|---|---|---|---|
| | Class I | Class II | Class III |
| High Density and Low Disturbance Potential (in feet)76 | | | |
| 0 | 50 | 110 | 150 |
| 1 | 54 | 119 | 162 |
| 2 | 58 | 128 | 174 |
| 3 | 62 | 136 | 186 |
| 4 | 66 | 145 | 198 |
| 5 | 70 | 154 | 210 |
| 6 | 74 | 163 | 370 |
| 7 | 78 | 172 | 390 |
| 8 | 82 | 180 | 410 |
| 9 | 86 | 189 | 430 |
| 10 | 90 | 198 | 450 |
| Medium Density or High Disturbance Potential (in feet)[77] | | | |
| 0 | 150 | 330 | 735 |
| 1 | 162 | 356 | 794 |
| 2 | 174 | 383 | 853 |

[75] Texture Class I - sands and loamy sands; Soil Texture Class II - sandy clay loams and sandy loams; Soil Texture Class III - all other soil textural classes (see Appendix E, Soil Classification Systems).

[76] Vegetation must be grass, transition forest, or forest and thick enough that, for 80% or more of the filter area, no bare ground can be seen through the grass or surface matter. These areas experience low levels of human disturbance by foot traffic.

[77] Vegetation density and/or surface litter is less than 80% of the ground or filter area will experience a high level of disturbance by foot traffic

| | | | |
|---|---|---|---|
| 3 | 186 | 409 | 911 |
| 4 | 198 | 436 | 970 |
| 5 | 210 | 462 | 1029 |
| 6 | 370 | 814 | 1813 |
| 7 | 390 | 858 | 1911 |
| 8 | 410 | 902 | 2009 |
| 9 | 430 | 946 | 2107 |
| 10 | 450 | 990 | 2205 |

Source: Riparian Buffer Strategies for Urban Watersheds, Metro Washington Council of Government publication, p.44. 1995

# Tire Tracked Soils

## Planning Considerations

The only measure in this group is Construction Entrance.

The Construction Entrance measure consists primarily of a stone pad and is used where construction traffic gains access to paved surfaces. While it is an integral part of a construction access road, it is also used for projects too small to require a construction access road. Commonly it is required to prevent unsafe roadway conditions caused by soil deposited onto paved surfaces. It reduces the potential of sediment transport from these paved surfaces during storm events as well as preventing dust clouds and slippery pavement.

## Construction Entrance

### Definition

A stone stabilized pad sometimes associated with a mud rack, automotive spray, or other measures located at points of vehicular ingress and egress on a construction site.

### Purpose

- To reduce the tracking of sediment from a construction site onto adjoining paved surfaces.

### Applicability

- At points of construction vehicle ingress and egress where sediment may be tracked onto adjoining paved surfaces by vehicles.

## Planning Considerations

The construction entrance is intended to cause sediment to drop off of vehicle tires and prevent it from being tracked onto adjoining paved areas. Its design and maintenance requirements are dependent upon how intensely the entrance is used and the nature of the sediments that can be tracked. Consider the texture of the sediments to be retained by the construction entrance.

- The minimum length of a construction entrance is 50 feet.
- Where the soils subject to tracking contain less than 80% sand, the minimum length of the construction entrance is 100 feet (see textural triangle in Appendix E).
- For sites containing clay or silty soils, consider developing a construction access road with a gravel base (see Chapter 4, Special Treatments, Construction Access Roads). The length of the construction entrance may be reduced by establishing an access road with a stable surface that is not subject to soil tracking.

If the construction entrance drains to a paved surface and its grade exceeds 2%, then plan on installing a water bar within the construction entrance to divert water away from the paved surface. For access roads that slope down to the construction entrance, consider installing a water bar and associated sediment barrier to protect the construction entrance from unnecessary siltation during storm events.

Placing a geotextile beneath the stone pad of the construction entrance can reduce the pumping of subsoil into the stone by construction traffic and reduce maintenance costs.

Select the site of the construction entrance to avoid poorly drained soils where possible. Where lateral flows of water must be maintained through the construction entrance, consider having an engineer design subsurface drainage or other drainage facilities to eliminate the obstruction to flow.

Consider requiring the installation of construction access fencing to restrict construction traffic to the construction entrance.

When the construction entrance is installed to the minimum standards and is properly maintained but still unable to prevent the majority of sediments from being tracked off site, the entrance must either be extended or a washing rack installed. If a washing rack or similar device is to be used to wash sediment from tires, make provisions to intercept the wash water and trap the sediment before it is carried off-site. Determine the sizing requirements for the sediment trapping facility so that it will hold the maximum volume of water that would be used over a 2-hour period (see Pumping Settling Basin measure for formula on pumping rate and storage requirements).

The use of a construction entrance may not eliminate the need for periodic street sweeping, but if properly maintain it should significantly reduce the need for street sweeping.

## Specifications

### Materials

**Stone:** Use angular stone sized according to the standards set by ASTM C-33, size No. 2 or 3, or CTDOT Standard Specifications section M.01.01, size #3. See Table 5. 8 for stone sizing requirements.

**Geotextile:** Fibers used in the geotextile shall consist of synthetic polymers composed of at least 85% by weight polypropylenes, polyesters, polyamides, polyethylene, polyolefins, or polyvinylidene-chlorides. The fibers shall be formed into a stable network of filaments or yarns retaining dimensional stability relative to each other. The geotextile used shall be specifically intended for "road stabilization" applications and shall be consistent with the manufacturer's recommendations for the intended use.

### Location

Locate the entrance to provide maximum utilization by construction vehicles. Avoid poorly drained soils, where possible.

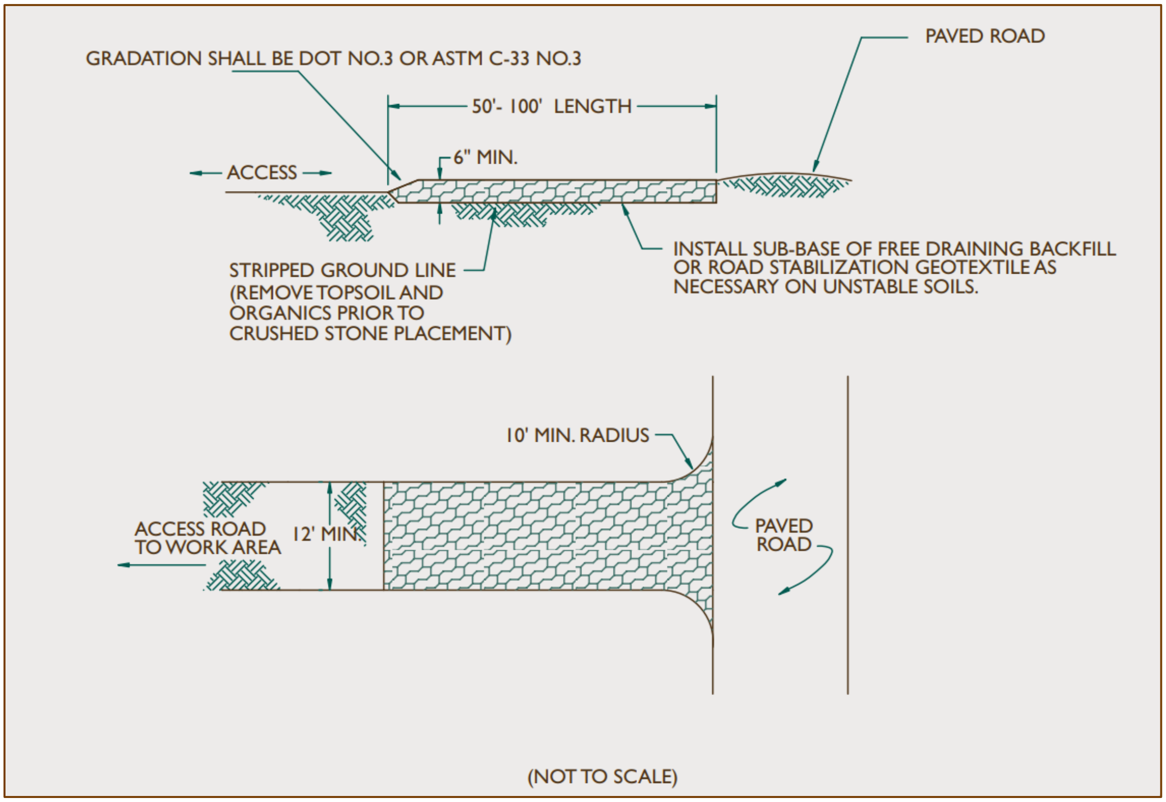
#### Construction Entrance Dimensions (see Figure 5- 84)

**Stone Thickness:** not less than 6 inches.

**Width:** A 12-foot minimum with points of ingress or egress flared sufficiently to accommodate the turning radius of the construction vehicles used. The width should be selected based on the size (width and turning radius) of the equipment that are planned to access the site.

**Length:** A 50-foot minimum except where the tracked sediments contain less than 80% sand, for which a 100-foot minimum is required. If the traveled length is less than the minimum, then the construction entrance shall be the traveled length. Increase lengths as needed based on site conditions to prevent the tracking of sediment onto paved surfaces.

*Figure 5- 84 Diagram of Typical Construction Entrance*




## Construction

Clear the area of the entrance of all vegetation, roots, and other objectionable material. At poorly drained locations install subsurface drainage such that the drain outlets are free flowing.

If using a geotextile in place of free draining material, unroll the geotextile in a direction parallel to the roadway centerline in a loose manner permitting it to conform to the surface irregularities when the stone is placed. Unless otherwise specified by the manufacturer, the minimum overlap of geotextile panels joined without sewing is according to the manufacturer's recommendations. The geotextile may be temporarily secured with pins recommended or provided by the manufacturer, but they shall be removed prior to placement of the stone.

Place the stone to the specified dimensions. Keep additional stone available or stockpile for future use. If the grade of the construction entrance drains to the paved surface and it exceeds 2%, construct a water bar within the construction entrance at least 15 feet from its entrance on the paved surface, diverting runoff water to a settling or filtering area.

Construct any drainage and settling facilities needed for washing operations. If wash racks are used, install according to the manufacturer's specifications.

## Washing

If most of the sediment is not removed by travel over the stone, wash tires before vehicles enter a public road. Divert wash water away from the entrance to a settling area to remove sediment.

Size settling area to hold the volume of water used during any 2-hour period. Using a wash rack may make washing more convenient and effective.

### Maintenance

Inspect construction entrances at least once a week and within 24 hours of the end of a storm that generates a discharge.[78] Maintain the entrance in a condition which will prevent tracking and washing of sediment onto paved surfaces. Provide periodic top dressing with additional stone or additional length as conditions demand. Repair any measures used to trap sediment as needed. Immediately remove all sediment spilled, dropped, washed, or tracked onto paved surfaces. Roads adjacent to a construction site shall be left clean at the end of each day.

If the construction entrance is being properly maintained and the action of a vehicle traveling over the stone pad is not sufficient to remove the majority of the sediment, then either (1) increase the length of the construction entrance, (2) modify the construction access road surface, or (3) install washing racks and associated settling area or similar devices before the vehicle enters a paved surface.

Roads adjacent to a construction site shall be clean at the end of each day.

At the completion of construction, all entrance and exit points to the site must be restored in accordance with the approved plans.

# Dewatering

## Planning Considerations

The dewatering measures are Pump Intake and Outlet Protection, Pumping Settling Basin, Portable Sediment Tank and Dewatering of Earth Materials. The function of these measures is to handle and treat water that is generated during dewatering operations. Dewatering may involve either the use of pumps or the draining of excavated and dredged soils that are too wet to transport without leakage.

The Pump Intake and Outlet Protection measure uses structures or other protective devices, such as barrels, boards, stones, strainers, and floats, which are attached to intake and discharge hoses to prevent the excessive pumping of sediments at the intake and the erosion at the point of discharge.

[78] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

The Pumping Settling Basin measure utilizes an enclosed sediment barrier or excavated pit constructed with stable sides, an inlet, and an outlet for the purpose of settling and/or filtering turbid water that is being pumped at a construction site. This measure is not needed if the pumped water is clear and sufficiently de-energized at the point of discharge. Similarly, a basin may not be needed if the volume of water is small and sufficient stable vegetative cover exists at the point of discharge to adequately treat the discharged water before draining into a wetland, watercourse, storm drain system or public road. In this case, the discharge area must be sufficiently stable so that it resists scouring and can filter the water.

The Portable Sediment Tank measure uses a tank or other similar container to temporarily store and retain sediment before the water is discharged or transported to an approved location for further treatment when a pumping settling basin is impractical.

The Dewatering of Earth Materials measure uses an excavation and dike with a spillway to hold excavated or dredged soils that are too wet to be regraded or transported. The purpose of this measure is to provide a containment area large enough to allow for sufficient water to drain from the soil so that it may be regraded or transported.

The use of these measures is dependent upon specific site conditions, the contractor's method of operations, and contractor's dewatering equipment. Innovative techniques for dewatering structures other than those shown are encouraged and should be evaluated on a case-by-case basis by the approving authority.

Dewatering needs should be identified in the erosion and sediment control plan and at least a general description of dewatering operations given. However, it should be recognized that any dewatering plan typically needs to be modified due to unforeseen site conditions or alternate methods available to the contractor.

For complex projects, the E&S plan shall, at a minimum, identify dewatering needs and possible dewatering discharge locations. If a detailed dewatering plan is not contained within the overall E&S plan, it shall be forwarded to the approving agency for review and approval prior to the start of dewatering activities. It is not uncommon that once a construction contractor is selected and prior to actual dewatering, the contractor's detailed dewatering plan is submitted to the reviewing agency for review and approval.

Regardless of when a detailed dewatering plan is submitted, the plan shall identify the specific methods, devices, and schedules to be used including, but not limited to:

- Details on protection at the inlet and outlet of pumps, method for floating the pump intake, or other methods to minimize and retain the sediment.
- Details on any containment berm construction when dewatering earth materials; and
- Identification of a contingency plan for emergency operations should the dewatering operation prove inadequate to meet the dewatering need or is found to be causing unacceptable turbidity problems (e.g., alternative discharge locations or use of a portable sediment tank).

If turbidity or siltation problems are not adequately controlled by the continency plan, then the operation shall be ceased, and a revised dewatering plan submitted for approval prior to further implementation.

To minimize the amount of sediment transport from dewatering operations:

- Divert surface waters[79] away from areas needing dewatering; use Diversions and Land Grading measures.
- Consider if well points and sumps can be used to lower the groundwater table[1] reducing the need for settling facilities.
- For sites that don't require continuous pumping, pump work areas before construction activities begin each workday.
- Provide filtration near the suction intake.
- Locate pumps, intake sumps, and other intake structures in areas which will not require constant moving, when possible.
- Locate pump discharge facilities (portable, permanent, or bio-filtering structures) to avoid disturbance of existing wetlands and watercourses, and.
- Provide protection at outlets from pumping operations to dissipate pumping surges and prevent erosion at the point of discharge.

## Pump Intake and Outlet Protection

### Definition

Structures or other protective devices, such as barrels, boards, stones, strainers, and floats, which are attached to intake and discharge hoses to prevent the excessive pumping of sediments at the intake and erosion at the point of discharge during pumping operations.

### Purpose

- To reduce the amount of sediments taken up by a pump during dewatering operations.
- To prevent soil erosion due to scouring and the resuspension of detained sediments at the point of pump discharge.
- In some instances, the pre-filtration of pump discharge waters may be enough to reduce or eliminate the need for a dewatering basin or portable sediment tank.

### Applicability

- Wherever dewatering is required by means of pumping such as cofferdams, building foundations, utility line installation (or repair), and pond construction or rehabilitation.

[79] Diverting surface waters or pumping groundwater waters may require a CT DEEP water diversion permit or a local inland wetlands permit (see Appendix A).

## Planning Considerations

There is no specific design for this measure. The pump intake protection shown in Figure 5- 85 and Figure 5- 86 illustrate basic design concepts that, when implemented during dewatering operations, reduce sediment uptake.

Typically, pump intakes are installed in sumps that have been excavated below the grade such that water drains away from the active construction area. The location and size of sumps are dependent upon the field conditions found at the time of construction and dewatering operations. The expected conditions and potential sump needs should be noted on the plans. The sumps may require relocation as work progresses.

The pump outlet protection shown in Figure 5- 87 illustrate basic design concepts that, when implemented during dewatering operations, reduce soil erosion and resuspension of sediments.

*Figure 5- 85 Pump Intake Protection Using Stone Filled Sump with Standpipe*

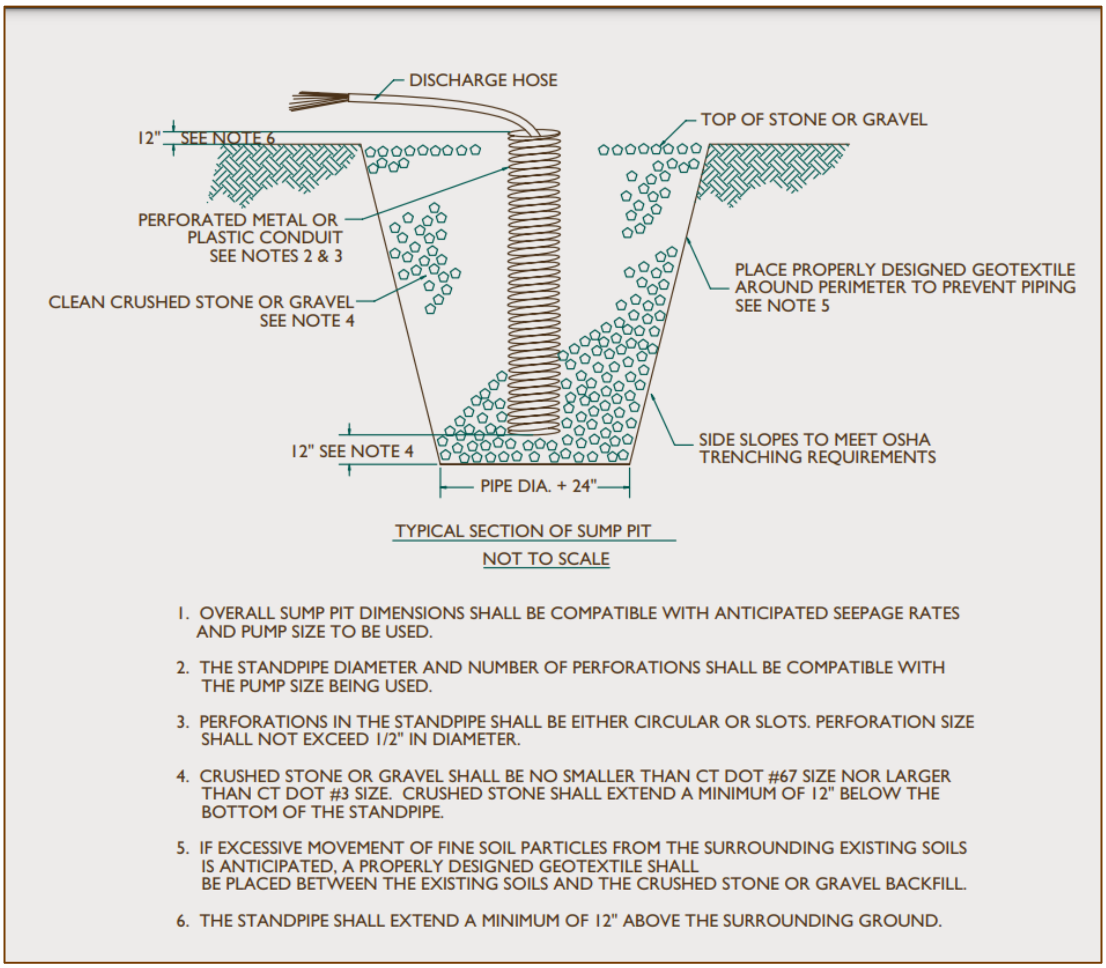


*Figure 5- 86 Pump Intake Protection Using Sump with Strainer*

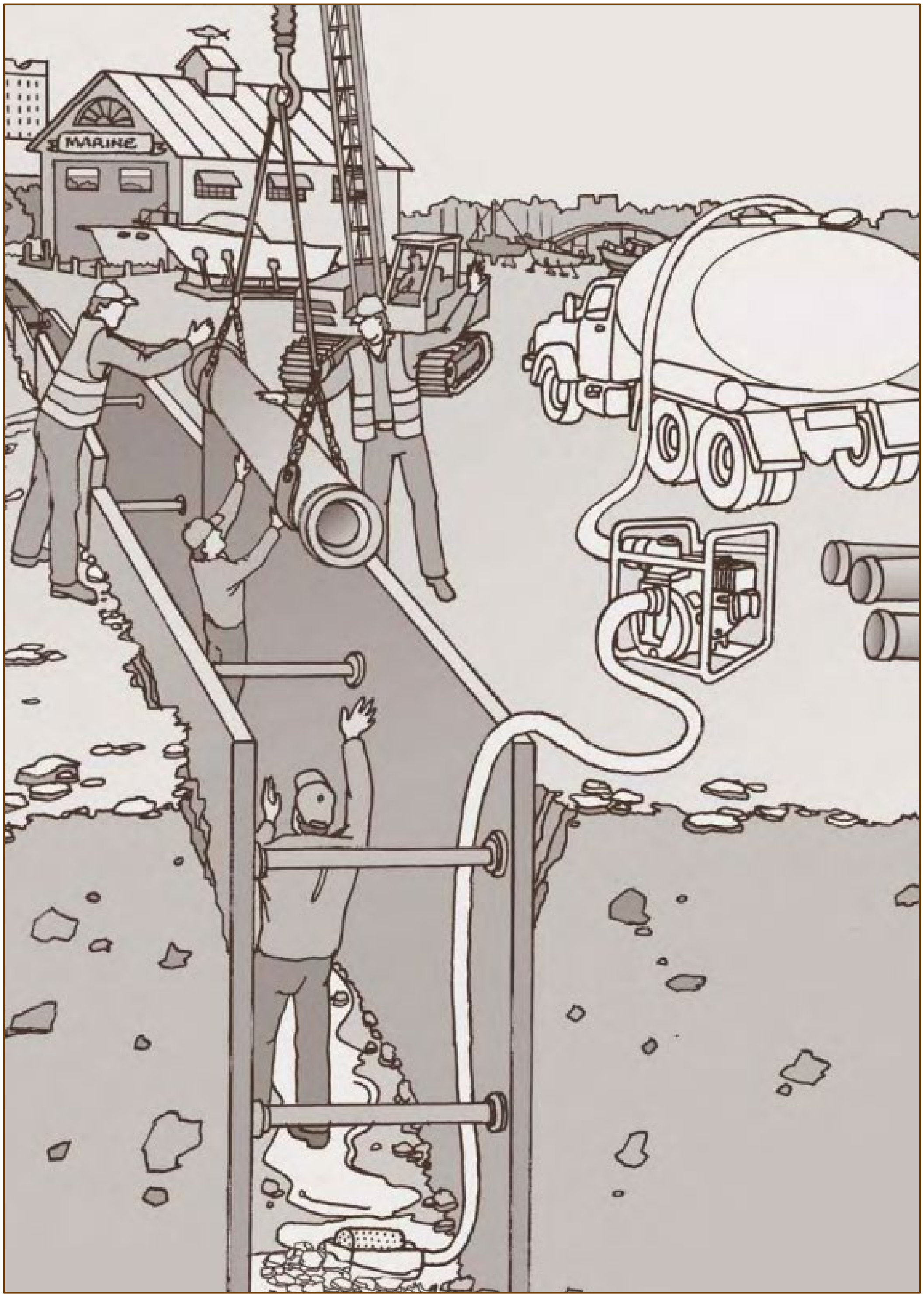
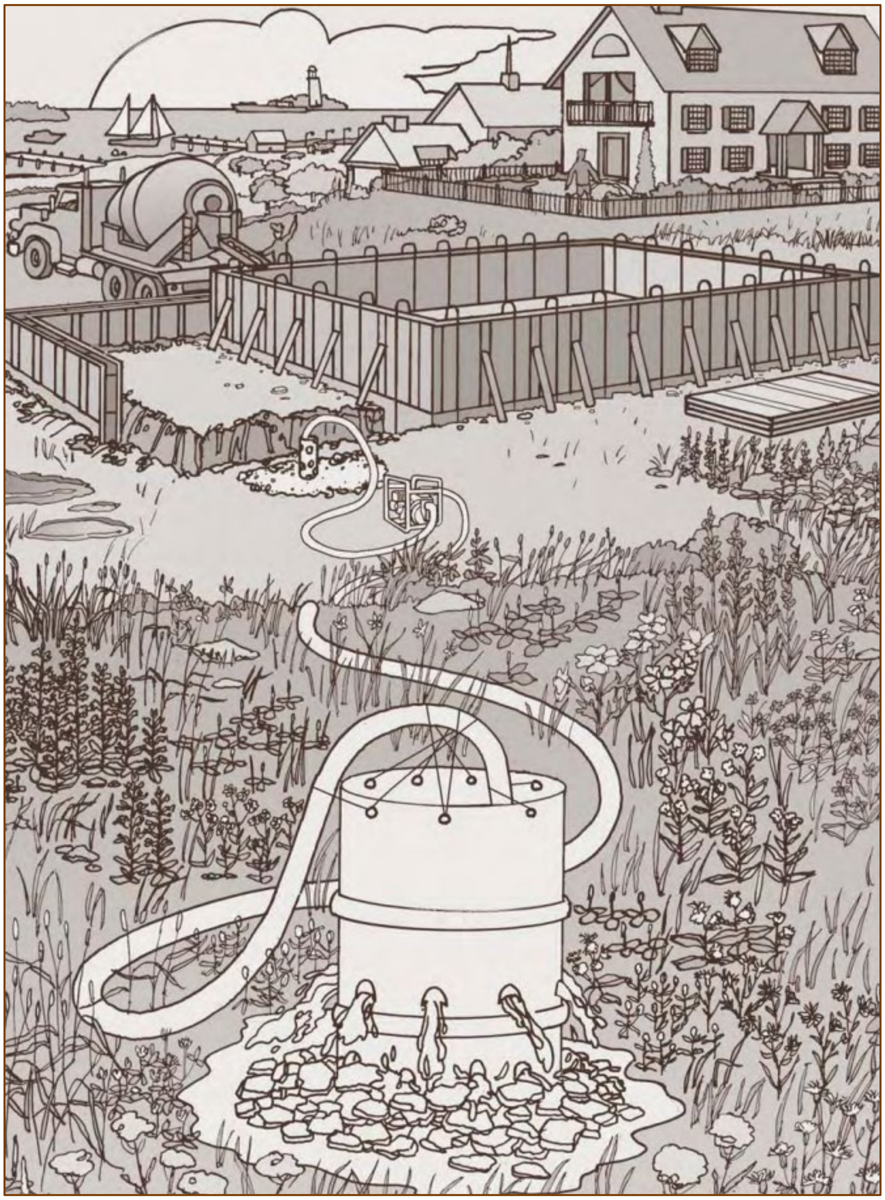


*Figure 5- 87 Examples of Pump Outlet Protection*



## Specifications

### Sizing Pumping Sumps

Determine the size of the pumping sump based upon the volume of water required to be pumped and the size of the pump. When using portable sediment storage tanks, the sump shall be capable of storing the amount of water that enters the dewatering site during the time that it takes to switch portable sediment storage tanks.

For dewatering trenches, cofferdams, and foundation excavations, the sump is typically excavated 2 feet or more below the grade of the proposed work.

For pond rehabilitation, the sump shall be a minimum of 2 feet below the pond bottom, depending upon the dewatering needs of material to be removed from the pond. The size of the sump is dependent upon conditions in the pond.

### Installation

1. Determine if a sump is needed and the appropriate method of pump intake and outlet protection.
2. Where standing water is encountered in the area of a proposed sump, begin dewatering the site by floating the pump intake at the water's surface. Carefully monitor water levels to prevent the uptake of bottom sediments.
3. Excavate the sump within or adjacent to the area to be dewatered. Install pump intake and outlet protection before pumping begins.
4. Installation of the pump intake protection should conform to pumping rates and the general design concepts. Figure 5- 85 shows a typical sump and intake constructed of stone imbedded with a perforated standpipe. It is generally used where there is no need to frequently move the pumping sump or where the stone can be used on site for bedding material. Figure 5- 86 shows a typical sump and intake that calls for lining (rather than filling) the pumping sump with stone and attaching a strainer to the suction hose so that the hose is suspended off the bottom of the pumping sump and is protected against pumping bottom sediments. This design is useful when frequent relocation of the pumping sump is anticipated. However, it does not reduce the need for a dewatering basin.
5. The pump outlet protection shall adequately dissipate the energy of the discharge so as to prevent erosion and the resuspension of sediments at the point of discharge. Figure 5- 87 illustrates an example of pump outlet protection. Pump outlet protection is required even if the discharge is to a pumping settling basin.

### Operation

Monitor pumping operations and adjust pumping rates as needed to keep the construction area dewatered and minimize pumping of sediment.

### Maintenance

Inspect the pumping sump, pump intake protection, and pump discharge conditions frequently during dewatering operations for proper functioning of equipment.

## Pump Settling Basins

### Definition

An enclosed sediment barrier or excavated pit constructed with a stable inlet and outlet such that sediment laden water from pumping operations is de-energized and temporarily stored, allowing sediments to be settled and/or filtered out before being released from the construction site.

## Purpose

To allow for the settlement of sediment from pumping operations prior to the water being discharged.

## Applicability

- When a pump discharge from a construction area is sediment laden.
- Not for use with hydraulic dredging operations in open waters (see Dewatering of Earth Materials measure).

## Specifications

### Materials

Whenever used in this measure:

- Straw bale barriers shall meet those required in the Straw Bale Barrier measure.
- Geotextile shall meet that required in the Geotextile Silt Fence measure.
- Modified riprap shall meet that required in the Riprap measure or the requirements of CTDOT Standard Specifications Subsection M.12.02.3.
- Pump surge energy dissipators shall be provided and capable of sufficiently de-energizing pump discharges to prevent scour and remain in place (see Pump Intake and Outlet Protection measure).

### Sizing

Pumping settling basins are sized to have a minimum retention time of 2 hours. Use the following formula to determine the storage volume required:

**Cubic feet of storage required =** Pump Discharge Rate (gpm) x 16

For sites where available storage is insufficient at the planned pumping rate, the maximum pumping rate is determined from the following formula:

**Pump Discharge Rate (gpm) =** Cubic feet of storage available / 16

In calculating the capacity, include the volume available from the floor of the basin to the crest of the outlet control.

### Location

Locate the pumping settling basin on the site such that surface water is directed away from the pumping settling basin (see Temporary Water Diversion measure).

### Installation

All dewatering basins, regardless of type, contain a water/sediment storage area, an energy dissipator for pump discharges entering the basin (see Pump Intake and Outlet Protection measure and an emergence overflow that provides for a stable filtration surface through which water may leave the basin. Pump discharge is located at a point in the dewatering basin that is farthest from the basin outlet.

Depending upon existing soil conditions and side slopes of the excavated pumping settling basin, soil stabilization may be required. The excavation may be lined with geotextile or stone to help reduce scour and to prevent the erosion of soil from within the structure.

> **Type I – Small Volumes:** Consists of an aboveground enclosure created by a straw bale barrier. See Straw Bale Barrier measure for material specifications and general installation requirements. This type of basin is located only on flat grades and is limited for use by its storage volume where the anticipated sediment delivery would not require cleaning and the expected use is for a very short duration. For calculating storage, use the top of the lowest straw bale on the perimeter to the crest of the outlet control. An example of use for this type of basin would be a dewatering operation for a trench where no adequate vegetated filter exists (see Vegetated Filter measure) before the discharge enters into critical area such as a wetland, or watercourse.

## Portable Sediment Tank

### Definition

A tank, bag, or other container into which sediment laden water is pumped in order to trap and retain sediment before discharging the water or to transport the sediment laden water to an approved location for further treatment.

- "Frac tanks" are impermeable containers into which sediment laden water is pumped and temporarily stored while settling and fractionation is achieved.

- Dewatering bags are made from durable geotextile filter fabric suitable for removal of sediment and designed to accommodate discharge pipes. They may be placed in a dumpster or truck bed for ease of removal once sediment has been collected.

## Purpose

- To trap and retain sediment.

## Applicability

- When a pump discharge from a construction area is sediment laden and space limitations prevent the use of a pumping settling basin.
- For sites with severe space limitations, a portable sediment tank may be used to transport sediment laden water to an approved location.
- Typically used with cofferdam dewatering associated with bridge repair work, utility work, or in the redevelopment of urban areas.
- Not for situations with high or continuous flows that will exceed the capacity of the tank(s).

## Planning Considerations

When pumping requirements are expected to exceed the two-hour storage capacity of the sediment tank and pumping cannot be discontinued for the length of time needed to drain the tank properly at the pumping site, consider using two or more portable sediment tanks that may be alternately filled, moved, and drained at an acceptable location. Former milk trucks or water trucks have been used for this purpose where off-site disposal has allowed for off-site dewatering basins or adequate filtration by vegetative buffers. Do not use a tank that was formerly used for contaminated or hazardous materials.

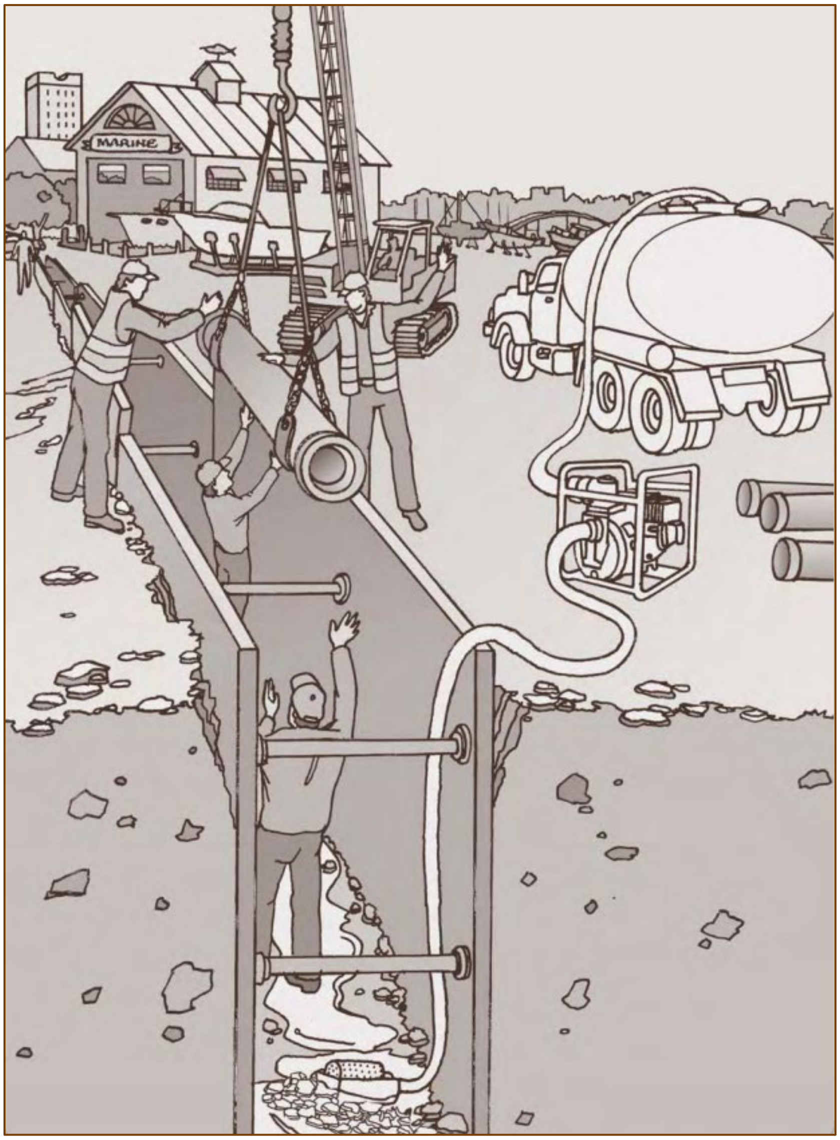
When a portable dewatering tank is to be used next to a cofferdam, the weight of the tank and maximum volume of water and associated structures must be considered when constructing the cofferdam to ensure the structural stability of the cofferdam. Alternately, if the cofferdam has already been built, before placing any tank adjacent to the cofferdam, consider the cofferdam’s ability to remain structurally stable when the tank is full.

## Specifications

### Materials

The tank is a structure constructed of steel, sturdy wood, or other material suitable for handling the pressure exerted by the volume of water to be stored. An example of a typical sediment tank is shown on Figure 5- 88. Dewatering bags are made from durable geotextile filter fabric. Other container designs may be used if the storage volume is adequate and is approved by the regulating agency.

*Figure 5- 88 Portable Sediment Tank in Operation*




### Location

- Locate non-portable sediment tanks and bags for ease of clean-out and disposal of the trapped sediment, and to minimize the interference with construction activities and pedestrian traffic.
- Release filtrate from filter bags to an appropriate area or inlet (free of sensitive resources and hazards) that is stabilized against potential erosion and is able to be monitored.
- Tank Sizing for On-Site Discharges

For discharging the portable sediment tank directly, size the tank to have a minimum retention time of at least 2 hours. Use the following formula to determine the storage volume required:

**Cubic feet of storage required =** Pump Discharge Rate (gpm) x 16

When the tank size available is insufficient at the planned pumping rate, the maximum pumping rate is determined from the following formula:

Pump Discharge Rate (gpm) = Cubic feet of storage available / 16

When the tank size available cannot meet the 2-hour storage requirement and reduced pumping rates are not practical, then several tanks may be alternately filled and drained with pumping rates restricted to meet tank transport, draining, and return times.

#### Bag Size

Filter bags should be sized based on:

- Volume and flow rate of sediment-laden water being pumped
- Quantity and type of sediment
- Permissivity of the given bag, log, or sock. A soil analysis along with hanging bag tests can determine the correct fabric and pore size necessary for the site-specific conditions.

#### Inlets and Outlets

- All pumps and pipes leading to tanks or bags must be able to be controlled with valves or manifolds.
- Discharge hoses must be inserted through appropriate openings and secured with wire, ties, clamps, rope, or similar materials to create a good seal.
- Filter bags are susceptible to punctures, so care must be taken in their placement and use. A tarpaulin can alleviate some puncture possibilities
- The pump discharge into the tank shall be located at a point in the portable sediment tank that is farthest from the tank outlet.
- The outlet of the tank shall be equipped with an energy dissipator.

### Maintenance

#### Tanks

- Inspect the sediment tank continuously during use.
- Once the water level nears the top of the tank, either shut off the pump while the tank drains and additional capacity is made available or transport the tank to an appropriate disposal site.
- For a tank that is discharging water while the pumping operation is ongoing and when the wet storage area has lost one half of its volume to sediment build up, discontinue pumping and remove accumulated sediments or replace the tank.
- For a tank that is used to transport the pumped water to a location distant from the pumping operation, discontinue pumping long enough to change the tank.
- Any transported discharge of water and cleaning of the tank shall be done in such a manner as to prevent sediment laden water from reaching a wetland, watercourse, or paved travel way.

### Bags

- Inspect the sediment tank continuously during use.
- Care should always be taken to properly monitor performance to ensure that pump rates or concentrations of sediment are not excessive.
- Once the sediment tank or sediment bags have reached their maximum capacity to retain sediments, these units shall be taken offline and any retained sediments shall be disposed of properly.

## Dewatering of Earth Materials

### Definition

A procedure that uses a perimeter earthen berm and excavation to create a containment area where excessively wet soil is placed to allow for the draining of water or evaporation of excessive moisture.

### Purpose

- To provide a containment area large enough to allow for sufficient water to drain from the soil so that it may be regraded or transported.

### Applicability

- When excavating saturated soils that are too wet to transport or to be contained with geotextile silt fence or hay bales.
- Not for dewatering contaminated soils. Handling of contaminated soils shall comply with the directives of the regulating agency (e.g., CT DEEP and EPA).

### Planning Considerations

- Select a containment site that will be large enough to contain the anticipated volume of material to be dewatered and any perimeter berm.
- Locate the containment area so that the material being dewatered does not interfere with other construction activities and can be left for the time necessary for dewatering.
- Avoid wetlands, watercourses, drainageways and wooded areas.
- Sandy and gravelly material will generally dewater quicker than fine silts and clays, particularly if the containment area is gently sloping.
- The containment area can be divided into cells to allow for alternating use of the cells.

### Design Criteria

- An engineered design is required if (1) the berm for the containment area exceeds 3 feet in height above stripped, natural, or original ground, or (2) the volume of materials needing dewatering exceeds 200 cubic yards at any one time. Use standard engineering practices.

### Sizing

- Size the containment area by the volume and type of material to be dewatered and the length of time that the material will remain stockpiled. Design the containment berm to withstand any anticipated loads.

### Site Selection

- Select a site where the slope is 8% or flatter. Do not locate on previously filled ground. Give preference to sites with well drained soils. An underdrain may be needed to improve the dewatering function of a containment area located on poorly drained soils.

## Specifications

1. Strip and stockpile the topsoil from the containment area.
2. Divert surface water away from containment area as necessary (See Temporary Diversion Measure).
3. Construct the berm around the containment area with suitable soils. Certain types of soils are subject to instability upon saturation or loading and must be avoided. Examples of these soils include fine sands, silt loams, clay, peat, and mucks. Sites containing such soils may require the borrowing of more suitable material from off site for berm construction.
4. Install a geotextile silt fence to filter the discharge from the disturbed area if an inadequate vegetated filter exists between the disturbed containment area and any wetland, watercourse, or storm drain inlet (see Vegetated Filter measure).
5. Place the saturated soil within the containment area such that drainage can occur.

## Maintenance

- Inspect containment area and associated sediment controls on a daily basis while dewatering operations are active. When dewatering operations are not active, inspect at least once a week and within 24 hours of the end of a storm that generates a discharge.[80]
- If the containment berm fails, determine the cause of the failure. If the berm failed due to overtopping, repair the berm and any damage caused by the berm failure and reduce usage of the containment area such that overtopping is prevented. If the berm experienced an internal structural failure, cease using the containment area, add additional controls to contain eroded sediments, repair the damage caused by the berm failure, and before repairing the berm have the dewatering operation reviewed by an engineer for repair requirements. Repair and clean out perimeter erosion and sediment controls as needed.

[80] For storms that end on a weekend, holiday, or other time after which normal working hours will not commence within 24 hours, a routine inspection is required within 24 hours only for storms that equal or exceed 0.5 inches. For storms of less than 0.5 inches, an inspection shall occur immediately upon the start of the subsequent normal working hours

- After dewatering operations are completed, regrade the containment area to a finished grade and stabilize in accordance with the planned use of the area.

# Appendix A Regulatory-Permit Index

## Regulatory Authority

The control of soil erosion and sediment is an essential element of water quality and soil health. As such, this is recognized most prominently in the regulatory structure of the Clean Water Act (CWA) as codified in 40 Code of Federal Regulations (CFR) Part 450 and Connecticut's Soil Erosion and Sediment Control Act (§22a-325 through §22a-329 of Connecticut's General Statutes, CGS). The requirements of these regulatory sections are implemented through Federal, State and local authority outlined in Figure A- 1 below.

**Federal Authority**

Clean Water Act
Agencies with Authority: Environmental Protection Agency, Army Corp of Engineers

**Federal Regulations**

National Pollution Discharge Elimination System (NPDES)
40 CFR 450

**Federal Regulations**

Navigable Waters Protection Rule
33 CFR 328.3 and 40 CFR 120.2.

CONNECTICUT DELEGATION OF NDPES PROGRAM

Connecticut NPDES Permits | US EPA

Permits and Licenses (ct.gov)

**State Authority**

CGS §22a-430b General duties of commissioner concerning soil and water erosion.

**Council Authority**

CGS §22a-325-329 Short title: Soil Erosion and Sediment Control Act.

**Local Authority**

Municipalities have land use and development regulations, these will often be regulated and enforced a Land Use Commissions. A project manager/homeowner must due their due diligence to review the local regulations. Where a municipality does not have a Land Use Commission, registration with the State is often required. See Chapter 1, **Guidelines Cited in General Permit for Construction Activities**

*Figure A- 1 Regulatory Authority for Soil Erosion and Sediment Control*

## Selection of Example Permits

This section describes the primary permitting processes that are or have elements applicable to soil erosion and sediment control in Connecticut. One of the primary permit processes that include soil erosion and sediment control is the Discharge of Stormwater Dewatering Wastewaters from Construction Activities, as noted in Chapter 1. However, there are a significant number of other permit processes that have soil erosion and sediment control requirements, those applicable to the state processes are noted below. This list a set of example permits whereby the requirements are related to soil erosion and sediment control but is not all encompassing. Additionally this list is subject to change per evolving interpretations, policy and legislation please see CT DEEP's permitting page and Army Corp of Engineers for the most up to date permit information. Additionally, as noted previously it is also paramount that a project manager, or project engineer perform due diligence in assessing the local requirements.

### Permit: Discharge of Stormwater and Dewatering Wastewaters from Construction Activities

This general permit applies to all discharges of stormwater and dewatering wastewater from construction activities which result from the disturbance of one or more total acres of land area on a site **regardless of project phasing**.

### Permit: General Permit for the Discharge of Stormwater Associated with Industrial Activity

This general permit applies to all discharges from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing or material storage areas at an industrial activity. Registration is required to be submitted in order for the discharges to be authorized by this general permit.

### Permit: General Permit for the Discharge of Stormwater from Department of Transportation Separate Storm Sewer Systems

This general permit applies to the discharges of stormwater and non-stormwater associated with the Department of Transportation.

## Permit: General Permit for Coastal Maintenance

This general permit applies to the maintenance of various coastal structures and activities within the tidal, coastal, and navigable waters of the state below the elevation of the coastal jurisdiction line and, where specifically allowed, in tidal wetlands. These maintenance activities include: marina and mooring boundary reconfiguration, remedial activities required by order, FEMA residential flood hazard mitigation, reconstruction of permitted structures, DOT maintenance activities, beach grading, removal of derelict structures, cultch placement, minor seawall repair, catch basin cleaning, flap gate repair, habitat restoration activities, temporary construction access and DEEP boat launch repairs.

## Permit: General Permit for the Discharge of Stormwater Associated with Commercial Activity

This general permit applies to all discharges from any conveyance which is used for collecting and conveying stormwater and which is directly related to retail, commercial, and/or office services whose facilities occupy ***five acres or more*** of contiguous impervious surface. Registration is required to be submitted in order for the discharges to be authorized by this general permit.

## Permit: General Permit for the Discharge of Stormwater From Small Municipal Separate Storm Sewer Systems Reissuance with Modifications

This general permit applies to all municipalities that have Urbanized Areas as determined by the U.S. Census Bureau. Specifically, it applies to a town's separate storm sewer system and how the town manages their system and what measures they take to reduce or eliminate the discharge of pollutants to that system. Registration is required to be submitted in order for the discharges to be authorized by this general permit.

## Permit: General Permit for the Discharge of Groundwater Remediation Wastewater

This general permit applies to the discharges of any groundwater remediation wastewater or well rehabilitation wastewaters and groundwater remediation recirculating system wastewater.

## Permit: General Permit for Minor Coastal Structures

These minor structures include: 4/40 docks, access stairs, non-harbor moorings, osprey platforms and perch poles, buoys and navigational markers, harbor moorings, swim floats, pump-out facilities and experimental activities and scientific monitoring devices. Registrations are required to be submitted and approved in writing by the Department in order for the 4/40 docks, access stairs and non-harbor moorings to be authorized by this general permit.

## Permit: General Permit for Water Resource Construction Activities

This general permit authorizes the following activities that require permitting through the DEEP under the Inland Wetlands and Watercourses Act, and Connecticut Water Diversion Policy Act, subject to certain conditions, if they are within the jurisdiction of the Commissioner: trail construction, public works projects, infrastructure repairs, and conservation activities. Statewide activities such as: beach maintenance, boat launch maintenance, drainage maintenance are also covered under this general permit. Furthermore, this general permit authorizes, subject to certain conditions, activities for which an authorization has been granted under Category 1 or Category 2 of the Department of Army (US Army Corps of Engineers) General Permit State of Connecticut.

The following categories require written authorization from the Commissioner: Trail Construction, Infrastructure Repairs, Public Works Projects, and Maintenance Plans. The following categories are filing only: Activities Authorized Under Category 1 or Category 2 of the Department of Army.

## Permit: General Permit to Conduct Maintenance, Repairs, and Alterations to Dams

This permit authorizes limited amounts of minor maintenance and repair activities on all dams including removing debris and sediment, replacing weir boards, installing security and safety fencing, replacing sealant in construction joints, establishing grass cover on existing riprapped embankments, maintenance of existing toe drain systems, seepage measurement devices, replacing less than 10 square yards of riprap, exercising and maintenance of gates and valves, cutting and removing woody vegetation (no removal of 3” or larger root systems), restoration of grass cover, filling up to 10 animal burrows, quantity limited concrete and masonry repairs allowed each year. No DEEP filing or registration is required, however, a notice to the municipality using the DEEP notice form is required.

## Permit: General Permit to Conduct Maintenance, Repairs, and Alterations to Dams (GP-015)

This permit authorizes two levels of limited minor repairs and alterations to dams and removal of remnants of dams. Work authorized under Section 3(a)1 of this permit to the limits specified may be done on dams less than 15 feet high and storing less than 50 acre-feet of water without professional engineering oversight including replacing up to 25 square yards of riprap, restoring eroded areas, filling up to 15 animal burrows, quantity limited concrete and masonry repairs. Section 3(a)2 of this permit authorizes increased amounts of work on any size dam with professional engineering oversight including Installing up to 200′ of toe drains, minor repairs to trash racks, gates, valves (no excavation), placing up to 75 square yards of riprap, removing tree root systems (low tree density), filling up to 20 animal burrows; minor concrete and masonry repair, sliplining up to a 36″ diameter outlet pipe, grouting voids, installing bridges over spillways not requiring a center support, digging test pits, drilling soil borings, and installing piezometers. Section 3(a)3 of this permit authorizes removal of remnants of dams no longer impounding water or collecting sediment. A filing using the DEEP GP-015-3(a)1 NO PE form or GP-015-3(a)2 and 3(a)3 PE form, a notice to the municipality using the DEEP notice form, and a filing fee of up to $200 is required.

## Permit: General Permit to Conduct Maintenance, Repairs, and Alterations to Dams (GP-016)

This permit authorizes limited amounts of minor repairs and alterations to dams and some minor dam removal activities including installing up to 400′ of toe drains, repair or replacement of trash racks, gates, and valves, placing up to 150 square yards of riprap, removing tree root systems (moderate tree density), filling up to 25 animal burrows, repairs to or construction of concrete portions of dams (limited concrete volume by formula), repointing or repairing masonry (square foot limit), sliplining outlet pipes (no size limit), grouting voids, installing bridges over spillways which may require center support, digging test pits, drilling soil borings, installing piezometers. Dam removal activities authorized include removal of low or moderate hazard class dams meeting certain criteria, and projects to provide fish passage. A filing using the DEEP GP-016-3(a) Approval filing form, a notice to the municipality using the DEEP notice form, a reply approval, and a filing fee of up to $250 is required.

# Appendix B RUSLE

Excerpt from the USDA ARS, National Sedimentation Laboratory: https://www.ars.usda.gov/midwest-area/west-lafayette-in/national-soil-erosion-research/docs/rusle/

The Revised Universal Soil Loss Equation (RUSLE) [is a computer program that] predicts long-term, average-annual erosion by water for a broad range of farming, conservation, mining, construction, and forestry uses.

The Revised Universal Soil Loss Equation (RUSLE) is an update to Agricultural Handbook No. 537, containing a computer program to facilitate the calculations. RUSLE also includes the analysis of research data that were unavailable when Agricultural Handbook 537 was completed. Although the original Universal Soil Loss Equation (USLE) has been retained in RUSLE, the technology for factor evaluation has been altered and new data have been introduced with which to evaluate the terms for specified conditions.

Both RUSLE1.06c and RUSLE2 were developed and are maintained principally by the USDA-Agricultural Research Service (ARS), the USDA-Natural Resources Conservation Service (NRCS), and the University of Tennessee.

RUSLE began development at the National Soil Erosion Research Laboratory in the early 1990's. It is now maintained by the ARS National Sedimentation Laboratory in Oxford Mississippi.

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Further information, the most up to date version and tutorials can be found on the ARS National Sedimentation Laboratory Website, https://fargo.nserl.purdue.edu/rusle2_dataweb/

# Appendix C Agency Contact Information

## *US Army Corps of Engineers*

General Questions: 1-202-761-0011
New England District
Attention: CENAE-OD-R
696 Virginia Road
Concord, MA, 01742-2751
P: 1-978-318-8238 & Toll Free: 1-800-343-4789
F: 978-318-8303
Website: New England District, U.S. Army Corps of Engineers

## *US Environmental Protection Agency*

Headquarters
Environmental Protection Agency
1200 Pennsylvania Avenue, N. W
Washington, DC 20460

Region 1 Office
5 Post Office Square – Suite 100
Boston, MA 02109-3912
P: 1-888-372-7341
W: http://www.epa.gov/region01/

## EPA Long Island Sound Office

| | |
|---|---|
| Long Island Sound Study | Stamford Government Center<br>888 Washington Blvd.<br>Stamford, CT 06904-2152<br>P: 1-203-977-1541<br>W: https://longislandsoundstudy.net/ |

## Connecticut Regulations and Statutes

| | |
|---|---|
| *Statutes:*<br>*https://www.cga.ct.gov/current/pub/titles.html* | Regulations and all associated documentation, including comment period instructions and submittals:<br>https://eregulations.ct.gov/eRegsPortal/ |

## Connecticut State Agencies & Councils

| | |
|---|---|
| Primary Directory of Connecticut | https://portal.ct.gov/Government/Departments-and-Agencies |

## CT State Library

| | |
|---|---|
| CT State Library<br>Preserving the Past. Informing the Future. | 231 Capitol Ave, Hartford, CT 06106<br>Phone: 1-860-757-6500<br>Website: https://ctstatelibrary.org/ |

## USDA Natural Resources and Conservation Service

Website: https://usda.gov

1185 New Litchfield Street Torrington CT 06790

| | |
|---|---|
| NRCS CT State Office | 344 Merrow Road,<br>Suite A<br>Tolland, CT 06084-3917<br>P: 1-860-871-4011 |
| NRCS Danielson Office | USDA, Natural Resources Conservation Service<br>71 Westcott Road, Danielson, CT 06239<br>Phone: 1-860-779-0557 |
| NRCS Hamden Office | USDA, Natural Resources Conservation Service<br>51 Mill Pond Road, Hamden, CT 06514-1703<br>Phone: 1-203-287-8038 |
| NRCS Norwich Service Center | USDA, Natural Resources Conservation Service<br>Yantic River Plaza, 238 West Town Street, Norwich, CT 06360<br>Phone: 1-860-887-3604 |
| NRCS Torrington Service Center | USDA, Natural Resources Conservation Service<br>1185 New Litchfield Street, Torrington, CT 06790<br>P: 1-860-626-8852 |
| NRCS Windsor Service Center | USDA, Natural Resources Conservation Service<br>100 Northfield Drive, 4th Floor, Windsor, CT 06095<br>Phone: 1-860-688-7725 |

## CT Agricultural Experiment Station

123 Huntington Street

New Haven, CT 06511

P: 203-974-8500

Toll-Free: 1-877-855-2237

Website: https://portal.ct.gov/CAES

## CT Council on Soil and Water Conservation

Email: ctcouncilswc@gmail.com

http://www.ctcouncilonsoilandwater.org/

## CT Council on Environmental Quality

79 Elm Street Hartford, CT 06106

Phone: 1-860-424-4000

Website: https://portal.ct.gov/ceq

## CT Department of Agriculture

450 Columbus Blvd.

Suite 701

Hartford, CT 06103

P: 1-860-713-2500

Toll Free: 1-800-861-9939

Website: https://portal.ct.gov/DOAG

## CT Department of Administrative Services

450 Columbus Boulevard

Hartford, CT 06103

P: 1-860-713-5100

Website: https://portal.ct.gov/DAS

## CT Department of Economic and Community Development

450 Columbus Boulevard

Hartford, CT 06103

P: 1-860-500-2300

Website: https://portal.ct.gov/DECD

## CT Department of Energy and Environmental Protection

79 Elm Street

Hartford, CT 06106-5127

P: 1-860-424-3000

W: https://portal.ct.gov/DEEP

## CT Department of Public Health

410 Capitol Ave.

Hartford, CT 06134

P: 1-860-509-8000

Website: https://portal.ct.gov/DPH

## CT Department of Transportation

2800 Berlin Turnpike

P.O. Box 317546

Newington, CT 06131-7546

P: 1-860-594-2000

**Office of Environmental Planning**

P: 1-860-594-2946

Website: https://portal.ct.gov/dot

## CT Cooperative Extension System

1376 Storrs Rd, Unit 4066

Phone: 1-860-486-2917

Email: cahnrdean@uconn.edu

Website: https://cahnr.uconn.edu/extension/

Extension Specialist Directory:
https://cahnr.uconn.edu/extension/specialists/

## CT Secretary of State

P.O Box 150470

165 Capitol Avenue Suite 1000

Hartford CT 06115-0470

Phone: 1-860-509-6200

Website: https://portal.ct.gov/sots

## Connecticut Business Registration System

https://business.ct.gov/New-Business-Registration-System?language=en_US

## CT Siting Council

CONNECTICUT SITING COUNCIL

New Britain, CT 06051

P: 1-860-827-2935

Email address: siting.council@ct.gov

Website: https://portal.ct.gov/CSC

# Conservation Districts

https://www.conservect.org/

CONNECTICUT Conservation Districts

**Connecticut River Coastal Conservation District**
deKoven House
27 Washington Street
Middletown, CT 06457
P: 1-860-346-3282
Email: *ctrivercoastal@conservect.org*

**Eastern Connecticut Conservation District**
139 Wolf Den Road
Brooklyn, CT 06234
P: 1-860-774-9600 ext: 13

238 West Town Street
Norwich CT 06360
P: 1-860-319-8806

**North Central Conservation District**
24 Hyde Avenue
Vernon, CT 06066-4503
Phone: 1-860-875-3881

**Southwest Conservation District**
Northern Research Station
51 Mill Pond Rd
Hamden, CT 06514
Phone: 1-203-859-7014
Email: SWCD@conservect.org

**Northwest Conservation District**
1185 New Litchfield St
Torrington, CT 06790
P: 1-860-626-7222
E: info@nwcd.org
W: https://nwcd.org/

# Appendix D – Design Storms

## Introduction

Many of the erosion and sediment control measures contained in these Guidelines are designed to convey peak rates of runoff and/or withstand associated flow velocities without erosion or flood damage for storm events of various sizes, which are also called "design storms." Design storms are defined in terms of.

1. rainfall depth and duration
2. recurrence interval (i.e., the likelihood or probability of the occurrence of a certain size storm event)
3. rainfall distribution (i.e., how rain falls during a storm event)

## Design Storm Rainfall Depth and Duration

Design storm rainfall depth and duration shall correspond to the 24-hour precipitation depth with a specified recurrence interval as defined by the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimates, as amended,[81],[81] or equivalent regional or state rainfall probability information developed from NOAA Atlas 14[81]. Erosion and sediment control measures should be designed based on, at a minimum, the 50$^{th}$ percentile (median) NOAA Atlas 14 precipitation depth[81], which is the

**Updated Design Storm Rainfall**

NOAA Atlas 14 replaces Technical Paper No. 40 (TP-40), which was developed by the U.S. Weather Bureau in 1961 and later updated by NWS HYDRO-35 in 1977, as the definitive source of design rainfall in Connecticut. The version of NOAA Atlas 14 for the northeastern United States, including Connecticut, was released in 2015 and revised in 2019. NOAA Atlas 14 contains precipitation frequency estimates for selected durations and frequencies with associated lower and upper bounds of the 90% confidence interval (5% lower and 95% upper confidence limits). NOAA Atlas 14 is a significant improvement over the TP-40 precipitation estimates since it generally includes more observation locations, more sophisticated statistical analysis methods, a much longer period of record, and more recent precipitation data, thereby accounting for observed increases in extreme precipitation as the climate has become warmer and wetter. NOAA Atlas 14 has also been adopted by CT DEEP as the source of design storm precipitation in the Construction Stormwater General Permit and in the CTDOT Transportation MS4 Permit. CTDOT has incorporated the use of NOAA Atlas 14 precipitation frequency estimates in the CTDOT Drainage Manual. The NOAA Atlas 14 results are published online through the Precipitation Frequency Data Server.

[81] NOAA Atlas 14 Volume 10 Version 3, Precipitation-Frequency Atlas of the United States, Northeastern States. NOAA, National Weather Service, 2015, revised 2019. https://www.weather.gov/media/owp/oh/hdsc/docs/Atlas14_Volume10.pdf

primary value reported by the online Precipitation Frequency Data Server (PFDS). The review authority may require at their discretion the use of greater 24-hour precipitation depths such as the upper bound of the 90% confidence interval (also reported by the PFDS) to account for larger and more intense observed storm events.

- NOAA Atlas 14[82] Precipitation frequency estimates should be selected for the project site based on the site address, latitude/longitude coordinates, or by clicking on the approximate center of the site.
- "Precipitation depth" and "Partial duration" time series type should be selected from the dropdown menus.
- Select precipitation depths from the storm duration row labeled "24-hour" (see **Figure D-1**).
- County-wide average 24-hour precipitation depths derived from NOAA Atlas 14[81] may also be used, provided that the county-wide average values are representative of the project site and the values are based on the latest version of NOAA Atlas 14[81]. Such values have been incorporated as standard options in hydrologic analysis software such as HydroCAD. However, site-specific precipitation estimates obtained from the NOAA Atlas 14[81] Precipitation Frequency Data Server are preferred.

[82]If a more recent generation of precipitation statistics is available from NOAA, that as the most reliable method to determine the appropriate hydrology should replace the references to NOAA Atlas 14.)

**POINT PRECIPITATION FREQUENCY (PF) ESTIMATES**

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 10, Version 3

PF tabular | PF graphical | Supplementary information | Print page

**PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | **0.332** (0.259-0.415) | **0.405** (0.315-0.506) | **0.523** (0.406-0.656) | **0.621** (0.479-0.784) | **0.756** (0.565-1.00) | **0.858** (0.629-1.16) | **0.965** (0.686-1.36) | **1.08** (0.730-1.57) | **1.25** (0.813-1.88) | **1.39** (0.881-2.13) |
| 10-min | **0.471** (0.367-0.588) | **0.573** (0.447-0.717) | **0.740** (0.574-0.929) | **0.879** (0.679-1.11) | **1.07** (0.800-1.42) | **1.22** (0.890-1.65) | **1.37** (0.971-1.93) | **1.54** (1.03-2.22) | **1.78** (1.15-2.67) | **1.97** (1.25-3.02) |
| 15-min | **0.554** (0.432-0.692) | **0.675** (0.525-0.843) | **0.872** (0.677-1.09) | **1.04** (0.800-1.31) | **1.26** (0.942-1.67) | **1.43** (1.05-1.94) | **1.61** (1.14-2.26) | **1.81** (1.22-2.61) | **2.09** (1.35-3.13) | **2.32** (1.47-3.56) |
| 30-min | **0.761** (0.593-0.950) | **0.922** (0.718-1.15) | **1.19** (0.921-1.49) | **1.41** (1.09-1.78) | **1.71** (1.27-2.26) | **1.93** (1.42-2.62) | **2.17** (1.54-3.06) | **2.44** (1.64-3.52) | **2.82** (1.83-4.23) | **3.14** (1.99-4.81) |
| 60-min | **0.968** (0.755-1.21) | **1.17** (0.912-1.46) | **1.50** (1.17-1.88) | **1.78** (1.37-2.24) | **2.15** (1.61-2.85) | **2.44** (1.79-3.30) | **2.74** (1.95-3.86) | **3.07** (2.07-4.44) | **3.56** (2.30-5.33) | **3.95** (2.50-6.06) |
| 2-hr | **1.28** (1.00-1.59) | **1.53** (1.20-1.90) | **1.95** (1.52-2.42) | **2.29** (1.78-2.87) | **2.76** (2.08-3.64) | **3.11** (2.30-4.20) | **3.49** (2.51-4.92) | **3.93** (2.66-5.65) | **4.59** (2.99-6.85) | **5.15** (3.27-7.84) |
| 3-hr | **1.49** (1.18-1.84) | **1.78** (1.40-2.20) | **2.25** (1.77-2.80) | **2.65** (2.07-3.31) | **3.19** (2.42-4.19) | **3.60** (2.67-4.84) | **4.03** (2.92-5.67) | **4.55** (3.09-6.51) | **5.34** (3.48-7.93) | **6.01** (3.82-9.11) |
| 6-hr | **1.89** (1.50-2.31) | **2.26** (1.80-2.77) | **2.87** (2.28-3.54) | **3.38** (2.67-4.19) | **4.09** (3.12-5.33) | **4.60** (3.45-6.17) | **5.17** (3.77-7.24) | **5.85** (3.98-8.32) | **6.89** (4.51-10.2) | **7.79** (4.97-11.7) |
| 12-hr | **2.32** (1.86-2.82) | **2.81** (2.25-3.42) | **3.61** (2.89-4.41) | **4.27** (3.40-5.26) | **5.19** (3.99-6.73) | **5.87** (4.42-7.81) | **6.60** (4.84-9.19) | **7.49** (5.13-10.6) | **8.86** (5.81-13.0) | **10.0** (6.42-15.0) |
| 24-hr | **2.72** (2.21-3.28) | **3.35** (2.71-4.05) | **4.38** (3.53-5.32) | **5.23** (4.20-6.39) | **6.41** (4.98-8.28) | **7.28** (5.54-9.65) | **8.23** (6.09-11.4) | **9.41** (6.46-13.2) | **11.3** (7.41-16.4) | **12.9** (8.25-19.1) |
| 2-day | **3.08** (2.52-3.69) | **3.86** (3.16-4.63) | **5.14** (4.18-6.19) | **6.20** (5.02-7.52) | **7.66** (6.01-9.87) | **8.73** (6.71-11.6) | **9.92** (7.44-13.8) | **11.5** (7.90-16.0) | **14.0** (9.21-20.2) | **16.2** (10.4-23.9) |
| 3-day | **3.35** (2.75-4.00) | **4.21** (3.46-5.04) | **5.63** (4.61-6.75) | **6.80** (5.53-8.21) | **8.42** (6.64-10.8) | **9.60** (7.42-12.7) | **10.9** (8.23-15.2) | **12.6** (8.74-17.6) | **15.5** (10.2-22.3) | **18.0** (11.6-26.5) |
| 4-day | **3.59** (2.97-4.28) | **4.52** (3.73-5.38) | **6.03** (4.95-7.21) | **7.28** (5.94-8.76) | **9.00** (7.11-11.5) | **10.3** (7.95-13.5) | **11.7** (8.81-16.2) | **13.5** (9.35-18.7) | **16.5** (10.9-23.8) | **19.2** (12.4-28.2) |
| 7-day | **4.29** (3.56-5.07) | **5.32** (4.42-6.29) | **7.00** (5.79-8.32) | **8.40** (6.90-10.0) | **10.3** (8.20-13.1) | **11.7** (9.13-15.3) | **13.3** (10.1-18.2) | **15.3** (10.6-21.1) | **18.5** (12.3-26.5) | **21.4** (13.9-31.3) |

*Figure D. 1 Precipitation Frequency (NOAA Atlas 14)*

*Figure D- 1 24-hour Design Storm Rainfall Depths from NOAA Atlas 14 Precipitation Frequency Data Server*

## Design Storm Rainfall Distribution

The design storm rainfall distribution shall correspond to the Natural Resources Conservation Service (NRCS) Type D regional rainfall distribution, which is derived from the NOAA Atlas 14 rainfall data (referred to as "NOAA_D" rainfall distribution). Other equivalent regional rainfall distributions specifically developed for use in Connecticut, or a site-specific rainfall distribution based on NOAA Atlas 14 data, may be used for design purposes at the discretion of the review authority.

## Design Storm Recurrence Interval

The recurrence interval (sometimes called the return period) is the average number of years between precipitation events of a certain size based on the probability that the precipitation event will be equaled or exceeded in any given year. For example, a storm with a 2-year recurrence interval (i.e., the "2-year storm") is expected to occur, on average, once every 2 years and has a 50% chance (1 in 2 probability) of occurring in any given year. These Guidelines contain design storm recurrence intervals specific to various types of erosion and sediment control measures, typically ranging from the 2-year to 100-year frequency storms

**Updated Rainfall Distribution**

The NOAA_D rainfall distribution replaces the NRCS Type III regional distribution, which has historically been used in Connecticut and other Atlantic coastal areas, as well as the Northeast Regional Climate Center (NRCC) regional rainfall distributions developed in 2015. In 2018, Connecticut NRCS began recommending the use of the NOAA_D regional rainfall distribution throughout Connecticut. The NRCS NOAA_D rainfall distribution is available as a standard rainfall distribution in hydrologic analysis software such as WinTR-55. In HydroCAD, the NRCC_D distribution is available as a pre-defined rainfall distribution for Connecticut, while NOAA_D is not. NOAA_D may be created as a user-defined rainfall distribution in HydroCAD. The NOAA_D rainfall distribution is available online in text format.

## Climate Change Considerations for Design Storms

While precipitation frequency estimates published in NOAA Atlas 14 reflect observed increases in extreme precipitation over the last several decades, NOAA Atlas 14 does not account for anticipated future increases in extreme precipitation due to projected climate change. The NOAA Atlas 14 analysis methods assume stationarity in both the historical data used in making the estimates and in future conditions. This assumption may not be appropriate under changing (i.e., non-stationary) climatic conditions. NOAA is working with several research universities to develop precipitation frequency estimates that account for non-stationary climate assumptions and factor in climate projections.

Several Northeastern U.S. states have also begun to develop and implement updated design storm precipitation estimates to account for projected future increases in extreme rainfall. The approach typically involves the use of downscaled General Circulation Model (GCM) output to estimate future increases in extreme precipitation, or relative increases in extreme precipitation based on the ratio of downscaled precipitation estimates under baseline (i.e., current or recent historic) and future conditions. Some uncertainly exists in the downscaled future precipitation estimates, particularly after mid-century, given their dependence on the potential for greenhouse gas emission reductions locally and globally. The University of Connecticut through the Connecticut Institute for Resilience & Climate Adaptation (CIRCA) is conducting ongoing research on this topic to better inform climate resilient design for the State of Connecticut.

When designing permanent post-construction stormwater management measures, project proponents should consider the use of greater design storm rainfall depths, in excess of the current NOAA Atlas 14 median values, to account for projected future increases in extreme precipitation. Future precipitation estimates should be based on the latest climate change projections for Connecticut and a planning horizon corresponding to a minimum 50-year service life for the proposed stormwater infrastructure.

# Appendix E- Soil Classification System

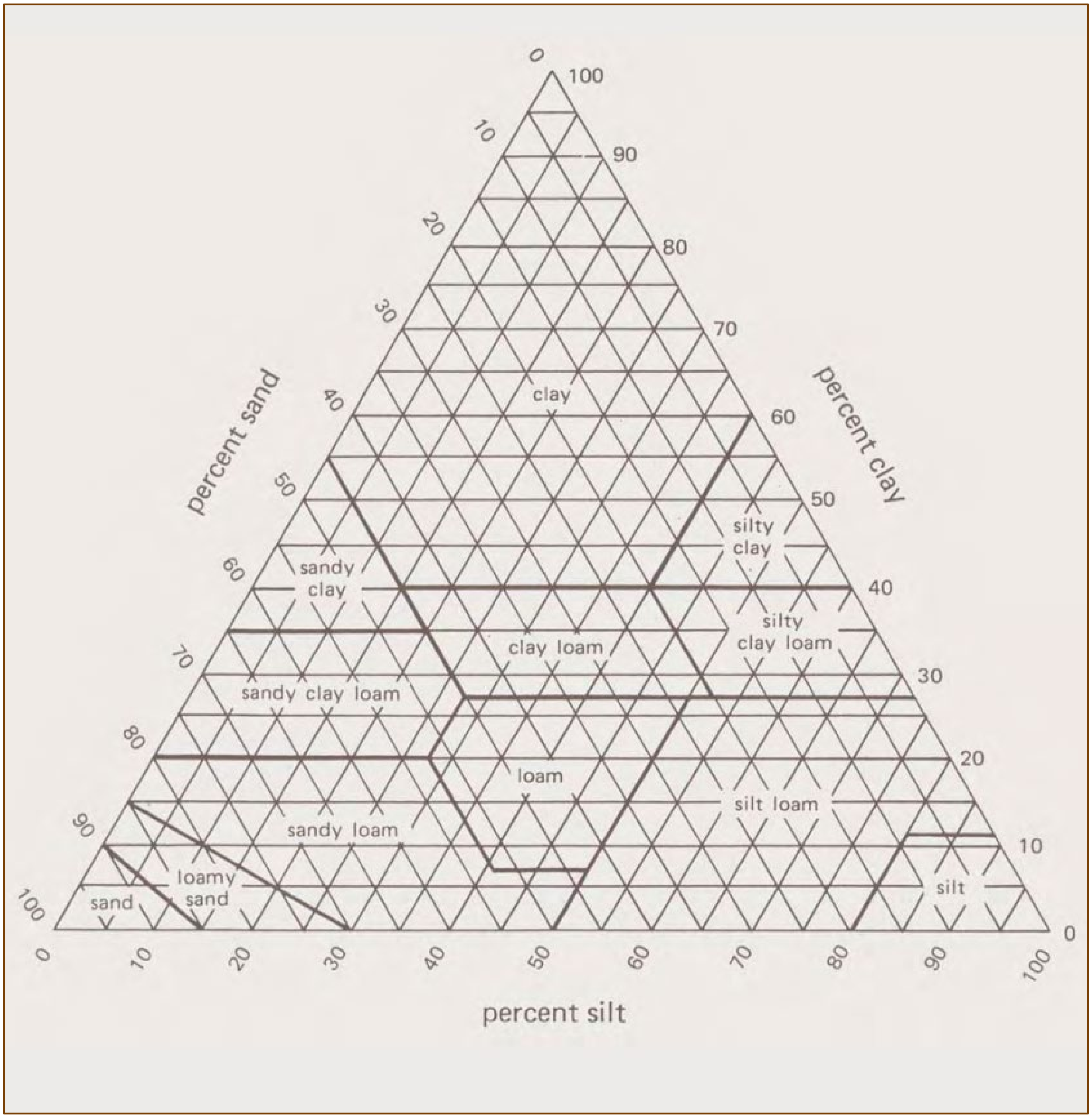
Soil is an aggregate of loose mineral and organic particles being distinguished from rock, which exhibits strong permanent cohesion between the mineral particles. The primary components of soil are gravel, sand, silt, and clay. Organic material is commonly present in surface samples of soil. A soil's properties are dependent upon its composition from these components. A number of soil classification systems have been established by different organizations to be used for specific purposes. They include:

- Textural Soil Classification System (USDA)
- American Association of State Highway Transportation Officials System (AASHTO)
- Unified Soil Classification System (USCS)
- American Society for Testing and Materials System (ASTM)
- Federal Aviation Agency System (FAA)
- Geologic Soil Classification System
- Agronomic Soil Classification System

Only the first three in this list will be discussed here. These systems index various qualities of the soil, depending on need. Indexing of the soil is needed to apply some of the qualitative and quantitative property relationships contained in these classification systems. Indexed properties are of two types: grain properties and aggregate properties. Grain properties include particle size distribution, density and mineral composition. Particle size distribution is determined by a sieve test for coarse soils and a dispersion test for fine soils. Aggregate soil properties are weight-volume relationships. The aggregate properties are derived from the percentages of solid material in the soil sample in relation to the air-filled and water-filled voids. The aggregate soil properties include soil porosity, void ratio, water content, degree of saturation, soil density, dry density, bulk density, compacted density, percent pore space and the density index. The most commonly used indexed property is particle size. The actual classification of a soil will depend on the percentage of each constituent (i.e. gravel, sand, silt and clay).

The Textural Soil Classification System by the USDA uses a qualitative description of each soil's texture and ignores the presence of gravel. A mechanical analysis is performed in the laboratory and a percentage obtained for each of the soil constituents. Total amount of sand, from coarse to very fine, is used, along with silt and clay contents, to determine the soil textural name from the USDA textural triangle (see Figure E- 1) or USDA's interactive Soil Texture Calculator. This system is commonly used for agricultural and farming practices. Since this system provides only a general qualitative description, other methods have been developed which more fully reflect the mechanical properties of the soil.

*Figure E- 1 USDA Textural Triangle*




The AASHTO System and Unified System classify soils specifically for their engineering properties. The AASHTO system classifies soils according to the properties that affect roadway construction and maintenance. The fraction of mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in Group A-1 are coarse grained and low in silt and clay. Soils in Group A-7 are fine grained. Highly organic soils are classified on the basis of visual inspection and assigned a Group A-8 classification. The AASHTO classification system is summarized inFigure E- 2.

AASHTO classification procedure:

Using the test data proceed through Figure E- 2 from left to right. The correct group will be found by the process of elimination. The first group from the left consistent with the test data is the correct classification. The A-7 group is subdivided into two subgroups A-7-5 and A-7-6, depending on the plastic limit. For plastic limit;

$$w_p = w_l - I_p\text{, less than 30, the classification is A-7-6}$$

$$w_p = w_l - I_p\text{, greater than or equal to 30, the classification is A-7-5}$$

NP means non-plastic

*Figure E- 2 AASHTO Soil Classification*

**Table 5.1. AASHTO Classification System**

| *General Classification* | *Granular materials (35% or less passing No. 200 Sieve (0.075 mm))* | | | | | | | *Silt-clay Materials More than 35% passing No. 200 Sieve (0.075 mm)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Group Classification* | *A—1* | | *A—3* | *A—2* | | | | *A—4* | *A—5* | *A—6* | *A—7* |
| | *A—1—a* | *A—1—b* | | *A—2—4* | *A—2—5* | *A—2—6* | *A—2—7* | | | | *A—7—5*<br>*A—7—6* |
| (*a*) Sieve Analysis: Percent Passing | | | | | | | | | | | |
| (*i*) 2.00 mm (No. 10) | 50 max | | | | | | | | | | |
| (*ii*) 0.425 mm (No. 40) | 30 max | 50 max | 51 min | | | | | | | | |
| (*iii*) 0.075 mm (No. 200) | 15 max | 25 max | 10 max | 35 max | 35 max | 35 max | 35 max | 36 min | 36 min | 36 min | 36 min |
| (*b*) Characteristics of fraction passing 0.425 mm (No. 40) | | | | | | | | | | | |
| (*i*) Liquid limit | | | | 40 max | 41 min | 40 max | 41 min | 40 max | 41 min | 40 max | 41 min |
| (*ii*) Plasticity index | 6 max | | N.P. | 10 max | 10 max | 11 min | 11 min | 10 max | 10 max | 11 min | 11 min* |
| (*c*) Usual types of significant Constituent materials | Stone Fragments Gravel and sand | | Fine Sand | Silty or Clayey Gravel Sand | | | | Silty Soils | | Clayey Soils | |
| (*d*) General rating as subgrade. | Excellent to Good | | | | | | | Fair to Poor | | | |

* If plasticity index is equal to or less than (liquid Limit—30), the soil is A—7—5 (*i.e.* PL > 30%)
If plasticity index is greater than (Liquid Limit—30), the soil is A—7—6 (*i.e.* PL < 30%)

The Unified System classifies soils according to their suitability for construction material, including its stability, permeability, resistance to erosion, compressibility and ability to bear loads without deformation. It considers grain-size distribution, plasticity index, liquid limit, and organic matter content in the soil. The Unified System is based on that portion of soil having particles smaller than 3 inches in diameter. Soil classes include coarse-grained soils (GW, GP, GM, GC, SW, SP, SM, SC), fine-grained soils (ML, CL, OL, MH, CH, OH), and highly organic soils (PT). Borderline soils require a dual classification symbol. Figure E- 3 summarizes the classification description of each class.

*Figure E- 3 Unified Soil Classification System*

| Major Divisions | | | Group Symbol | Group Name |
|---|---|---|---|---|
| **Coarse Grained Soils More than 50% Retained on No 200 Sieve** | Gravel, More than 50% Retained on No 4 Sieve | Clean Gravel | GW | Well-Graded Gravel, Fine to Coarse Gravel |
| | | | GP | Poorly-Graded Gravel |
| | | Gravel with Fines | GM | Silty-Gravel |
| | | | GC | Clayey-Gravel |
| | Sand, More than 50% of Coarse Fraction Passes No 4 Sieve | Clean Sand | SW | Well Graded Sand, Fine to Coarse Sand |
| | | | SP | Poorly Graded Soil |
| | | Sand with Fines | SM | Silty-Sand |
| | | | SC | Clayey-Sand |
| **Fine Grained Soils More than 50% Passes on No 200 Sieve** | Silt and Clay Liquid Limit Less than 50 | Inorganic | ML | Silt |
| | | | CL | Clay |
| | | Organic | OL | Organic Silt, Organic Clay |
| | Silt and Clay Liquid Limit 50 or More | Inorganic | MH | Silt of High Plasticity, Elastic Silt |
| | | | CH | Clay of High Plasticity, Fat Clay |
| | | Organic | OH | Organic Clay, Organic Silt |
| **Highly Organized Soils** | | | PT | Peat |

# Appendix F – Definitions and Abbreviations

| Abbreviation / Term | Definition |
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| **2:1** | Expression of slope gradient of run to rise where for every 2 units of horizontal distance there is a 1-unit vertical rise, referred to as two to one. |
| **Abutment** | Support for a bridge, taking the horizontal thrust from the bridge in addition to its weight. |
| **A.c.** | Acre or acres (also abbreviated as Ac.). |
| **Access road** | A vehicular travel way constructed to provide ingress and egress to an area. |
| **Acoe** | See USACOE |
| **Acre-foot** | A term used to denote a volume of water that will cover one acre to the depth of one foot. One acre-foot contains 325,851 gallons of water. Sometimes referred to as "Ac. ft." |
| **Aggregate** | Granular material such as sand, gravel, crushed gravel, or crushed stone. Aggregate is classified by size and gradation. See CTDOT Standard Specification Section M.01.01 for gradation of aggregate. |

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| **Ansi** | American National Standards Institute. |
| **Apa** | Aquifer Protection Area. |
| **Apron** | A lining extending downstream from a hydraulic structure to prevent erosion and scour. |
| **Aquifer** | A porous water-bearing formation of permeable rock, sand, or gravel capable of yielding economically significant quantities of groundwater. |
| **Artesian** | A groundwater condition where a confined aquifer transfers static water pressures over some distance and can be under pressure. |
| **Articulating concrete block** | A type of slope stabilization structure consisting of a manufactured system consisting of concrete blocks that form open cells and that can be filled with plantable soil, sand, aggregate, etc. |
| **Astm** | American Standards of Testing and Materials. |
| **Auxiliary spillway** | See emergency spillway. |
| **Balled & bur lapped** | Nursery plant stock dug for transplanting in which soil around the roots is undisturbed; the ball of earth is then bound in burlap or similar mesh fabric. |
| **Bare root** | Nursery plant dug for transplanting from which the soil is removed from the roots. |

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| **Barrel** | A length of pipe, conduit or culvert laid horizontally through a roadway or dam embankment. |
| **Base flow** | The portion of stream flow that is not due to storm runoff but is the result of groundwater discharge or discharge from lakes or similar permanent impoundments of water. |
| **Bed load** | Sand, silt, gravel, or soil and rock detritus carried by a stream, river, or other similar flowing waterbody on or immediately above its bed. The bed load is part of the sediment load composed of relatively coarse material. The movement of bed load is executed by rolling, sliding along the bed, or saltation (bouncing along the bed or moving by the impact of bouncing particles) of bed particles. |
| **Bedding** | Material used under and around a structure (e.g., a culvert) to form a stable base for the structure. |
| **Berm** | A man-made deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, sometimes referred to as a bench. |
| **Borrow area** | An area from which soil or rock is taken to build an embankment, earth dam, or other construction. |
| **Bmp** | Best Management Practice. |
| **Break grade** | To change grade, as in a tile line, ditch, or channel. |

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| **Cellular confinement system** | A type of slope stabilization structure consisting of a manufactured three-dimensional sheet or mat with cells that are filled with materials such as plantable soil, sand, or aggregate, providing weight and shear resistance while still maintaining vegetation. |
| **Cfr** | Code of Federal Regulations. |
| **Cfs** | Cubic feet per second, the rate of fluid flow at which 1 cubic foot of fluid passes a measuring point in one second. |
| **Cgs** | Connecticut General Statutes. |
| **Channel** | A drainageway that possesses a definite bed and banks which confine flowing water. |
| **Channel capacity** | Capacity of a channel constructed or natural, when flowing full or at design flow. Usually defined in terms of “Q” usually expressed as cfs. |
| **Channel grade** | |
| **Stabilization structure** | A permanent open structure used to control the grade and head cutting in natural or artificial channels. |
| **Channel stabilization** | Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, or other measures. |
| **Chute** | An open conduit for the purpose of transporting water down a slope or across obstructions. Same as flume. |
| **Circa** | Connecticut Institute for Resilience & Climate Adaptation. |

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| **Cjl** | Connecticut Coastal Jurisdiction Line. |
| **Clay** | A mineral soil consisting of particles less than 0.005 to 0.002 millimeters in equivalent diameter, depending on the soil classification. |
| **Closed drain** | That portion of a subsurface drain that rises to the surface to receive surface water. |
| **Cofferdam** | A temporary wall constructed to exclude water from an excavation, formed by sheet piling, earth, sandbags, or other similar materials that are structurally capable of withstanding the water pressure without failure. |
| **Colloid** | In soil, organic or inorganic matter having particle sizes ranging from 0.0001 to 0.000001 millimeter. |
| **Compost filter sock** | A three-dimensional tubular filtration device constructed by filling a mesh tube with a compost filter media. See filter sock. |
| **Concrete** | A mixture of coarse aggregate, fine aggregate, water and Portland-pozzolan cement, also referred to as Portland cement concrete. |
| **Construction entrance** | A stone stabilized pad sometimes associated with a mud rack, automotive spray, or other measures located at points of vehicular ingress and egress on a construction site used to reduce the tracking of sediment off site onto paved surfaces. |

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| **Construction general permit** | Connecticut Department of Energy and Environmental Protection General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities. |
| **Construction phasing** | Divides a construction project into multiple phases, which are distinct and complete sets of activities that have a specific functional goal wherein the work to be completed in one phase is not dependent upon the execution of work in a later phase in order to make it functional. |
| **Construction sequencing** | A site-specific work schedule that coordinates the timing of site development related land-disturbance activities and the implementation of temporary and permanent erosion and sediment control measures during any particular phase to minimize soil erosion and sedimentation. |
| **Continuity equation** | In hydrology, an axiom stating that the rate of flow past one section of a water conveyance system is equal to the rate of flow past another section of the same water conveyance system plus or minus any additions or subtractions between the two sections. |
| **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. |
| **Control section** | A constriction or obstruction used in the design of hydraulics structures, |

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| | such as spillways or grade stabilization structures, at which depths upstream are subcritical and downstream are supercritical. |
| **Core trench** | Excavation for a core wall in the construction of an earth embankment. |
| **Cover** | Vegetation or other material providing soil protection. |
| **Creep** | The very slow, generally continuous downslope movement of soil and debris under the influence of gravity. The movement of sand grains along the land surface. |
| **Crest** | The top of a dam, dike, spillway, or weir, frequently restricted to the overflow portion. |
| **Critical depth** | The depth of water flowing in an open channel or conduit under conditions of critical flow. |
| **Critical flow** | The flow condition at which the discharge is a maximum for a given specific energy, or at which the specific energy is a minimum for a given discharge. |
| **Cross section** | A view of a vertical plane as cut through the ground surface (sometime subsurface) for determining contours, quantities of earthwork, channel capacity, etc. |
| **Cross-sectional area** | The area of a cross section or a section of the stream at right angle to the main (average) direction of flow of a stream and bounded by the |

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| | stream's wetted perimeter and free surface. |
| **Crz** | Critical Root Zone. |
| **Csm** | Cubic feet per second per square mile. |
| **Ct** | Connecticut. |
| **Ct deep** | Connecticut Department of Energy and Environmental Protection. |
| **Ctdot** | Connecticut Department of Transportation. |
| **CTDOT #3 stone** | A gradation of aggregate found in CTDOT Standard Specifications Section M.01.01. |
| **Ctdot drainage manual** | Connecticut Department of Transportation Hydraulics and Drainage Manual, as amended. |
| **CTDOT standard specifications** | Document entitled "State of Connecticut Department of Transportation, Standard Specifications for Roads, Bridges and Incidental Construction", as amended. |
| **Ct dph** | Connecticut Department of Public Health. |
| **Cu. Yds. Or c.y.** | Cubic yards; a term expressing volume, especially of earth fill. |
| **Cut** | Portion of land surface or area from which earth or rock has been removed or will be removed by excavation; the depth below original ground surface to excavated surface. |
| **Dam** | A barrier to confine or raise water for storage or diversion, to create a |

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| | hydraulic head, or for retention of soil, rock, or other debris. |
| **Dbh** | Diameter at Breast Height. |
| **Dcia** | Directly Connected Impervious Area. DCIA is impervious area with a direct hydraulic connection to a storm drainage system or a waterbody via continuous paved surfaces, gutters, drainpipes, or other conventional conveyance and detention structures that do not reduce runoff volume. |
| **Deposition** | Transported material deposited because of decreased transport capacity of water or wind. |
| **Detention facility** | A surface water runoff storage facility that is normally dry but designed to hold surface water temporarily during and immediately after runoff event to reduce downstream peak discharges. |
| **Dewatering** | The removal of water by pumping, infiltration, open air drying, or other methods; drainage of the soil profile. |
| **Dewatering of earth materials** | A procedure that uses a perimeter earthen berm and/or excavation to create a containment area where excessively wet soil is placed to allow for the draining of water or evaporation of excessive moisture. |
| **Dike** | An embankment to confine or control water. |
| **Discharge** | 1. Rate of flow, specifically fluid flow. 2. A volume of fluid passing a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, |

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| | or cubic meters per second (commonly referred to in hydraulic equations as Q). |
| **Disturbed area** | Area where vegetation, topsoil, or overburden is removed or where topsoil, spoil, and other material is placed. |
| **Diversion** | A channel and/or supporting ridge, or other man-made structure constructed to change the direction of water from one area to another. |
| **Downstream** | In a direction toward which a watercourse or drainageway is flowing. |
| **Drainage area** | The land which drains water to a given point. Synonymous with watershed, drainage basin or catchment area, typically measured in acres, hectares, or square miles. |
| **Drainage basin** | See drainage area. |
| **Drainage coefficient** | A term expressing the rate at which water runs off from a drainage area. drainage pattern. Arrangement of a system of surface or subsurface drains or overland flow paths. |
| **Drainageway** | A man-made or natural channel or course along which water moves in draining an area. |
| **Drop inlet** | An L-shaped conduit placed in an earth-filled dam, used to drop water from one level to another for gradient control and channel stabilization. |

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| **Drop inlet spillway** | Overfall hydraulic structure in which water flows down into a vertical riser conduit. |
| **Drop spillway** | A spillway, usually less than 20 feet (6 meters) high having a vertical downstream face, and water drops over the face without touching the face. |
| **Dust control** | The control of dust on construction sites, construction roads and other areas where dust is generated to prevent the movement of dust from exposed soil surfaces. |
| **E&s** | Erosion and sediment control. |
| **E&S measure** | A defined procedure intended for controlling the detachment of soil, the movement of water, and/or the deposition of sediment; erosion and sediment control measure. |
| **Embankment** | A man-made deposit of material that is raised above the natural surface of the land and used to contain, divert or store water; support roads or for other similar purposes. |
| **Emergency spillway** | Auxiliary outlet to a water impoundment which transmits floodwater exceeding the capacity of the principal spillway. |
| **Epa** | U.S. Environmental Protection Agency. |
| **Erosion** | The wearing away of land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. erosion and sediment control. The |

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| | device placed, constructed on, or applied to the landscape that prevents or curbs the detachment of soil, its movement, and/or deposition. |
| **Eutrophication** | The process by which waters become over-enriched by nutrients, primarily nitrogen and phosphorus, to a point where excessive algal growth occurs. |
| **Fascine** | A group or bundle of twigs, whips, or branches which are staked into rows of shallow trenches, on the contour, then filled with soil. A soil bioengineering technique to stabilize slopes by slowing water movement down the slope, increasing infiltration, trapping slope sediments, and increasing soil stability with root systems. |
| **Fhwa** | Federal Highway Administration. |
| **Fiber roll** | A coconut fiber (coir log), straw, or excelsior woven roll (wood excelsior fibers) encased in netting of jute, nylon, or burlap used to dissipate energy along bodies of water. See filter sock. |
| **Filter** | A layer or combination of layers of pervious materials designed and installed in such a manner as to provide drainage, yet prevents the movement of soil particles due to flowing water. |
| **Filter cloth** | Synthetic fabrics used as a filter, usually beneath riprap or between materials with significant differences in grain size, to prevent the movement of fine material through |

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| | course material but at the same time allowing the passage of water. |
| **Filter sock** | A temporary sediment barrier consisting of a mulch-filled tube of flexible netting material. Common types of filter socks include straw wattles, compost filter socks, and fiber rolls. |
| **Filter strip** | A strip or area of vegetation for removing sediment, organic material, nutrients, and chemicals from runoff or wastewater. |
| **Flash board** | A plank generally held horizontally in vertical slots on the crest of a dam or check structure to control the upstream water level. |
| **Floodplain** | Any land area susceptible to being inundated by water, usually adjacent to a stream, river or waterbody and usually associated with a particular design flooding frequency (e.g., 100-year floodplain). |
| **Flume** | An open conduit for the purpose of transporting water down a slope or across obstructions. Same as chute. |
| **Fps** | Feet per second. |
| **Freeboard** | Vertical distance between the maximum water surface elevation anticipated in the design and the top of a water control structure provided to prevent overtopping of the structure because of unforeseen conditions. |
| **Ft/s** | Feet per second. |

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| **Ft.** | Feet. |
| **Fugitive dust** | Solid airborne particulate matter emitted from any source other than through a stack (see Regulations of Connecticut State Agencies section 22a-174-1(31). |
| **Gabions** | Flexible wire mesh baskets composed of rectangular cells filled with riprap or other hard, durable rock. |
| **Geotextile** | Fabric or synthetic material placed (1) between the soil and a pipe, gabion, stone, or retaining wall to enhance water movement and /or retard soil movement, (2) as a blanket or mat to add reinforcement and/or separation (3) to provide an aboveground sediment barrier. |
| **Geotextile silt fence** | A temporary sediment barrier consisting of a geotextile fabric pulled taut and attached to supporting posts and entrenched used to intercept and retain sediment from disturbed areas. |
| **Grade** | 1. The slope of a road, channel, or natural ground. 2. Any surface prepared for the support of construction such as that for paving or laying conduit. 3. Ground surface elevation. |
| **Gradient** | Change of elevation, velocity, or other characteristic per unit of length; slope. |
| **Grading** | Act of altering the ground surface to a desired grade or contour by |

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| | cutting, filling, leveling, and/or smoothing. |
| **Gravel filter** | Graded sand and gravel aggregate placed around a drain to prevent the movement of fine materials into the structure. |
| **Groundwater** | Water occurring in the zone of saturation in an aquifer or soil. |
| **Grub** | The clearing of stumps, roots, trees, bushes, and undergrowth. |
| **Gully erosion** | The erosion process whereby water accumulates in narrow channels, and removes the soil from this narrow area to depths ranging from 1 foot to as much as 97 feet in a relatively short period of time. |
| **Hardpan** | A hardened soil layer in the lower A or B soil horizon (the lower topsoil area or just below) caused by cementation of soil particles. |
| **Hardy** | Capable of living over winter without artificial protection. |
| **Head** | The height of water above any plane of reference. |
| **Head cutting** | An erosive process where the stream bottom is eroded in the direction of the head of the stream. |
| **Hec 1** | Computer program with associated manual entitled “Flood Hydrograph Package” developed by the US Army Corps of Engineers, Hydrologic Engineering Center, dated May 1991, Version 4.0. |

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| **Hec 2** | Computer program with associated manual entitled "Water Surface Profiles" developed by the US Army Corps of Engineers, Hydrologic Engineering Center, dated May 1991, Version 4.6.2. |
| **Hec 15** | Hydraulic Engineering Circular No. 15 by the Federal Highway Administration entitled Design of Roadside Channels with Flexible Linings, dated April 1988. |
| **Hydraulic gradient** | The slope of the hydraulic grade line; the slope of the free surface of water flowing in an open channel. |
| **Hydroseeding** | A method of broadcasting seed and sometimes lime, fertilizer, and mulch together in a mixture of water. |
| **Impoundment** | Generally, an artificial collector or storage of water, as a reservoir, pit, dugout, or sump. |
| **Infiltration rate** | A soil characteristic determining or describing the maximum rate at which water can enter the soil under specified conditions. |
| **Inland wetland** | A wetland as that term is defined in section 22a-38 of the Connecticut General Statutes. |
| **Inlet protection** | A temporary, somewhat permeable barrier, installed around storm drainage inlets in the form of a fence, berm, or excavation around an opening, trapping and filtering water and thereby reducing the sediment content of sediment laden water by settling. |

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| **Internal drainage** | Drainage of the soil profile; may be either natural or augmented by man. |
| **Invert elevation** | The vertical bottom inside elevation of a pipe, sewer, or other conduit or orifice in a pond or similar waterbody which defines the water level. |
| **Land grading** | Reshaping of the ground surface by excavation or filling or both, to obtain planned grades to control surface runoff and reduce erosion potential. |
| **Landscape mulch** | Application of a mulch that protects the soil surface on a long-term basis and promotes the growth of landscape plantings. |
| **Landscape planting** | Planting trees, shrubs, or ground covers for stabilization of disturbed areas. |
| **Lbs.** | Pounds. |
| **Level spreader** | A temporary discharge outlet to disperse or spread runoff as sheet flow over a vegetated area to promote infiltration and to prevent channelization and erosion. Level spreaders consist of a long linear shallow trench or low berm and a broad stable discharge structure constructed at zero grade (i.e., level lip) over which water flows as sheet flow across a stabilized, well-vegetated flat or gently sloped area without causing erosion |
| **Liming** | The application of lime to reduce soil acidity and to supply calcium for plant growth. |

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| **Live crib walls** | A combination of structural elements and vegetation. The structure is a hollow box-like structure made with an interlocking arrangement of untreated logs or timber members spiked together and anchored into the slope and filled with suitable earth fill materials. The vegetation is usually layers of live branch cuttings, which root inside the structure and extend into the slope. A soil bioengineering technique used to protect exposed or eroded streambanks from the erosive forces of flowing water and stabilize the toe of slope, and to reduce steepness and provide stability where space is limited and a vertical structure is needed. |
| **Live staking** | A stake or pole fashioned from live woody material (usually willow or poplar cuttings) that root easily and grow rapidly under certain conditions. A soil bioengineering technique used to create a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by contributing to the reduction of excess soil moisture. |
| **Living shoreline** | A set of shoreline erosion control practices, ranging from non-structural vegetated approaches to hybrid hard structural/restorative natural methods, that address erosion, inundation, and water quality in a manner that improves or protects the ecological condition of the coastline. Such practices are designed to restore, enhance, maintain, or create natural coastal or |

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| | riparian habitat (e.g., intertidal flats, tidal marsh, beach/dune systems, and bluffs), functions, and processes and to mitigate flooding or shoreline erosion through a continuous land-water interface. |
| **Low impact development (lid)** | A site design strategy that maintains, mimics, or replicates predevelopment hydrology through the use of numerous site design principles and small-scale treatment practices distributed throughout a site to manage runoff volume and water quality at the source. |
| **M** | Meters. |
| **Major storm** | A storm predicted by the National Oceanic and Atmospheric Administration (NOAA) National Weather Service with warnings of flooding, severe thunderstorms, or similarly severe weather conditions or effects. |
| **Manning's formula** | A formula used to predict the velocity and/or elevation of water in an open channel under uniform flow conditions (see permanent lined waterway, vegetated waterway and subsurface drain measures). |
| **Meanders** | A series of sinuous curves or loops during a mature stream, produces as the stream swings from side to side in flowing across its floodplain. |
| **Min.** | Minutes. |
| **Mm** | Millimeter. |
| **Mulch for seed** | Application of a mulch that will protect the soil surface on a temporary basis and promote the |

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| | establishment of temporary or permanent seedings. |
| **Natural rate of erosion** | The rate at which erosion takes place as a result of the combined effects of natural climatic occurrences and not because of the activities of man. |
| **Noaa atlas 14** | NOAA Atlas 14, Volume 10, Version 3, Precipitation-Frequency Atlas of the United States, Northeastern States, as amended. |
| **Npdes** | National Pollution Discharge Elimination System. |
| **Nrcs** | USDA Natural Resources Conservation Service (formerly known as the USDA Soil Conservation Service or SCS). |
| **Orifice** | A opening with a closed perimeter through which water flows. |
| **Outfall or outlet** | Point where confined water flows from a conduit into an open channel or body of water or where one body of water drops away into another body of water. |
| **Outlet channel** | A conveyance system constructed or altered primarily to carry water from manmade structures such as terraces, conduits, and diversions. |
| **Outlet protection** | Structurally lined aprons or other acceptable energy dissipating devices placed between the outlets of pipes or paved channel sections and a stable downstream channel. |
| **Owner of record** | The person or party having a fee interest in the land and who may |

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| | bear liability for the environmental conditions on the property. |
| **P.a.** | Public Act (state). |
| **P.l.** | Public Law (federal). |
| **Peak discharge** | The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event. |
| **Perennial stream** | A stream that flows year-round. |
| **Permanent diversion** | A channel constructed across a slope with a supporting earthen ridge on the lower side. |
| **Permanent lined waterway** | A permanent waterway, including chutes and flumes, with an erosion resistant lining composed of concrete, stone, or other appropriate durable material. |
| **Permanent seeding** | Establishment of permanent stand of grass and/or legumes by seeding and mulching exposed soils with a seed mixture appropriate for long term stabilization. |
| **Permanent slope drain** | A permanent open or enclosed structure or series of structures consisting of pipe(s), culvert(s) and/or manhole(s) used to convey water from a higher elevation to a lower elevation. |
| **Permanent turf reinforcement mat** | A manufactured mat composed of non-biodegradable polymer or synthetic fibers mechanically, structurally, or chemically bound together to form a continuous matrix used where design flows exceed the stability of the soils and/or proposed vegetation. |

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| **Permeability** | A generic term for the property that describes the rate at which gases and liquids can flow through the soil and porous media (e.g., a geotextile). |
| **Permissible velocity** | The highest velocity at which water is conveyed in a channel or other conduit and not cause scour or erosion. |
| **Ph** | A measure of the hydrogen ion concentration in a solution, expressed as the logarithm (base ten) of the reciprocal of the hydrogen ion concentration in gram moles per liter. On the pH scale (0 - 14), a value of 7 represents neutral conditions; decreasing values, below 7, indicate increasing hydrogen ion concentration (acidity); increasing values, above 7, indicate decreasing hydrogen ion concentration (alkalinity). |
| **Phase** | A distinct and complete set of activities that have a specific functional goal wherein the work to be completed in the phase is not dependent upon the execution of work in a later phase in order to make it functional. |
| **Phreatic line** | The line marking the upper surface of the zone of water saturation in the soil. |
| **Piping** | Removal of soil material through subsurface flow channels or "pipes" developed by seepage water. |
| **Planting stock** | Young plants or cuttings, either nursery grown or naturally occurring. |

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| **Portable sediment tank** | A tank or container into which sediment laden water is pumped in order to trap and retain the sediment before discharging the water or to transport the sediment laden water to an approved location for further treatment. |
| **Post-construction stormwater management** | Controlling and providing retention and/or treatment for water that drains off a site during and after a period of rainfall or snow for the purpose of improving water quality and controlling water quantity. |
| **Ppm** | Parts per million. |
| **Precast concrete** | A plain or reinforced concrete element cast in other than its final position. |
| **Preconstruction meeting** | A meeting that is held prior to the initiation of construction between concerned parties for the purpose of reviewing the contract with the contractor(s) and to identify special concerns, regulatory permit requirements and restrictions. |
| **Psi** | Pounds per square inch. |
| **Pump intake and outlet protection** | Structures or other protective devices into which or on which intake and discharge hoses are placed during pumping operations; used to reduce the amount of sediment taken up by a pump during dewatering operations and to prevent soil erosion due to scouring and the resuspension of detained sediments at the point of pump discharge. |
| **Pumping settling basin** | An enclosed sediment barrier or excavated pit constructed with a |

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| | stable inlet and outlet such that sediment laden water from pumping operations is de-energized and temporarily stored, allowing sediments to be settled and/or filtered out before being released from the construction site. |
| **Pure live seed** | The product of the percentage of germination plus the hard seed and percentage of pure seed divided by 100. |
| **Q** | Engineering term used to define flow discharge rate or flow capacity, usually given as a volume over time (i.e., cubic feet per second, gallons per day, etc.). |
| **Raindrop erosion** | The detachment and airborne of small soil particles caused by the impact of raindrops on soil. |
| **Rainfall amount** | The amount of specified rainfall, such as daily, annual or for a storm, usually expressed by depth of the rain water which accumulates on a horizontal surface without infiltration and evaporation. |
| **Rainfall frequency** | The frequency, usually expressed in years, at which a given rainfall intensity and duration can be expected to be equaled or exceeded. |
| **Rainfall intensity** | The rate of rainfall of any given time interval, usually expressed in units of depth per time. |
| **Rcp** | Reinforced concrete pipe. |
| **Recurrence interval** | The average number of years between precipitation events of a certain size based on the probability that the precipitation event will be |

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| | equaled or exceeded in any given year. |
| **Reinforced concrete** | Concrete containing reinforcement, including prestressed steel, and designed on the assumption that the two materials act together in resisting forces. |
| **Retaining wall** | A wall that provides stability to a slope, constructed of mortared block or stone, cast-in-place concrete, timber, reinforced earth, gabions, precast concrete modular units or similar structures. |
| **Retention facility** | A post-construction stormwater management facility that holds stormwater runoff on-site (via infiltration or reuse) through the use of structural stormwater Best Management Practices (BMPs) or non-structural LID site planning and design strategies. |
| **Revetment** | A facing of stone, bags, blocks, pavement, etc., used to protect or armor a bank against erosion. |
| **Rill** | A small channel eroded into soil surface by runoff which can be filled easily and removed by normal tillage. |
| **Rill erosion** | An erosion process in which numerous small channels from several inches up to 1 foot in depth are formed. |
| **Riparian land** | Land situated along the bank of a stream or other body of water. |

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| **Riprap** | A permanent, erosion-resistant ground cover of large, loose, angular stone. |
| **Riser** | A vertical pipe extending from the bottom of a pond that is used to control the discharge rate for a specified design storm. |
| **Root ball** | The intact ball of earth or growing medium containing the roots of a nursery plant. |
| **Root zone** | Depth of soil that plant roots readily penetrate and in which the predominant root activity occurs. |
| **Roughness coefficient** | A factor in velocity and discharge formulas representing the effect of channel roughness on energy losses in flowing water. |
| **Runoff** | That portion of the precipitation (excess rainfall, snow melt or irrigation) on a drainage area that is discharged from the area in the form of flow across the surface of the ground. |
| **Rusle** | Revised Universal Soil Loss Equation. |
| **Sand** | A mineral soil generally consisting of soil particles ranging from 5.0 to 0.5 milimeters in diameter. |
| **Scale** | The ratio of a distance on a photograph or map to its corresponding distance on the ground (e.g., 1:24,000 or 1 inch = 200 feet). |
| **Scarify** | To break the surface of the soil with a narrow-bladed implement. |

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| **Scour** | To abrade and wear away; used to describe the wearing away of channels or stream beds. |
| **Scs** | Soil Conservation Service (now known as the USDA Natural Resources Conservation Service or NRCS). |
| **Sediment load** | Amount of sediment carried by running water or wind. |
| **Sedimentation** | Deposition of waterborne or windborne particles resulting from a decrease in transport capacity. |
| **Sedimentation basin** | A surface water runoff storage facility intended to trap suspended solids, suspended and buoyant debris, and adsorbed or absorbed potential pollutants which are carried by surface water runoff. |
| **Seeding** | A process of establishing a stand of vegetation using seed or other vegetative material capable of establishing itself. |
| **Seepage** | The movement of water into, through, and out of the soil (generally observed at its discharge point from the soil). |
| **Sequence** | The logical order of progressive series of activities that will result in the completion of a single-phase project or an individual phase of a multi-phased project. |
| **Settling efficiency** | The percentage of particles of a prescribed size trapped in a sediment basin under design conditions. |

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| **Sheet erosion** | The removal of a thin, uniform layer of soil from the land surface by the overland flow of water. |
| **Sheet flow** | Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel. |
| **Side slope** | The slopes of any cut or fill section, such as dams, ditches, diversions, and channels. Usually given as a ratio of horizontal distance to vertical distance or in degrees. |
| **Silt** | A mineral soil generally consisting of soil particle ranging between 0.076 and 0.002 millimeter in size. |
| **Slash** | The residue (e.g., tree tops and branches) left on the ground after logging or accumulating as a result of storm, fire, girdling, or delimbing. |
| **Slope** | The degree of deviation of a surface from horizontal, measured as a percentage, as a numerical ratio, or in degrees. |
| **Slough** | A failed earthen surface, as in land slide. |
| **Sodding** | Stabilizing fine-graded disturbed areas with the use of cut pieces of turf. |
| **Soil** | The unconsolidated minerals and material on the immediate surface of the earth that serve as a natural medium for the growth of plants. |
| **Soil amendment** | Any material, such as lime, compost, or fertilizer, that is worked into the |

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| | soil to make it more amenable to plant growth. |
| **Soil bioengineering** | The use of live and dead plant materials in combination with natural and synthetic support materials (e.g., rock, wood, concrete, and geotextiles) for slope stabilization, erosion reduction, and vegetative establishment. |
| **Soil erosion** | Detachment and movement of soil from the land surface by water or wind (see erosion). |
| **Soil horizon** | A layer of soil differing from adjacent genetically related layers in physical, chemical, and biologic properties or characteristics. |
| **Solar array** | An on-the-ground installation of arrays of photovoltaic cell panels, supporting structures and related equipment to produce electricity. |
| **Spillway** | An open or closed channel or both, used to convey excess water from a reservoir or other storage facility. |
| **Spoil** | Excess soil or rock excavated from a channel, ditch basin or other area that will not be reused on the project site. |
| **Spreader** | A device for distributing water uniformly in or from a channel. |
| **Sq. Ft. Or ft2** | Square feet. |
| **Standpipe** | A vertical pipe or box connected to a horizontal pipe or box which controls the level of water in a detention or sediment trap or basin. |

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| **Stilling basin** | An open structure or excavation at the foot of an overfall, drop, or spillway to reduce the energy of the water discharge. |
| **Stone check dam** | A temporary stone dam placed across a swale, waterway or channel used to reduce the velocity of concentrated storm water flows, thereby reducing erosion of the swale, waterway, or channel. |
| **Stone slope protection** | Applying stone aggregates for permanent protection on slopes where vegetative soil cover measures are either impractical or difficult to establish. |
| **Stormwater** | The water which drains off a catchment area during and after rain or snowfall; waters consisting of precipitation runoff. |
| **Stormwater runoff** | The water and associated material draining into streams, lakes or sewers as a result of a precipitation or snowmelt. |
| **Straw bale barrier** | A temporary sediment filter consisting of a row of entrenched and anchored bales of straw used to intercept and detain small amounts of sediment from small disturbed areas. (Hay bales no longer appear in this section as sediment control devices. More current technical information on hay bales and other sediment barrier options reflects the limitations and problems in the use of hay bales as a sediment control measure. Hay bales are comprised primarily of grasses that still have grain or seeds attached. If not |

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| | certified as noxious weed-free, hay bales can have undesirable impacts by spreading invasive plants. Therefore, straw bales have replaced hay bales in this manual as the preferred material for baled sediment barriers.) |
| **Straw wattle** | A straw-filled tubes of flexible netting materials. Commonly used filler materials include wheat and rice straw. See filter sock. |
| **Stream deflector** | A structure placed within a stream channel that are used to divert flows away from a road, structure, utility, or unstable streambank. |
| **Subgrade** | The soil prepared and compacted to support a structure or a pavement system. |
| **Substrate** | The undisturbed natural soil base used to support a structure. |
| **Subsurface drain** | An underground water conveyance system consisting of a perforated conduit, such as pipe, tubing, tile, or a stone filled trench installed beneath the ground to intercept and convey groundwater. |
| **Sump** | Pit, tank or reservoir in which water is collected, stored, or withdrawn. |
| **Surface roughening** | Providing a rough soil surface with horizontal depressions created by operating a tillage or other suitable implement on the contour, or by leaving slopes in a roughened condition by not fine grading them, used to promote the establishment of vegetative cover with seed, reduce |

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| | stormwater runoff velocity, increase infiltration, and reduce sheet erosion and provide for sediment trapping. |
| **Surface runoff** | Precipitation that falls onto the surfaces of roofs, streets, ground, etc., and is not absorbed or retained by that surface, but collects and runs off. |
| **Surface water** | All water whose surface is exposed to the atmosphere. |
| **Suspended load** | The relatively fine part of the sediment load that is distributed throughout the flow cross section and stays in suspension for appreciable lengths of time. The particle suspension is the result of vertical velocity fluctuations characteristic of turbulent flow. The suspended load consists mainly of clay, silt, and sand. |
| **Swale** | A type of drainageway consisting of a shallow longitudinal depression that conveys stormwater. It is commonly heavily vegetated and is normally without flowing water. |
| **Swcd** | Soil and Water Conservation District. |
| **Swpcp** | Stormwater Pollution Control Plan. |
| **Swqm** | Connecticut Stormwater Quality Manual. |
| **Tackifier** | Any granular, powder, liquid, liquid concentrate, or jelled substance that when mixed with water, applied to a target, and allowed to dry and cure, will provide sufficient adhesive |

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| | characteristics to cause mulch materials to adhere to one another. |
| **Tacking** | The process of binding mulch fibers together by the addition of a sprayed chemical compound. |
| **Tailwater** | Water located or discharged immediately downstream of a hydraulic structure on a stream. |
| **Temporary diversion** | A temporary channel with a berm of tamped or compacted soil placed in such a manner to divert flows. |
| **Temporary erosion control blanket** | A manufactured blanket composed of biodegradable/photodegradable, natural or polymer fibers and/or filaments that have been mechanically, structurally, or chemically bound together to form a continuous matrix used as temporary surface protection to newly seeded and/or disturbed soils to absorb raindrop impact and to reduce sheet and rill erosion and to enhance the establishment of vegetation. |
| **Temporary fill berm** | A very temporary berm of soil placed at the top of an unprotected fill slope. |
| **Temporary lined channel** | A channel designed to convey flows on a short-term basis and is lined with a flexible impermeable geomembrane or other erosion resistant covering. |
| **Temporary lined chute** | A temporary structure made of concrete, bituminous concrete, riprap, sacked concrete, gabions, half round pipes, revetment erosion control mats with cement grout or |

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| | similar materials used to carry concentrated runoff down a slope. |
| **Temporary pipe slope drain** | A flexible or rigid conduit used to conduct water from the top of a slope to the toe of the slope. |
| **Temporary sediment basin** | A temporary dam, excavated pit, or dugout pond with a controlled outlet(s) such that a combination of wet and dry storage areas are created. |
| **Temporary sediment trap** | A temporary ponding area with a stone outlet formed by excavation and/or constructing an earthen embankment used to detain sediment-laden runoff from small disturbed areas long enough to allow the majority of the sediment to settle out. |
| **Temporary seeding** | Establishment of temporary stand of grass and/or legumes by seeding and mulching soils that will be exposed for a period greater than 1 month but less than 12 months. |
| **Temporary soil protection** | Application of a degradable material that will protect the soil surface on a temporary basis without the intention of promoting plant growth. |
| **Temporary stream crossing** | A temporary bridge or culvert(s) across a watercourse for use by construction traffic. |
| **Terrace** | An embankment or combination of an embankment and channel constructed across a slope to control erosion by diverting surface runoff instead of allowing it to flow uninterrupted down a slope. |

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| **Test pit** | A general term for any type of hole, pit, shaft, etc. dug or drilled for subsurface reconnaissance. |
| **Three dimensional** | |
| **Geosynthetic** | |
| **Turf reinforcement** | A permanent turf reinforcement mat. |
| **Tidal wetland** | Those areas which border on or lie beneath tidal waters whose surface is at or below an elevation of one foot above local extreme high water (see section 22a- 29(2), CGS for regulatory definition). |
| **Time of concentration** | Time required for water to flow from the most remote point of a watershed to the design point. |
| **Topsoiling** | The application of topsoil to promote the growth of vegetation following the establishment of final grades. |
| **Total suspended solids (TSS)** | The concentration of suspended solids in a liquid (mg/l). |
| **Tpz** | Tree Protection Zone. |
| **Tr-20** | Computer program with associated manual by the USDA-NRCS referenced as Technical Release #20 used to calculate stormwater peak flows (dated 1984 or latest version). |
| **Tr-55** | Publication with ancillary computer program by the USDA-NRCS referenced as Technical Release #55 detailing techniques used to solve for peak flows in small watersheds (1986 or latest version). |
| **Tracking** | Using tracked equipment on cut and fill slopes and embankments to establish a series of indentations |

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| | parallel to the contour of the slope that will retain seed and moisture. |
| **Trap efficiency** | The amount (expressed as a percent) of the total sediment delivered to the basin that will remain in the sediment basin. It is a function of residence time, characteristics of the sediment, nature and properties of inflow, and other factors. |
| **Trash rack** | A structural device (i.e., screen or grate) used to prevent debris from entering a spillway, channel, drain, pump, or other hydraulic structure. |
| **Tree protection** | The protection of desirable trees from mechanical and other injury during construction. |
| **Tree revetment** | Tree trunks and branches (without the root wad) overlapped and anchored to the earth with cables or earth anchors. A soil bioengineering technique used to stabilize banks by absorbing energy, reducing velocity, capturing sediment, and enhancing conditions for colonization of native species. |
| **Tree well** | A device constructed to maintain the original grade around an existing tree and allow air to the roots. |
| **Trunk** | The portion of a stem or stems of a tree before branching begins. |
| **Turbidity** | A measure of the light-scattering ability of a material suspended in water, visually the cloudiness of a liquid, caused by suspended solids. |
| **Turbidity curtain** | A temporary impervious barrier installed in a stream, river, lake, or |

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| | tidal area which will retain silts, sediment and turbidity within the construction area used to promote the settling of suspended solids in water. |
| **Turf** | A layer of soil containing a dense growth of grass and its matted roots, also may be referred to as sod. |
| **Underdrain** | See subsurface drain. |
| **Upstream** | Toward, at, or from a point nearer the source of a watercourse; in a direction from which a watercourse or drainageway is flowing. |
| **Usacoe** | United States Army Corps of Engineers. |
| **Usda** | United States Department of Agriculture. |
| **Usgs** | United States Geological Survey. |
| **Vegetated filter** | A maintained area of well-established herbaceous or woody vegetation through which small volumes of sediment-laden water pass and are filtered. |
| **Vegetated waterway** | A natural or constructed channel or swale shaped or graded in earth materials and stabilized with non-woody vegetation for the non-erosive conveyance of water. |
| **Velocity** | Speed at which an object or medium moves. Usually measured as a function of distance over time (i.e., feet per second). |
| **Water bar** | A channel with a supporting berm on the down slope side constructed |

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| | across a construction access road, driveway, log road, or other access way. |
| **Watershed** | All the surface area of land that contributes runoff to a common point. Usually measured in acres, hectares, or square miles. Same as drainage area may be referred to as drainage basins or catchment area. |
| **Water table** | The upper surface or top of the saturated portion of the soil or bedrock, indicates the uppermost extent of groundwater. |
| **Waterway** | A type of drainageway that is a natural course or constructed channel for con- ducting the flow of water that carries only intermittent flows. Examples of waterways include but are not limited to drainageways that serve as a collector of a series of swales, outlet for diversions and collectors of runoff from large, impervious areas such as commercial parking lots and shopping centers. |
| **Weir** | A horizontal edge, surface, or dam used to regulate the water level to cause ponding, diversion, pumping, or downstream eddies. |
| **Wet storage** | The volume in a sediment basin or sediment trap that is located below the invert of the lowest outlet structure for the basin that will create a pool for settling suspended sediment during a runoff event. |
| **Wind erosion** | Detachment and transportation of soil by wind. |

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| **X:y** | Expression of slope gradient of run to rise where x equals the number of distance units horizontal for every y number of distance units vertical. (see 2:1). |