2002 Connecticut Guidelines

For

Soil Erosion and Sediment Control

by
The Connecticut Council on Soil and Water Conservation
in Cooperation with the
Connecticut Department of Environmental Protection

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1 Introduction to the Guidelines

Chapter 1

Introduction to the Guidelines

Purpose and Function of The Guidelines

The 2001 revision of the Connecticut Guidelines for Soil Erosion and Sediment Control (hereafter referred to as "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.

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 a number of programs beyond the original intent of the legislation that required the creation of this document. Such programs include water pollution control; coastal resource management; tidal wetlands; structures / dredging / fill in tidal, coastal and navigable waters; inland wetlands and watercourses; diversion of water; encroachments within stream channel encroachment lines; dam safety; and solid waste management (See Regulatory Index, Appendix F).

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.

resources of the state." A copy of the Act is found in Appendix B of the Guidelines.

The Act required:

- *Municipal planning and zoning commissions to amend their regulations to make proper provisions for soil erosion and sediment control, mandating the submission and certification for adequacy of erosion and sediment control plans in applications before them where the disturbance of land is greater than one half acre,*

- *The Council on Soil & Water Conservation to develop guidelines to outline methods and techniques for minimizing erosion and sedimentation based on the best currently available technology, and*

- *Guidelines to contain model municipal regulations that may be used by the municipalities to comply with the Act.*

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 issued a 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 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 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.

Major Changes

This 2001 revision of the Guidelines is intended to provide an easier to use format and to incorporate new technological advances. An attempt has been made to incorporate sediment control specifications developed by other state agencies. Finally, additions have been made to place greater emphasis on protecting nutrient sensitive Long Island Sound from sediment borne pollutants.

Format Changes: Erosion and sediment control measures have been regrouped according to their function and some selection charts have been revised or added to help the site planner develop an erosion and sediment control plan. Symbols for representing erosion and sediment control measures on plans have been offered in an attempt to be consistent with other states having similar guidelines. The format and style of individual measures in the Guidelines has also been standardized. A folded wall chart has been added to provide users with a single sheet reference to all of the erosion and sediment control measures found within the Guidelines.

Technical Changes: A number of new measures have been added, including:

- *Surface Roughening*
- *Temporary Erosion Control Blankets*
- *Permanent Turf Reinforcement Mats*
- *Stone Check Dam*
- *Temporary Sediment Trap*
- *Pumping Settling Basin*
- *Pump Intake and Outlet Controls*
- *Portable Sediment Tank*
- *Dewatering of Earth Materials*

Several measures have been reorganized to create new measures. For example, temporary mulch and permanent mulch were reorganized to create the new measures called:

- *Mulch for Seed*
- *Landscape Mulch*
- *Temporary Soil Protection*
- *Stone Slope Protection*

Similarly, the old diversion measure has been broken into four measures relating to diversion; grade stabilization structures have been broken into four related measures; and sediment barriers have been broken into four measures.

Measures that require design by an engineer contain sections entitled "Design Criteria" and "Installation Requirements". These are distinguished from non-engineered measures which have a "Specifications" section. Some measures need an engineer only when certain criteria are exceeded. These measures contain "Design Criteria" and "Specifications" sections but no "Installation Requirements." Erosion and sediment control (E&S) plans using measures that require engineered designs are

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The Erosion and Sedimentation Process

Chapter 2 The Erosion and Sedimentation Process

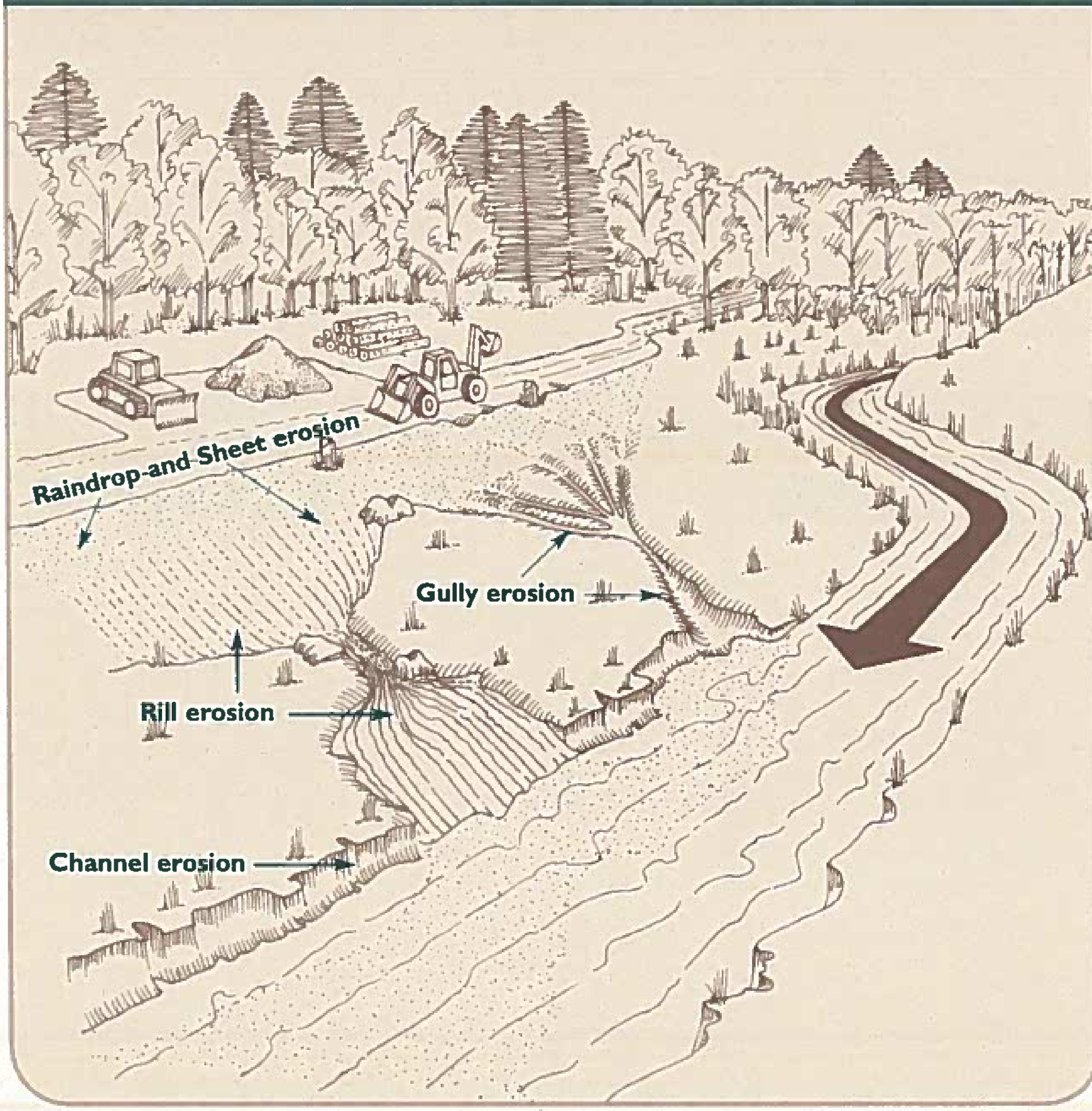
Definition

Soil erosion and sedimentation is a three-stage process: **detachment → transport → deposition**. 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 away of mountains and the building up of floodplains, some 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 directed at erosion caused by water.

Figure 2-3 Types of Erosion



Soil Characteristics

Soil characteristics which 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 have a tendency 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 five 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 falls through the process of evapo-transporation*
- *Improves infiltration rates*

By limiting and/or staging the removal of existing vegetation, and by decreasing the area and duration of exposure, soil erosion and sedimentation can be significantly reduced. Give special consideration to the maintenance of 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 sum total of all atmospheric influences, principally moisture (including rainfall), temperature, wind, pressure, and evaporation. It determines the frequency, intensity, and duration of rainfall which in turn determines the amounts of runoff produced in a given area. As both the volume and velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases. Where storms are frequent, intense, or of long duration, erosion risks are high. Seasonal and regional changes in temperature, as well as variations in rainfall, help to define the high erosion risk period of the year.

Although wind can potentially remove more sediment than rainfall, in most cases in Connecticut it plays a relatively minor role in soil erosion. 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 that 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.

One period of higher erosion potential exists during the spring thaw. It is a time when the coastal storm track increases rainfall potential. Additionally, because the ground is still partially frozen, the absorptive capacity 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.

Figure 2-5 Particle Size vs Damage Impact

Damage Impact With Change in Particle Size

Boulders, Cobbles, Gravel → Very Coarse to Medium Sand → Fine Sand, Silts and Clay

	Boulders, Cobbles, Gravel	Fine Sand, Silts and Clay
Biological	• burying of benthic (a.k.a. bottom living) organisms • habitat degradation by damaging rooted plants and possibly by changing substrate (e.g. cobble to sand) • decrease in biological diversity	• loss of aquatic eggs, larva and fry • clogging of fish gill increasing disease susceptibility • damage to food chain • decrease in biological diversity • increase algal blooms in downstream impoundments • reduced ability to grow plants on eroded land
Chemical	• water temperature increase from increase sunlight absorption caused by shallowing of water body	• nutrient transport (causing increased eutrophication of downstream water bodies and lost fertility from eroded land) • water temperature increase from sunlight absorption cause by water opacity (a.k.a. cloudiness or turbidity) • can result in lower dissolved oxygen levels
Physical	• reduced channel capacity, navigation obstruction requiring dredging, reduced flood storage increasing future 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 • loss of land	• turbidity adversely affecting use for surface water drinking supply and manufacturing, increasing filtration costs • poor aesthetics

Erosion and Sediment Action Associated with Land Use Changes and Development

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.

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Erosion and Sediment Control Plans

Chapter 3 Erosion and Sediment Control Plans

Part I: General Guidelines

Definition of an E&S Plan

Connecticut General Statutes §22a-327(5)("CGS") defines a soil 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 which illustrates in detail what is contained in the plan and how it will be implemented. The information required by the statute for the map is contained collectively in the site drawing(s) and the erosion and sediment control drawing(s) referenced later in this chapter. The narrative may be contained on the site plan sheets, but typically it exists as 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 documentation are considered to be part of the E&S plan and are either attached to the narrative or placed on the drawings.

The E&S plan is an integral part of an overall site plan. It should be a separate plan when needed for clarity, but can also be on the site plan if the proposed E&S measures can be clearly shown and noted. The E&S plan itself shall contain notes to ensure that the controls are installed, inspected and maintained properly. This could be done in a separate specifications package supplemented by notes on the drawings.

Figure 3-1 E&S Plan Complexity

LESS

Single House
Low Soil Erodibility
Flat Terrain
No Wetlands or Watercourses Nearby
Low Density Population
Small Disturbed Area (5 Ac. or Less)

MORE

Subdivision with Roads
High Soil Erodibility
Steep Slopes
In or Near Wetlands or Watercourses
Dense Population
Large Disturbed Area >5 Ac.
Located within Public Water Supply Watershed

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 individual municipal planning and zoning commission regulations.

Additional regulatory agencies, such as a municipal inland wetland agency and the Connecticut DEP, 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 pollution control, diversion of water, encroachments riverward of stream channel encroachment lines, tidal wetlands and tidal, coastal and navigable waters.

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 **Figure 3-1**).

E&S plans using measures that contain "DESIGN CRITERIA" shall be signed and sealed by a professional engineer licensed to practice in Connecticut.

Site planners and plan reviewers may use the checklists contained in Part III of this chapter as a guide to E&S plan content. Most projects are subject to a local regulatory review. The procedure outlined in this chapter is recommended for the development of all plans.

19. Connecticut Aquifer Protection Areas Map, available from the DEP store (also available from town halls); and

20. Information Directory & List of Publications available from the DEP store listing all documents available from the DEP.

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, or if limitations exist that will impact site development. Features such as existing topography, wetlands, watercourses, expected surface and groundwater quality, habitats of endangered species, steep slopes 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 structural measures, such as detention basins and sedimentation basins can be identified. For example, the development of a site located near the top of a watershed may result in decreased infiltration and increased runoff (e.g. wooded land to grass or vegetation to pavement). In this case detention or recharge facilities may be needed to reduce or eliminate the expected increases in runoff.

The presence of wetlands or flood prone areas can severely limit the siting of detention and sedimentation basins on the site, not to mention other structural features such as buildings and roads.

Soil limitations that interfere with the siting of structures and construction can be identified from the published soil surveys. Complex sites may require a more detailed soil survey by a soil scientist or geologist in order to identify problems not indicated by a general soil survey. Highly erodible soils coupled with the close proximity of a sensitive resource (e.g. public water supply reservoir, cold water fisheries, endangered species habitat) 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 includes mapping of wetlands by a soil scientist or, in the case of tidal wetlands, a wetlands ecologist. This detailed 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 ground water characteristics.

The combined data is used to develop the following maps:

Site Locus Map

A map that shows the site's relationship to roads and other environmental features such as major watercourses. 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.

Topography: Show the existing contour elevations at intervals of from 1 to 5 feet depending upon the slope of the terrain. Existing topographic maps (e.g. USGS, local government, or topographic maps from previous proposals) 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) a photogrammetric contour map with 2-foot contour intervals is suggested, especially in areas proposed for intensive development where existing topography may cause serious site limitations.

The topography of any given site is the composite of the physical features that make up the site including slopes and drainage ways and their relationship to each other. Most slopes in their natural vegetated state have achieved a state of stability and are not subject to excessive erosion. When sites are developed and the natural vegetation is removed, the potential for erosion increases dramatically. The longer and steeper the slope, the greater the erosion potential. On sites where soil survey information is available, slope designations appear in the form of a letter within the symbol denoting the soil type. Slopes can also be described as a ratio of rise to run. (See **Land Grading** measure for description of slope ratios and potential limitations created by slope gradients).

Drainage Patterns: Show the location of all existing depressions, drainage swales, permanent and intermittent watercourses, FEMA floodways and 100-year flood boundaries, Stream Channel Encroachment Lines (if any), and buffers established by regulation. Since regulatory buffers vary from town to town, it is important that the site planner consult with the individual town wetland staff or commission early in the development of the site plan.

The site development should be compatible with natural drainage patterns to the fullest extent possible. These drainageways should be used to convey runoff through and off the site to avoid the expense and

Minimize direct impact to coastal resources and other sensitive areas.

When the project is located in a public drinking water supply watershed area review the DEP's publications Protecting Connecticut's Water-Supply Watersheds, A Guide For Local Officials, January 1993, and Protecting Connecticut's Groundwater, A Guide For Local Officials, January 1997, DEP Publication # 26. **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 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. Wetlands, watercourses and downstream culverts which will receive runoff from the site should be located and surveyed 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. Down slope wetlands and watercourses (especially those containing drinking water reservoirs or cold water fisheries habitat) which will receive runoff from the site are concerns.

Drainage conditions up slope or off site from a proposed embankment cut need to be checked to insure that the cut does not eliminate a hydrologic and hydrogeologic feature. These features could be providing for flood storage and/or water quality renovation on or adjacent to the site. Additionally, drainage swales and depressions that traverse the cut area will require an engineered design to ensure channel stability both on and off site.

Principles of Site Planning 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. Specific control measures are discussed in detail in Chapter 5 of these Guidelines.

After reviewing the data and determining the site limitations, the planner can then develop a site plan. This plan is based upon basic erosion and sediment control principles. These principles are as follows:

Plan Development to Fit Environmental Conditions

Start by selecting a site that is suitable for a specific proposed activity. 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.

- *Utilize the existing topography.*
- *Align roads on the contour wherever possible and use them to divert surface water, thereby reducing slope lengths.*
- *Concentrate development on flattest area of the site to avoid excessive slope cuts or fills where possible.*
- *Avoid steep slopes and soils with severe limitations for the intended uses. If there are no feasible alternatives to avoiding steep slopes and/or erodible soils, sound engineering practices should be employed to overcome the site limitations. For example, long steep slopes need to be broken up by benching, terracing or diversions to avoid erosion problems. Seeps emanating from cut slopes will need provisions for internal drainage to prevent slope failure.*
- *Avoid flood prone areas, wetlands, beaches, dunes 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.*
- *Utilize the natural drainage system whenever possible. If the natural drainage system of a site can be preserved 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 storm water management criteria easier.*

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 particular phase. A sequence should be developed on the

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-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.*

Reduce on Site Potential Internally and Install Perimeter 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 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. It is generally more expensive to correct off-site damage than it is to install proper internal controls.

- *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 settlement and filtering of sediments.*
- *Concentrated runoff from development should be safely conveyed to stable outlets using riprapped channels, waterways, diversions, storm drains or similar measures.*
- *Design conveyance systems to withstand the velocities of projected peak discharges.*
- *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.[4] Sediment basins are needed on large and small sites when sensitive areas such as wetlands, watercourses, and streets would be impacted 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

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 and maintenance of erosion and sediment controls is essential to the success of an E&S plan.

Select Erosion and Sediment Control Measures

Erosion and sedimentation 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 taken into account when providing for erosion control.

The selection of erosion and sediment control measures consists of the following four steps:

Step 1. Identify problem areas.
Step 2. Identify the control problems.
Step 3. Identify a strategy or strategies for each problem.
Step 4. Select appropriate measures from the control groups.

On Page 3-11 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 measure selection matrix follow the four basic steps:

[4] For requirements, see the current General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities issued by the DEP

Figure 3-2 Measure Selection Matrix

Identify Problem Areas	Identify Control Problems	Identify Strategy	Select Specific Measure: Functional Group	Select Specific Measure: Measure	Plan Key
	Control Soil Detachment	Preserve and Conserve Existing Site Resources	Protect Vegetation	Tree Protection	TP
Disturbed Areas			Preserve and Conserve Soil	Topsoiling	TO
				Land Grading	LG
	Raindrop Splash			Surface Roughening	SR
Short or Shallow Slopes				Dust Control	DC
	Sheet & Rill Erosion	Protect Surface	Vegetative Soil Cover	Temporary Seeding	TS
				Permanent Seeding	PS
	Wind Erosion			Sodding	SO
				Landscape Planting	LP
Steep Slopes			Non-Living Soil Protection	Temporary Soil Protection	TSP
				Mulch for Seed	MS
				Landscape Mulch	LM
Long Slopes				Temporary Erosion Control Blanket	ECB
				Permanent Turf Reinforcement Mat	TRM
				Stone Slope Protection	SSP
		Protect Surface and/or Convey Runoff	Stabilization Structures	Retaining Walls	RW
Stockpile Areas				Riprap	RR
	Control Water Movement			Gabions	G
				Permanent Slope Drain	PSD
Borrow Areas				Channel Grade Stabilization Structure	CSS
	Gully Erosion			Temporary Lined Chute	TC
				Temporary Pipe Slope Drain	TSD
	Channel & Stream Erosion		Drainageways and Watercourses	Vegetated Waterway	VW
Drainage Ways		Convey Runoff		Temporary Lined Channel	TLC
				Permanent Lined Waterway	PW
				Temporary Stream Crossing	TSC
Wetlands and Watercourses		Direct Runoff	Diversions	Temporary Fill Berm	TFB
				Water Bar	WB
				Temporary Diversion	TD
				Permanent Diversion	PD
Waterbodies		Intercept Grnd Water	Subsurface Drains	Subsurface Drain	SD
		Detain Runoff	Detention Structures	Detention Basin	DB
Areas of Flooding and Existing Erosion	Natural Resource Degradation	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
Drainage Outlets				Hay Bale Barrier	HB
	Protect Onsite and Offsite Areas			Geotextile Silt Fence	GSF
				Turbidity Curtain	TC
				Vegetative Filter	VF
Travel Areas		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				Dewatering of Earth Materials	DWM

3.3.4 Limits of cuts and/or fills
3.3.5 Soils, bedrock
3.3.6 Seeps, springs
3.3.7 Inland wetlands boundaries
3.3.8 FEMA identified floodplains, floodways and State established stream channel encroachment lines
3.3.9 Streams, lakes, ponds, drainage ways, dams
3.3.10 Existing vegetation
3.3.11 Tidal wetland boundaries and coastal resource limits (e.g. mean high water, shellfish beds, submerged aquatic vegettion, CAM boundary)
3.3.12 Public water supply watershed, well heads or aquifer boundaries (when available)

3.4 Drainage Patterns

3.4.1 Existing and planned drainage patterns (including offsite areas
3.4.2 Size of drainage areas
3.4.3 Size and location of culverts and storm sewers (existing and planned)
3.4.4 Size and location of existing and planned channels or waterways
3.4.5 Major land uses of surrounding areas

3.5 Road and Utility Systems

3.5.1 Planned and existing roads and buildings with their location and elevations
3.5.2 Access roads: temporary and permanent
3.5.3 Location of existing and planned septic systems
3.5.4 Location and size of existing and planned sanitary sewers
3.5.5 Location of other existing and planned utilities, telephone, electric, gas, drinking water wells, etc.

3.6 Clearing, Grading, Vegetation Stabilization

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

4. Erosion & Sediment Control Drawings

4.1 Location of E&S measure on site plan drawing with appropriate symbol

4.2 Construction drawings and specifications for measures

4.3 Maintenance requirements of measures during construction of project

4.4 Person responsible for maintenance during construction of project

4.5 Maintenance requirements of permanent measures after project completion

4.6 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

4.7 Handling of emergency situations (e.g. severe flooding, rains or other environmental problems).

4.8 If not provided in the narrative, the information listed in check list paragraph 1.6 (see Narrative heading)

Chapter 4

Large Construction Site Sequences and Special Treatments

Large Construction Site Sequences and Special Treatments Introduction

This chapter provides samples of sequences of activities for large construction sites and discussions on difficult soil erosion and sediment control problems which can require a combination of measures. The actual sequence used may be different than those listed below to fit a specific project or field conditions. This information supplements the guidance provided in Chapter 3 regarding the development of an erosion and sediment control plan.

12. Place, grade and compact the processed aggregate in the roadway base.

13. Topsoil and grade in all slope areas to within 2 feet of the proposed curbing.

14. Install first course of bituminous concrete.

15. Install curbing if required.

16. Apply stabilization measures to remaining disturbed areas in accordance with the erosion and sediment control plan (topsoil, seeding, sodding, mulching, etc.)

17. Inspect and clean drainage system, as needed.

18. Install the final course of bituminous concrete pavement.

19. After roadway shoulders are stabilized in accordance with the applicable E&S measure, remove temporary erosion and sediment controls (e.g. geotextile silt fences).

Limitations of Sequence:
This sequence is for new roadway construction on undisturbed land. Roadway reconstruction requires a more complex sequence that includes such items as maintenance and protection of traffic.

Large Building Sites and Parking Areas

This sequence applies to any building site or a single phase of a multi-phase project.

1. Flag the limits of construction necessary to facilitate the preconstruction meeting.

2. Hold preconstruction meeting. (Remember to call before you dig 1-800-922-4455).

3. Flag remainder of the limits of construction and tree protection zones.

4. Install the construction entrance.

5. Install perimeter erosion and sediment controls and tree protection devices in accordance with the E&S plan.

6. Cut trees within the defined clearing limits and remove cut wood. Chip brush and slash, stockpile chips for future use or remove off site.

7. Construct sediment basins.

8. Strip and stockpile all topsoil that is within the footprint of the construction site and reference stockpile management for erosion and sediment controls. (See Chapter 4, Part II on stockpile management). Either remove tree stumps to an approved disposal site or chip in place as indicated on the plans.

9. Make all cuts and fills required. Establish the subgrade for the topsoil areas, parking and roadway as required and bench the building to a subgrade. Allow a reasonable amount of area around the footprint of the building for the construction activities.

10. Begin construction of the building.

11. Prior to installing surface water controls such as temporary diversions and stone dikes, inspect existing conditions to ensure discharge locations are stable. If not stable, review discharge conditions with the design engineer and implement additional stabilization measures prior to installing water surface controls.

12. Install all sanitary sewers, drainage systems and utilities to within 5 feet of the building or as otherwise modified by the design engineer to adjust for unforseen site conditions.

13. Prepare sub-base, slopes, parking areas, shoulder areas, access roads and any other area of disturbance for final grading.

14. Install process aggregate in parking areas.

15. Place topsoil where required. Complete the perimeter landscape plantings.

16. Fine grade, rake, seed and mulch to within 2 feet of the curbing.

17. Upon substantial completion of the building, complete the balance of site work and stabilization of all other disturbed areas. Install first course of paving.

18. When all other work has been completed, repair and sweep all paved areas for the final course of paving. Inspect the drainage system and clean as needed.

19. Install final course of pavement.

20. After site is stabilized remove temporary erosion and sediment controls (e.g. geotextile silt fences).

Limitations of this sequence:
This sequence does not include the construction of an access road. (See New Roadway Construction Sequence). It is not for previously disturbed sites. For redevelopment of existing building site(s) expect the sequence to be more complex. Separate sequences are required when the construction of multiple buildings are planned to occur in phases.

Slope of Placed Fill

As in the preceding section, the following information should be gathered before final design is achieved.

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 down slope of the sand with a fine silt or clay without providing adequate drainage.

It will be important to notice 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. It is important to notice existing drainage patterns above your 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 fail during spring months when the groundwater table is high. It is important to look at the timing of the failure to see if that information offers any clues to the mode of failure. If the location is critical, these slopes will need to be repaired or stabilized.

Seepage and water are big factors in many slope failures. If seepage or overland flow is causing or worsening the slope condition, use engineered measures whose strategy is 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 Repair Designs

The actual construction techniques used for the repair of some slope failures can be simple. These designs are all made up of a combination of systems found within these Guidelines. Some of the design components can be changed and modified to fit the situation or the preferences of the designer.

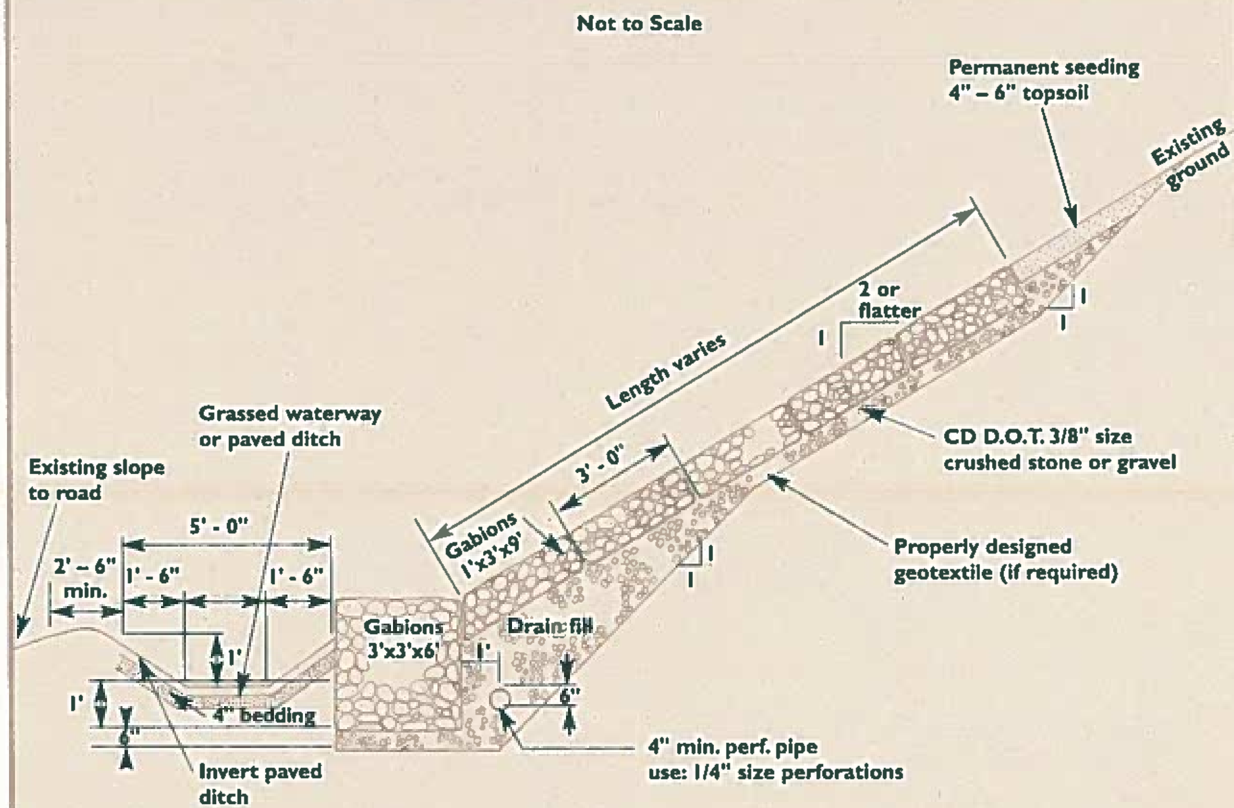
Figure 4-1, **Figure 4-2** and **Figure 4-3** illustrate three different designs for the repair of slope failures that integrate the use of several E&S measures to create a stable slope. **Figure 4-1** shows a drainage blanket covered with 4" to 6" of topsoil. **Figure 4-2** shows the use of gabions. 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.

There are many parameters that need to be considered in the design of stable slopes. These Guidelines are not meant to be an all inclusive design manual, but are meant to assist engineers and regulators in asking appropriate questions of themselves and the designers during design review and construction of projects resulting in new slopes.

Depending on site conditions, the designer may want to use the "Infinite Slope Analysis", "Bishop's Slip Circle", or "Sliding Wedge Analysis".

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 4-2 Slope Repair Example 2: Using A Gabion Blanket



Combination Systems for Slope Stabilization:
E&S Measures Include:

PS Permanent Seeding
TO Topsoiling
SD Subsurface Drain
G Gabions
RR Riprap
LW Permanent Lined Waterway
GW Grassed Waterway

Source: USDA-NRCS

Stockpile Management

Stockpile management of topsoil and other types of erodible soils is necessary to prevent unnecessary damage resulting from erosion of stockpile material. Locate stockpiles so that natural drainage is not obstructed. Attempt to maximize the distance of stockpiles from wetlands, watercourses, drainage ways, and steep slopes. 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 or hay bale barrier around the stockpile area approximately 10 feet from the proposed toe of the slope (see **Geotextile Silt Fence** and **Hay 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). The seed mix used depends upon the stockpiled material and the length of time it is to remain stockpiled. Information gathered from 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.

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:

- O *Will the deflected water negatively impact the opposite bank?*
- O *Will the increased velocities and tractive stresses cause unacceptable bank and bed erosion?*
- O *Are the construction materials suitable for the planned longevity?*
- O *Are the deflectors located and spaced for optimum results?*
- O *Are the deflectors properly sized as to height and lateral extent?*
- O *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 publication Wildlife and Fisheries Habitat Improvement Handbook, December 1988, for additional advice on stream deflector design and construction.

Construction Access Road

Construction access roads are unpaved roadways consisting of a travel surface 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 a number of E&S measures: **Construction Entrance** is used where the construction access road meets a paved access point; **Temporary Diversion** and **Temporary Lined Channel** are used to control concentrated flows where they enter and cross the construction access road; **Temporary Stream Crossing** is used to carry concentrated flows across the construction access road; **Outlet Protection**, **Level Spreader** or **Stone Check Dam** may be used to de-energize concentrated flows from diversions and in temporary channels; **Water Bar** is used to maintain natural drainage patterns and break flow lines within the construction access road; **Geotextile Silt Fencing** and **Hay Bale Barriers** are used 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** are used to protect disturbed side slopes; and **Dust Control** is used when construction access road conditions create airborne dust.

Temporary 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

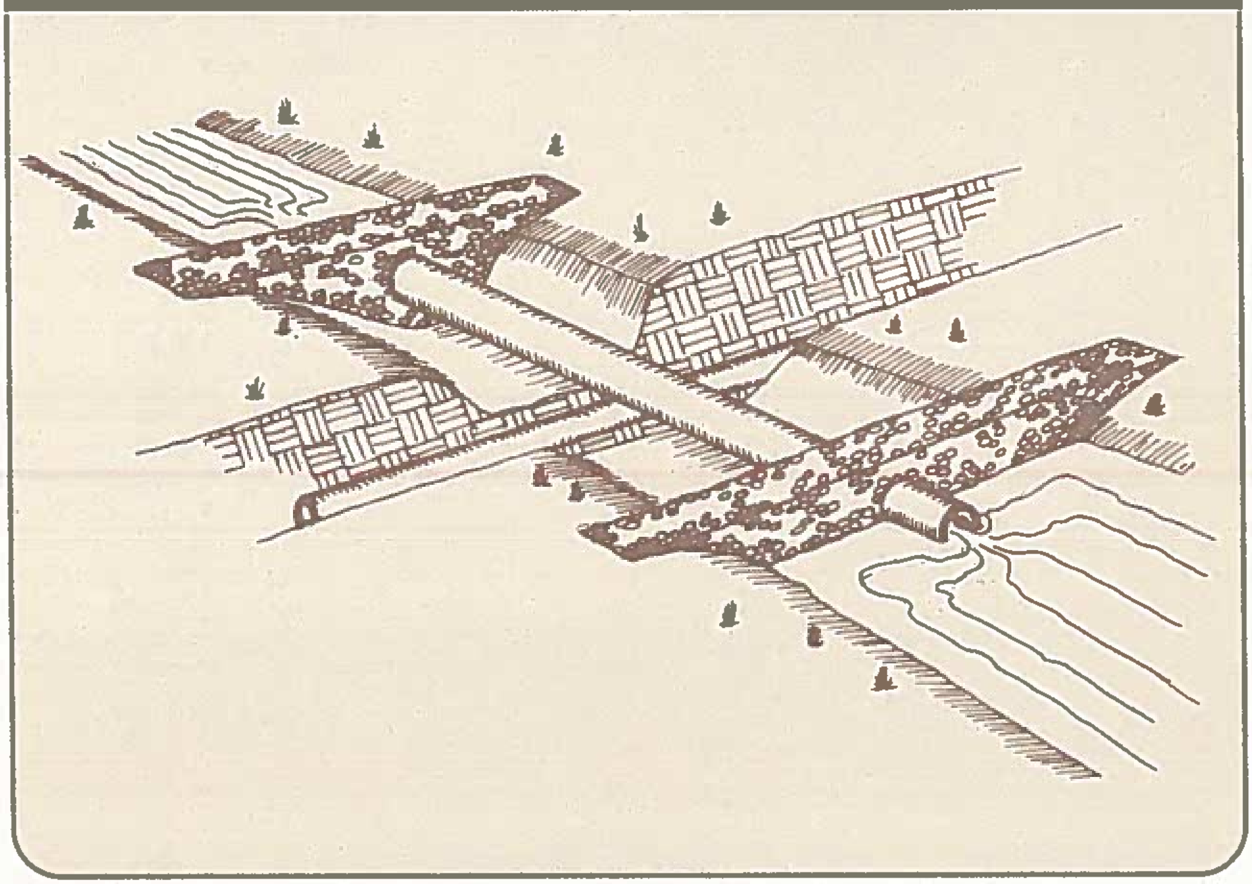
Diversion Channel Crossing - Used when in-stream construction will last longer than 72 hours. It consists of the construction of a temporary diversion channel (stabilized as needed with a channel lining to prevent erosion) with associated cofferdams and riprap to divert water flows around the stream bed to be crossed 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 DOT 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 stabilized, the cofferdams are removed, new cofferdams are 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.

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**.)

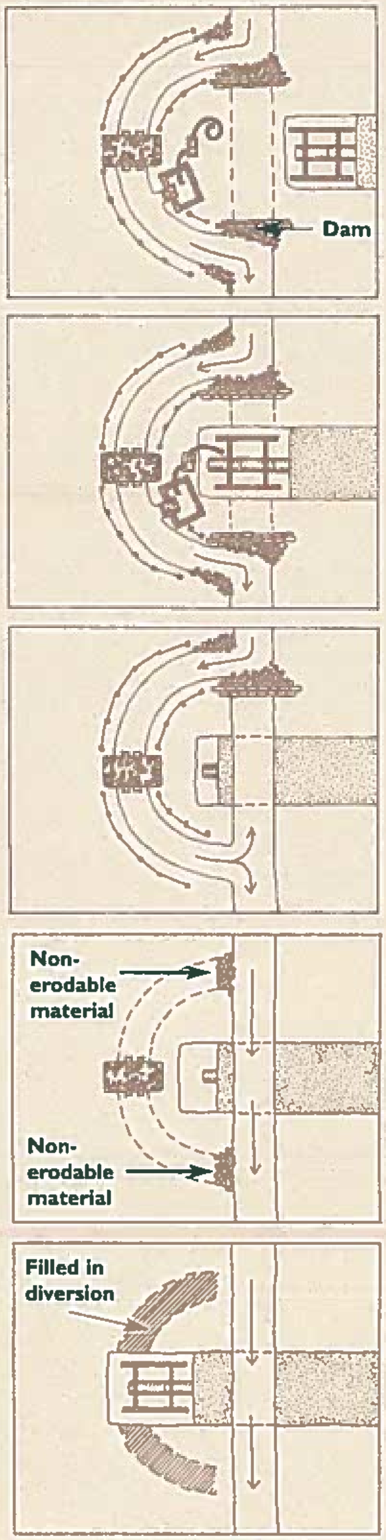
Regardless of the method used, water that is trapped between or within cofferdams should be removed using the measures given in the Dewatering Functional Group.

Figure 4-4 Pipe Flume Crossing Illustration



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

Figure 4-5B Diversion Channel Crossing Sequence



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

7. **Construct utility across blocked streambed, dewatering as necessary.**

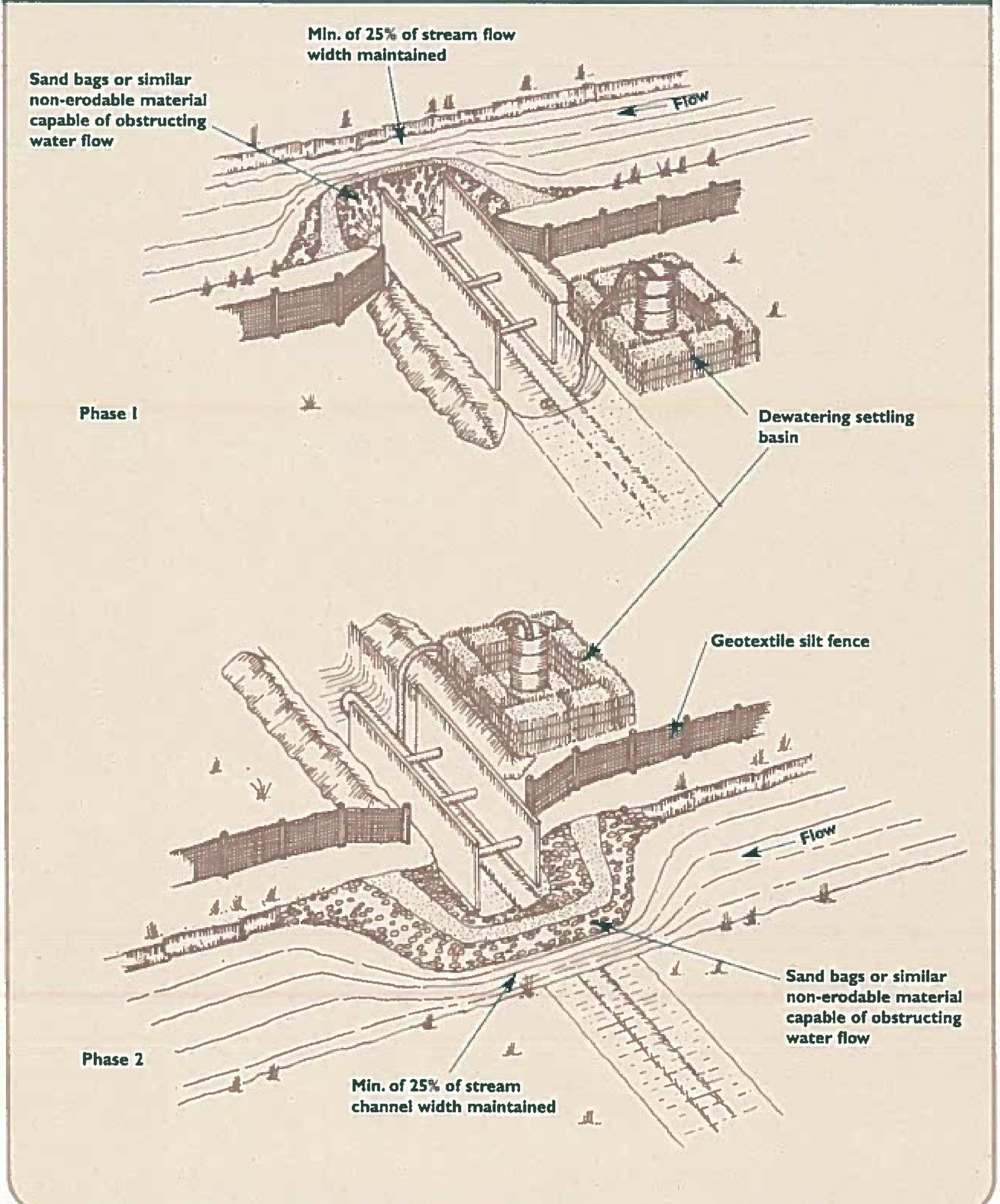
8. **After re-establishing stream channel, remove dam from downstream end of existing channel.**

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 construction and stabilize disturbed soils.**

Source: Adapted from "Damming by the Numbers" Erosion Control. July/August, 1995.

Figure 4-7 Sequential Cofferdam Crossing Detail



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

5 The Functional Groups and Measures

5-1 Protect Vegetation

Protect Vegetation Planning Considerations

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. 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.

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.

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 conditions 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 a distance of 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.*

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 TP-7**). 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 of 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 TP-7**)

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, in order 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[2]

Before beginning construction, examine the trees selected for retention with an arborist 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, storage or stockpiles of any construction materials, including topsoil, within the tree protection zone of any tree to be retained.

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

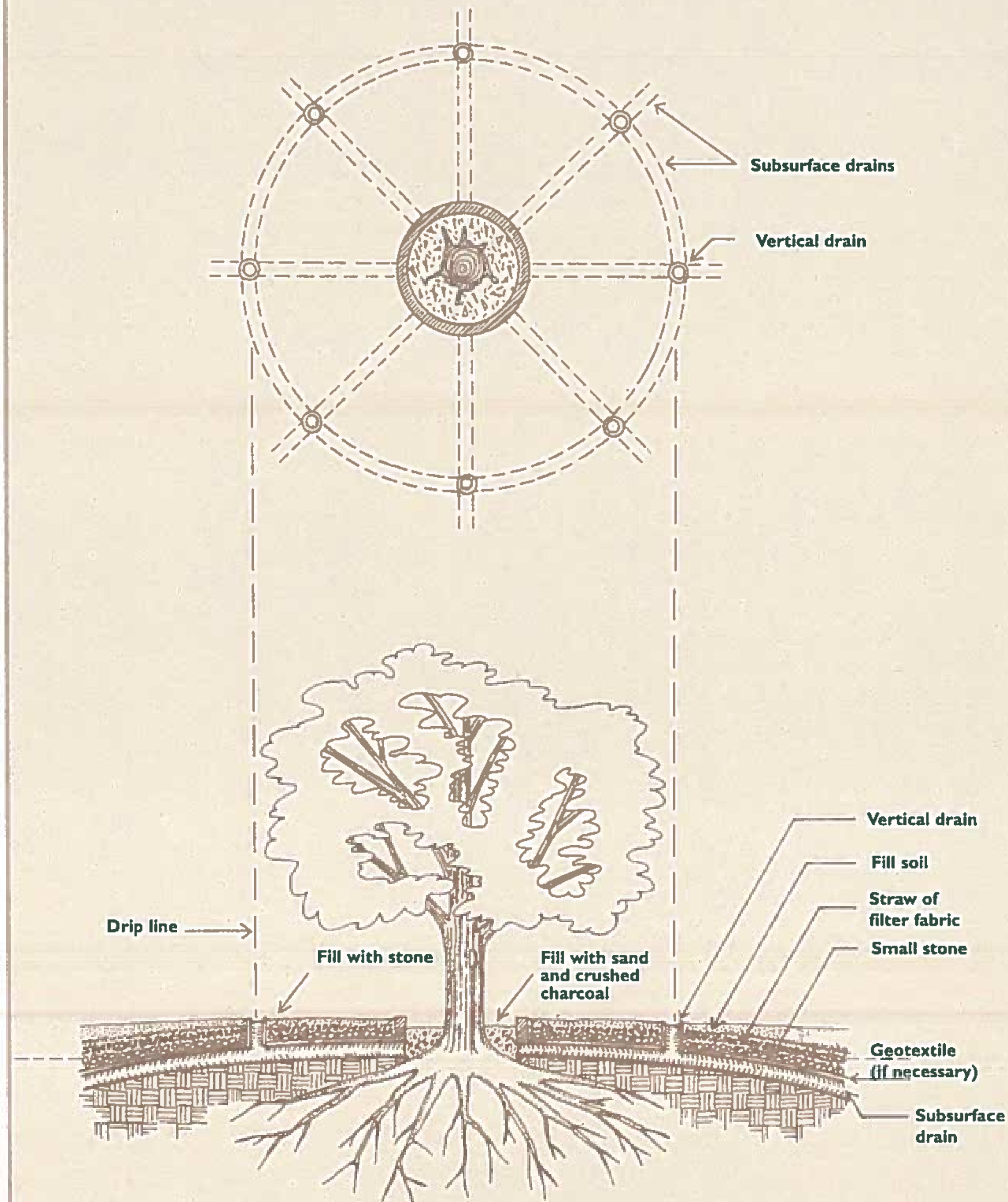
Inspect tree protection zones weekly during site construction for damage to the tree crown, trunk, root system and soil compaction. When trees have been damaged or when tree protection zones are violated during construction, immediately consult an arborist licensed to practice in Connecticut to determine 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.

[2] 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.

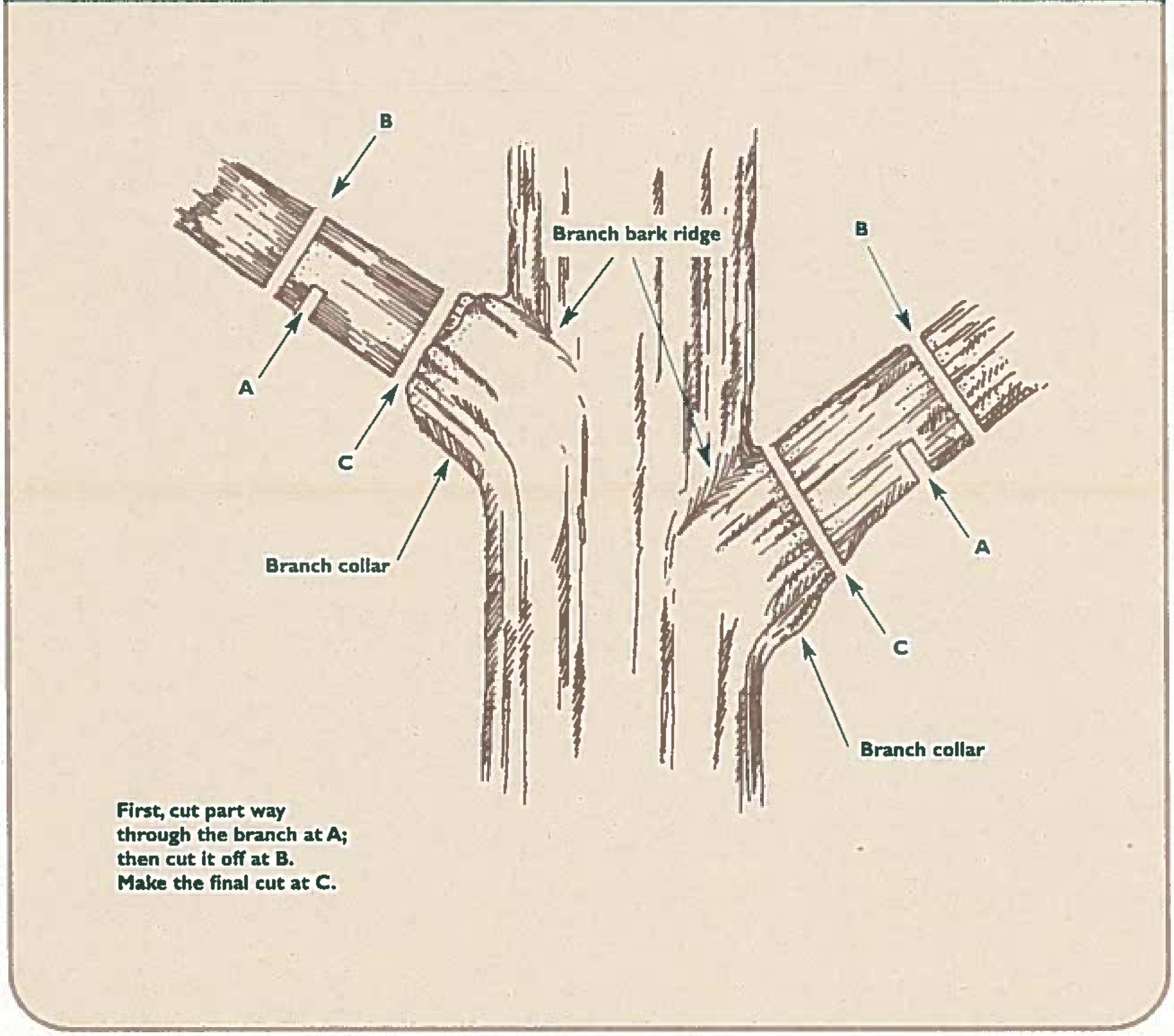
In addition, any activity involving the cutting, removal, harvesting or trimming of trees within the limit of public roads or grounds in the State of Connecticut is subject to CGS §23-65(f). Many towns also have local ordinances which place certain restrictions on tree cutting or pruning

Figure TP-3 Example of Tree Well



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

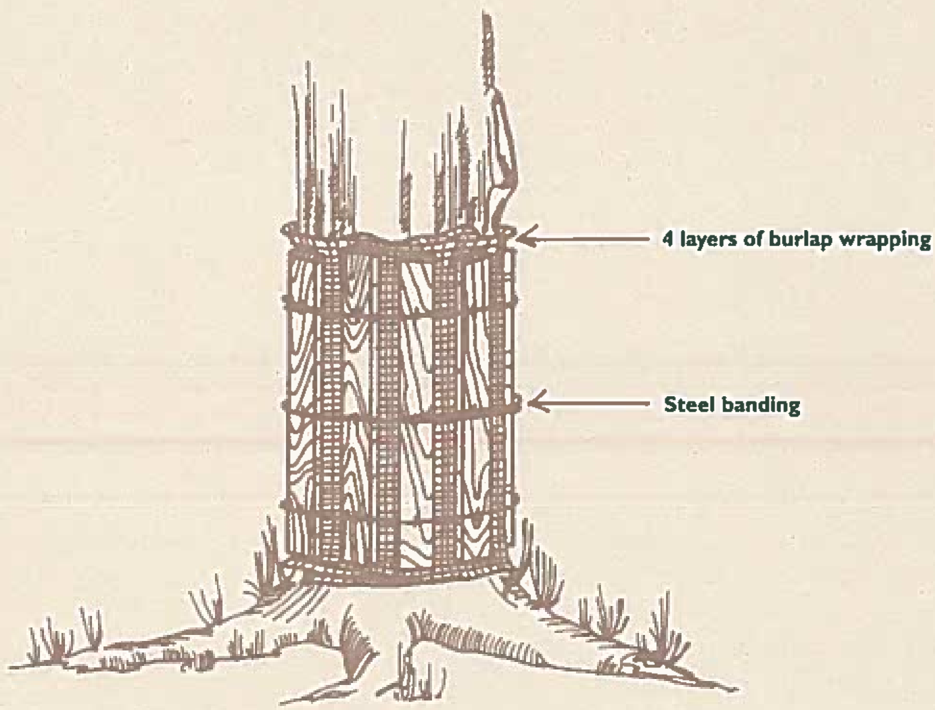
Figure TP-5 Pruning Details



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

Figure TP-7 Mechanical Tree Protection

Correct methods of fencing tree protection zones



Correct trunk armoring

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

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

Planning Considerations

The measures in this group include: **Topsoiling, Land Grading, Surface Roughening,** and **Dust Control**. All four measures involve manipulating or amending 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.

stockpiled longer than 30 days, it must be protected with a temporary seeding, matting or other acceptable means of preventing erosion. (See Stockpile Management, Chapter 4, Special Treatments).

- *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 **Figure TO-1**. Calculate topsoil needs in advance of stripping to determine if there is sufficient topsoil of good quality to justify stripping.

Stripping

Stripping shall be confined to the immediate construction area. A 4- to 6-inch stripping depth is common, but depth may vary depending on the particular soil. Place all perimeter dikes, basins, and other sediment controls prior to stripping.

Figure TO-1 Topsoil Required for Application of Various Depths

Depth in Inches	Cu. Yds / 1,000 ft²	Cu. Yds/ Acre
4	12.4	537
5	15.5	672
6	18.6	806

Stockpiling

Stockpile topsoil that is stripped from the 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 distance from wetlands and/or watercourses.

The side slopes of all stockpiles shall not exceed 2:1.

Install a sediment barrier down slope to trap sediments eroding from the stockpile. Stabilize the stockpiled material if it is to remain for a period of 30 day or longer (see **Temporary Soil Protection**, **Temporary Seeding**, **Permanent Seeding**, and **Mulch for Seed** measures for application timing requirements).

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. For a tracking description, see **Surface Roughening** measure.

Land Grading (LG)

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

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 close 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 work day 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:vertical or a percentage of the vertical divided by the horizontal. **Figure LG-1** identifies the methods by which slope is determined.

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 **Figure 3-4**, Selection Matrix) or other structural measures designed by the engineer.

Exceptions: Slope limitations may be increased providing detailed soil mechanics analysis calculations are performed which confirm an acceptable safety factor for the finished slope.

Slope Length Limitations and Reverse Slope Benches

Reverse slope benches are required whenever the vertical height of any **slope steeper than 3:1 exceeds 15 feet** (see **Figure LG-3**), except when engineered slope stabilization structures 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.*

Controlling Water Movement

Make provisions to safely conduct 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 insure 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:

$$A = X(15 - Y)$$

A = Maximum overland flow distance in feet above the crest of the designed 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 for designed 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.

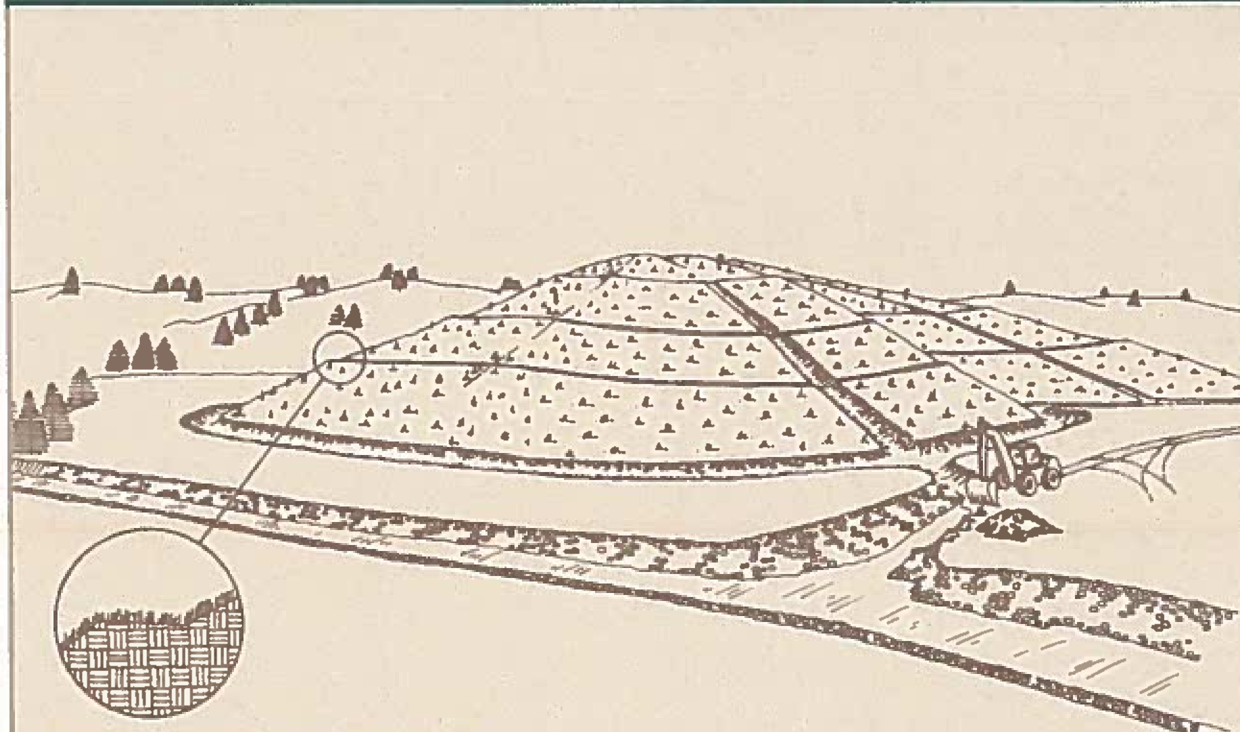
Either divert surface water from the face of all cut and fill slopes by the use of diversions, ditches and drainageways or otherwise convey it down the slope by the use of other appropriate measures. Surface water may be allowed to flow down cut and fill slopes when all of the following conditions exist:

- *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 I);*
- *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 slope distance (B) does not exceed 15 times the side slope (X) of the cut or fill slopes.*

Figure LG-2 contains an example that uses the formula referenced above.

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).

Figure LG-3 Illustration of Reverse Slope Bench



Cross slope bench with reverse slope of 5:1 or flatter, at least 1 foot deep.

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

(see **Figure SR-1**)

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 compact severely, and may be tracked. In sandy soils tracking may not be as effective as the other roughening methods described.

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.

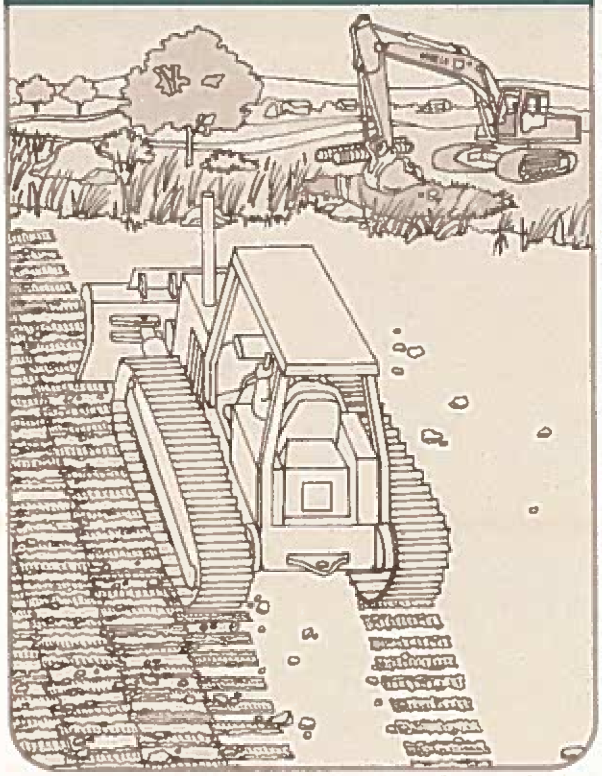
Stabilizing with Seed and/or Mulch

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.

Figure SR-1 Tracking Slopes



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 travelways to keep the travelway damp.

Non-Asphaltic Soil Tackifier

Non-asphaltic soil tackifier consists of an emulsified 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. The solutions shall be non-asphaltic, nontoxic to human, animal and plant life, non-corrosive and nonflammable. 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.

Maintenance

Repeat application of dust control measures when fugitive dust becomes evident.

Planning Considerations

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.

The **Landscape Planting** measure is most commonly 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 even 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.

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.

Specifications

Seed Selection

Select grass species appropriate for the season and site conditions from **Figure TS-2**.

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 seeding dates given in **Figure TS-2** 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 bulldozer, 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).

Apply ground limestone and fertilizer according to soil test recommendations (such as those offered by the University of Connecticut Soil Testing Laboratory or other reliable source). Soil sample mailers are available from the local Cooperative Extension System office. Appendix E contains a listing of the Cooperative Extension System offices.

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 of 10-10-10 or equivalent. Additionally, lime may be applied using rates given in **Figure TS-1**.

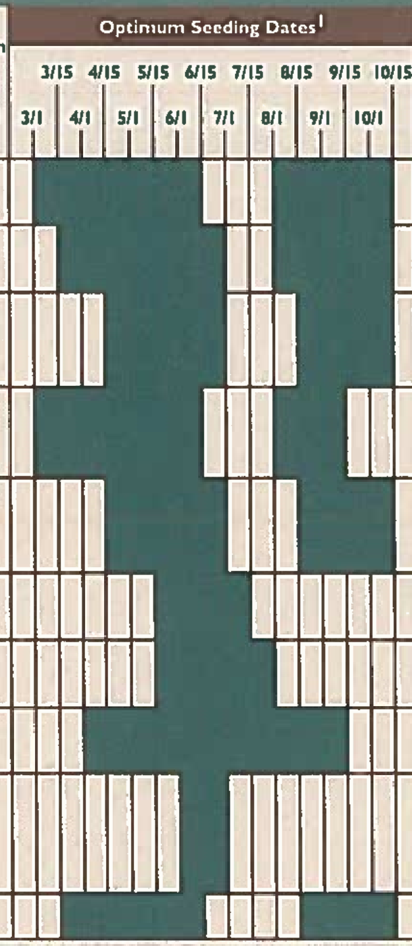
Figure TS-1 Soil Texture vs. Liming Rates

Soil Texture	Tons / Acre of Lime	Lbs / 1000 ft² of Lime
Clay, clay loam and high organic soil	3	135
Sandy loam, loam, silt loam	2	90
Loamy sand, sand	1	45

Seeding

Apply seed uniformly by hand, cyclone seeder, drill, cultipacker type seeder or hydroseeder at a minimum rate for the selected seed identified in **Figure TS-2**. Increase seeding rates by 10% when hydroseeding.

Figure TS-2 Temporary Seeding Rates and Dates



Species[4]	Seeding Rates (pounds) /Acre	Seeding Rates (pounds) /1000 sq. ft.	Optimum Seed Depth[2] (inches)	Plant Characteristics
Annual ryegrass Lolium multiflorum	40	1.0	0.5	May be added in mixes. Will mow out of most stands
Perennial ryegrass Lolium perenne	40	1.0	0.5	Use for winter cover. Tolerates cold and low moisture.
Winter Rye Secale cereale	120	3.0	1.0	Quick germination and heavy spring growth. Dies back in June with little regrowth.
Oats Avena sativa	86	2.0	1.0	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	3.0	1.0	Quick germination with moderate growth. Dies back in June with no regrowth.
Millet Echinochloa crusgalli	20	0.5	1.0	Warm season small grain. Dies with frost in September.
Sudangrass Sorghum sudanense	30	0.7	1.0	Tolerates warm temperatures and droughty conditions.
Buckwheat Fagopyrum esculentum	15	0.4	1.0	Hardy plant that will reseed itself and is good as a green manure crop.
Weeping lovegrass Eragostis curbula	5	0.2	0.25	Warm-season perennial. May bunch. Tolerates hot, dry slopes, acid infertile soils. Excellent nurse crop. Usually winter kills.
DOT All Purpose Mix[3]	150	3.4	0.5	Suitable for all conditions.

1 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.

2 Seed at twice the indicated depth for sandy soils.

3 See Permanent Seeding **Figure PS-3** for seeding mixture requirements.

4 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.

Source: USDA–NRCS

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 sets 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). Cool season grasses generally are the sod formers, such as bluegrass, while the warm season grasses, such as the perennial ryes, do not form sod.

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 **Seed Bed Preparation**). Previously applied hay and straw mulch can be incorporated into the soil without adding supplemental nitrogen.

Specifications

Seed Selection and Quantity

Select a seed mixture appropriate to the intended use and soil conditions from **Figure PS-2** and **Figure PS-3** 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.

When buying seed make sure the quality of the seed is given 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 of 95% and 98% and a germination rate between 70% and 90%. Some seeding mixtures call for pure live seed. An example of calculating pure live seed is given in **Figure PS-3**.

Increase seeding rates 10% when using frost crack seeding[2] or hydroseeding.

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 April 1 through June 15 and August 15 through October 1, 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.

Install all necessary surface water controls.

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.

Note: *On areas where wood chips and/or bark mulch was previously applied, either remove the mulch or incorporate it into the soil with a nitrogen fertilizer added. Nitrogen application rate is determined by soil test at time of seeding; anticipate 12 lbs nitrogen per ton of wood chips and/or bark mulch.*

Seedbed Preparation

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

Apply fertilizer and ground limestone according to soil tests conducted by the University of Connecticut Soil Testing Laboratory or other reliable source. A pH range of 6.2 to 7.0 is optimal for plant growth of most grass species.

Where 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 10-10-10 or equivalent and limestone at 4 tons per acre or 200 pounds per 1,000 square feet. Additionally, lime may be applied using rates given in **Figure PS-1**. A pH of 6.2 to 7.0 is optimal.

For areas that were previously mulched with wood chips or bark and the wood chips or bark are to be incorporated into the soil, apply additional nitrogen at a rate that is determined by soil tests at time of seeding.

Work lime and fertilizer into the soil to a depth of 3 to 4 inches with a disc or other suitable equipment.

Figure PS-1 Soil Texture vs. Liming Rates

Soil Texture	Tons / Acre of Lime	Lbs / 1000 ft² of Lime
Clay, clay loam and high organic soil	3	135
Sandy loam, loam, silt loam	2	90
Loamy sand, sand	1	45

[2] Frost crack or dormant seeding is a method used to establish a seeding during the off season and should be used only in extreme cases as there is a smaller chance of success. It can be an effective way to plant grass seed during late winter or early spring. This method is most effective on frozen ground where a seedbed has been prepared, or on areas that have been disturbed and where topsoil exists but vegetation has not been established. Frost crack or dormant seeding can also be used to re-seed or over-seed an area previously seeded, but where the survival was poor. The existing plants will remain undamaged, while the frost works the seed into the soil in bare areas. In all cases, seedings of this type need to be mulched to protect the seed from wind and water until satisfactory growing conditions occur (See Mulch for Seed measure). This method works particularly well with legumes, such as crown vetch and flat pea, which have a hard seed coat and the freezing action breaks down the seed coat to allow for germination.

Figure PS-2 Selecting Seed Mix to Match Need

Area To Be Seeded	Mixture Number[1]	
	Mowing Desired	Mowing Not Required
BORROW AREAS, ROADSIDES, DIKES, LEVEES, POND BANKS AND OTHER SLOPES AND BANKS		
A) Well or excessively drained soil[2]	1,2,3,4,5 or 8	5, 6, 7, 8, 9, 10, 11, 12, 16, ***22***
B) Somewhat poorly drained soils[2]	2	5, 6
C) Variable drainage soils[2]	2	5, 6, 11
DRAINAGE DITCH AND CHANNEL BANKS		
A) Well or excessively drained soils[2]	1, 2, 3, or 4	9, 10, 11, 12
B) Somewhat poorly drained soils[2]	2	
C) Variable drainage soils[2]	2	
DIVERSIONS		
A) Well or excessively drained soils[2]	2, 3 or 4	9, 10, 11
B) Somewhat poorly drained soils[2]	2	
C) Variable drainage soils[2]	2	
EFFLUENT DISPOSAL		5 or 6
GRAVEL PITS[3]		26, 27, 28
GULLIED AND ERODED AREAS		3, 4, 5, 8, 10, 11, 12
MINESPOIL & WASTE, AND OTHER SPOIL BANKS (If toxic substances & physical properties not limiting)[3]		15, 16, 17, 18, 26, 27, 28
SHORELINES (Fluctuating water levels)		5 or 6
SKI SLOPES		4, 10
SOD WATERWAYS AND SPILLWAYS	1, 2, 3, 4, 6, 7, or 8	1, 2, 3, 4, 6, 7, or 8
SUNNY RECREATION AREAS (Picnic areas and playgrounds or driving and archery ranges, nature trails)	1, 2 or ***23***	
CAMPING AND PARKING, NATURE TRAILS (Shaded)	19, ***21*** or ***23***	
SAND DUNES (Blowing sand)	25	
WOODLAND ACCESS ROADS, SKID TRAILS AND LOG YARDING AREAS		9, 10, 16, ***22***, 26
LAWNS AND HIGH MAINTENANCE AREAS	1, 19, ***21*** or ***29***	

[1] The numbers following in these columns refer to seed mixtures in **Figure PS-3**. Mixes for shady areas are in ***bold-italics*** print (including mixes 20 through 24).

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

[3] 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.

Source: USDA-NRCS

Figure PS-3 Seed Mixtures for Permanent Seeding (con't)

No.	Seed Mixture (Variety)[1]	Lbs/Acre	Lbs/1,000 Sq. Ft.
12[6]	Switchgrass (Blackwell, Shelter, Cave-in-rock) Perennial Ryegrass (Norlea, Manhatten) Crown Vetch (Chemung, Penngift) with inoculant[1]	10[1] 5 15 Total 45	.25 .10 .35 1.05
13[6]	Crown Vetch (Chemung, Penngift) with inoculant[1] (or (Flatpea (Lathco) with inoculant[1]) Switchgrass (Blackwell, Shelter, Cave-in-rock) Perennial Ryegrass (Norlea, Manhatten)	10 (30) 5[1] 5 Total 20 (or 40)	.25 (.75) .10 .10 .45 (or .95)
14[5]	Crown Vetch (Chemung, Penngift) with inoculant[1] (or (Flatpea (Lathco) with inoculant[1]) Perennial Ryegrass (Norlea, Manhatten)	15 (30) 10 Total 25 (or 40)	.35 (.75) .25 .60 (or 1.00)
15[6]	Switchgrass (Blackwell, Shelter, Cave-in-rock) Big Bluestem (Niagra, Kaw) or Little Bluestem (Blaze, Aldous, Camper) Perennial Ryegrass (Norlea, Manhatten) Bird's-foot Trefoil (Empire, Viking) with inoculant[1]	5[1] 5[1] 5 5 Total 20	.10 .10 .10 .10 .40
16[5]	Tall Fescue (Kentucky 31) Flatpea (Lathco) with inoculant[1]	20 30 Total 50	.45 .75 1.20
17[6]	Deer Tongue (Tioga) with inoculant[1] Bird's-foot Trefoil (Empire, Viking) with inoculant[1] Perennial Ryegrass (Norlea, Manhatten)	10[1] 8 3 Total 21	.25 .20 .07 .52
18[6]	Deer Tongue (Tioga) with inoculant[1] Crown Vetch (Chemung, Penngift) with inoculant[1] Perennial Ryegrass (Norlea, Manhatten)	10[1] 15 3 Total 28	.25 .35 .07 .67
19[5]	Chewings Fescue Hard Fescue Colonial Bentgrass Bird's-foot Trefoil (Empire, Viking) Perennial Ryegrass	35 30 5 10 20 Total 100	.80 .70 .10 .20 .50 2.30
20[5]	Deleted due to invasive species		
21[5]	Creeping Red Fescue (Pennlawn, Wintergreen)	Total 60	1.35
22[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Tall Fescue (Kentucky 31)	40 20 Total 60	.90 .45 1.35
23[5]	Creeping Red Fescue (Pennlawn, Wintergreen) Flatpea (Lathco) with inoculant[1]	15 30 Total 45	.35 .75 3.60
24[5]	Tall Fescue (Kentucky 31)	Total 150	3.60

Sodding (SO)

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.
- 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 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.
- In watersheds where maintenance of high water quality is particularly important.
- 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, sodding 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 of 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*
- *Is aesthetically impressive.*

These reasons are particularly true where quick establishment and protection is important, such as sites in public water supply watersheds or near watercourses, where maintenance of high water quality may be particularly important to fisheries or human consumption.

Additionally, 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 the silts, sediments 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 top soiling must be made. Generally speaking, 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.

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 ft. 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 waterings 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 re-install 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. For liming and fertilization, follow soil test recommendations when possible.

Definition

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

Purpose

- To aid in protecting and stabilizing soil.
- To intercept precipitation and retard runoff while providing increased plant diversity, food and shelter for wildlife, and improved air quality; to develop high quality riparian buffers and enhanced site aesthetics.

Applicability

- On steep or irregular terrain, where mowing to maintain an herbaceous plant cover is not feasible.
- Where ornamental plantings are desired to improve site aesthetics.
- In shady areas where turf establishment is difficult.
- 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. However, other factors are considered when choosing whether to plant grass and/or other herbaceous vegetation, or whether woody landscape plantings should be utilized.

Some disadvantages to using grass are:

- *Permanent grass cover requires periodic mowing to prevent the area from being occupied with shrubs and tree seedlings 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.*
- *Grass provides limited value for wildlife. However, extensive turf 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 particular attributes which provide benefits that grass or herbaceous cover cannot. These benefits include:

- *Improving air quality;*
- *Modifying air circulation patterns;*
- *Reducing heating and cooling costs;*
- *Providing shade;*
- *Preventing blinding reflections;*
- *Softening architectural features;*
- *Screening undesirable views;*
- *Controlling or screening undesirable noises;*
- *Calming and controlling traffic;*
- *Providing wildlife food and shelter; and*
- *Restoring natural conditions to a disturbed site.*

Landscape planting plan

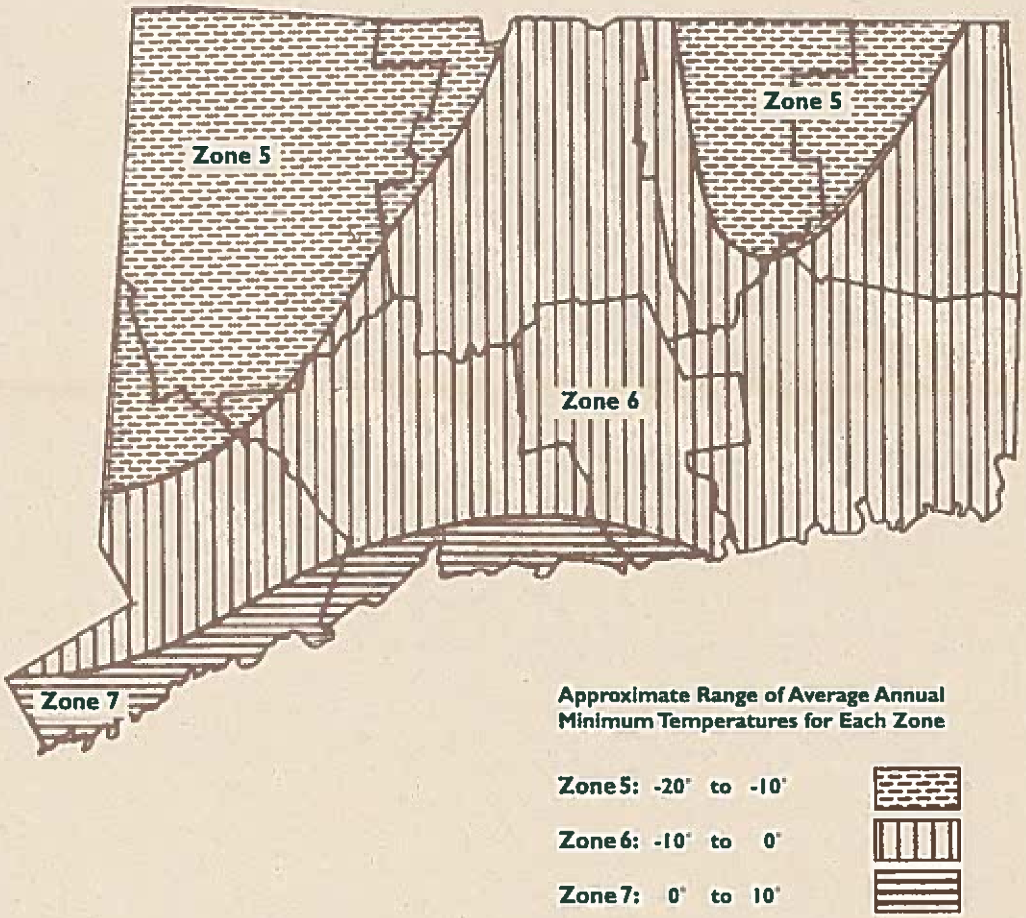
If landscape plantings are intended, then a landscape planting plan should be developed. The landscape planting plan should identify the species, location, number of each planting specified to be planted, the type of planting stock (i.e. bare-root, balled and burlapped, etc.), and the timing for planting.

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 extraordinary and long term maintenance. The following characteristics should be taken into account 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 exposure to salt at shoreline or roadsides, high winds, polluted air, or heat from reflected sun may limit plant survivability. The specific conditions at each site must be taken into account when selecting the appropriate plant for the site.

Figure LP-1 Hardiness Zone Map of Connecticut



Source: Adapted from USDA-NRCS FOTG Section I iii Maps, July 1994.

Landscape Planting (LP)

A broad range of plant material is available to fulfill the desired functions of a landscape planting. Although some plants known to be hardy to Connecticut are included in the list below, 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.

Invasive Species: Certain introduced shrubs, like Autumn Olive (Elaegnus umbellata), Honeysuckles (Lonicera spp), Multiflora Rose (Rosa multiflora), 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 Center for Conservation and Biodiversity at The University of Connecticut maintains a list entitled: "Invasive, Non-Native Plant Species Occurring in Connecticut", listed as Publication #1, which should be consulted to avoid selecting undesirable, non-native invasive plants.

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 may also require watering if planting is delayed. Bare root plant may be stored in a cool, shaded area for as long as 10 days. If bare root plants must be kept for longer than 10 days, they should be "heeled in" (temporarily planted in a trench) until they can be permanently planted. All stock should be handled carefully and as few times as possible.

Transplanting Procedures

Transplanting Balled in Burlap Plant Material: **Figure LP-2** shows the proper planting of balled and burlapped plant material, using a deciduous tree as an illustration.

Stock Examination: Determining Proper Planting Depth - 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 - 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 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 LP-3**. 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.

Site Preparation (see **Figure LP-2**): 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 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 LP-2**).

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

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 loose 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 LP-7 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 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, cutting 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 considered to be 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.

Figure LP-4 Trees for Landscape Planting

Common Name (Botanical Name)	Leaf type[1]	Height	Soil Moisture Preferred: Wet	Moist	Dry	pH range	Users: Lawns	Seashore	Street	Shade tolerance	Salt tolerance[2]	Pollution Tolerance[2]: O_3	SO_2	F	Remarks
BEECH *(Fagus grandifolia)*	D	70-120		X		6.5-7.5	X			Fair	S	-	S	-	Long-lived. Has edible nuts. Needs lots of space.
BIRCH, BLACK, WHITE and GRAY *(Betula spp.)*	D	50-80	X	X		4.0-5.0	X			Good	-	S	S	-	Prefers deep, moist soils such as stream banks. Graceful form.
CEDAR, EASTERN RED *(Juniperus virginiana)*	E	20-50	X	X	X	6.0-6.5	X			Good	-	T	T	T	Long-lived.
CHERRY, JAPANESE *(Prunus serrulata)*	D	15-20		X		6.5-7.5	X	X		Good	-		-	T	Very showy pink or white flowers. Usually grafted on 6-7 ft. stem.
CRABAPPLE *(Malus spp.)*	D	15-20		X		6.5-7.5	X	X	X	Fair	I	S	S	-	White or pink flowers. Many varieties, some with edible fruit.
DOGWOOD, FLOWERING *(Cornus kousa)*	D	30-40		X		5.0-6.5	X	X		Good	-	T	T	T	Ideal street tree. White or pink flowers. Has poor drought resistance.
HAWTHORN *(Crataegus spp.)*	D	15-25		X		6.0-7.5	X	X		Fair	I	-	S	-	Thorny. Washington and Lavalle types are good ornamentals. Tolerates parking lot conditions. Has some insect and disease problems.
LOCUST, HONEY *(Gleditsia tri-acanthos inermis)*	D	50-75	X	X	X	6.5-7.5	X	X	X	Good	T	S	-	-	Sturdy, wind-firm tree. Overused in urban areas.
MAPLE, HEDGE *(Acer campestre)*	D	20-30		X	X	6.5-7.5	X	X		Good	-	T	T	I	Prefers well-drained, deep fertile soil. May be used in clipped hedges.
MAPLE, RED *(Acer rubrum)*	D	50-80	X	X		4.5-7.5	X	X	X	Good	S	T	T	-	Grows rapidly when young. Good tree for suburbs but not city.
MAPLE, SUGAR *(Acer saccharum)*	D	50-70	X	X	X	6.5-7.5	X			Fair	I	T	T	-	Outstanding fall foliage. Suburban, but not city tree. Slow-growing and shapely. Intolerant of salt.
OAK, PIN *(Querus palustris)*	D	60-80	X	X	X	5.5-6.5	X	X		Good	T	S	S	I	Most easily transplanted of the oaks.
OAK, RED NORTHERN *(Querus rubra borealis)*	D	70-90		X	X	4.5-6.0	X	X	X	Good	T	T	T	I	Most rapid-growing oak. Needs room.
OAK, SCARLET *(Querus coccinea)*	D	60-80			X	6.0-6.5	X	X		Good	T	S	T	I	Prefers sandy or gravelly soils.
OAK, WHITE *(Querus alba)*	D	60-80		X	X	6.5-7.5	X	X	X	Fair	T	S	S	I	Long-lived, stately tree. Grows slowly.
PINE, AUSTRIAN *(Pinus nigra)*	E	30-50		X	X	4.0-6.5	X		X	Good	T	-	-	-	Very hardy and rapid-growing. Will tolerate shallow soil and drought.
PINE, JAPANESE BLACK *(Pinus thunbergii)*	E	30-50		X	X	4.0-6.5	X		X	Fair	T	-	-	-	Disease problems.
PINE, SCOTCH *(Pinus sylvestris)*	E	60-90			X	4.0-6.5	X			Good	I	S	S	S	Disease problems.
PINE, WHITE *(Pinus strobus)*	E	80-100			X	4.0-6.5	X			Fair	S	S	S	S	Very attractive, rapid-growing tree. Prefers deep sandy loam. Subject to white pine blister rust.
YEW, JAPANESE *(Taxus cuspidata)*	E	15-20		X		6.0-6.5	X			Good	-	T	-	I	Hedges and borders. Preferred food of white-tailed deer.

[1] D is deciduous plants
E is evergreen or coniferous plant

[2] Pollution tolerance and salt tolerance: "S" Sensitive. Will show physical damage
"T" Tolerant.
"I" Intermediate. Damage depends on growing conditions and exposure to pollutant.
"-" No information at this time.

Source: USDA-NRCS

Figure LP-5 Shrubs for Landscape Planting (con't)

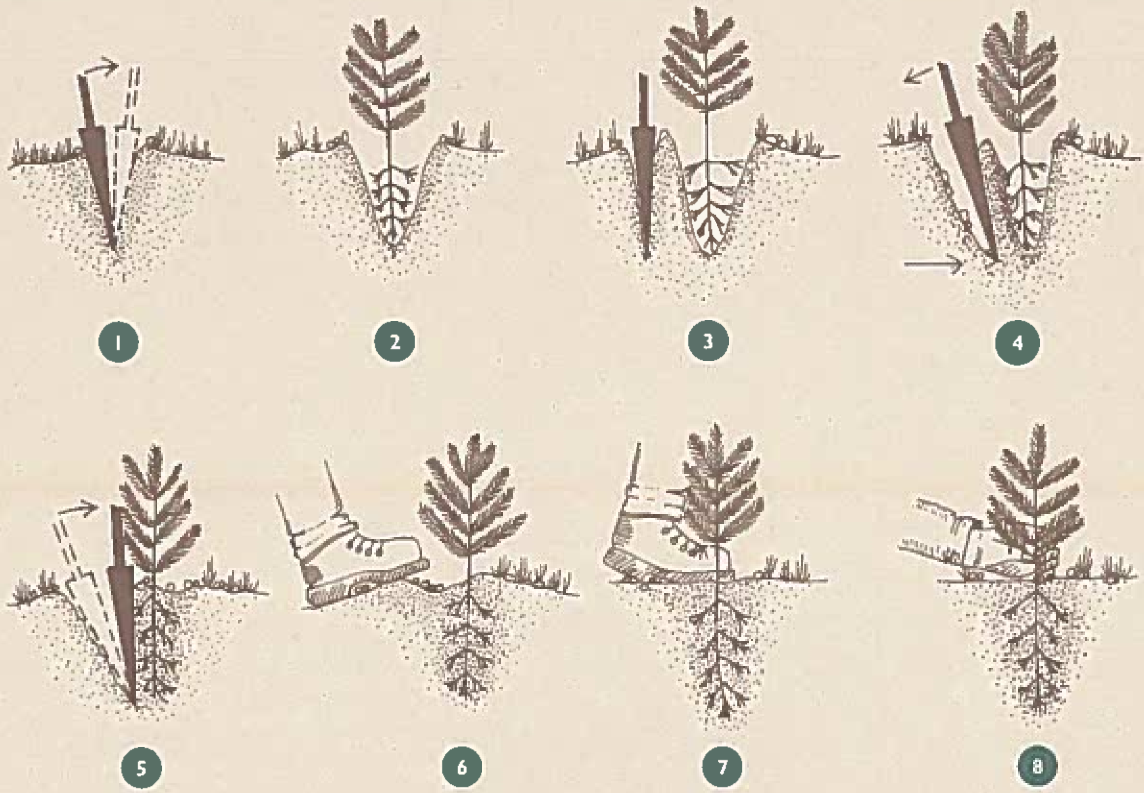
Common Name (Botanical Name)	Leaf type[1]	Drainage Tolerance	Shade tolerance	pH range	Mature Height in Ft.	Uses
SHORE JUNIPER "EMERALD SEA" *(Juniperus conferta)*	E	Droughty to Well-Drained	Fair	5.0-6.0	1	Stabilizing sand dunes and sandy road banks. Flowers and fruits inconspicuous.
SIEBOLD FORSYTHIA *(Forsythia suspensa seibold)*	D	Droughty to Well-Drained	Poor	4.5-6.0	4-6	Over used. Flowers yellow, fruit inconspicuous.
SWEETFERN *(Comptonia peregrina)*	D	Droughty to Moderately Well-Drained	Fair	5.0-6.0	3-4	Natural masses. Flowers inconspicuous.
SWEET PEPPERBUSH *(Clethra alnifolia)*	D	Moderately Well-Drained to Poorly Drained	Good	5.5-6.5	3-8	Borders and hedges. Flowers white, fruit inconspicuous.
WINTERBERRY *(Ilex verticillata)*	D	Well-Drained to Poorly Drained	Fair	5.0-6.0	10	Ornamental screens. Flowers inconspicuous, fruits red berries in 3-4 years. Winter food for songbirds.
WYTHEROD VIBURNUM *(Viburnum cassinoides)*	D	Well-Drained to Somewhat Poorly Drained	Good	5.5-6.5	4-6	Natural mass. Flowers white, fruit green to black. Very showy in fall.

[1] E-Evergreen D-Deciduous

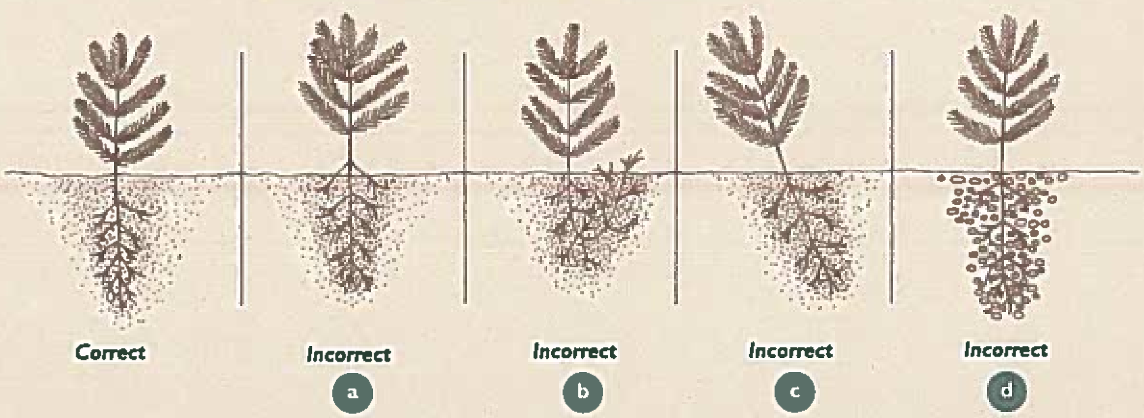
Source: USDA-NRCS

Landscape Planting (LP)

Figure LP-7 Planting Bare Root Stock



1. Insert bar at angle shown and push forward to upright position.
2. Remove bar and place seedling at correct depth.
3. Insert bar two inches toward planter from seedling.
4. Pull bar toward planter firming soil at bottom of roots.
5. Push bar forward from planter firming soil at top of roots.
6. Fill in last hole by stamping with heel.
7. Firm soil around seedling with feet.
8. Test planting by pulling lightly on seedling.



a. Don't expose roots to air during freeze or plant in frozen ground.
b. Don't bend roots so that they grow upwards out of the ground.
c. Plant seedlings upright – not at an angle.
d. Always plant in soil – never loose leaves or debris. Pack soil tightly.

Source: Virginia Erosion and Sediment Control Handbook, 1992.

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. With the exception of some **TRM**, these measures are intended to dissipate the erosive energy of raindrops. With the exception of 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.

TECBs 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**.

PTRMs are geotextiles that are laid on or within the soils 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.

ECB and **TRM** 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**.

Figure 1 is provided to assist in the selection of mulch material by comparing and contrasting the types of biodegradable mulches commonly used in the **Temporary Soil Protection**, **Mulch for Seed** and **Landscape Mulch** measures.

4-Short Term Non-living Soil Protection

Temporary Slope Protection (TSP)

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 through the use of 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 raindrop 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 (anticipate 12 lbs. nitrogen per ton of wood chips).

4-Short Term Non-living Soil Protection

Mulch For Seed (MS)

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, in particular, 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

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.

See **Figure MS-1** for a procedure to estimate the adequacy of mulch coverage.

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.

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 with a rainfall amount of 0.5 inch or greater 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.**

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. See **Figure LMu-1** for suggested application rates for wood chips and shredded bark. Do not pile mulch against any tree or shrub trunk. Avoid excessive depths on slopes where mulch could slip when saturated.

Figure LMu-1 Suggested Landscape Mulch Application Rates for 100% Cover

Mulch	Rate
Wood Chips/ Shredded Bark	10 cu yds./1000 sq. ft.

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.

- *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.*

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 ECB-1**)

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 insure that all lap joints are secure, all edges are properly anchored and all staking or stapling patterns follow manufacturer's recommendations.

Maintenance

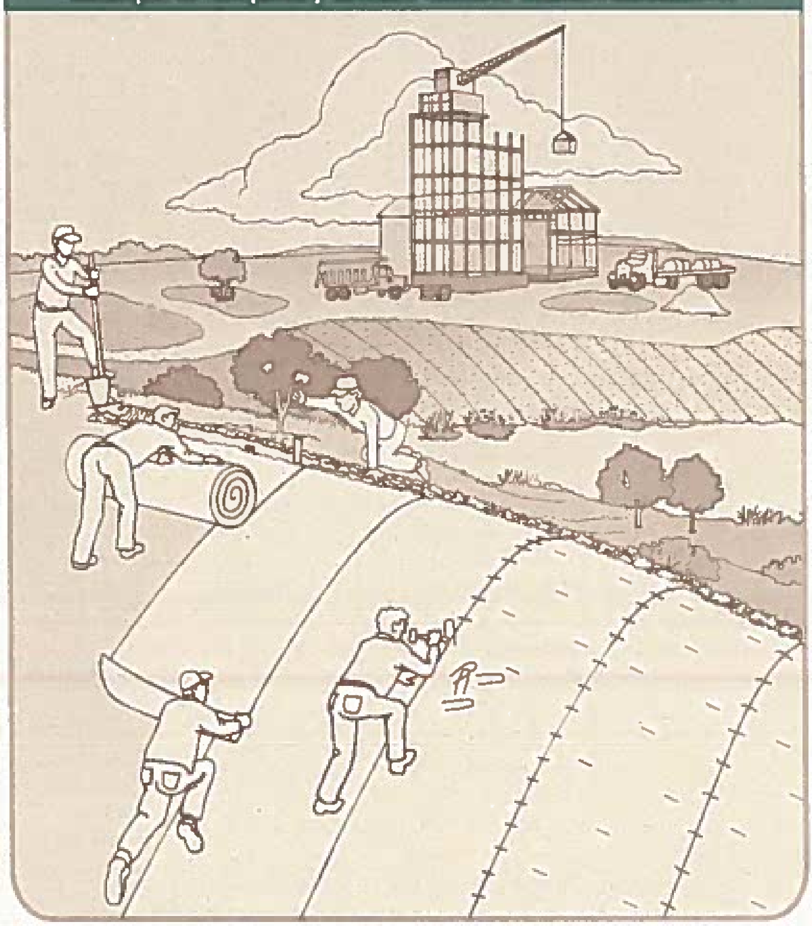
Inspect temporary erosion control blankets at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for failures. Blanket failure has occurred when (1) soils and/or seed have washed away from beneath the blanket and the soil surface can be expected 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.

Figure ECB-1
Example of Temporary Erosion Control Blanket Installation



- *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

Prepare site and install in accordance with manufacturer's requirements. **Figure TRM-1** 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.

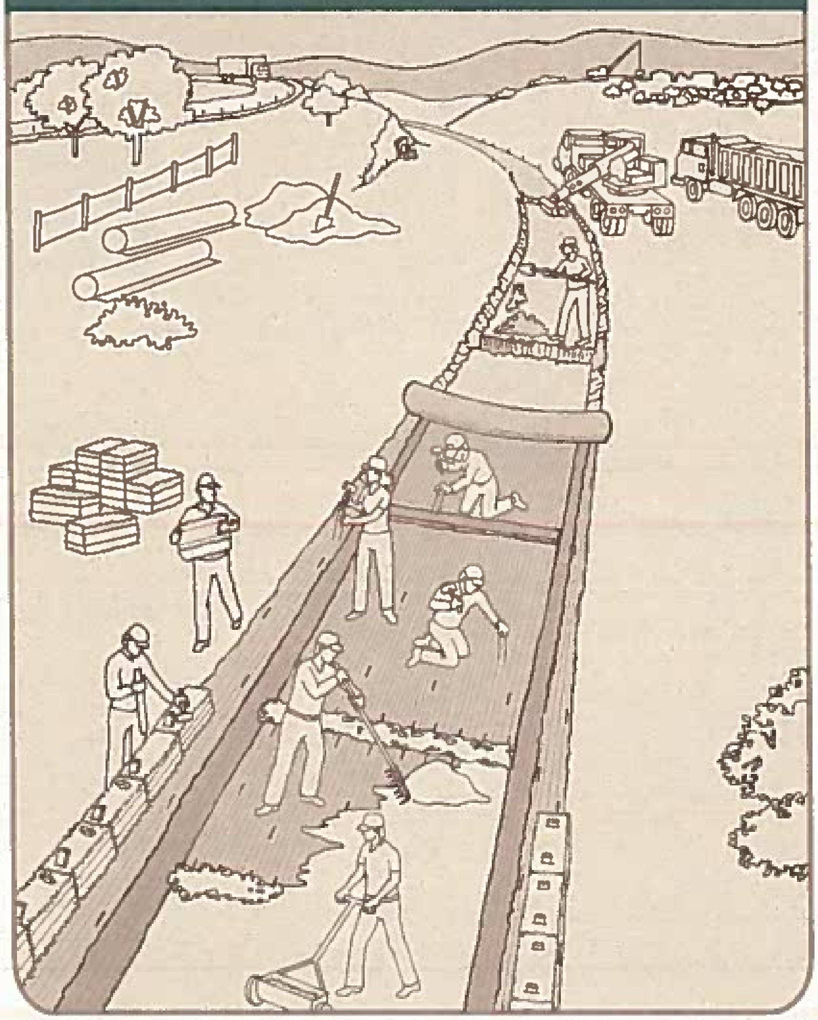
Inspect the installation to ensure that the mat is in direct contact with the prepared soil surface, all lap joints are secure, all edges and interior mats are properly anchored and/or treated, backfilling follows the manufacturer's requirements, and the vegetative soil measures used have been correctly applied.

Maintenance

Inspect permanent turf reinforcement mats at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater for failures until the turf has become 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 work day.

After the turf has become established, inspect annually or after major storm events.

Figure TRM-1 Example of TRM Channel Application



5-5 Stabilization Structures

Planning Considerations

The stabilization structures measures are **Retaining Wall, Riprap, Gabions, 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. 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 and Gabions 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** measure involves 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 or high velocity stream flows.

continued on next page

Retaining Wall (RW)

Definition
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.

Purpose
To prevent erosion and slope failure on steep slopes and stream banks.

Applicability
- Where erosion or slope failure may occur due to excessive loadings, steepness, seepage or other unstable soil conditions.
- Where site constraints won't allow slope stabilization by flattening and seeding.

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.

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 Criteria
Consider foundation bearing capacity, sliding, overturning, drainage and loading systems. 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.

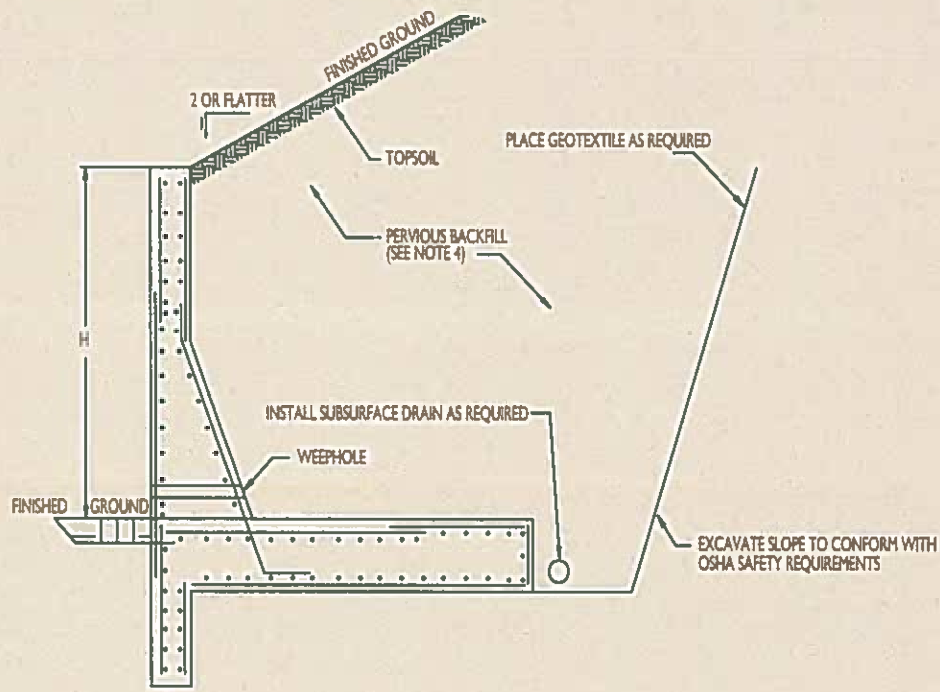
Drainage
Unless adequate provisions are designed to control both surface and groundwater behind the retaining wall, a substantial increase in active pressures tending to slide or overturn the wall will result. Provide surface drainage when backfill or natural ground is higher than the top of the wall. 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.

Load systems
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.

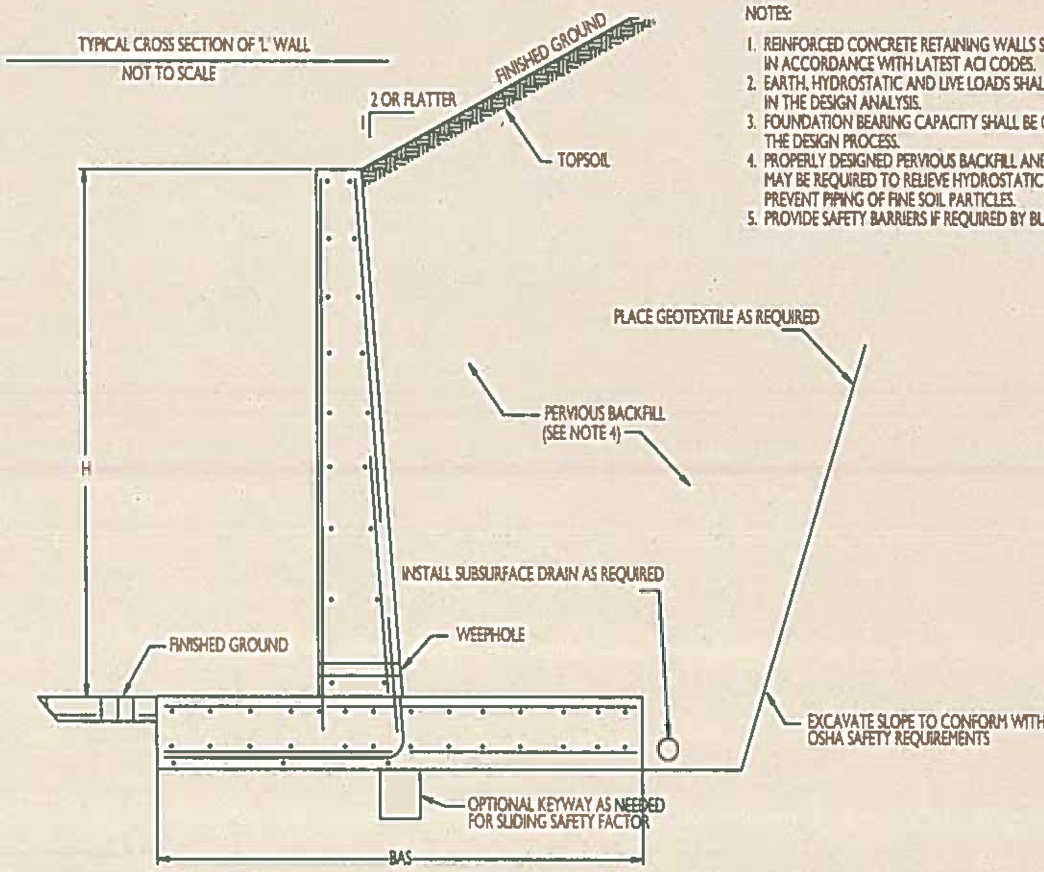
Additional Design Considerations for Retaining Walls Along Stream Banks.
Bottom scour: Control bottom scour in a channel before any retaining wall type of bank protection can be considered feasible. This is not necessary if the retaining wall can be safely and economically constructed to a depth below the anticipated lowest depth of bottom scour.

Starting and ending points: Start and end the retaining wall at a stabilized or controlled point on the stream.

Figure RW-1 Concrete Retaining Walls



TYPICAL CROSS SECTION OF 'L' WALL
NOT TO SCALE

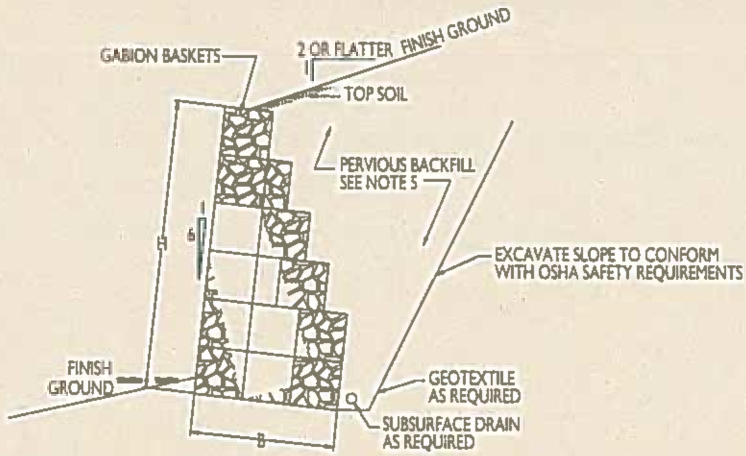


NOTES:

1. REINFORCED CONCRETE RETAINING WALLS SHALL BE DESIGNED IN ACCORDANCE WITH LATEST ACI CODES.
2. EARTH, HYDROSTATIC AND LIVE LOADS SHALL BE CONSIDERED IN THE DESIGN ANALYSIS.
3. FOUNDATION BEARING CAPACITY SHALL BE CONFIRMED IN THE DESIGN PROCESS.
4. PROPERLY DESIGNED PERVIOUS BACKFILL AND GEOTEXTILE MAY BE REQUIRED TO RELIEVE HYDROSTATIC PRESSURES AND PREVENT PIPING OF FINE SOIL PARTICLES.
5. PROVIDE SAFETY BARRIERS IF REQUIRED BY BUILDING CODE

Source: USDA-NRCS

Figure RW-3 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.

Source: USDA-NRCS

Figure RR-1 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 (150 mm) in size.

(B) No stone shall be larger than 30 inches (760 mm) in size, and at least 75% of the mass shall be stones at least 15 inches (380 mm) in size.

Intermediate Riprap: This material shall conform to the following gradation:

Stone Size (English) / (metric)	% of mass
18" or over / 460mm or over	0
10" or 18" / 255mm to 460mm	30-50
6" to 10" / 150mm to 255mm	30-50
4" to 6" / 100mm to 150mm	20-30
2" to 4" / 50mm to 100mm	10-20
less than 2" / less than 50mm	0-10

Modified Riprap: this material shall conform to the following gradation:

Stone Size (English) / (metric)	% of mass
10" or over / 255mm or over	0
6" to 10" / 150mm to 255mm	30-50
4" to 6" / 100mm to 150mm	30-50
2" to 4" / 50mm to 100mm	20-30
1" to 4" / 25mm to 50mm	10-20
less than 1" / less than 50mm	0-10

Source: Section M.02.06, State of Connecticut Department of Transportation, Standard Specifications for Roads and Bridges and incidental Construction. Forms 815, 1995.

Figure RR-2 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

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: *DOT Standard Specifications do not accept rounded stone or broken concrete for riprap.*

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.

Riprap for Channel Stabilization

Riprap for 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.

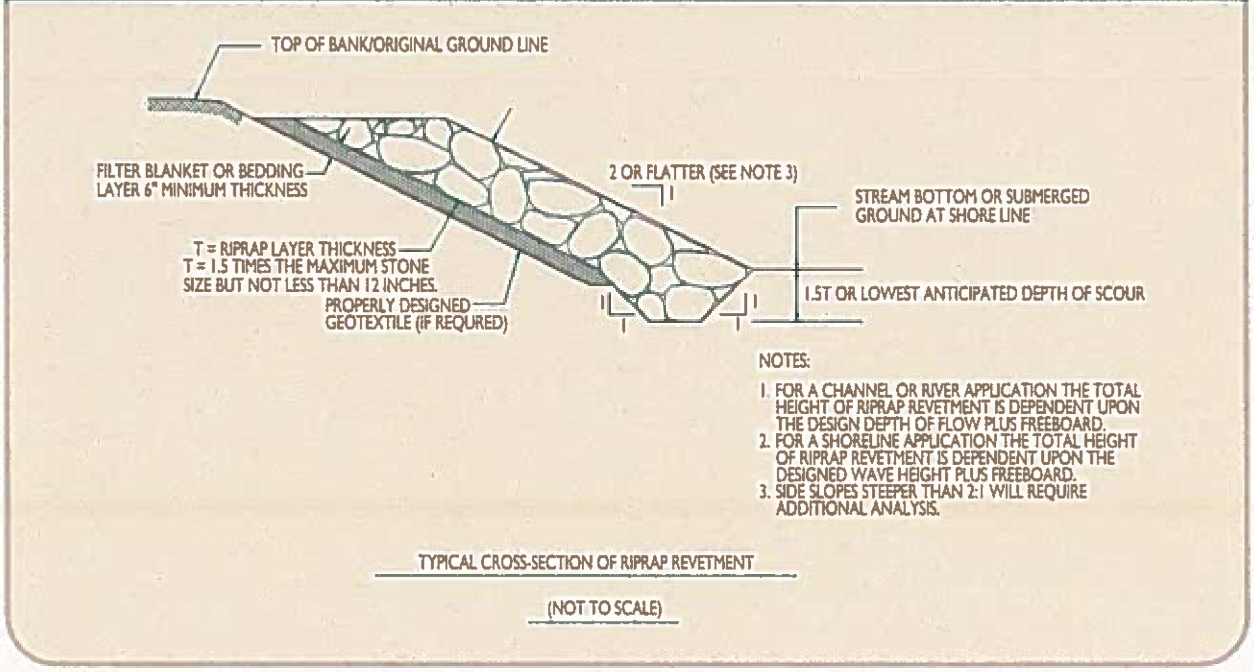
Riprap shall extend up the banks of the channel to a height equal to the design depth of flow or to a point where vegetation can be established to adequately protect the channel.

The riprap size to be used in a channel bend shall extend upstream from the point of curvature a minimum of 0.4 times the water surface width, and downstream 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 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 RR-4**).

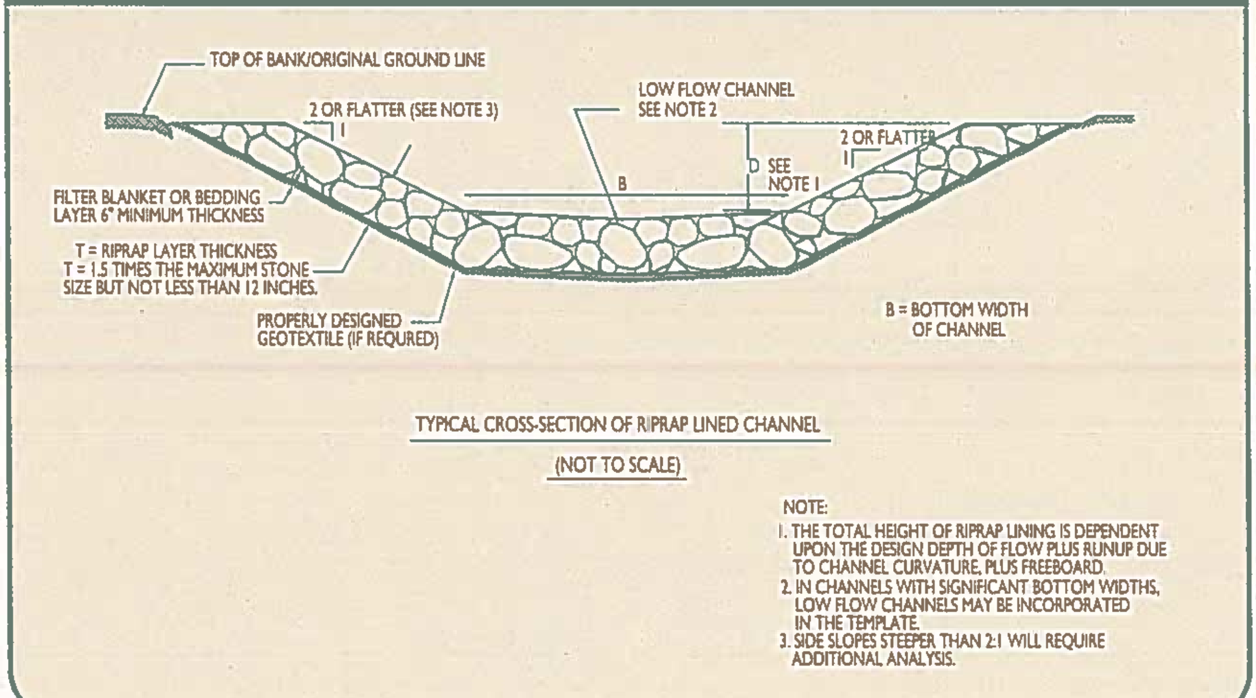
For riprapped and other lined channels, the height of channel lining above the design water surface shall be based on the size of the channel, the flow velocity, the curvature, inflows, wind action, flow regulation, etc. (see **Figure RR-5**).

Figure RR-4 Riprap for Channel and Shoreline Stabilization



Source: USDA-NRCS

Figure RR-5 Riprap for Armored Channel Stabilization



Source: USDA-NRCS

Gabions (G)

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 in channels, stream deflectors, grade control structures, revetments, retaining walls, abutments, stonecheck dams, and similar installations.

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. A pH below 5 for the soil and water may determine whether an additional protective coating is required for the wire.

Design Criteria

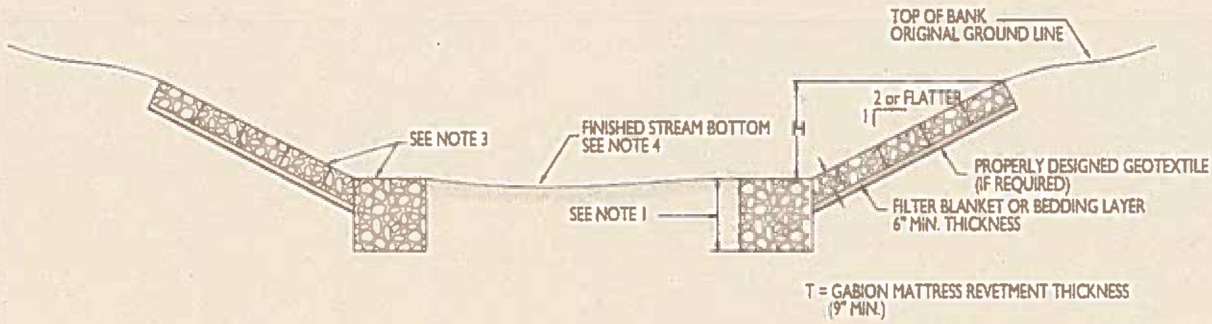
General
The design shall be in accordance with accepted engineering practices. Geotextiles and filter blankets used with the gabions shall be designed for specific soil conditions and rockfill sizes. See **Riprap** measure for geotextile, bedding and filter blanket requirements. **Figure G-1** and **Figure G-2** show the use of gabions for retaining walls and revetments, respectively.

Materials
Minimum material specifications shall meet the requirements of DOT 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 Construction Specification 64 entitled "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.

Installation Requirements
Installation shall be in accordance with either DOT 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.

Figure G-2 Gabion Revetment



TYPICAL CROSS SECTION

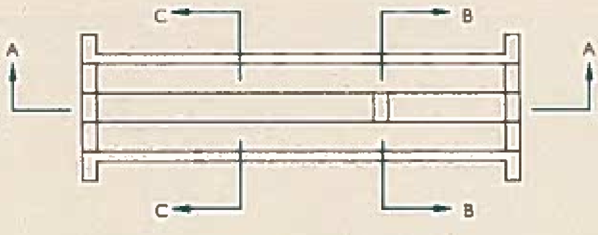
N.T.S

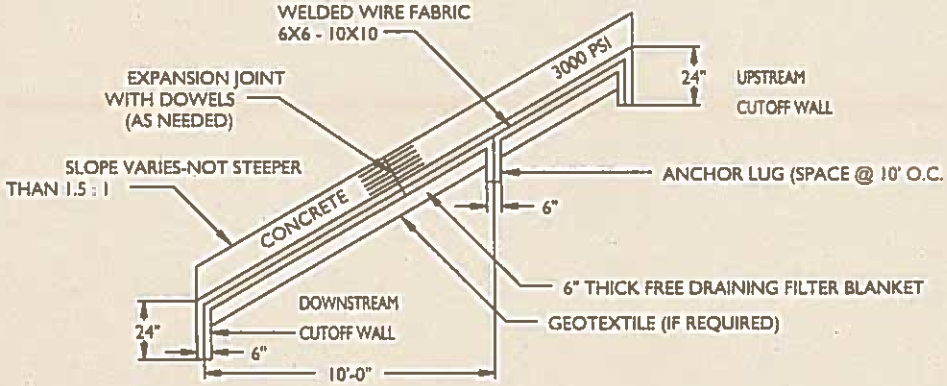
NOTES:

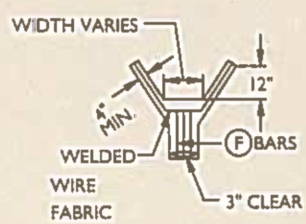
1. SIZE OF ANCHOR OR TOE BASKET TO BE DETERMINED ON A CASE-BY-CASE BASIS. THE BOTTOM OF THE BASKET SHALL BE AT LEAST THE DEPTH OF ANTICIPATED SCOUR.
2. THE TOTAL HEIGHT OF GABION REVETMENT IS DEPENDENT UPON THE DESIGN FLOW DEPTH PLUS FREEBOARD.
3. FACE OF ANCHOR BASKET AND LOWER REVETMENT BASKETS MAY REQUIRE GROUT OR GUNITE PROTECTION TO PREVENT ABRASION AND INCREASE GABION WIRE LONGEVITY.
4. STREAM BOTTOM MAY REQUIRE RIPRAP OR GABION MATTRESS FOR STABILITY.
5. WIRE BASKETS SHALL CONFORM WITH CT DOT SPECIFICATIONS SECTION 7.04 OR USDA SPECIFICATION 64.

Source: USDA-NRCS

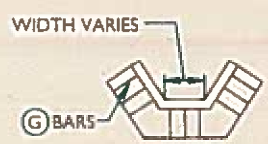
Figure PSD-1 Example of Permanent Slope Drain







*10' - 0" C-C MAXIMUM TYPICAL SPACING BETWEEN ANCHOR LUGS. WHERE CUTOFF WALL IS NOT REQUIRED, ANCHOR LUG SHALL BE A MAXIMUM OF 2' FROM END OF CHANNEL.



MARK	SIZE	LENGTH	SHAPE	SPACING
(F)	#4	1'-8"	STRAIGHT	6"
(G)	#4	1'-8"	STRAIGHT	6"
Dowel	#4	1'-6"	STRAIGHT	6"

Source: USDA-NRCS

Figure CSS-1 Example of Grade Stabilization Structure

Figure TC-1 Chute Size Determination

Group A			Group B		
Size	Bottom Width b (ft)	Maximum Drainage Area[1] (acres)	Size	Bottom Width b (ft)	Maximum Drainage Area[1] (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 Depth of Chute (d) = 8 inches Length of inlet & outlet section (L) = 6 feet			Height at entrance (h) = 2 feet Depth of Chute (d) = 10 inches Length of inlet & outlet section (L) = 10 feet		

[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.

Source: USDA-NRCS

(f) **Erosion control blankets and turf reinforcement mats**, when used, shall be designed in accordance with manufacture's recommendations.

Inlet Design

(a) 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 TC-2**).

(b) The lining of the side slopes at the chute entrance shall extend the distance H above the lining invert as shown in **Figure TC-2.**

(c) The entrance floor at the upper end of the chute shall have a minimum slope toward the outlet of 0.25 inch per foot.

(d) 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 TC-2**. 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

1. Install the chute on undisturbed soil, if possible, or if not possible, on well compacted fill.
2. Begin construction of the chute at its lower end. Compact or place the lining so that it is free of voids and reasonably smooth.
3. Construct the cutoff walls at the entrance and at the end of the discharge aprons so that they are continuous with the lining.
4. 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 with a rainfall amount of 0.5 inch or greater 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.

Temporary Pipe Slope Drain (TSD)

Definition
A flexible or rigid pipe used to conduct 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 conservation practices in an overall surface water disposal 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 TSD-2**) or rigid conduit (see **Figure TSD-3**) designed for the 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 TSD-3**).

The pipe slope drains shall be sized according to **Figure TSD-1** 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, hay bale check dams and geotextile silt fences are not appropriate.

Figure TSD-1 Size of Slope Drain

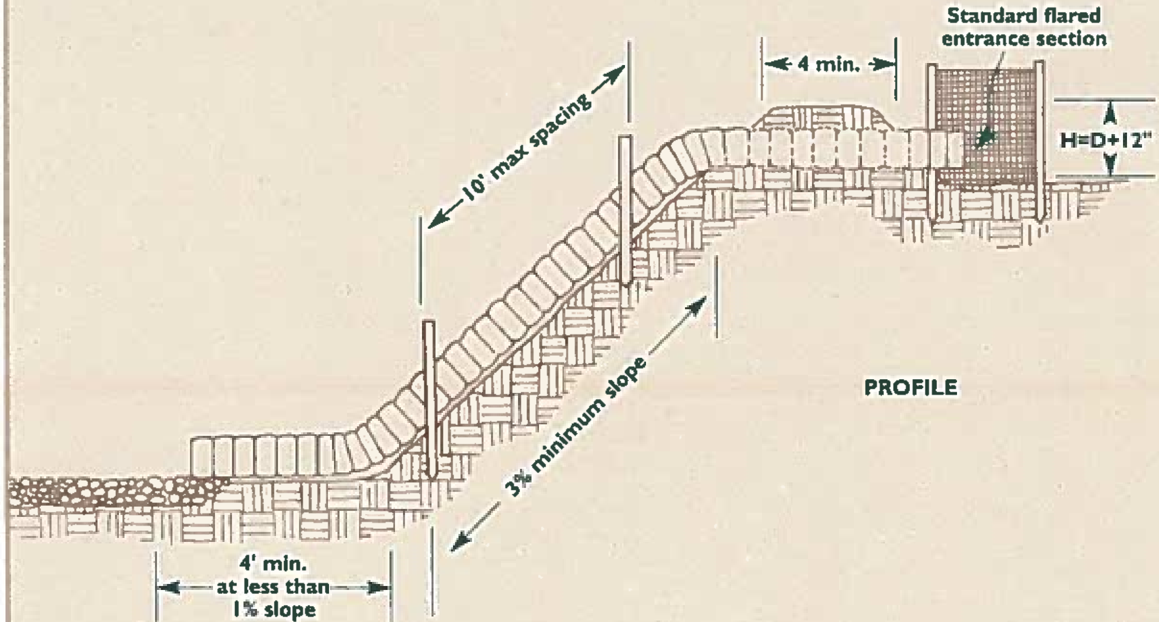
Maximum Drainage Area (Acres)	Pipe Diameter, D (in.)
0.5	12
2.5	18
5.0	24

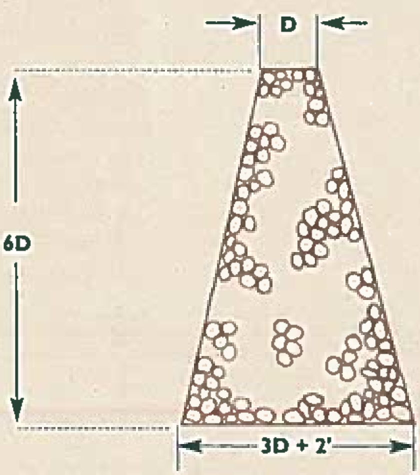
Source: USDA-NRCS

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 with a rainfall amount of 0.5 inch or greater 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.

Figure TSD-3 Example of Temporary Pipe Slope Drain





CONSTRUCTION SPECIFICATIONS

1. The pipe slope drain shall have a slope of 3% or steeper.
2. Top of the earth dike over the inlet pipe and all dikes carrying water to the pipe shall be at least 1 foot higher than the top of the pipe.
3. Add 0.3 foot to dike height for settlement.
4. Soil around and under the slope pipe shall be hand tempered in 4–inch lifts.
5. The pipe shall be plastic or corrugated metal pipe with watertight 12–inch wide connecting bands or flange connections.
6. Pipe anchors to be placed at 10–foot maximum spacing.
7. Riprap to be 6 inches in a layer at least 12 inches thickness and pressed into the soil.
8. Periodic inspection and required maintenance must be provided after each rain event.

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 Matting** for added protection.

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 that is based upon one developed by the Connecticut Department of Transportation in its Drainage Manual to determine the design standards 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 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 the construction of any measure within this group 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 and 162.500 MHz for northwestern CT) or from the Internet at http://www.nws.noaa.gov.

Vegetated Waterway (VW)

Definition
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.

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.

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), grade stabilization structures and other management practices (e.g. irrigation) to hasten the establishment of the grass cover.

Give consideration to 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 NRCS National Engineering Handbook - Part 650, DOT 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.

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 **Figure VW-1**. 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 **Figure VW-2.**

Dimensions
To select channel dimensions use **Figure VW-5** through **Figure VW-18**.

Base the dimensions of the waterway 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.

Figure VW-2 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	Vegetative Retardant Factors 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 or Poor Stand		
between 10" and 1"	D	E
between 24" and 2"	C	D
between 30" and 2"	B	D

Source: USDA-NRCS

Maintenance

Initial Establishment

Inspect the waterway 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 until vegetation becomes well established and the contributing areas are stabilized. Check for seed and mulch movement and/or rill erosion. Vegetated waterways shall be repaired immediately. For seeded and mulched channels, see **Permanent Seeding** measure Maintenance section for initial establishment and first mowing requirements. For sodded channels, see **Sodding** measure Maintenance section.

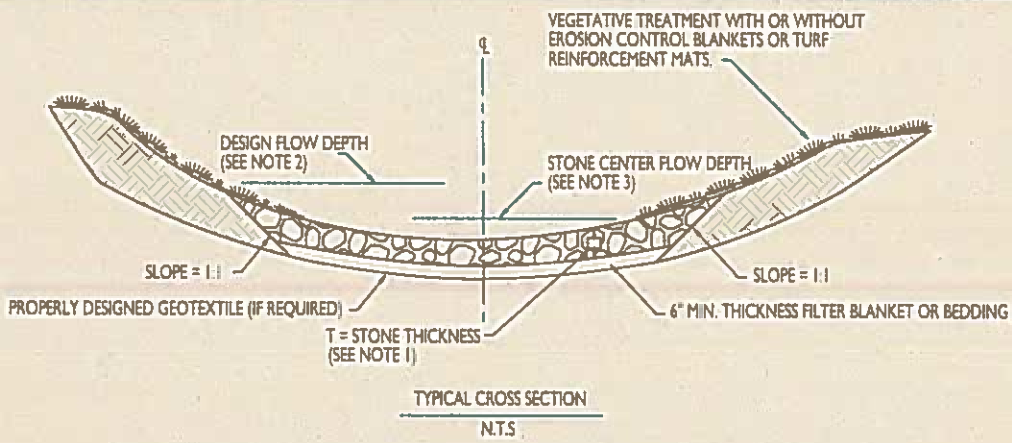
Long Term Maintenance

After the vegetation is established, periodically inspect the waterway to determine if the vegetation is withstanding flow velocities without damage. Repair damage immediately. If damage occurs repeatedly, consider other methods of waterway stabilization.

Mow vegetated waterways at least once a year and keep clear of debris and sediment. Do not allow brush and trees to grow in the flow path. Exclude vehicular traffic, except for maintenance or where adequate protection has been provided for crossing.

Maintain a vigorous sod by applying lime and a complete fertilizer as indicated by soil tests. Repair bare or eroded areas immediately, reseed and mulch.

Figure VW-3 Diagram of Vegetated Waterway with Stone Center



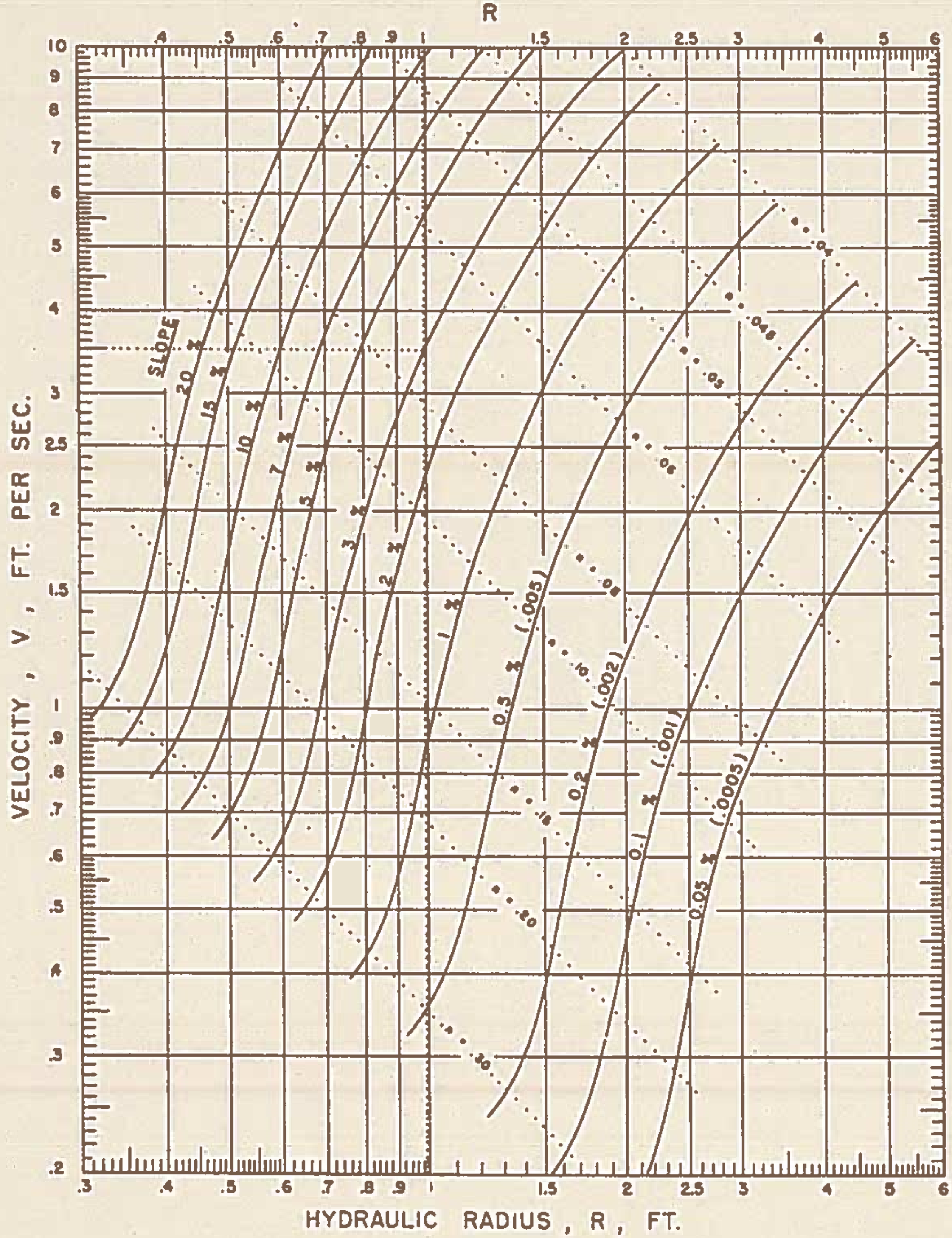
NOTES:

1. MINIMUM STONE LAYER THICKNESS = 1.5 TIMES D_{75} (FROM FIGURE VW-4) BUT NOT LESS THAN 12".
2. THE TOTAL WATERWAY DEPTH IS DEPENDENT UPON THE DESIGN DEPTH OF FLOW PLUS RUNUP DUE TO 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.

Source: USDA-NRCS

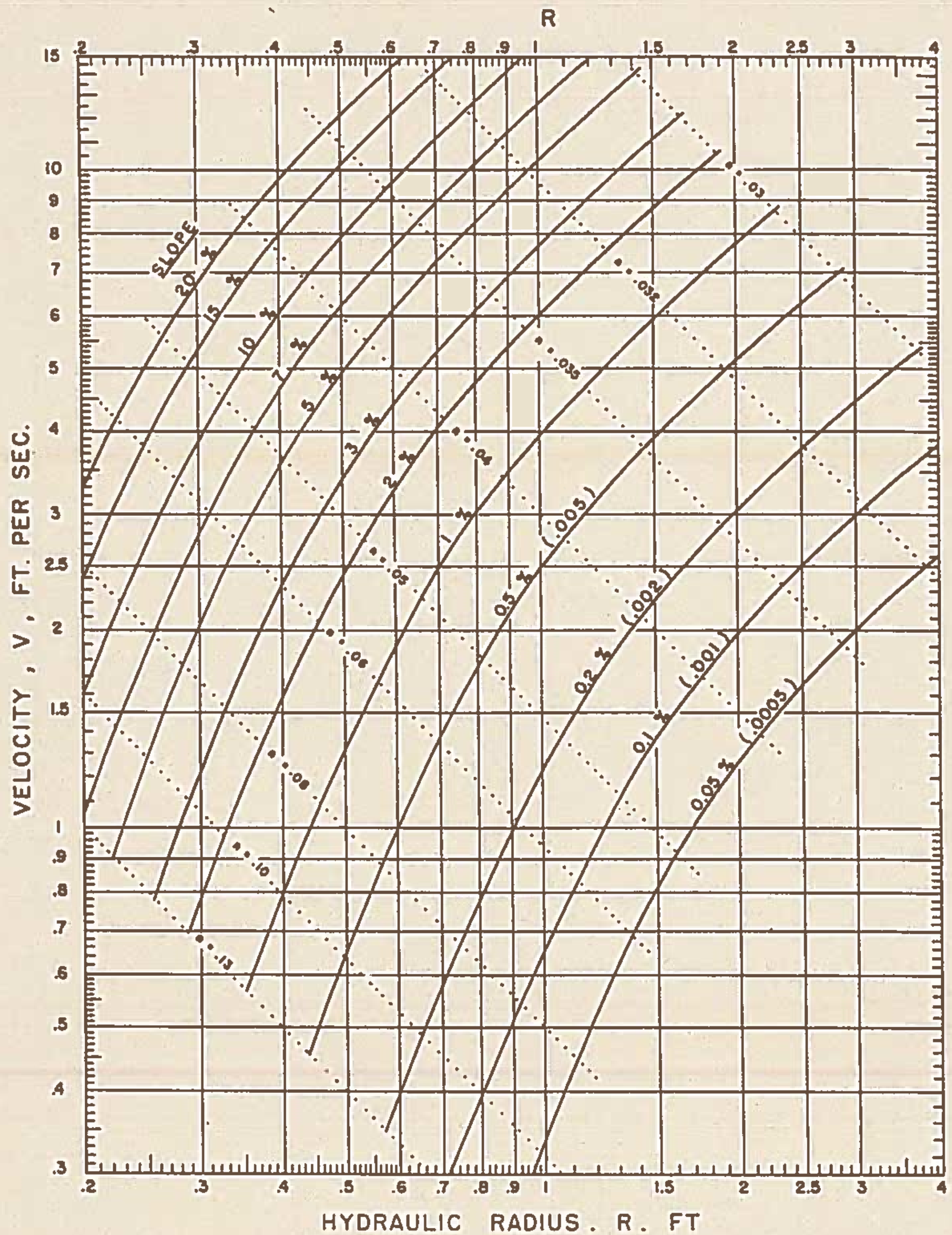
Vegetated Waterway (VW)

Figure VW-5 Solution of the Manning Formula for Retardant B (High Vegetative Retardant)



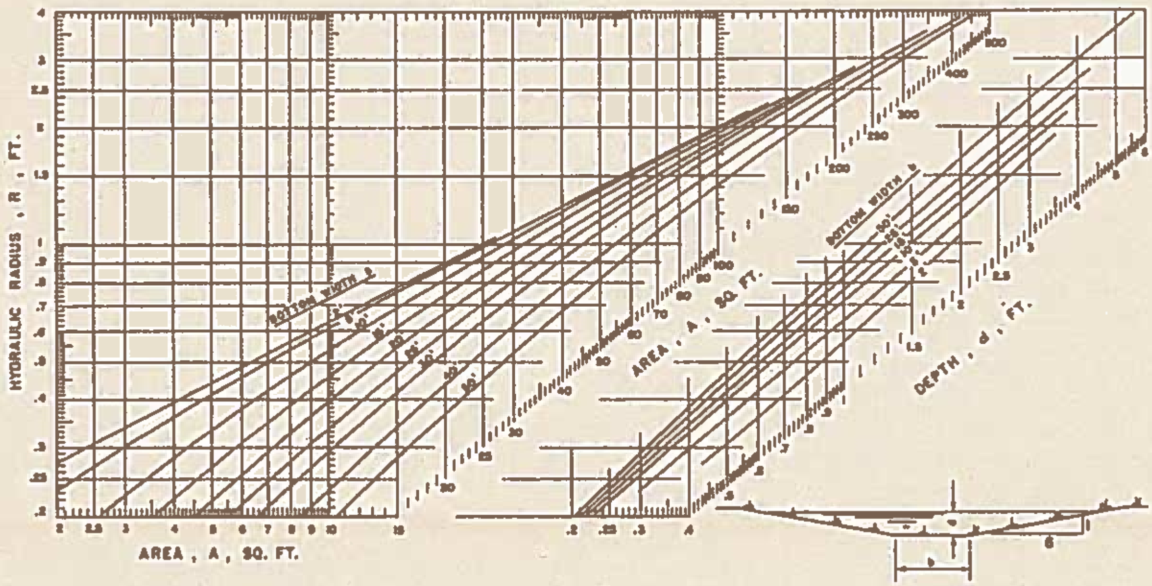
Source: USDA-NRCS

Figure VW-7 Solution of the Manning Formula for Retardant D (Low Vegetative Retardant)



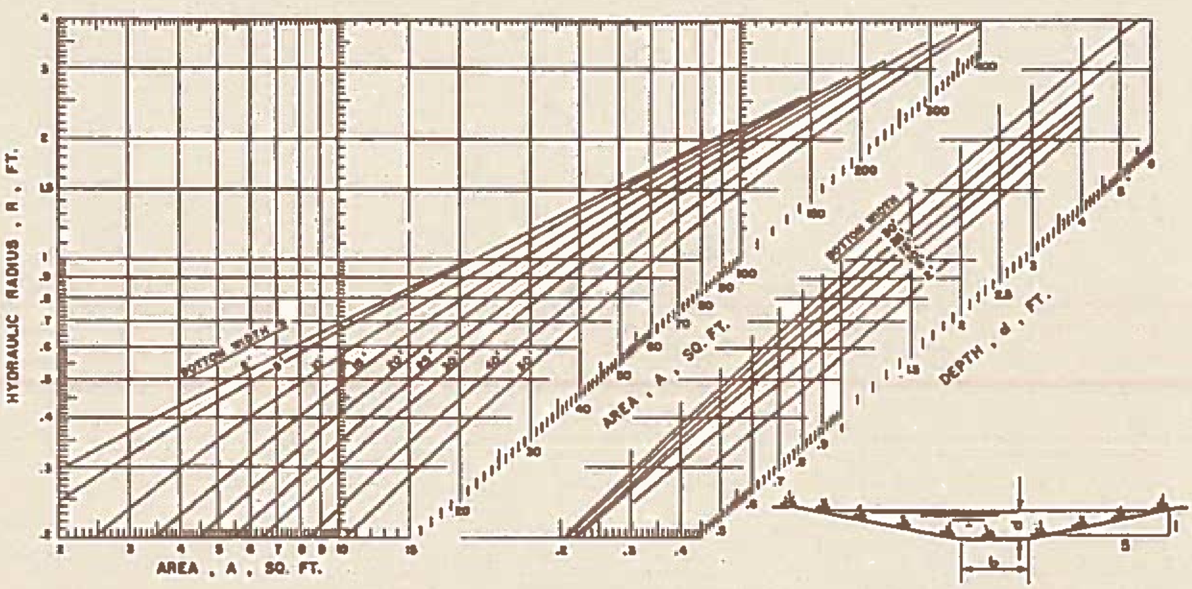
Source: USDA-NRCS

Figure VW-9 Dimensions of Trapezoidal Channels with 6 to 1 Side Slopes



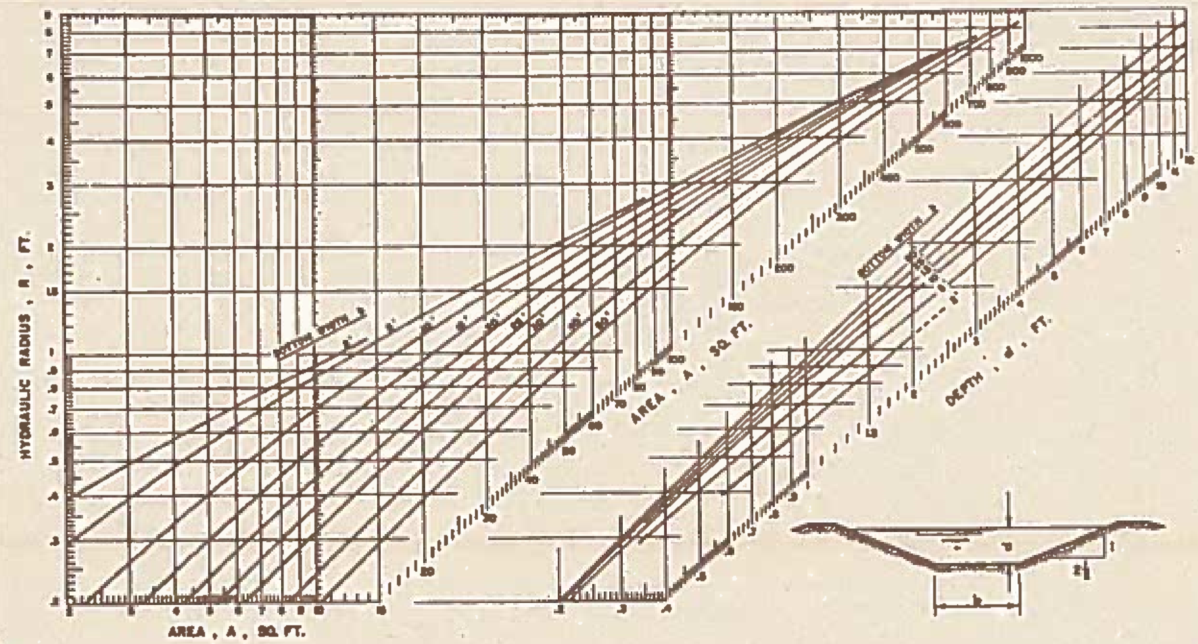
Source: USDA-NRCS

Figure VW-10 Dimensions of Trapezoidal Channels with 5 to 1 Side Slopes



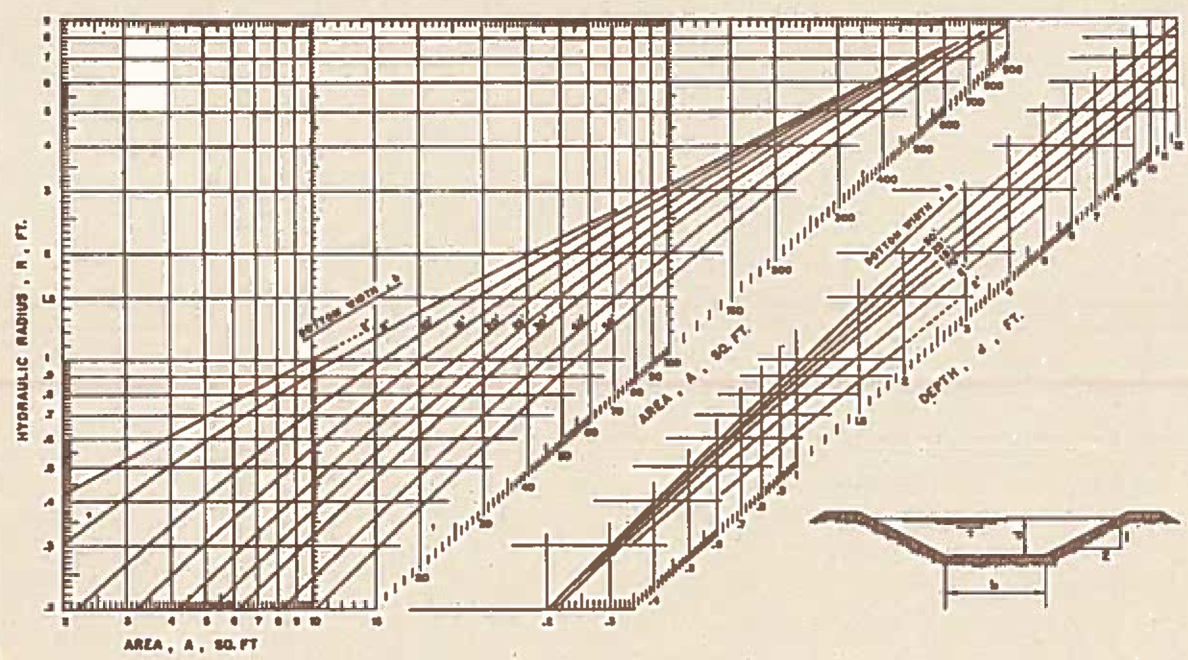
Source: USDA-NRCS

Figure VW-13 Dimensions of Trapezoidal Channels with 2-1/2 to 1 Side Slopes



Source: USDA-NRCS

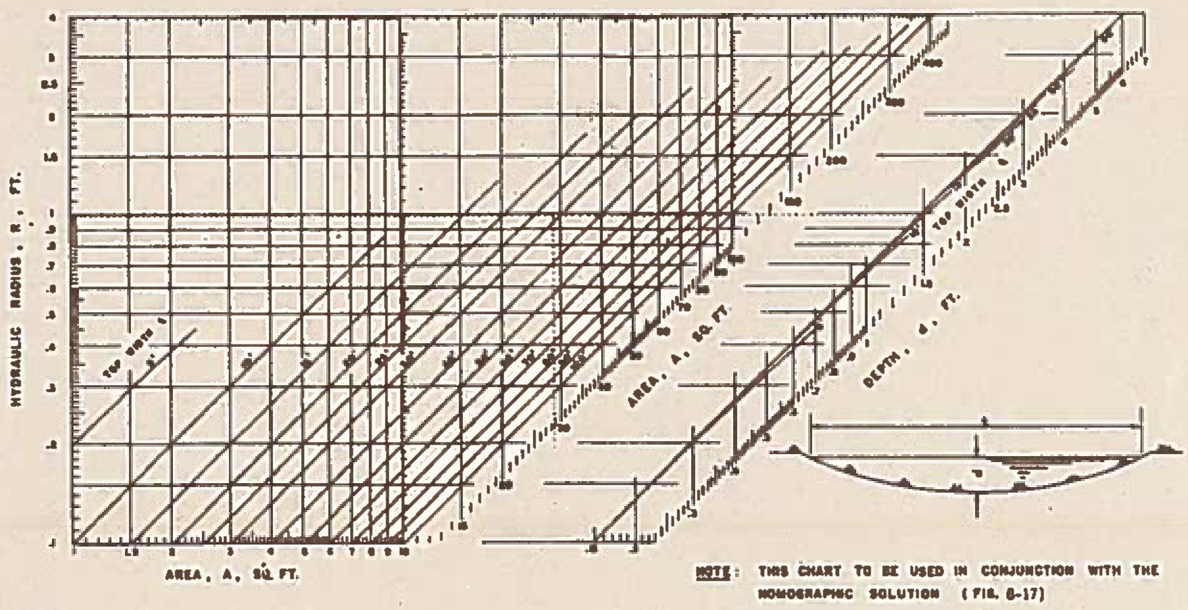
Figure VW-14 Dimensions of Trapezoidal Channels with 2 to 1 Side Slopes



Source: USDA-NRCS

Vegetated Waterway (VW)

Figure VW-17 Dimensions of Parabolic Channels



Source: USDA-NRCS

Vegetated Waterway (VW)

Temporary Lined Channel (TLC)

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 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 drainage way 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 and 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 Design Storm Using a Risk Assessment

The design storm is determined by using the procedures outlined in Appendix J, "Risk Assessment Adapted from CT DOT Drainage Manual." Using the form "Design Frequency Risk Analysis" 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 DEP, ponds

Permanent Lined Waterway (PW)

Definition

A permanent waterway, including chutes and flumes, with an erosion resistant lining composed of concrete, stone, 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 storm water 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 the velocity of concentrated runoff is of such magnitude that a lining is needed to prevent erosion of the channel.
- 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 the extra cost to contain design runoff in a limited space.
- In natural channels, waterways, drainageways, roadside ditches and other man-made channels that are modified or constructed and where vegetation alone will not prevent erosion.
- Major streams need full design considerations and calculations.

Planning Considerations

The installation of this measure should come only after the capacity and velocity have been determined by a detailed design. 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, riprap, concrete 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. Vegetated or riprap channels 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 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. If a concrete lining is chosen, the concrete must be placed on a firm, well drained foundation to prevent cracking or failure. A 6-inch gravel blanket is recommended under a concrete lining.

Plan on installing non-reinforced concrete or mortared flagstone linings only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

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.

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

Figure PW-2 Channel Lining Recommended Side Slopes	
Lining	Steepest Recommended Side Slope
Riprap	2 to 1
Non-Reinforced Concrete - Hand placed, formed concrete Height of lining 1.5 feet or less	vertical
Hand-placed, screened concrete or mortared in-place flagstone Height of lining less than 2 feet	1 to 1
Height of lining more than 2 feet	2 to 1
Reinforced slip form concrete - Height of lining less than 3 feet	1 to 1

Source: USDA-NRCS

Lining Thickness

Riprap - maximum stone size + thickness of filter or bedding (see **Figure PW-3**)

Concrete - 4 inches + 6 inches bedding.

Flagstone - 4 inches including mortar bed + 6 inches bedding

Figure PW-3 Riprap Lining Specifications

Riprap Specification	Maximum Stone Size	Minimum Thickness	Minimum Bedding Thickness
standard	30 inches	36 inches	12 inches
intermediate	18 inches	18 inches	6 inches
modified	10 inches	12 inches	6 inches

Source: DOT Standard Specifications Section M12.02 and DOT 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

If soil conditions dictate, 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 riprap and subsurface drain criteria. Subsurface weep holes shall be used with impervious linings.

Materials

Riprap and flagstone 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). Flagstone shall be flat for ease of placement, and have the strength to resist exposure and breaking.

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 entertainment. Cement used shall be Portland Types I, II, or if required Types IV or V. See **Figure PW-10** for example of a permanent concrete lined chute or flume.

Mortar used for mortared in place flagstone shall consist of a workable mix of cement, sand and water with a water-cement ratio of not more than six gallons of water per sack of cement.

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 concrete 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.

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 (Q_d) based on hydraulic computations. Use a 10-year frequency discharge.

2. Determine Maximum Permissible Velocity (V_{max}). See Figure PW-4.

3. Select channel shape and slope. (S_o).

4. Determine d_{max} for the selected lining and slope (use HEC-15 Maximum Permissible Depth (MPD) charts). Note: d_{max} does not apply to concrete lined channels.

5. Calculate area (A) and hydraulic radius (R) for the selected channel geometry and d_{max}

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 **Figure PW-7** for determining Manning's "n".

7. Calculate design velocity (Vd) from R and S_o using Manning's equation or nomographs widely available.

$$V = \frac{1.49}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} \qquad \text{(Manning's Equation)}$$

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 (Q_a) using the **Continuity Equation:**

$$Q_a = VA$$

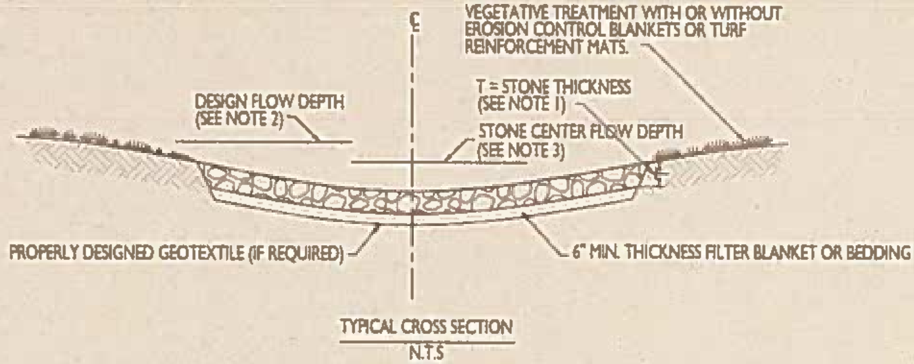
Where

Q_a = the allowable discharge
V = the average velocity in the channel (ft./sec.)
A = cross sectional area of flow

9. Check V_d against V_{max}. If $V_d > V_{max}$ select larger channel or use more stable lining.

10. Compare allowable discharge (Q_a) with design discharge (Q_d). If $Q_a >> Q_d$ the channel is over designed. If $Q_a < Q_d$ the channel is inadequate.

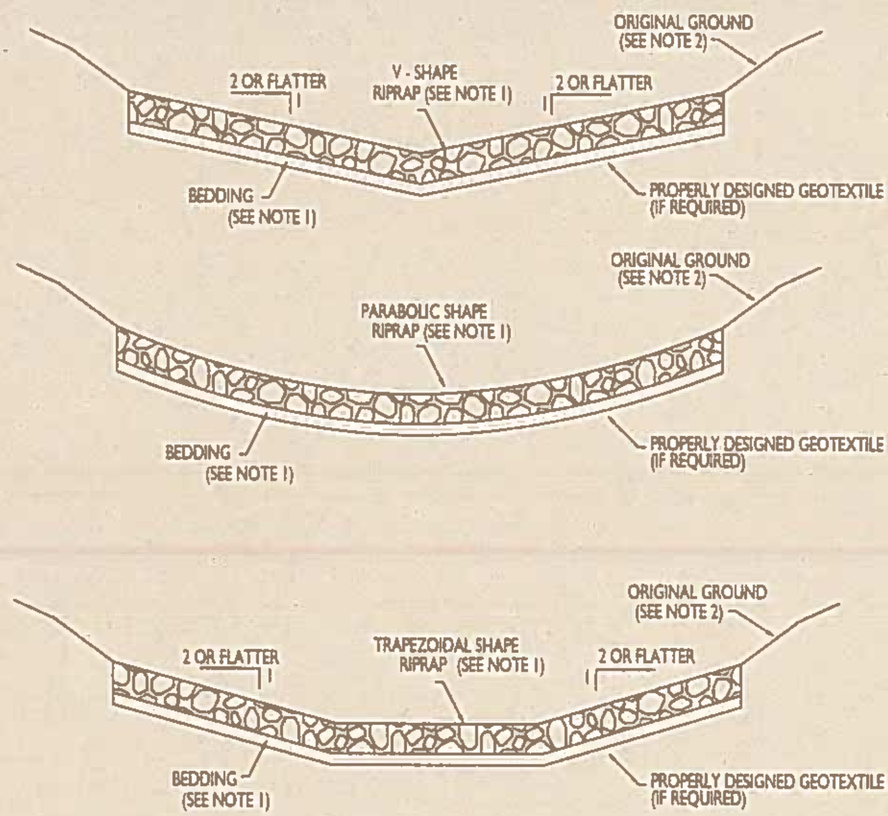
Figure PW-5 Waterways with Stone Centers



NOTES:
1. MINIMUM STONE LAYER THICKNESS = SEE FIGURE PW-3.
2. THE TOTAL WATERWAY DEPTH IS DEPENDENT UPON THE DESIGN DEPTH OF FLOW PLUS RUNUP DUE TO 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.

Source: USDA-NRCS

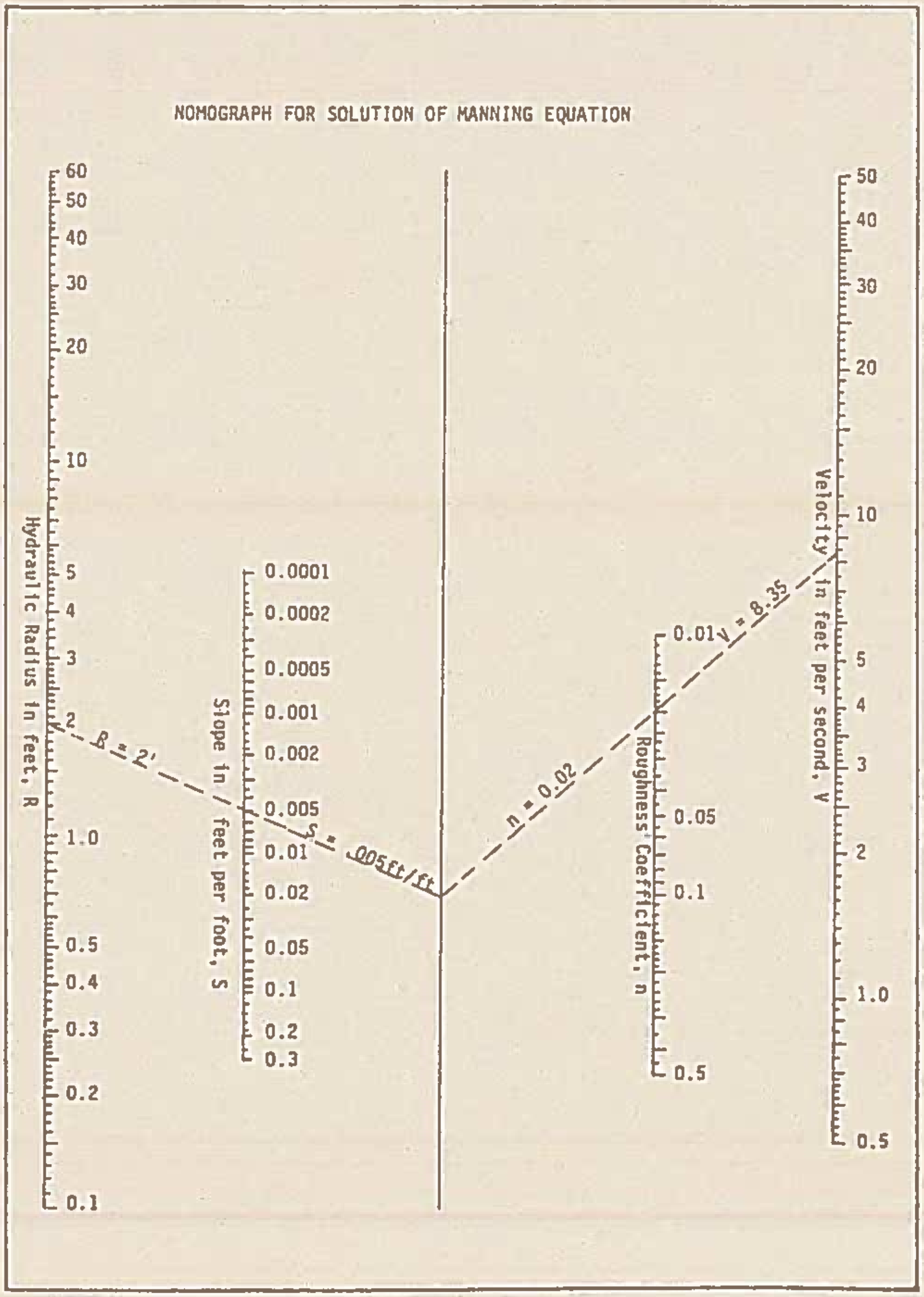
Figure PW-6 Typical Waterway Cross Sections



NOTES:
1. FOR MINIMUM RIPRAP AND BEDDING LAYER THICKNESS' SEE FIGURE PW-3.
2. VEGETATIVE TREATMENT WITH OR WITHOUT EROSION CONTROL BLANKETS OR TURF

Source: USDA-NRCS

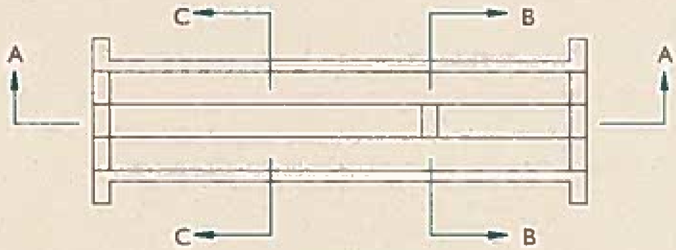
Figure PW-8 Nomograph for Solution of Manning Equation



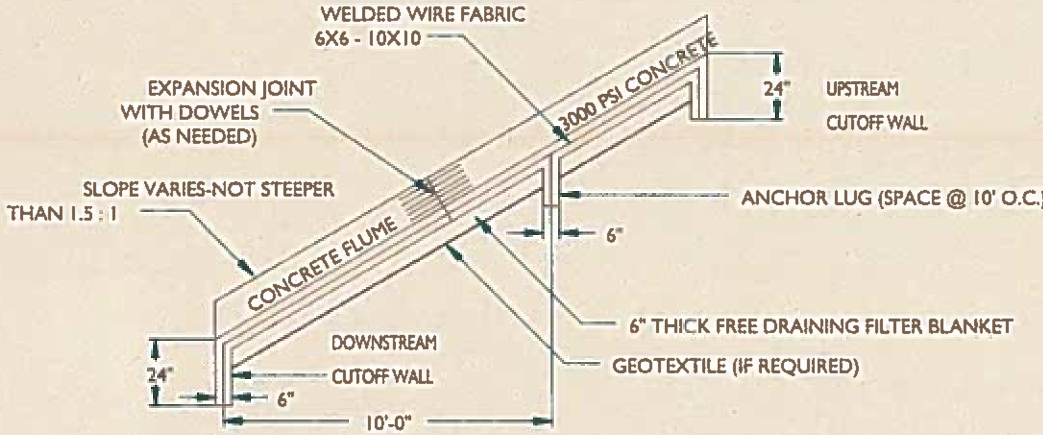
Source: Virginia Erosion and Seiment Control Handbook, 1992.

Permanent Lined Waterway (PW)

Figure PW-10 Example of Permanent Lined Chute or Flume

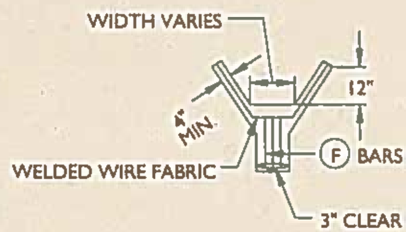


PLAN VIEW
N.T.S.



SECTION A-A
N.T.S.

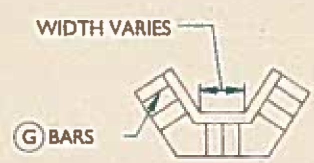
NOTE: ENERGY DISSIPATOR NEEDED AT OUTLET
(SEE OUTLET PROTECTION MEASURES)



*10' - 0" C-C MAXIMUM TYPICAL SPACING BETWEEN ANCHOR LUGS. WHERE CUTOFF WALL IS NOT REQUIRED, ANCHOR LUG SHALL BE A MAXIMUM OF 2' FROM END OF CHANNEL.

SECTION B-B
(THROUGH ANCHOR LUG)
N.T.S.

MARK	SIZE	LENGTH	SHAPE	SPACING
F	#4	1'-8"	STRAIGHT	6"
G	#4	1'-8"	STRAIGHT	6"
Dowel	#4	1'-6"	STRAIGHT	6"



SECTION C-C
(THROUGH CUTOFF WALL)
N.T.S.

Source: USDA-NRCS

"Design Frequency Risk Analysis" 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 water resources 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 DEP, 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. 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 measure in accordance with accepted engineering standards and practices. The installation of the temporary stream crossing shall not impact structures in close proximity to 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, prestressed concrete beams, metal beams, or other approved materials.

Temporary Culvert Crossing Criteria

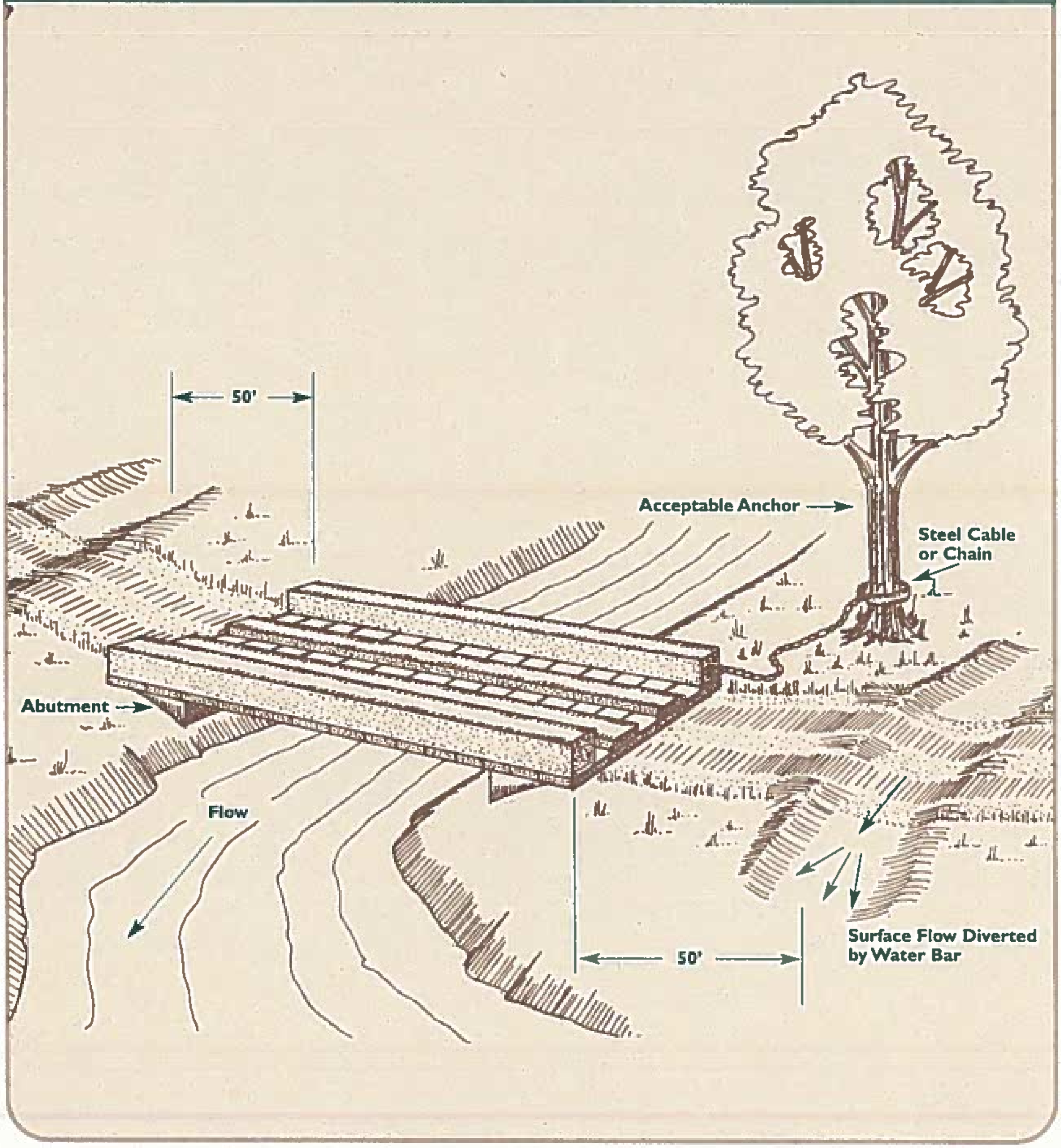
Culvert Size: Multiple culverts may be used in place of one large culvert if they have the equivalent capacity of the larger one. The minimum-sized culvert diameter that may be used is 18 inches.

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 **Construction 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.

Figure TSC-1 Temporary Bridge Crossing



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

Temporary Stream Crossing (TSC)

5-7 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 storm water 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.

continued on next page

Temporary Fill Berm (TFB)

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 or hay 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.

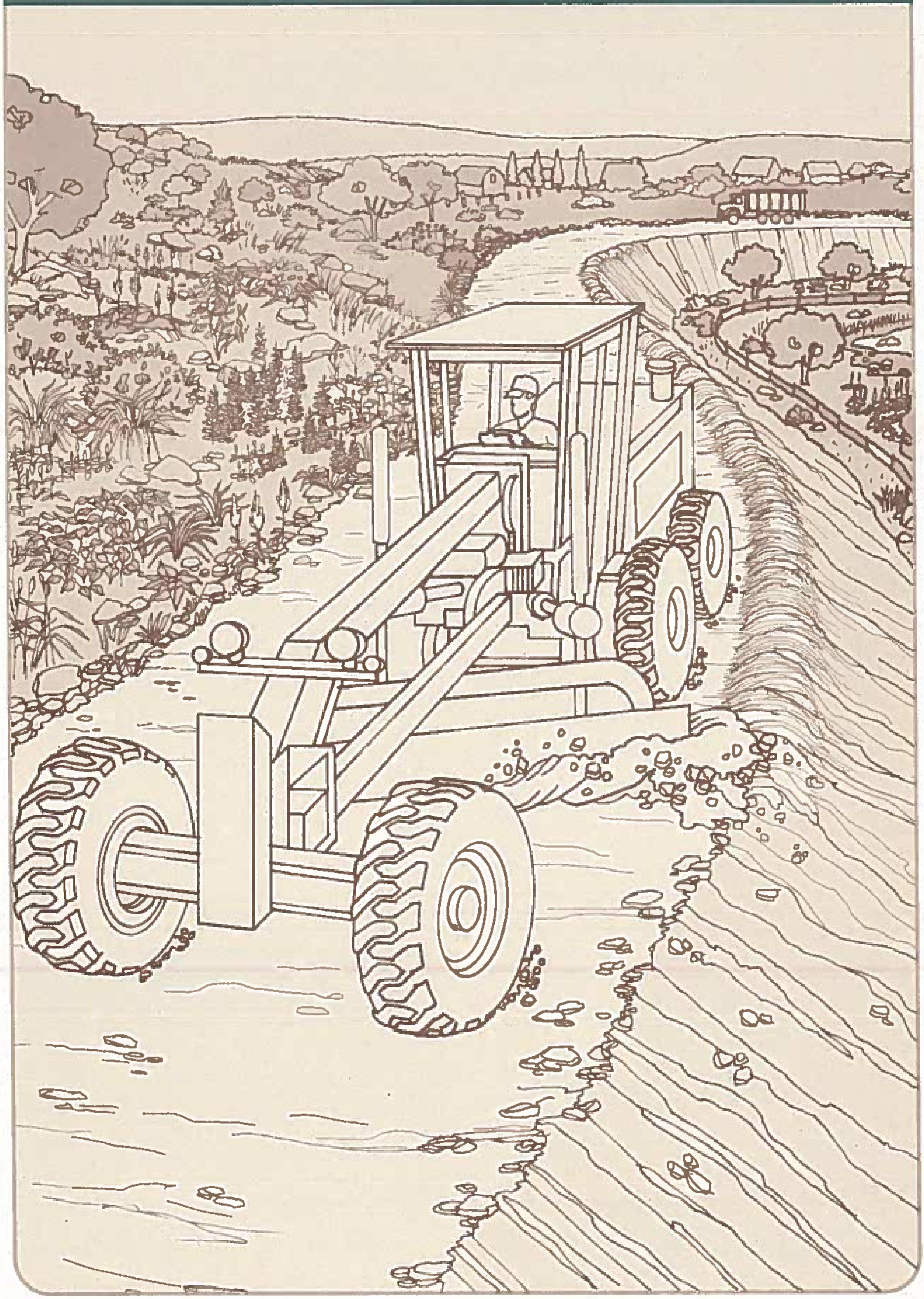
Specifications

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 up slope side of the berm slope is no steeper than 3:1, the down slope side of the berm slope is no steeper than 1:1, and the down slope 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%.*

Figure TFB-1 Illustration of Temporary Fill Berm



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 that the water bar is exposed to vehicular traffic and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater. 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.

Immediately reshape and repair any observed damage to the water bar.

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 Diversion (TD)

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 use is 1 year or less. For uses 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 assure 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 should be of a parabolic or trapezoidal shape to prevent a 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 or hay 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 storm as the design storm.

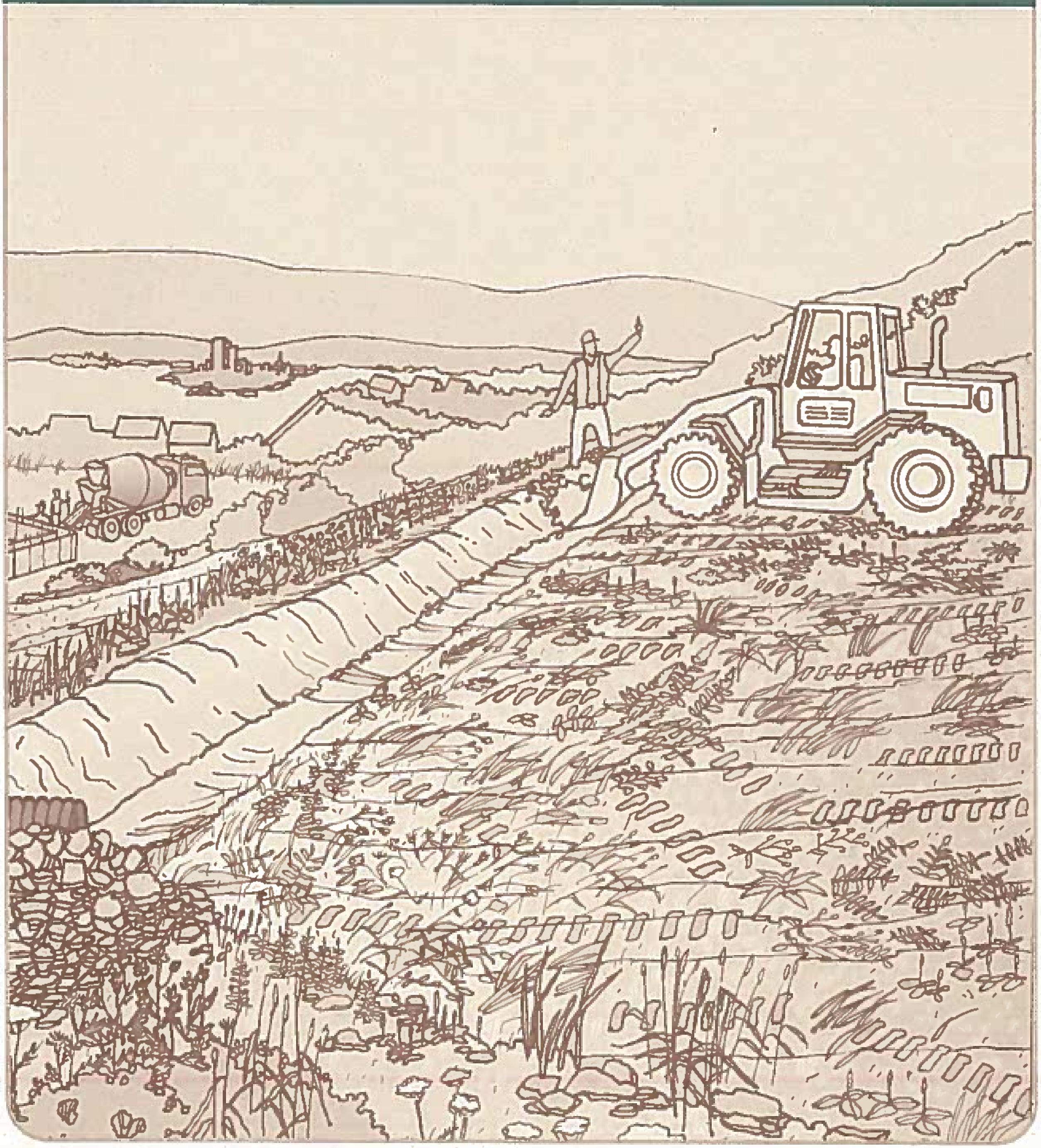
Specifications
For engineered temporary diversions, construct the temporary diversion in accordance with the design standards and specifications. For all non-engineered temporary diversions, comply with the following specifications.

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 stabi-

Figure TD-1 Requirements for Non-Engineered Temporary Diversions



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 PD-1**):

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.

Outlet
Provide the permanent diversion with a stable outlet which will reduce the energy of concentrated discharge so as not to cause downstream erosion.

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, 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.

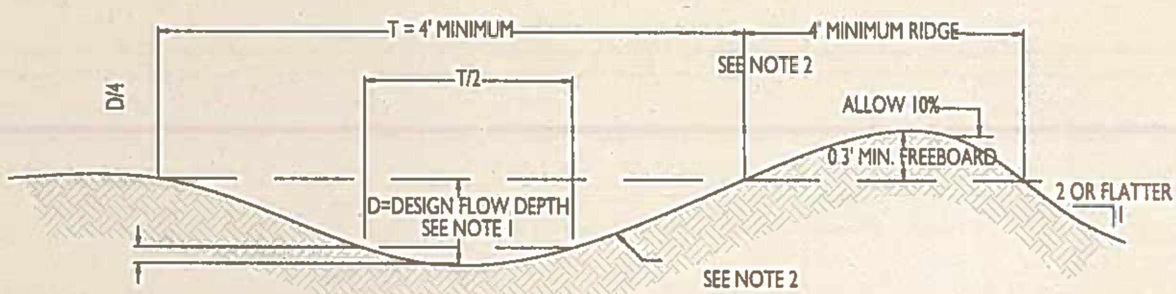
Install Sediment Controls for Contributing Areas
Install sediment controls to trap sediment before it enters the diversion. Field experience has demonstrated that many newly constructed vegetated channels become damaged from sediment deposition and require costly repairs as a result of improper up slope protection and control measures.

Maintenance
Inspect the permanent diversion 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 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 and debris from the channel.

Figure PD-1 Permanent Diversion



NOTES:
1. MINIMUM DESIGN CAPACITY SHALL CONVEY A 10 YR. - 24 HOUR PEAK FLOW WITHOUT EROSION.
2. INSTALL EROSION CONTROL BLANKETS OR TURF REINFORCEMENT MATS AS NEEDED FOR EROSION RESISTANCE.

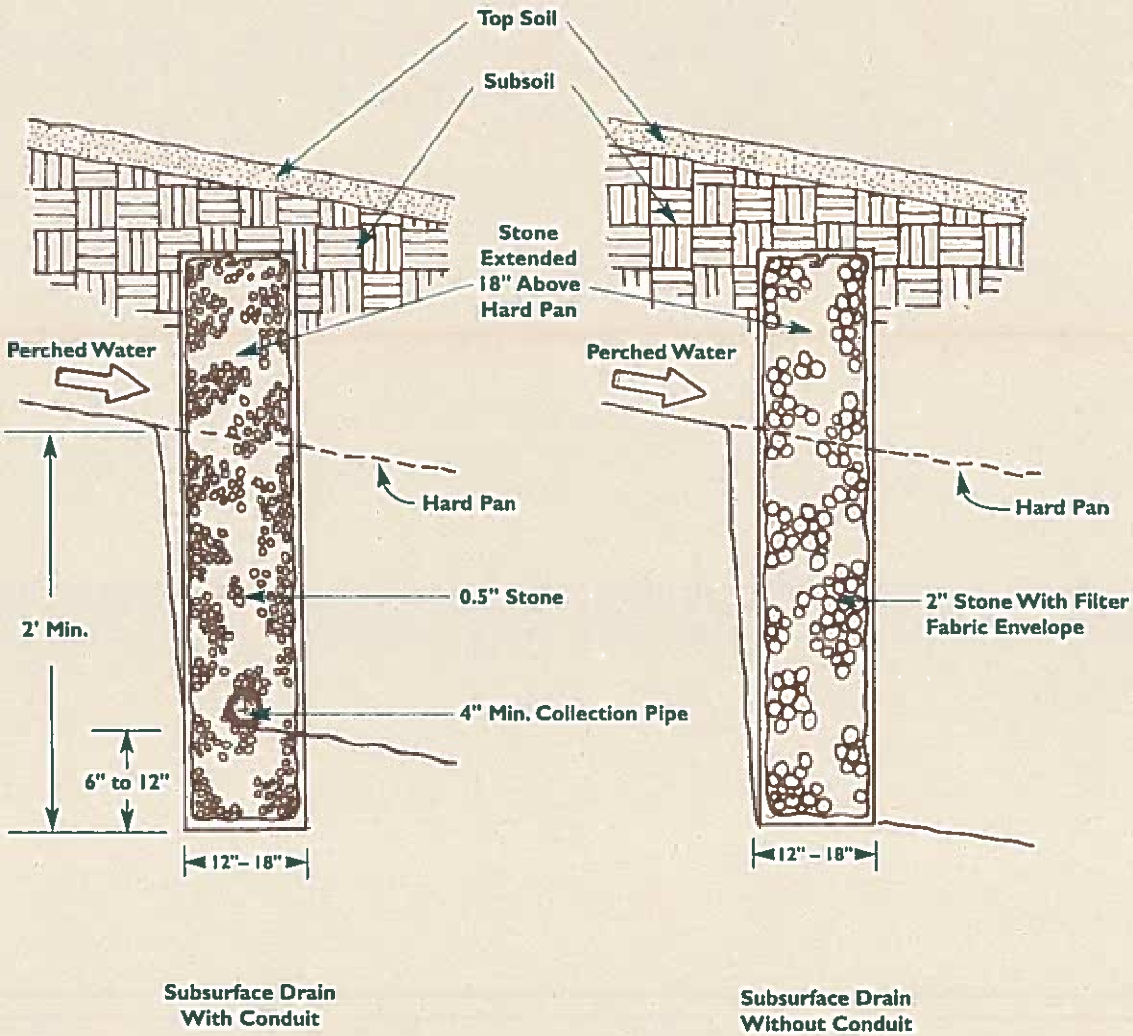
Source: USDA-NRCS

5-8 Subsurface Drains

Planning Considerations

The only measure included in this group is **Subsurface Drain**. See the measure for planning considerations.

Figure SD-1 Subsurface Drains With and Without a Conduit



Equation (SD-1) Manning's Formula

$$Q = VA = A\frac{1.49}{n}R^{\frac{2}{3}}S^{\frac{1}{2}}$$

Where Q = volume of flow
V = the average velocity in the drain (ft./sec.)
A = Cross-sectional area of the flow within the pipe
n = Manning's roughness coefficient, based upon the lining of the drain
(n=.011 for PVC pipe, n=.015 for corrugated plastic pipe, n=.025 for corrugated metal pipe)
R = the hydraulic radius (feet)
S = the slope of the drain (feet/foot)

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 **Figure SD-5**, 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 SD-7**, **Figure SD-8** and **Figure SD-9** for determining drain pipe diameters for various tile materials.

Figure SD-4 Inflow Rates

Soil Texture	Unified Soil Classification[1]	Inflow rate of 1,000 ft. of line in cfs[2]
Coarse Sand & Gravel	GP, GW, SP, SW	0.15 to 1.00
Sandy Loam	SM, SC, GM, GC	0.07 to 0.25
Silt Loam	CL, ML	0.04 to 0.10
Clay and Clay Loam	CL, CH, MH	0.02 to 0.20

[1] Obtain Unified Soil Classification from the County Soil Survey or perform laboratory analysis.
[2] 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%.

Source: USDA-NRCS

Figure SD-5 Design of Random or Interceptor Drains

Minimum Grade of Drain (%)	Maximum Length (feet) 4" Drain	Maximum Length (feet) 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'
5.0	2000'	5800'

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 SD-10**, **Figure SD-11** and **Figure SD- 12**.

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 ultra violet light, fire, weathering and vandals shall be used.

Exposed PVC outlets shall be protected against damage by the use of 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 drain 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 acceptable alternative.

Prefabricated Curtain Drains

Several types of prefabricated curtain drains have been recently developed. Materials shall be selected as appropriate for the specific site conditions in accordance with manufacturer's recommendations.

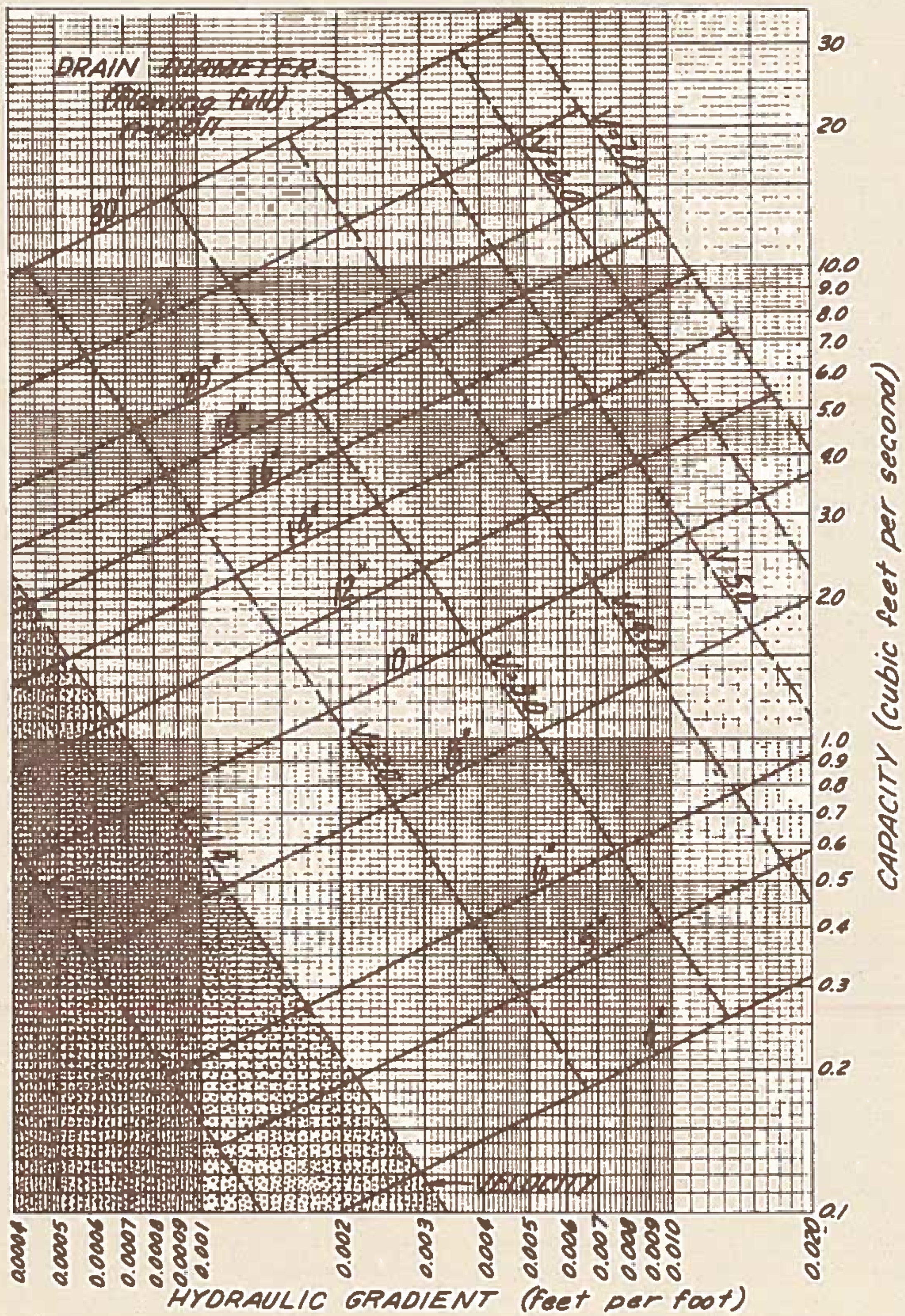
Installation Requirements

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. Place backfill material in the trench in such a manner that the drain pipe 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

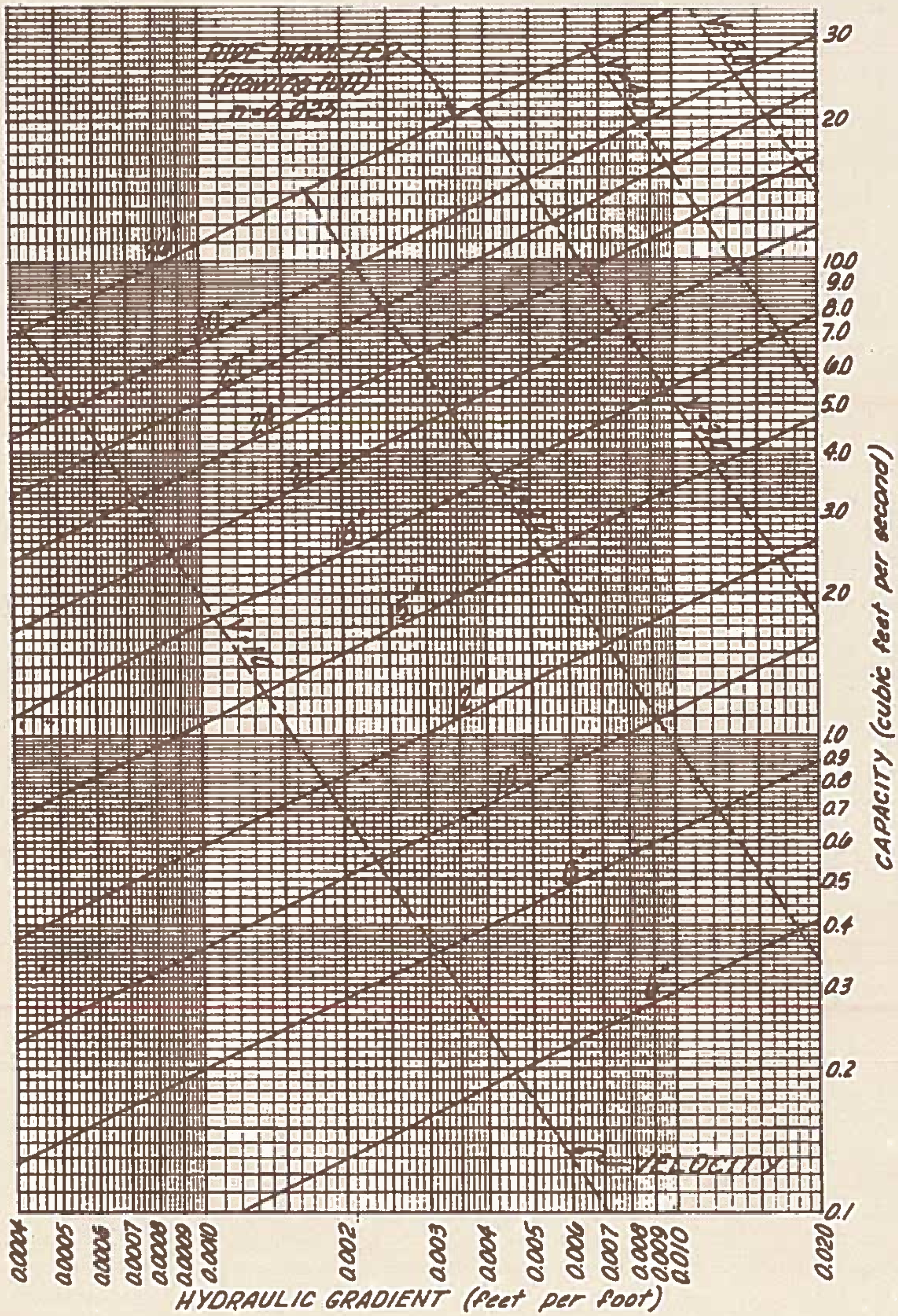
Inspect the outlets to subsurface drains annually to ensure that they are free-flowing, not clogged with sediment and the animal guards are in place. Keep the outlet clean and free of debris. Keep any surface inlets open and free of sediment and other debris. Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees.

Figure SD-7 Drainage Capacity Chart for Smooth Plastic, Clay, or Concrete Tile (n=0.015)



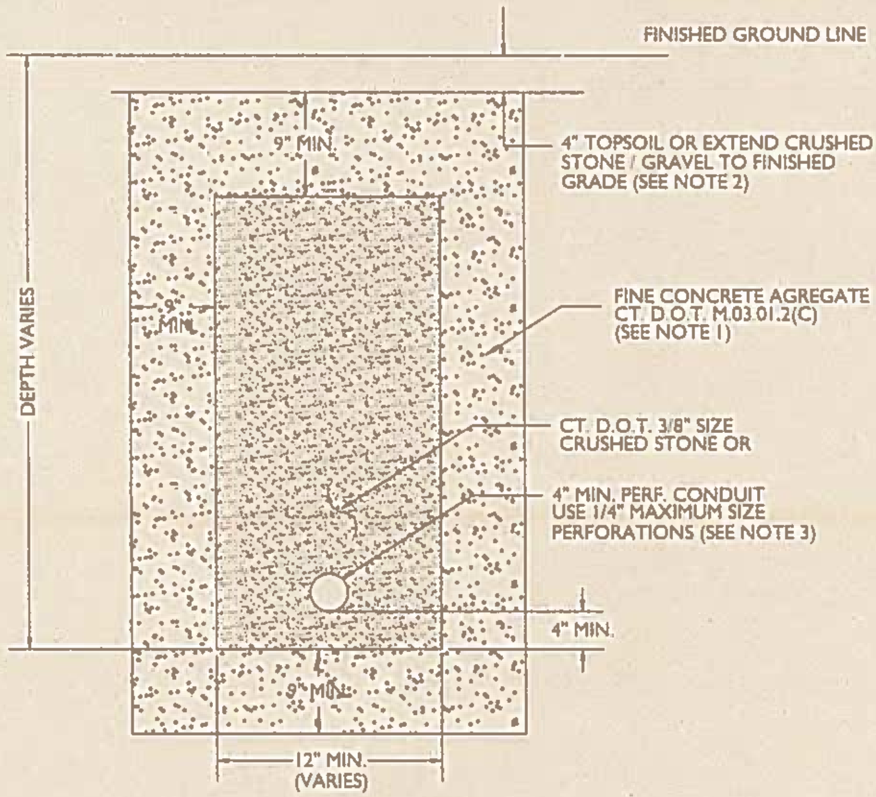
Source: USDA-NRCS

Figure SD-9 Drainage Capacity Chart for Corrugated Metal Pipe (n=0.25)



Source: USDA-NRCS

Figure SD-11 Typical Section of Two-Zone Subsurface Drain
(Soils with Intermediate to High Piping Potential)



TYPICAL SECTION
(NOT TO SCALE)

NOTES:

1. FINE CONCRETE AGGREGATE IS USED TO PREVENT PIPING OF ADJACENT SOILS INTO THE COARSE AGGREGATE.
2. IF SURFACE WATER IS TO BE INTERCEPTED, EXTEND FINE AGGREGATE TO THE GROUND SURFACE.
3. CONDUIT MAY BE HEAVY DUTY PERFORATED HIGH DENSITY POLYETHYLENE OR SPECIALLY DRILLED P.V.C.

Source: USDA-NRCS

5-9 Detention Structures

Planning Considerations

The only measure included in this group is **Detention Basin**. See the measure for planning considerations.

9-Detention Structures

Detention Basin (DB)

Definition

An impoundment made by constructing a dam or an embankment (embankment detention basin), or by excavating a pit or dugout (excavated detention basin). Basins resulting from both excavation and embankment construction are classified as embankment detention basins where the depth of water impounded against the embankment at emergency spillway elevation is three feet or more.

Purpose

- To regulate the rate and amount of runoff from development sites during and after construction operations.
- To minimize the effects of downstream erosion and flooding.

Applicability

Where there is a need to control or prevent downstream erosion and flooding due to site development or from other land use changes.

Planning Considerations

Increased downstream erosion, sedimentation and flooding may be caused by increased runoff volume, increased peak discharge, reduced time of concentration, or reduced natural storage.

To minimize design and regulatory approval costs, design detention basins to avoid inland wetlands and watercourses and so that they are not subject to water diversion or dam safety regulation. A local or state inland wetlands permit will be required if a detention basin is proposed in a wetland area.

A state water diversion permit from the DEP's Inland Water Resources Division will be required if the contributing drainage area to the detention basin is greater than 100 acres. If the contributing drainage is less than 100 acres and no inland wetlands or watercourses are involved, then a diversion permit will not be required. However, if wetlands or watercourses are involved, a diversion permit may be required and a permit need determination should be sought from the DEP.

The DEP also regulates all dam construction within the state. Contact DEP Inland Water Resources Division early in the planning process to determine the need for a dam construction permit. Try to keep the effective height of the dam less than 15 feet and the product of the storage volume in acre-feet times the effective height of the dam less than 3,000 (see design criteria below). If these limitations are exceeded the design criteria for the embankments of the detention basin are raised to a higher standard.

Carefully consider the visual design of detention basins in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of basins, excavated material and plantings are to relate visually to their surroundings and to their function. See **Figure DB-1** for a schematic of a detention basin.

In planning the detention basin consider safety features to protect the public. Design and locate any safety features so as not to interfere with the hydraulic operation of the structure.

For projects which include a temporary sediment basin, it is sometimes advantageous to locate the temporary sediment basin at the site of the detention basin. Sharing the same location may minimize site disturbance and cost. When this approach is used, the size requirements of both the detention and sediment basins must be determined and the larger of the two must be in place during the construction period. After construction, the minimum size shall be that of the detention basin. The construction should be phased so increases in runoff are controlled during the development of the project. One approach would be to construct the detention basin along with its berm and outlet works first, and expand the storage volume, if need be, to that required for the sediment basin.

The permanent outlet works may have to be temporarily modified during the construction period to provide the necessary wet and dry storage requirements for the temporary sediment basin and enhance the basin's ability to remove sediment. Upon stabilization of the contributing watershed, accumulated sediment is removed from the basin and any work, such as modifying the outlet works or installing permanent plantings, is done to complete the permanent detention basin.

considered before the design process begins and should be determined by the completion of the local regulatory processes. The owner may be a homeowner, a homeowners association or a municipality.

Design Criteria[1]

Overall

Design the detention basin to be compatible with the floodplain management and stormwater management programs of the local jurisdiction and with local regulations for controlling sediment, erosion and runoff. The basin shall properly regulate storm discharges from the site to a safe, adequate outlet. Consider the duration of flow as well as the peak discharge. Provide adequate erosion control measures and other water-quality practices. Plan and design the basin to ensure minimal impact on visual quality and human enjoyment of the landscape. Blend structures and materials aesthetically with their surroundings.

Attempt to locate detention basins where:

- *Failure of the detention basin would not, within reasonable expectations, result in loss of life, damage all-weather 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 Department of Environmental Protection under the CGS §§22a-401 through 22a-411.*

- *the effective height of the dam for an embankment detention 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.*

- *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.*

Detention basins that exceed any one of the above conditions shall be designed to meet the criteria in Earth Dams and Reservoirs, Technical Release 60 (TR-60) by the USDA Soil Conservation Service (NRCS).

Design Storms

If the primary purpose of the detention basin is to minimize downstream erosion and subsequent sedimentation, the peak discharge from the 2-year, 10-year and 25-year storm frequency, 24-hour duration, Type III distribution storms shall be analyzed.

If the primary purpose of the detention basin is to minimize flooding, the peak discharge from the 2-year, 10-year, and 100-year frequency, 24-hour duration, Type III distribution storms shall be analyzed.

No increase in peak flow from the 2-year, 10-year and 25-year storms shall be allowed unless downstream increases are compatible with an overall floodplain management system. Check local requirements for additional criteria that may include larger storms. Some of the items to consider in determining if increased peak flows are compatible with an overall floodplain management system are:

- *the timing of peak flows from sub-watersheds;*
- *the increased duration of high flow rates;*
- *the stability of the downstream channels; and*
- *the distance downstream that the peak discharges are increased.*

See **Figure DB-6** and **Figure DB-7** for structure routing graphs.

Spillway Design

The outlets for the basin shall consist of a combination of an outlet control structure (sometimes referred to as a principal spillway) and an emergency spillway. These outlets shall pass the peak runoff from the contributing drainage area for the design flood. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the outlet control structure shall pass the entire routed peak runoff expected from the design storm. **However, an attempt to provide a separate emergency spillway shall always be made. An emergency spillway shall be provided on all detention basins with a contributing drainage area equal to or exceeding 20 acres. (Refer to Emergency Spillway subsection found on Page DB-15).** 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 manuals and procedures for calculations of the peak rate of runoff. Notably, the flow through any dewatering orifice or pipe shall not be utilized when calculating the design elevations because of its potential to become clogged; therefore, available spillway storage shall begin at the first stage of the outlet control structure.

Outlet Control Structure

A structural spillway may be installed which combines the outflow requirements of a principal (primary) spillway and emergency (secondary) spillway. Another type of outlet control structure may consist of a riser pipe and barrel that controls the elevation of the water and the rate of discharge for the detention basin. The barrel and riser shall be hydraulically sized such that full pipe (barrel) flow is achieved when the water level is at or below the crest of the emergency spillway. For many applications outlet control structures consist of a vertical pipe or box of corrugated metal, plastic or reinforced concrete, with a minimum diameter of 15 inches, joined by a water

[1] For structures which are regulated under CGS §22a-401, the design criteria may be more stringent than that found in the **Detention Basin DesignCriteria.**

Detention Basin Trash Rack: Design Example 2

Example #2 below calculates the minimum area on a box-shaped trash rack on the high stage outlet (see **Figure DB-3**) where the design flow (Q) for this outlet is 75.0 cfs, the acceptable velocity is set at 2 fps, and the trash rack bars obstruct 25% of the trash rack opening area. Given that the bars obstruct 25% of cross-sectional opening area, increase the opening area as follows:

$$A_{required} = \frac{Q}{V} = \frac{75 \text{ cfs}}{2 \text{ fps}} = 37.5 \text{ ft}^2$$

and

$$A_{adjusted} = A_{required} \left(\frac{1}{1 - 0.25}\right) = \frac{37.5}{0.75} = 50.0 \text{ ft}^2$$

Adjusted required opening area is 50.0 ft.^{2}.

Use the following formula to check the total available area of the trash rack using the suggested design dimension given in **Figure DB-3**.

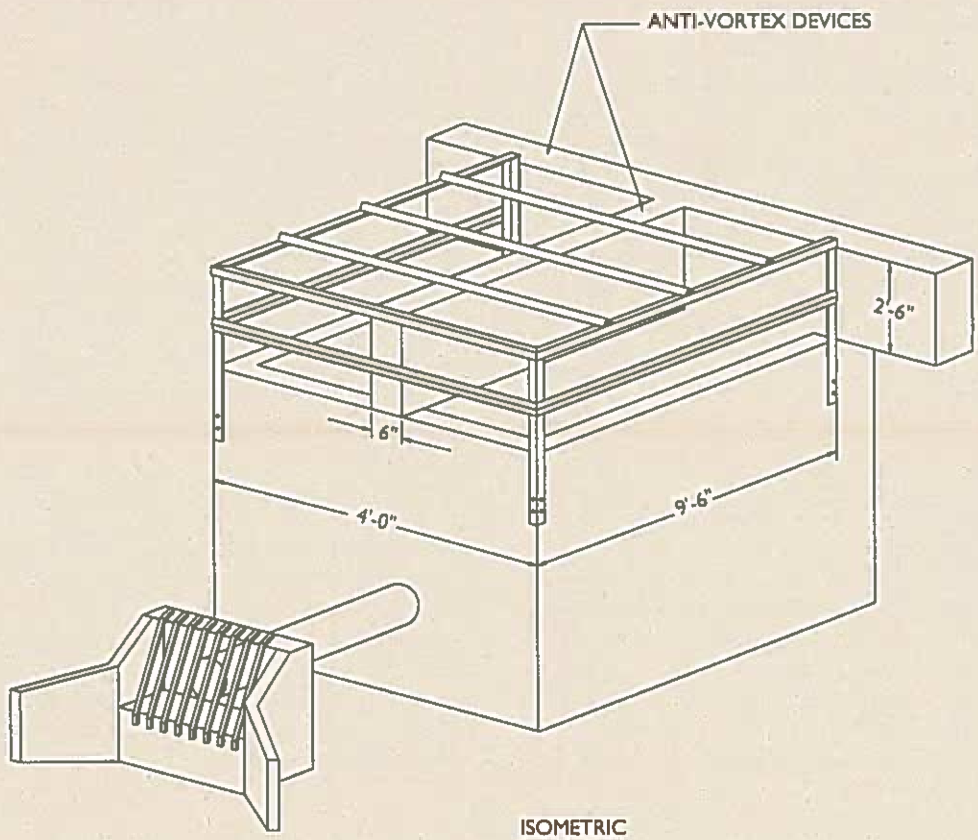
Area = [(side length) (2sides) + (front)] [(height) – (face of anti–vortex device)]

Area=[(9.5 ft.) (2) = (4.0 ft.)] [2.5 ft.) - [(0.5 ft.) (2.5 ft. = 9.5 ft.)]

Area = [57.5 ft.^{2}] - [6.0 ft.^{2}] = 51.50 ft.^{2}

Since the designed surface area of the high stage trash rack (51.50 ft.^{2}) is greater than the adjusted required opening area (50.0 ft.^{2}), then the trash rack design is acceptable.

Figure DB-3 High Stage Trash Rack for Design Example 2



ISOMETRIC
(Not To Scale)

NOTES:
1. TRASH RACK SHALL BE FABRICATED OF STRUCTURAL STEEL IN COMFORMANCE WITH ASTM A-36.

2. ALL STRUCTURAL STEEL SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM A-123.

Source: USDA-NRCS

Detention Basin (DB)

PVC Pipe: The PVC shall meet the requirements of **Figure DB-5**. **Connections between pipe joints and anti-seep collar connections to pipe shall 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 PVC pipe to less flexible pipe or structures shall be designed to avoid stress concentrations that could rupture the PVC. When using PVC pipe the maximum outlet control structure barrel size shall be 12 inch, except a larger PVC pipe may be used if the engineering design calculations justify the use of a larger pipe.

Figure DB-5 PVC Pipe*

Nominal Pipe Size (inches) Strength	Maximum	Depth of Fill Over Pipe (feet)
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

Smooth Steel: The minimum wall thickness shall be 3/16 inch. Previously used pipe may be used providing it is in good condition and does not have deep rust pits. The maximum outlet control structure barrel diameter shall be 48 inches. Pipe joints shall be threaded or welded by a competent welder. There are also several acceptable pre-engineered couplings available from pipe distributors.

Concrete Pipe With Rubber Gasket Joints: The pipe shall be designed with a 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.

Inlet: The inlet of the outlet control structure shall be structurally sound and made from materials compatible with the pipe. The inlet shall be designed to prevent floatation. The inlet shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated. The inlet materials are subject to the same limitations and requirements as the pipe materials.

Hood Inlet: If the pipe is designed for pressure flow, the minimum available head between the top of the pipe and the crest of the emergency spillway shall be adequate to prime the pipe. This head shall be at least 1.4 times the pipe diameter. See **Figure DB-9** for hood inlet detail.

Drop Inlet: If the pipe is designed for pressure flow the weir length of the drop inlet shall be adequate to prime the pipe when the water surface is at or below the emergency spillway crest. For pipe barrels placed on critical slope or flatter, the drop inlet shall be at least 2D deep, where D is the barrel diameter. For pipe placed on steeper than critical slope, the drop inlet shall be at least 5D deep, where D is the barrel diameter.

Outlets: The outlet for the outlet control structure area shall be protected to prevent erosion. In addition, the outlet 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 an impact basin, outlet protection, riprap, excavated plunge pools or use of other generally accepted methods.

Pipes larger than 18 inches shall have an energy dissipator such as one of the following:

- *Saint Anthony Falls type outlet;*
- *impact basin;*
- *stilling basin or plunge pool; or*
- *outlet protection in accordance with the outlet protection measure*

Anti-Seep Collars: Since very little time is spent in determining potential phreatic water surfaces within detention basins, it is accepted practice to design anti-seep controls as if the basin were always full of water. Anti-seep collars shall be designed for installation on the barrel of the outlet control structure within the normal saturation zone of the embankment to increase the seepage length by at least 10%, if either of the following two conditions exist:

1. The settled height of the embankment exceeds 10 feet.

2. The embankment soils have less than 15% passing the #200 sieve and the barrel is greater than 10 inches in diameter.

The 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 the spacing be greater than 25 feet. Collars shall not be closer than 2 feet from a pipe joint. Collars shall be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure 90%-95% standard proctor compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight. See **Figure DB- 10** for details.

Alternatives to 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. However, due to the constraints that collars impose on embankment fill placement and compaction, collars may sometimes be ineffective if proper placement procedures are not followed precisely.

Alternative measures have been developed and are being incorporated into embankment designs. These measures include a structure known as a "filter diaphragm." A filter diaphragm consists of a layer of sand and fine gravel which runs through the dam embankment perpendicular to the barrel. The measure controls the

Earth Embankment

Freeboard: A minimum freeboard of 1.0 foot shall be provided between the routed water surface elevation for the design storm and the top of the embankment of the 100 year storm.

Top Width: The minimum top width of the embankment shall be 8 feet.

Side Slopes: For embankment stability the combined upstream and downstream side slopes of the settled embankment when added together shall not be less than 5:1 with neither slope steeper than 2:1. Slopes shall be designed to be stable in all cases.

Materials: The fill material for the embankment shall be taken from approved borrow areas. It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized stones, rocks, or other organic or unsuitable material. The material selected shall have enough strength for the embankment to remain stable and be tight enough, when properly compacted, to prevent excessive seepage of water through the dam. Fill containing particles ranging from small gravel or coarse sand to fine sand and clay in desired proportions is appropriate. Embankment material should contain at least 15% passing the #200 sieve and not more than 50% passing the # 200 sieve.

No stones larger than 6 inches shall be allowed within the compacted embankment. Within two feet of any structure, the maximum size shall be 3 inches. Construction shall not take place during cold periods where temperatures are consistently lower than 40 degrees Fahrenheit. The soil intended for the embankment shall be laboratory tested with a written report by a professional engineer licensed to practice in Connecticut, experienced in the field of soil mechanics. The report shall carry the engineer's findings and suggested design parameters if at variance with those proposed in the design.

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 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 transversed 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, conduits, and structures to avoid damage and achieve desired compaction.

Foundation Cutoff for Embankment Detention Basin: A foundation cutoff constructed with relatively impermeable materials shall be provided for all embankments. The minimum depth of the cutoff shall be 2 feet. The cutoff trench, as a minimum, shall extend up both abutments to the emergency spillway crest elevation. The minimum bottom width shall be 4 feet and wide enough to permit operation of compaction equipment. 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 earthfill and structures without excessive consolidation. Any unsuitable materials shall be removed from the foundation area before construction.

Installation Requirements

Construct the detention basin in accordance with the engineered design.

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

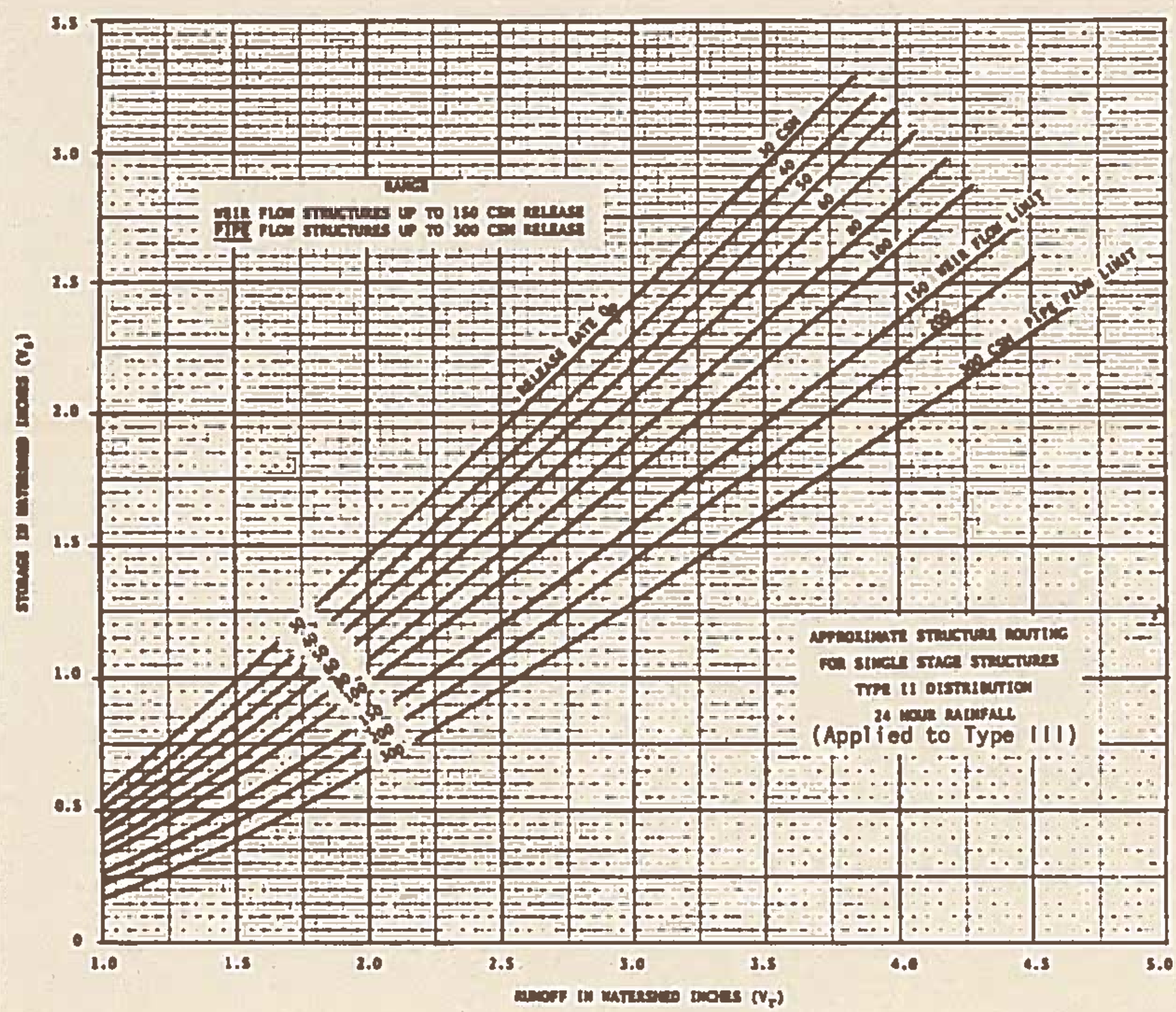
Install sediment controls to trap sediment before it enters and leaves the detention basin construction site.

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**, whichever is applicable.

Safety

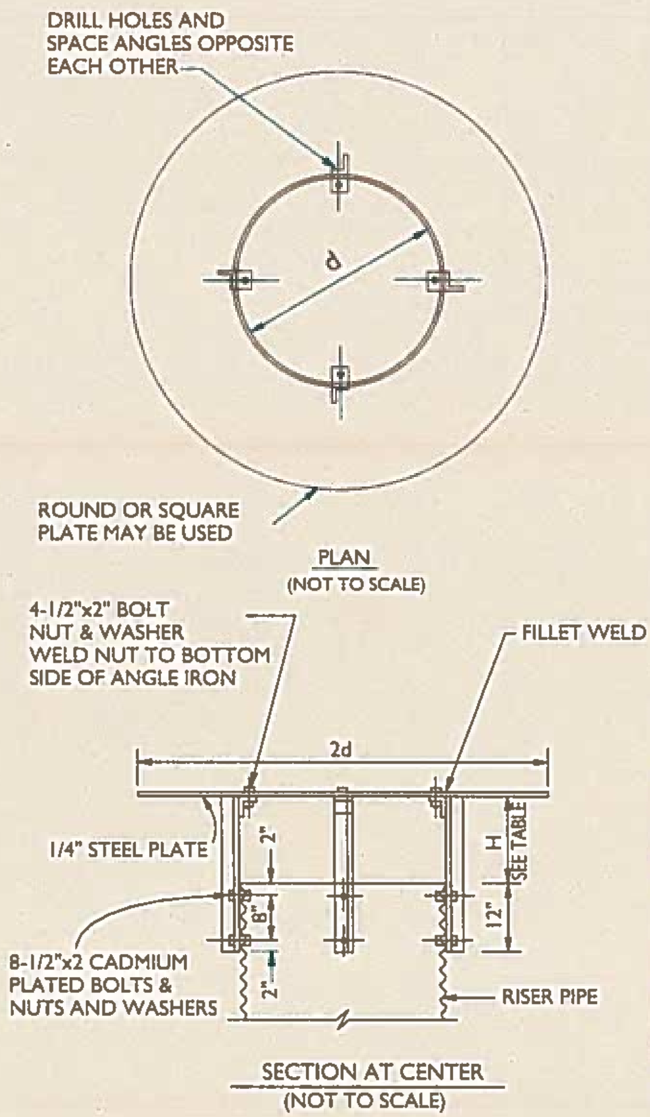
Install safety features and devices to protect humans and animals from such accidents as falling or drowning. Temporary fencing can be used until barrier plantings are established. Use protective measures such as guardrails and fences on spillways and impoundments as needed.

Figure DB-6 Structure Routing Graph



Source: USDA-NRCS

Figure DB-8 Example of Anti-Vortex with Trash and Safety Guard Diagram

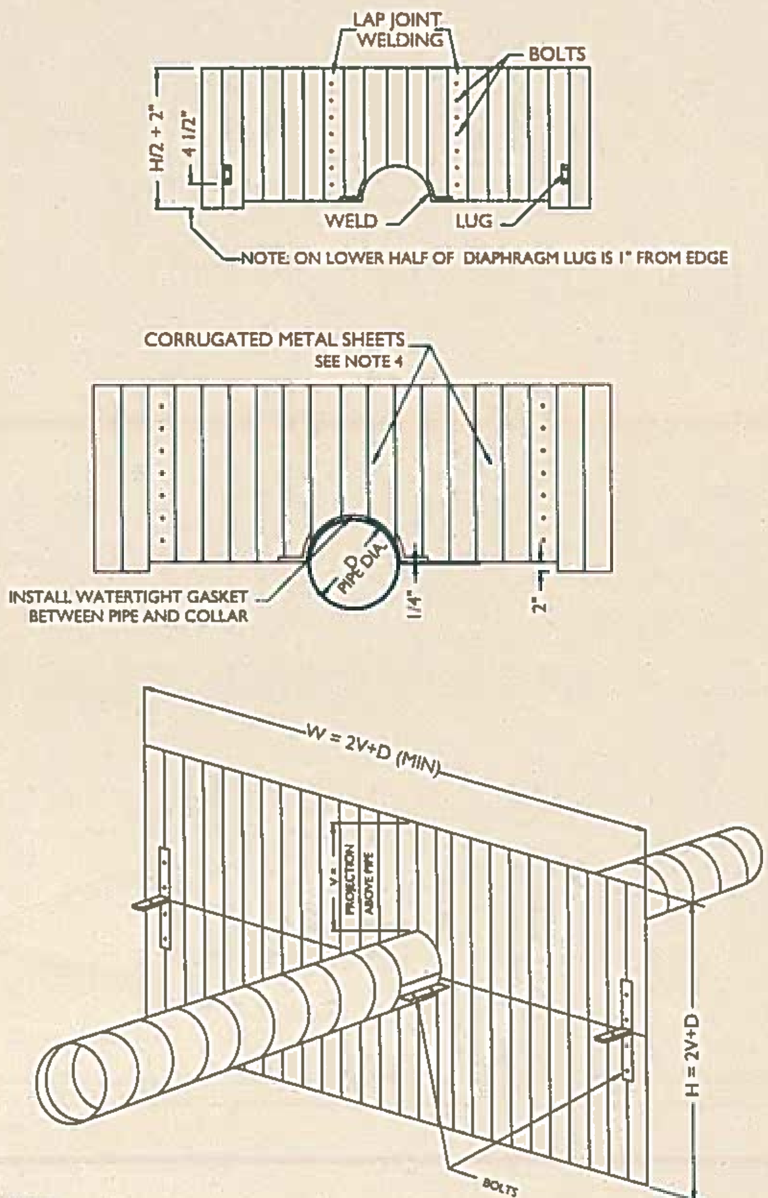


INLET d DIA. INCHES	BARREL DIA. INCHES	H INCHES
12	6	6
12	8	6
15	10	6
15	12	7
18	12	6
24	15	7 1/2
24	18	10
* 30	18	8 1/2
* 30	24	13 1/2
* 36	24	12

* USE ANGLE IRON STIFFENERS ON PLATE AS SPECIFIED.

Source: USDA-NRCS

Figure DB-10 Anti-Seep Collar



NOTES:

1. ANTI-SEEP COLLARS TO BE FULLY BITUMINOUS COATED.
2. THE MAXIMUM SPACING OF ANTI-SEEP COLLARS ALONG THE CONDUIT SHALL BE NO GREATER THAN 14V, AND IN NO CASE GREATER THAN 25 FEET.
3. ANTI-SEEP COLLARS SHALL BE PLACED AT LEAST 2 FEET FROM PIPE JOINTS.
4. SEE FIGURE DB-4 FOR GAUGE.

Source: USDA-NRCS

5-10 Energy Dissipators

Planning Considerations

The energy dissipator measures are **Level Spreader, Outlet Protection** and **Stone Check Dam**. These measures serve the common function of dissipating the energy of runoff waters for the specific purpose of reducing erosion potential. They may be installed for either permanent or temporary use. While level spreaders and outlet protection are typically installed for permanent use, stone check dams are for temporary installations.

The **Level Spreader** measure includes a depression at the outfall for a channel or culvert with a broad stable discharge area used for the purpose of de-energizing and dispersing the runoff water 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 insure 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.

The **Stone Check Dam** measure uses a dam constructed of stone across a drainageway to reduce the potential for channel erosion. Stone 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**.

Definition

An outlet for diversions and other water conveyances consisting of an excavated depression with a broad stable point of discharge constructed at zero grade across a slope.

Purpose

To reduce the depth and velocity of concentrated runoff and release it uniformly as sheet flow onto a stable area.

Applicability

- Where there is a need to carry storm water away from disturbed areas and to avoid stressing erosion control measures.
- Where sediment reduced runoff can be released in 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 slope of 5% or flatter and is stabilized by vegetation.

Planning Considerations

The **Temporary Diversion** measure and the **Water Bar** measure each calls for a stable outlet for concentrated storm water flows. The level spreader is a relatively low-cost structure to release small volumes of concentrated flow where site conditions are suitable.

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 (such as a permanent pond or detention basin) located below the level spreader.

For higher design flow conditions, a rigid outlet lip design is required to ensure the desired sheet flow conditions.

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

Slopes shall be sufficiently smooth to preserve sheet flow and prevent flow from concentrating.

Criteria provided below are for flows from a 10-year frequency storm that is equal to or less than 20 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 (Q_{10}).

Select the appropriate length, width and depth of the spreader from **Figure LS-1**.

Provide a 20-foot transition section in the diversion channel so that the width of the diversion will smoothly transition with the width of the spreader to ensure more uniform outflow.

Make the depth of the level spreader, as measured from the lip, at least 6 inches. The depth may be made greater to increase temporary storage capacity, improve trapping of debris and to enhance settling of any suspended solids.

Figure LS-1 Minimum Dimensions for Level Spreader

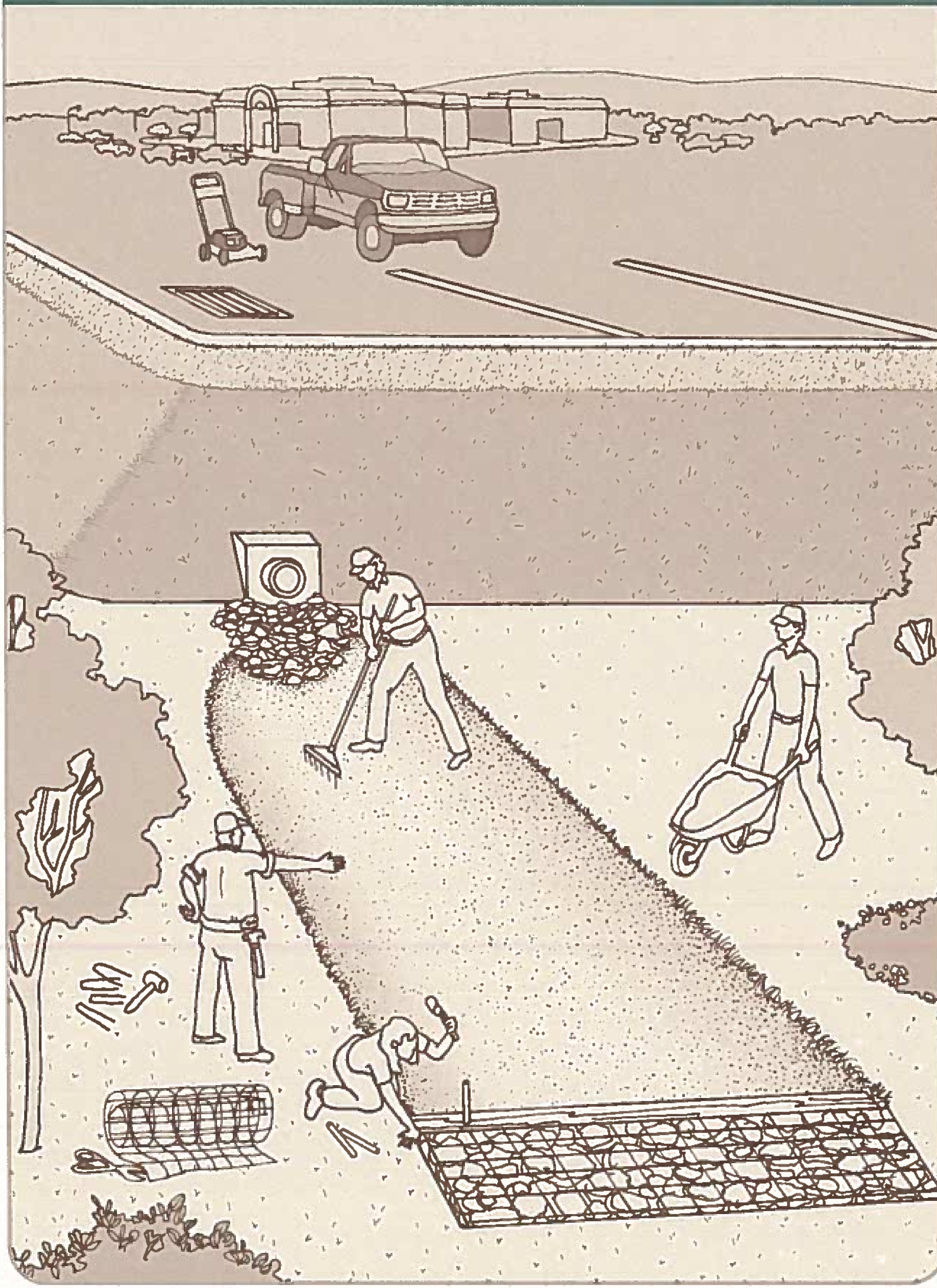
Design Flow, Q_{10} (cfs)	Depth (ft.)	Width of Lower Side Slope of Spreader (ft.)	Length (ft.)
0 – 10	0.5	6	10
10 – 20	0.6	6	20

Grade

The grade of the channel for the last 20 feet of the dike or diversion entering the level spreader shall be no steeper than 1%.

The grade of the level spreader channel shall be 0.0%.

Figure LS-3 Illustration of a Level Spreader with a Rigid Lip



10-Energy Dissipators

Outlet Protection (OP)

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 storm water flows.

Applicability
At the outfall of all 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 publicly maintained drainage system. Where flow is excessive for the economical use of an apron, excavated stilling basins may be used. Acceptable designs for 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. December 1975.*
- *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, 1989.*

(All of the above are available from the U.S. Government Printing Office.)

- *Plunge Pool Design at Submerged Pipe Spillway Outlets, American Society of Agricultural Engineers, Volume 37(4):1167-1173, 1994.*

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 **Figure OP-1**. The exit velocity of the water in the conduit shall be calculated using the greater of the conduit design storm or the 25-year frequency storm. When the exit velocity of the water in the conduit exceeds the allowable velocity for the soil, outlet protection is required. Outlet protection is also required if the conduit outfall is set above the receiving channel (i.e., cantilevered) causing the water to drop at the outlet end of the culvert.

Figure OP-1 Allowable Velocities for Various Soils

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

Source: USDA-NRCS

Riprap Aprons
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 apron to the receiving channel.

Outlet Protection (OP)

Outlet Protection Design Example Problem

Given: D_o = 1.5 ft, Q = 14.5 cfs, TW = 0.7 ft.
Find: L_a, W, d_{50}
Solution:

For L_a (length of apron):

$$L_a = \frac{1.7Q}{D_o^{3/2}} + 8D_o = \frac{1.7(14.5\text{ cfs})}{1.5^{3/2}} + 8(1.5) = 25.4$$

Answer: L_a = 25.4 ft.

For W (apron width):

$$W = 3D_o + L_a = 3(1.5) + 29.9\text{ ft.}$$

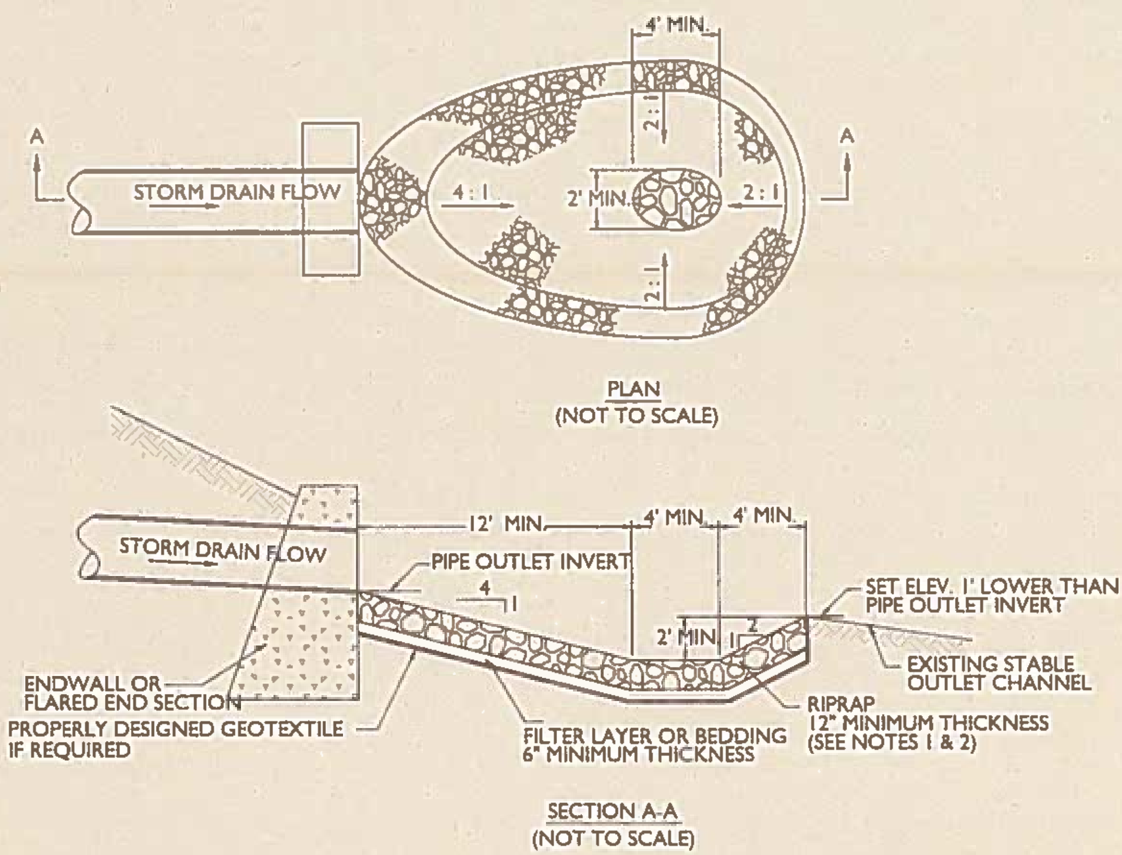
Answer: W = 30 ft.

For d_{50} (median stone diameter):

$$d_{50} = \left(\frac{0.02}{TW}\right)\left(\frac{Q}{D_o}\right)^{4/3} = \left(\frac{0.02}{0.7}\right)\left(\frac{14.5}{1.5}\right)^{4/3} = 0.58\text{ ft.}$$

Answer: d_{50} = 0.58 ft. or 7 inches

Figure OP-3 Configuration of Outlet Protection using a Riprap Stilling Basin



NOTES:

1. RIPRAP SIZE AND THICKNESS SHALL BE ADJUSTED UPWARD AS THE STORM DRAIN SIZE AND OUTLET VELOCITY INCREASE. SEE PLANNING CONSIDERATIONS SECTION FOR DESIGN REFERENCES.
2. CONSIDER THE APPLICATION OF CEMENTIOUS GROUT IN THE RIPRAP TO PREVENT VANDALISM AND FACILITATE SEDIMENT AND DEBRIS CLEANOUT.

Source: USDA-NRCS

Application

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 may be used under the stone to provide a stable foundation and to facilitate removal of the stone.

In Drainageways: The minimum height of the check dam shall be the flow depth of the drainageway but it shall not exceed 3 feet in height at the center. Extend the stone check dam to the full width of the drainageway, plus 18 inches on each side leaving the height of the center of the stone check dam approximately 6 inches lower than the height of the outer edges (see **Figure SCD-2**).

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 SCD-2**).

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 20 feet above the catch basin or culvert. For culvert inlets, locate the check dam at least 6 feet from the inlet (see **Figure SCD-3**).

Catch Basins in Depressions or low spots (yard drains): Encircle the entire catch basin with a stone 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 SCD-4**).

Culvert Inlets: Locate the stone check dam approximately 6 feet from the culvert in the direction of the incoming flow (see **Figure SCD-5**).

Special Case Combinations for Added Filtration & Frozen Ground Conditions: These are non-engineered stone 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 SCD-6**): 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/Hay Bales (**Figure SCD-6**): Stone check dams that are installed with a core of hay bales. The hay bales provide filtering capacity while the stone check dam provides stability. The hay bales must meet the minimum standards set forth in **Hay Bale Barrier** measure. At the location of the stone check dam first lay a loose bed of hay several inches thick along the entire length of the check dam alignment. Place hay bales with the ends of adjacent bales tightly abutting one another. Wedge any gaps with loose hay. Bury hay bales 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 hay bales and maintenance.

Maintenance

For permanent stone check dams, inspect and maintain the stone check dam in accordance with the standards and specifications provided in the design.

For temporary stone check dams, inspect stone check dams 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 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 has 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, stone check dams) are needed to reduce failure rate.

Maintain the stone check dam until the contributing area is stabilized.

After the contributing area is stabilized, remove accumulated sediment. Stone check dams may 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.

Stabilize any disturbed soil that remains from check dam removal operations.

Figure SCD-3 Stone Check Dam Above Catch Basin in Drainageway on Slope

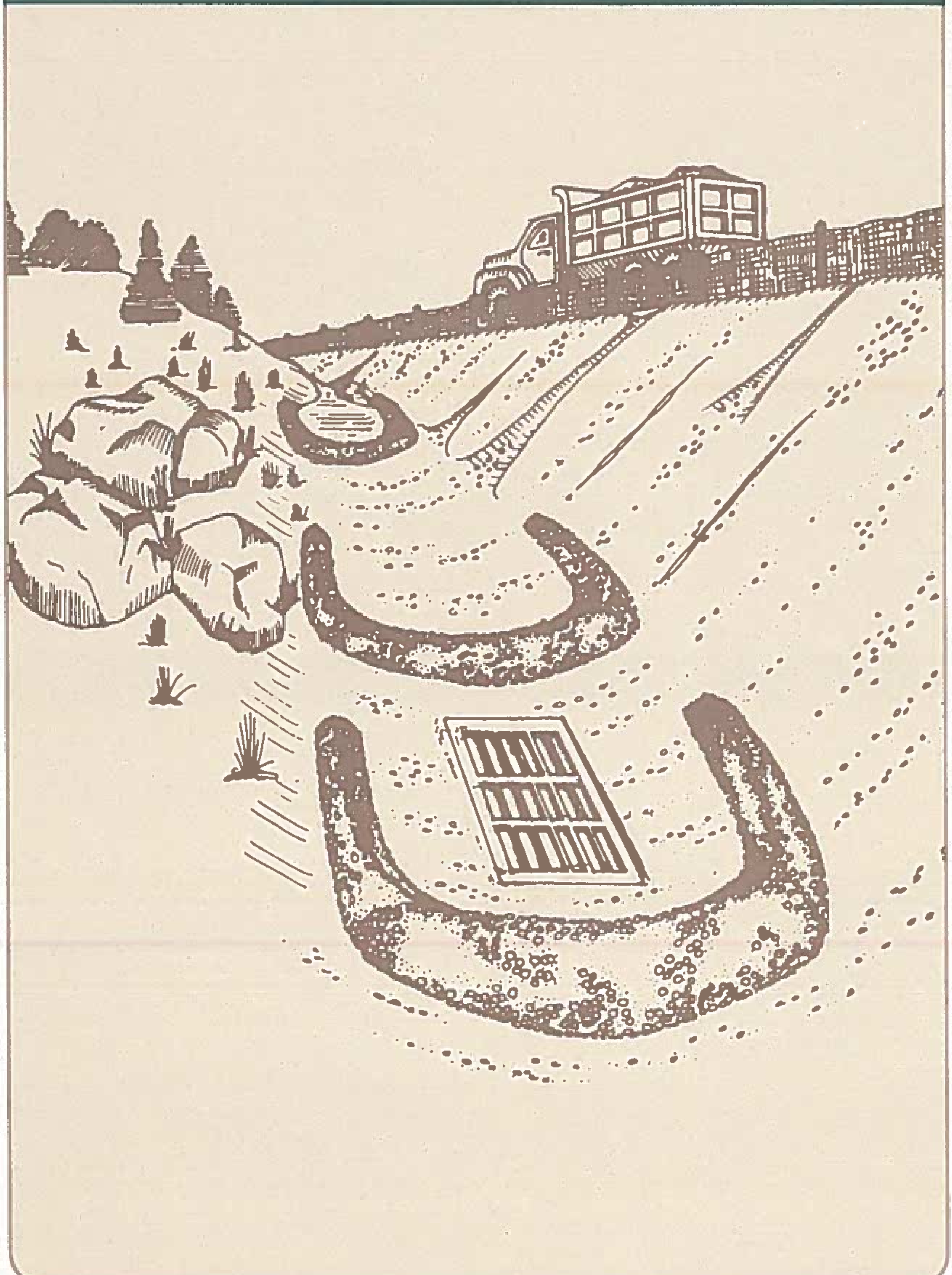
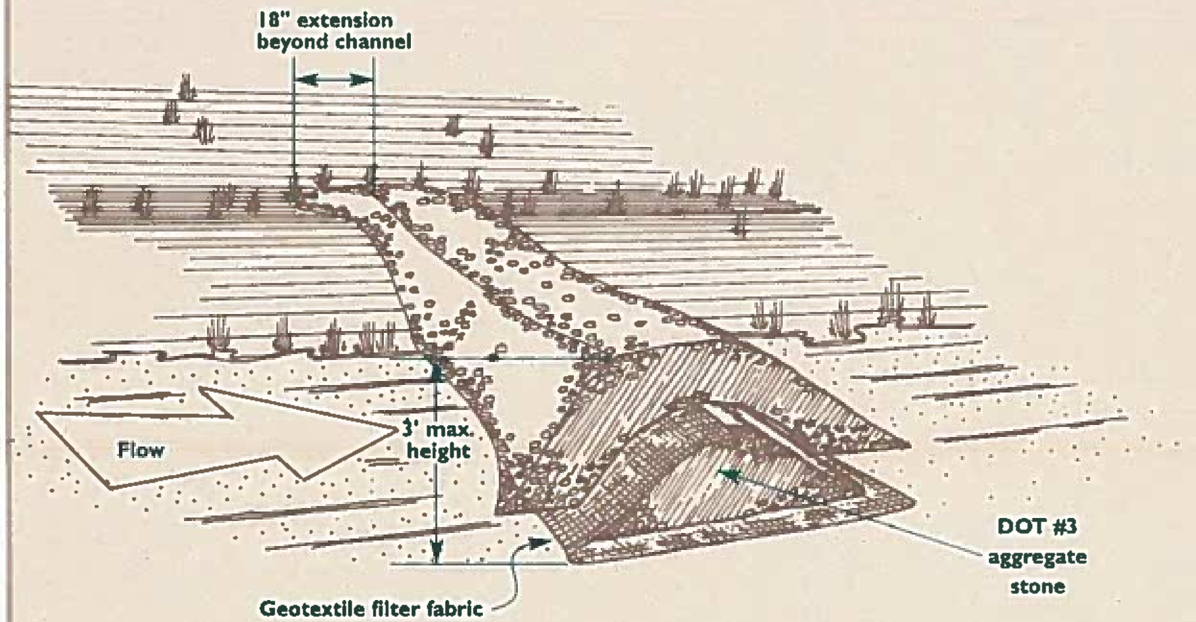
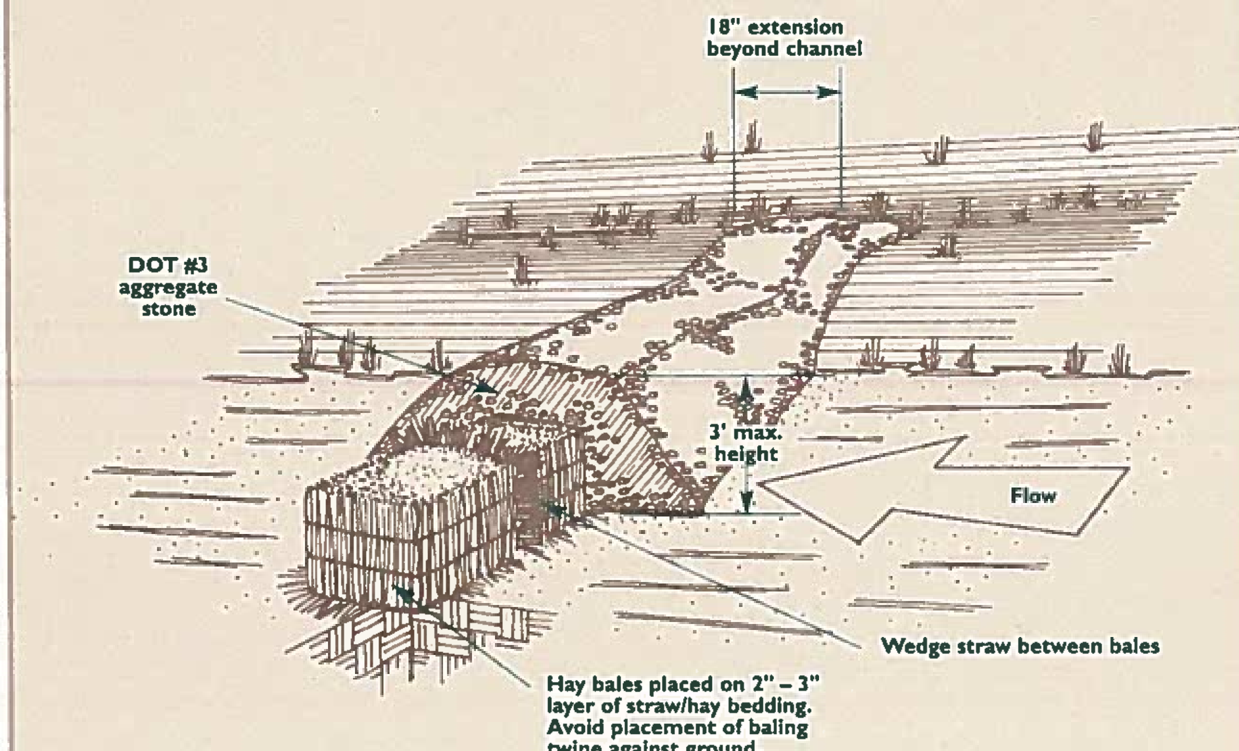


Figure SCD-6 Special Case Combination Stone Check Dams





Planning Considerations

The measures included in the sediment impoundments and barriers functional group include **Temporary Sediment Basin, Temporary Sediment Trap, Hay 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 75%–90% trap efficiency[1] for a 10 year 2 hour return frequency storm.

[1] Temporary sediment basins and traps are not intended for use as post-construction storm water management controls. Post-construction storm water management controls may require a design that is based upon a target settling efficiency rather than a trap efficiency.

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On land, hay bale barriers and geotextile silt fences may be used separately or in combination with each other, such as for catch basin protection, culvert inlet protection and dewatering facilities. Hay Bales or geotextiles can be used in combination with stone when added protection is needed for work in critical watersheds (e.g. public water supply, nearby cold water fisheries) or when the ground is frozen. This special application is described in the **Stone Check Dam** measure found in the Energy Dissipators Functional Group.

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.

Historically, stone check dams were included as a sediment barrier. The stone check dam measure has been revised and placed in the Energy Dissipators Functional Group.

In tidal waters or water deeper than 2 feet, a **Turbidity Curtain** is used as a sediment barrier. Its design and installation is determined by water fluctuation, depth, velocity, wave conditions and manufacturer's recommendations.

In non-tidal water less than 2 feet deep geotextile silt fences, hay bale barriers, 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.

Only one measure is identified as a filter (**Vegetated Filter**) and is more limited in its application than any other measure 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 there is a sufficient length of flow through the filter to meet filtering needs. Frequently, a vegetated filter can not be used either due to the steepness of slope or the failure to have a wide enough filtering area to meet the minimum flow lengths through the filter.

Figure SB&F-1 identifies the limitations for each sediment barrier and filter measure. Stone check dams (non-engineered) are included only for reference when they are combined with hay bales or geotextile silt fencing.

Temporary Sediment Basin (SB)

Definition

A temporary dam, excavated pit or dugout pond constructed across a waterway or at other suitable locations with a controlled outlet(s) such that a combination of wet and dry storage areas are created. 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.
- To prevent undesirable deposition of sediment in wetlands, on bottom lands and developed areas.
- 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 five 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 or utilities.
- Not for use as a post-construction stormwater renovation 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 to the problem.

Consider sequencing construction so that the basin is located in an area that won't be developed until after the contributing watershed is stabilized. Also, sequence construction activities and locate the basin to minimize interference with other construction activities and construction of utilities.

Locate the basin outside of wetlands and try to locate it 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, plan to provide and maintain construction equipment access for the removal of accumulated sediment.

To minimize the size of the temporary sediment basin, plan to divert clean waters around the basin and intercept only runoff from disturbed areas.

For projects which include a permanent detention basin, it is sometimes advantageous to locate the temporary sediment basin at the site of the detention basin. Sharing the same location may minimize site disturbance and cost. When this approach is used, the size requirements of both the detention and sediment basins must be determined and the larger of the two must be in place during the construction period. After construction, the minimum size shall be that of the detention basin. One approach would be to construct the detention basin along with its berm and outlet works first, and expand the storage volume, if need be, to that required for the sediment basin. The permanent outlet works are modified during the construction period to provide the necessary wet and dry storage requirements and enhance the basin's ability to remove sediment. Upon stabilization of the contributing watershed, accumulated sediment is removed from the basin and any work, such as modifying the outlet works or installing permanent plantings, is done to complete the permanent detention basin.

Finally, the E&S plan should identify the sediment removal threshold(s), the method(s) of disposing of the sediment removed from the basin, the method of basin removal and final stabilization of the sediment basin after the contributing drainage area is stabilized.

Contact DEP Inland Water Resources Division early in the planning process to determine the potential need for a dam construction permit and/or water diversion permit. A local or state inland wetlands permit will be required if the temporary sediment basin is proposed in a wetland and/or watercourse area. Additional local permits may be required for work within floodplain and wetlands buffer areas. Check local ordinances and regulations regarding health and safety, as sediment basins may attract children and can be dangerous.

Depth: The average depth shall be 4 feet or greater.

Width: The minimum width shall be:

$W = 10\sqrt{Q_5}$

where: 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:

$W = 10\sqrt{Q_5}$

where: W = width in feet

Q_{25} = peak discharge from a 25-year frequency storm in cfs.

Figure SB-1 Determining Erosion Rates

Land Use	Ave. Annual Erosion
Wooded area	0.2 ton/ac/yr
Developed urban areas, grassed areas, pastures, hay fields, abandoned fields with good cover	1.0 ton/ac/yr
Clean tilled cropland (corn, vegetables, etc.)	10 ton/ac/yr
Construction Areas	50 ton/ac/yr

Source: USDA-SCS

Figure SB-2 Estimated Sediment Density

Soil Texture *	γ2 Submerged (lbs/cu. ft.)
Clay	40-60
Silt	55-75
Clay-silt mixtures (equal parts)	40-65
Sand-silt mixtures (equal parts)	75-95
Clay-silt-sand mixtures (equal parts)	50-80
Sand	85-100
Gravel	85-125
Poorly sorted sand 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 SB-7**)

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 **Figure SB-5**). 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 SB-10**). 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 water tight connection to a horizontal pipe (barrel) extending through the embankment and outletting 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

1. **Corrugated Steel Pipe:** Pipe gauge is not to be less than that indicated in **Figure SB-3.** 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 **Figure SB-3**. 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.

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 prevent 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.

3. **Plastic Pipe:** PVC pipe shall meet the requirements of **Figure SB-4**. 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.

Figure SB-4 PVC* Pipe Requirements

Nominal Pipe Size (Inches)	Strength	Maximum Depth of Fill Over Pipe (Feet)
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.

4. **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 inch. Pipe joints shall be threaded or welded by a competent welder.

5. **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.

Figure SB-3 Corrugated Steel and Aluminum Pipe Requirement

Corrugated Steel Pipe

							Risers Only		
Pipe Diameter	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

					Risers Only		
Pipe Diameter	8 to 21	24	30	36	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.

Temporary Sediment Basin (SB)

Figure SB-5 Design Data		
Drainage Area (acres)	Frequency (years)	Minimum Duration (hours)
Less than 50	25	24
50-100	100	24

Source: USDA-NRCS

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 SB-10** and **Figure SB-11**): 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.

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, 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 **Figure SB-5**.

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 NRCS Practice Standard 378, August 1982. Sediment basins that exceed the above conditions shall be designed to meet the criteria in 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.

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.

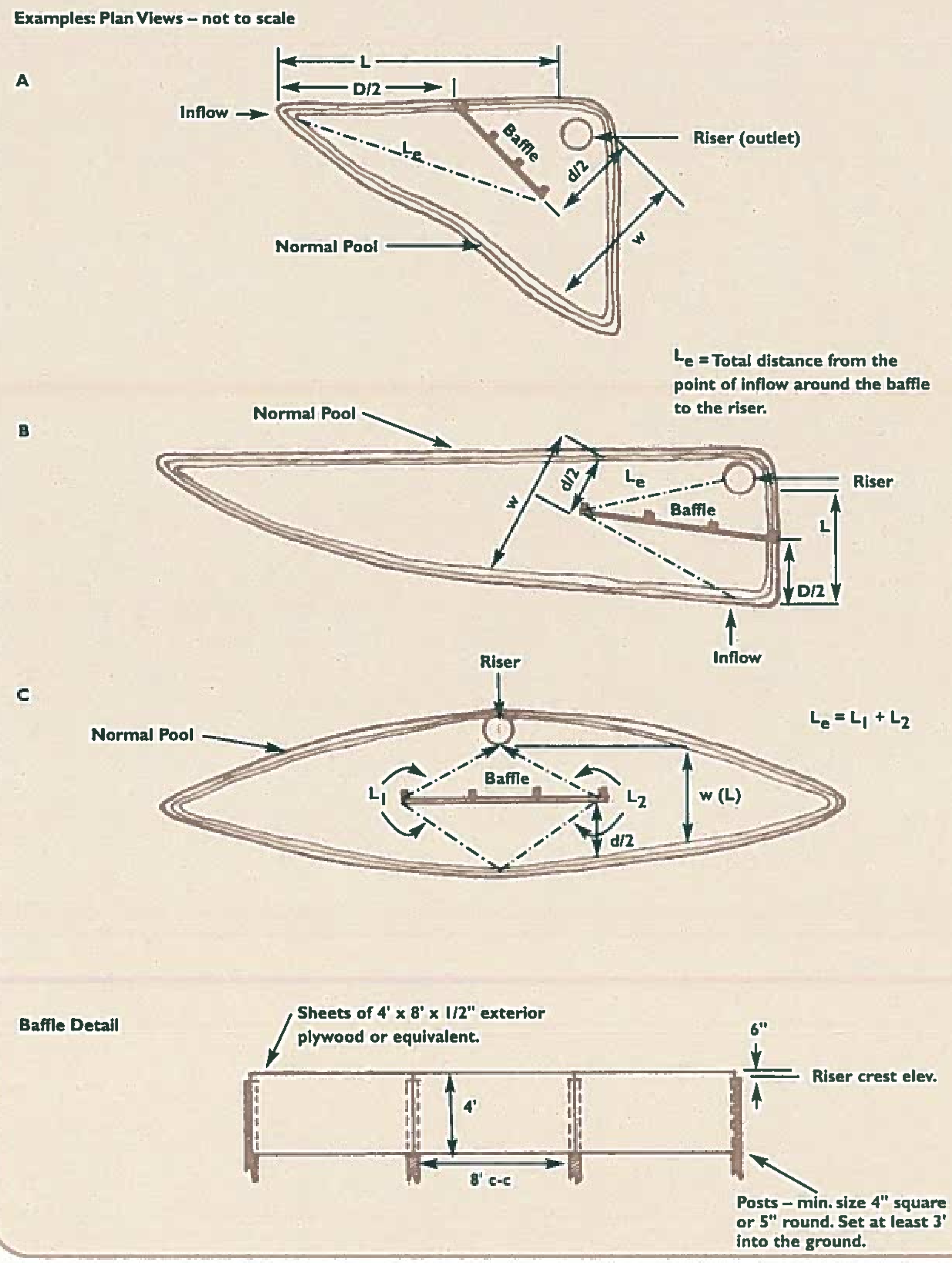
Maintenance

Inspect the temporary sediment basin at least once a week and within 24 hours of the end of a storm with a rainfall amount of 0.5 inch or greater 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 Chapter 4, Special Treatments (Stockpiling). 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.

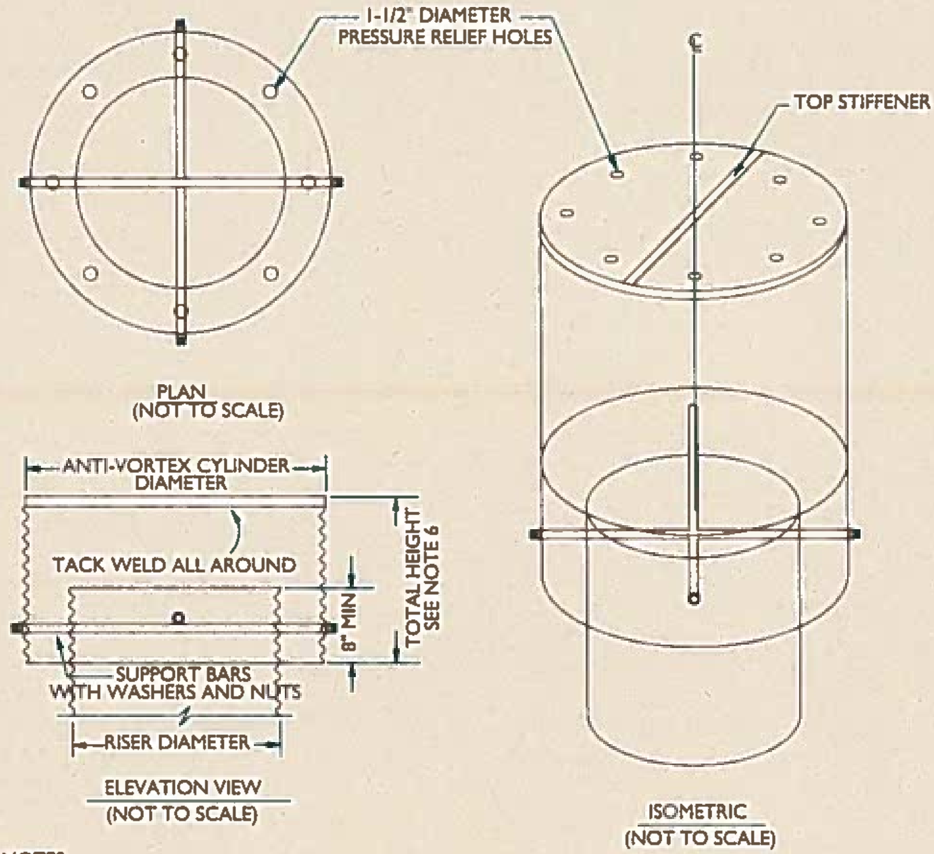
Sediment removal, transportation and disposal shall occur as shown on the plans as limited by the design criteria.

Figure SB-7 Sediment Basin Baffle Details



Source: USDA-NRCS

Figure SB-9 Concentric Trash Rack and Anti-Vortex Device



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).

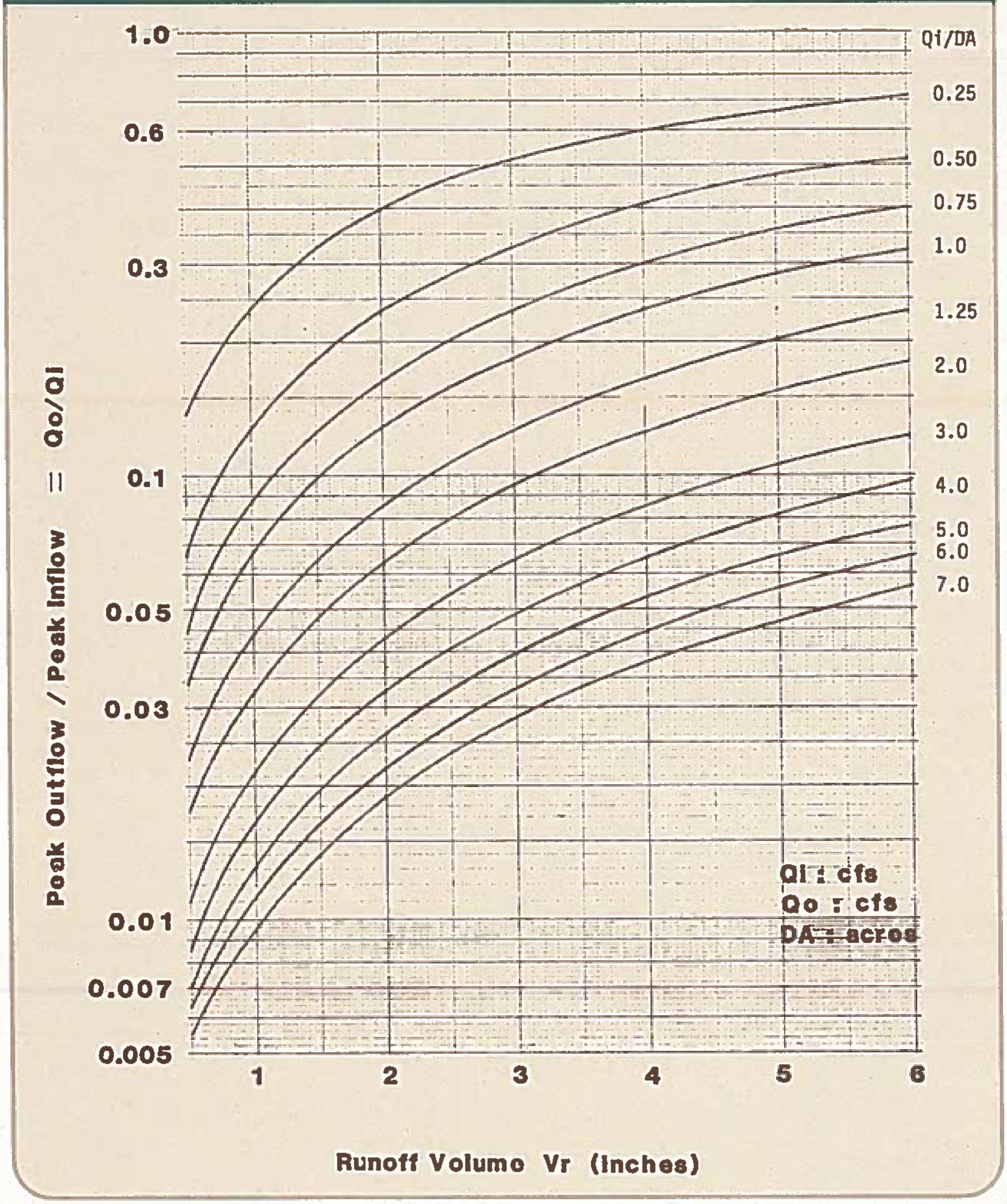
Source: USDA-NRCS

Figure SB-11 Table Containing Design Data for Earth Spillways When Used as Emergency Spillway

Stage (Hp) in feet	Spillway variables	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
		BOTTOM WIDTH (b) IN FEET																
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

Source: USDA-NRCS

Figure SB-13 Maximum Peak Outflow for Detention Time Graph



Source: USDA-NRCS

Temporary Sediment Basin (SB)

Design Example 1 *(continued)*

Q_o = 8.1 cfs = maximum allowable principal spillway discharge.

$$Q_o = (0.27)(Q_i) = (0.27)(30) = 8.1 \text{ cfs}$$

$$\text{Release rate} = \frac{(8.1 \text{ cfs})(640 \text{ Ac./sq. mi.})}{(100 \text{ Ac.})} = 51.8 \text{ csm}$$

V_r = 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.

$$V_s = 0.67 \text{ inches} = \frac{(0.67 \text{ in.})(100 \text{ Ac.})}{(12 \text{ in./ft.})} = 5.58 \text{ Ac. ft.}$$

V_s = 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 (SB)

Temporary Sediment Trap (TST)

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 use is 2 years or less. For uses greater than 2 years use **Temporary Sediment Basin** measure.
- When diverting sediment-laden water with temporary diversions that meet the above limitations for use.

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 drainage way and the dry storage created by the construction of a pervious stone dike across the drainage way. 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 guarantee 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 maintained.

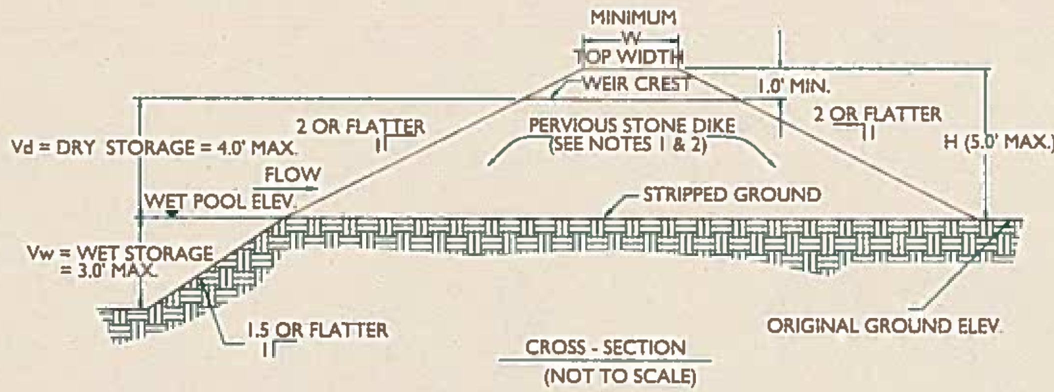
Specifications

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.

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. **Figure TST-1** 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 TST-2**). 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 TST-2 Minimum Top Width (w) Required for Temporary Sediment Trap Embankments According to Height of Embankment (feet)



1. PERVIOUS STONE DIKE SHALL BE CONSTRUCTED OF CT DOT MODIFIED RIPRAP WITH #3 STONE ON FACE.
2. NON-OVERFLOW PORTIONS AND ABUTMENTS OF TEMPORARY SEDIMENT TRAPS MAY BE CONSTRUCTED OF COMPACTED EARTHFILL.

TOP WIDTH VS. HEIGHT

H = HEIGHT OF EMBANKMENT
W = TOP WIDTH OF EMBANKMENT

H (ft)	W(ft)
1.5	2.0
2.0	2.0
2.5	2.5
3.0	2.5
3.5	3.0
4.0	3.0
4.5	4.0
5.0	4.5

Source: USDA-NRCS

Maintenance

Inspect the temporary sediment trap 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. 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 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.

Figure TST-4 Views of a Temporary Sediment Trap Outlet

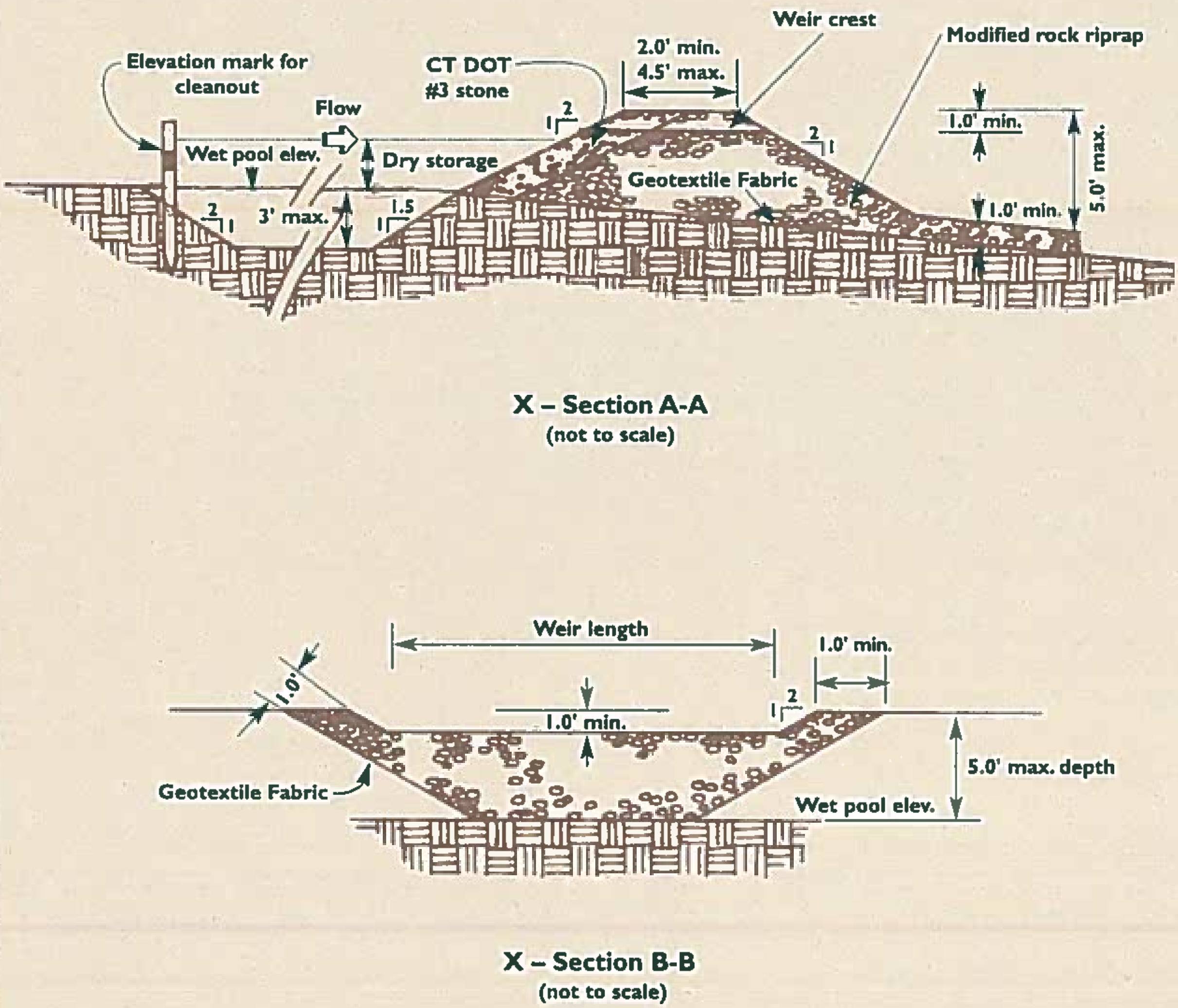


Figure HB-1 Hay Bale Design Slope/ Length Limitations	
Slope Steepness[1]	Slope Length and Wing Spacing
5:1 or shallower	100 feet
3:1 to 5:1	75 feet
2:1 to 3:1	50 feet

[1] Where the gradient changes through the drainage area the steepest slope section shall be used.

Hay 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).

Staking Hay Bales: Anchor each bale with at least 2 stakes, driving the first stake in each bale toward the previously laid bale to force the bales together. Stakes must be driven a minimum of 18 inches into the ground.

Fill any gaps between the bales with hay or straw to prevent water from escaping between the bales.

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 hay or straw scattered over the disturbed area immediately uphill from the hay bale barrier tends to increase barrier efficiency.

Substitute Measures

Geotextile Silt Fence may be used as a substitute. When frozen or other similar ground conditions prevent the proper trenching or anchoring of hay bales, a sediment barrier consisting of a stone check dam with a hay bale core may be substituted for the hay bale barrier. See **Stone Check Dam** measure, "Special Case Combinations for Added Filtration & Frozen Ground Conditions" for details.

Maintenance

Inspect the hay bale barrier 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 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 HB-4**).

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:

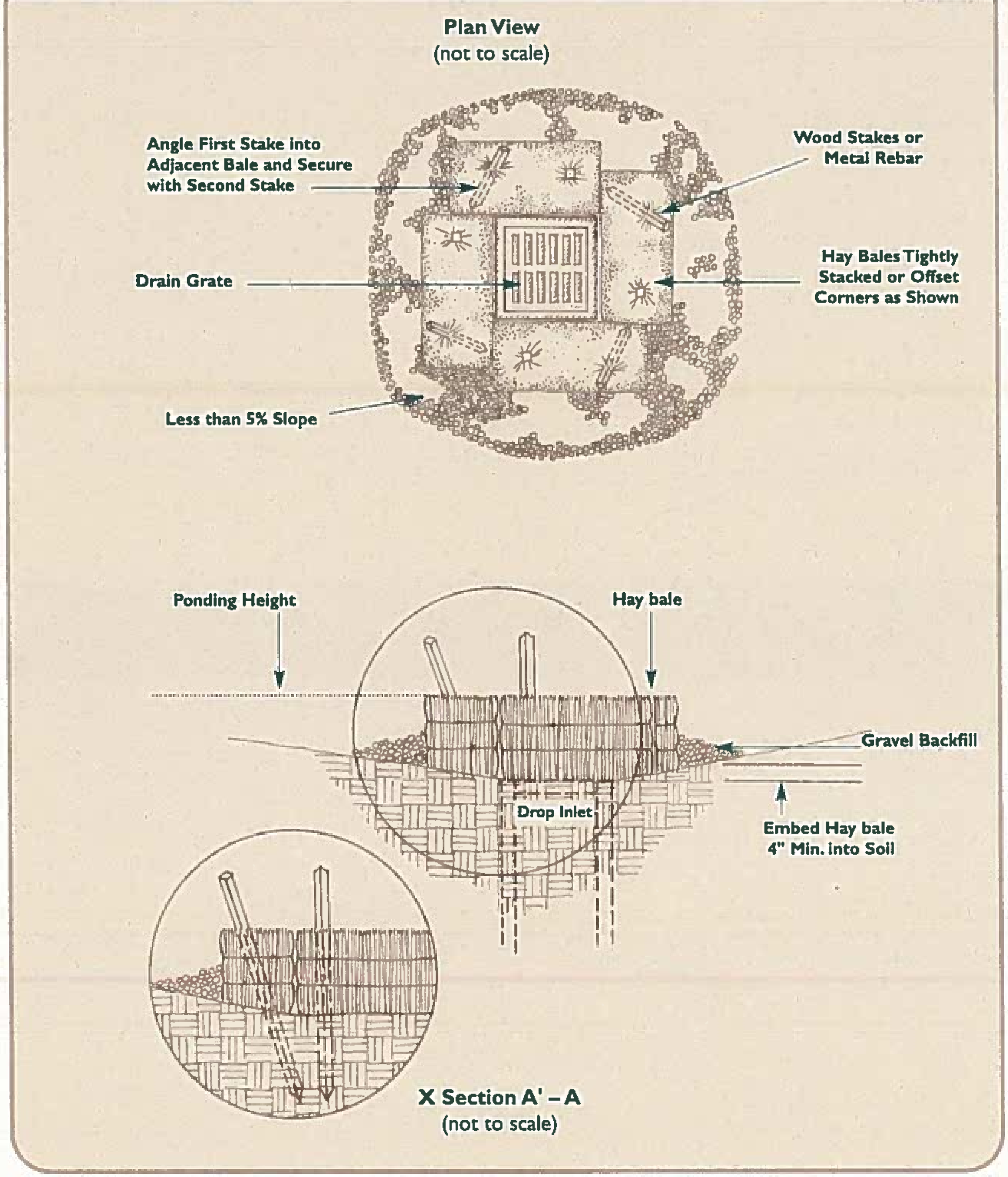
(a) the barrier has been overtopped, undercut or bypassed by runoff water,
(b) the barrier has been moved out of position, or
(c) the hay bales have deteriorated or been damaged.

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 hay bale barrier. See **Figure HB-5** for trouble shooting failures.

Maintain the hay bale barrier until the contributing area is stabilized.

After the upslope areas have been permanently stabilized, pull the stakes out of the hay bales. Unless otherwise required, no removal or regrading of accumulated sediment is necessary. The hay bales may then be left in place or broken up for ground cover.

Figure HB-3 Hay Bale Barrier at Catchbasin in Hollow



Geotextile Silt Fence (GSF)

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 storm water 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.
- Not for use in areas where rock, frozen ground or other hard surface prevents proper installation of the barrier (see Special Case Combinations in **Stone Check Dam** measure).
- Prohibited from use in drainageways whose flow is supported by ground water discharge.

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 controls are not possible or to act as a backup to inlet controls.

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 **Figure GSF-1**. 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 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 **Figure GSF-2**.

For toe of slope (Figure GSF-3): Locate 5-10 feet down gradient from the toe of slope, generally on the contour with maintenance and sediment removal requirements in mind. When the contour can not be followed install the fence such that perpendicular wings are created to break the velocity of water flowing along the fence. See **Figure GSF-2** for spacing requirements.

Swales (see **Figure GSF-4**): 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 up slope from the catch basin and the other immediately down slope 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.

Remove the sediment deposits or, if room allows, install a secondary silt fence up slope 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.

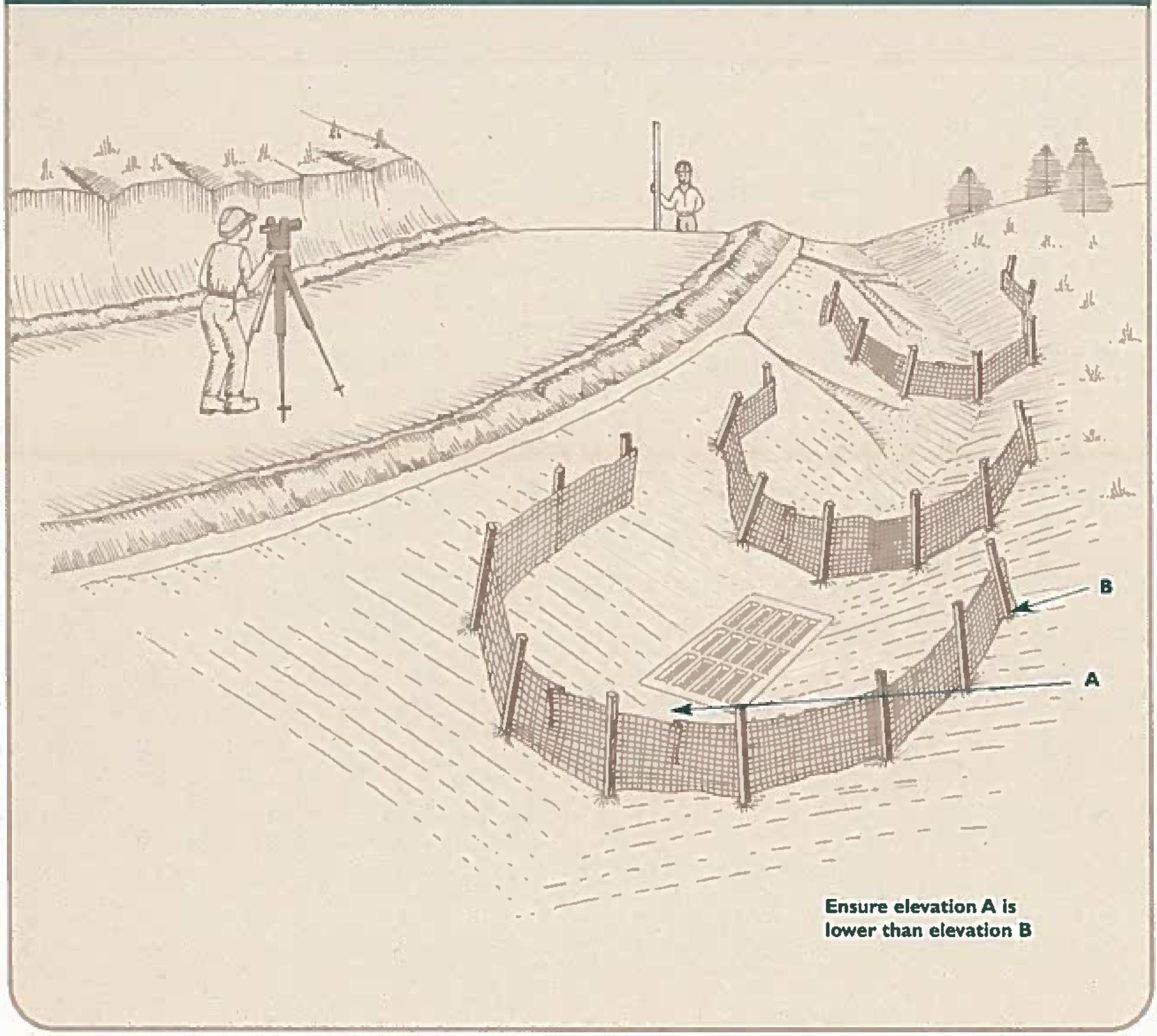
When repetitive failures occur at the same location, review conditions and limitations for use and determine if additional controls (e.g. temporary stabilization of contributing area, diversions, stone barriers) are needed to reduce failure rate or replace fence. See **Figure GSF-5** for trouble shooting 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 removal or regrading is required if sediment depth is less than 6 inches.

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.

Figure GSF-4 Swale and Catch Basin Installations



Turbidity Curtain (TC)

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.

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 channel flows.

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.

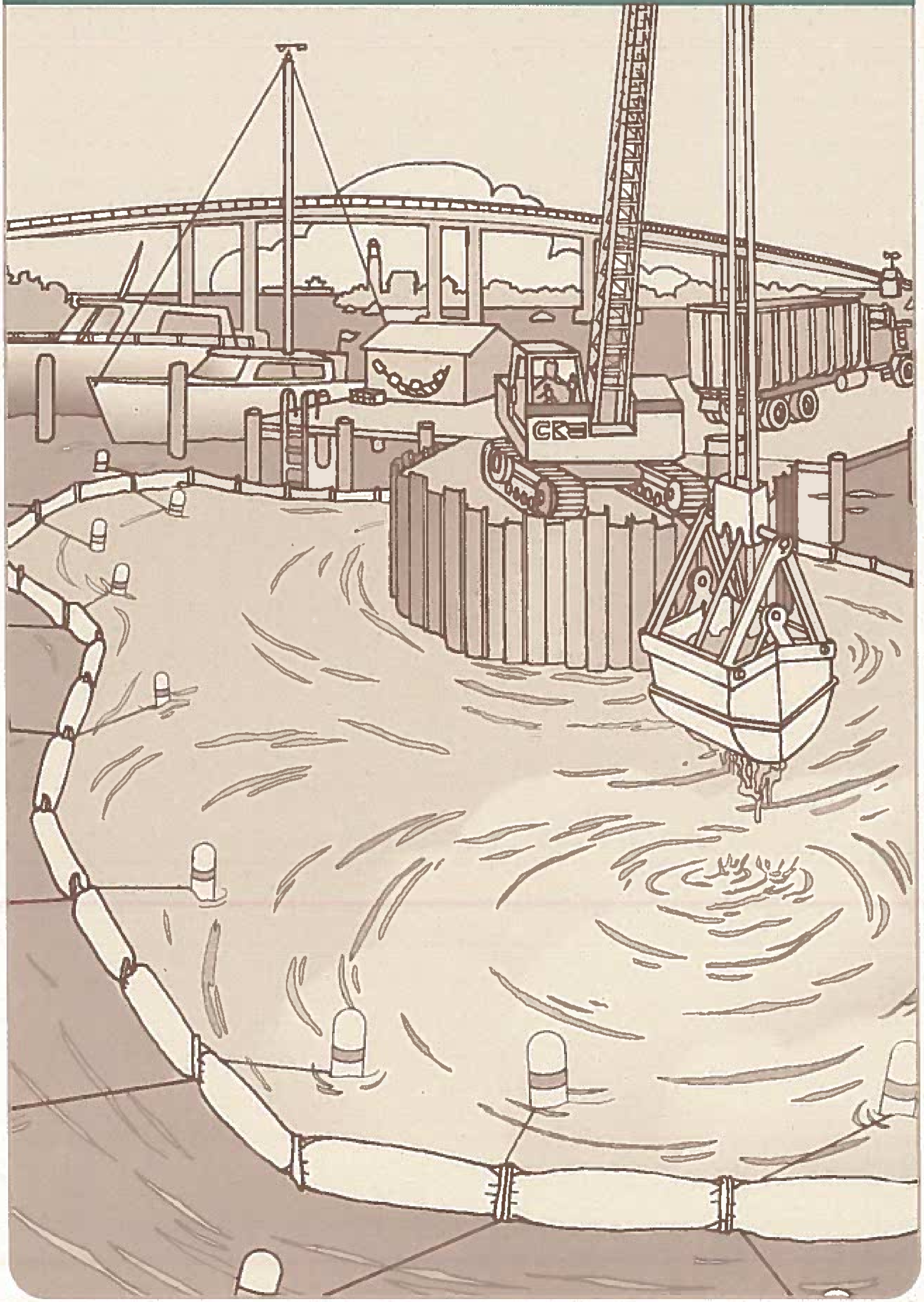
Specifications

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

Figure TC-1 Illustration of a Turbidity Curtain in Tidal Waters



Turbidity Curtain (TC)

Vegetated Filter (VF)

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.
- 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** or **Hay Bale Barrier**.

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. A 90% total suspended solids (TSS) removal efficiency rate 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. A 50% TSS removal rate can be expected over a period of time if design conditions of the filter deteriorate.

When planning to use existing vegetation it must be healthy, have a vigorous growth habit and be protected from damage by construction equipment.

When planning to establish a 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 haybale 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 greater 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 **Figure VF-1** 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.

5-12 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.

12-Tire Tracked Soils

Construction Entrance (CE)

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 off site onto 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 construction entrance is 50 feet, but where the soils subject to tracking contain less than 80% sand, then the minimum length of the construction entrance is 100 feet (see textural triangle in Appendix H). 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 the establishment of 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 is 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.

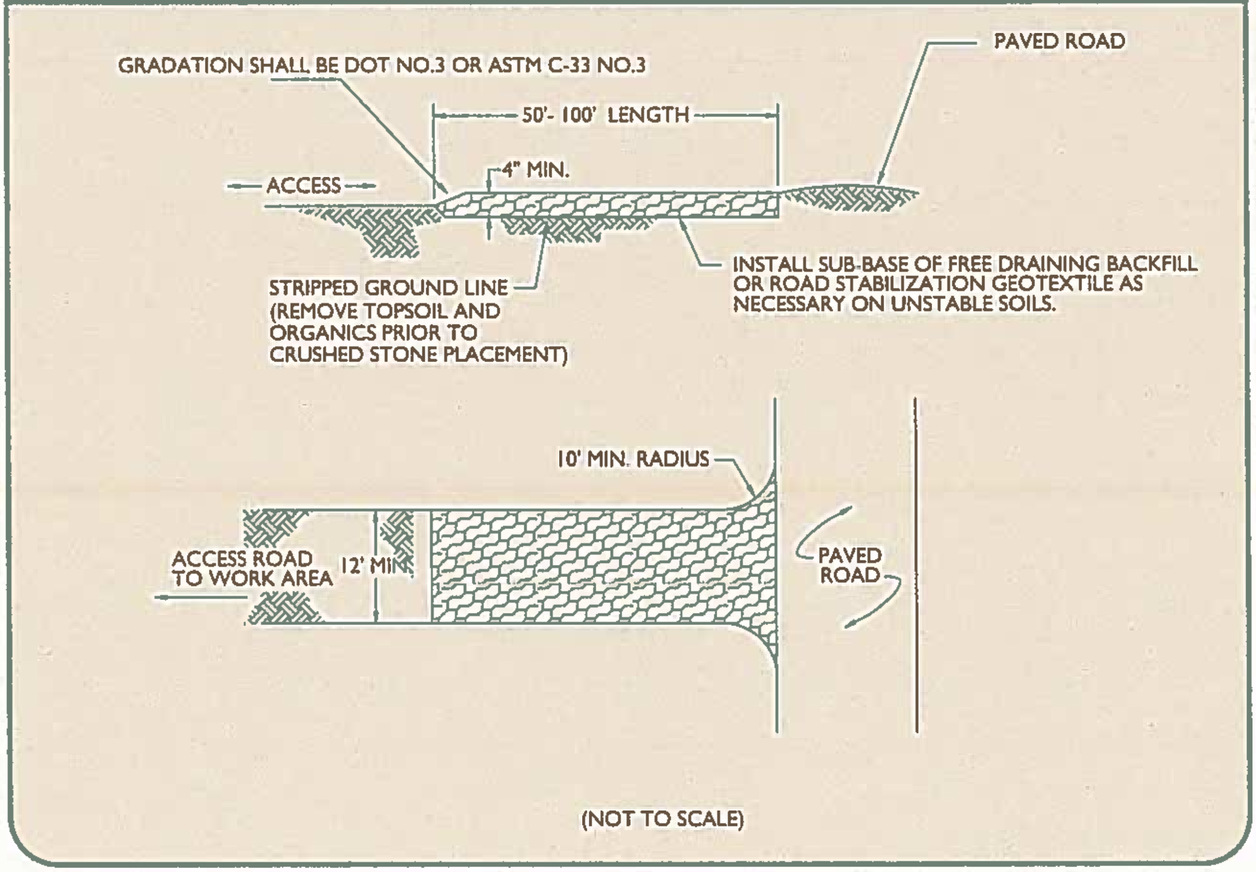
Specifications

Materials

Stone: Use angular stone sized according to the standards set by ASTM C-33, size No. 2 or 3, or DOT Standard Specifications section M.01.01, size #3. See **Figure CE-1** 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.

Figure CE-2 Diagram of Typical Construction Entrance



Source: USDA-NRCS

Construction Entrance (CE)

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 devises, 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.

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 wastewater.

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 unforseen onsite conditions or alternate methods available to the contractor.

continued on next page

Pump Intake And Outlet Protection (PuP)

Definition

Structures or other protective devices into which or on which intake and discharge hoses are placed 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.

Applicability

Wherever dewatering is required by means of pumping such as cofferdams, building foundations, utility line installation (or repair) and pond construction or rehabilitation.

Planning Considerations

There is no specific design for this measure. The pump intake protection shown in **Figure PuP-1** and **Figure PuP-2** illustrate basic design concepts which 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 PuP-3** illustrate basic design concepts which when implemented during dewatering operations reduces soil erosion and resuspension of sediments.

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 time that it takes to switch portable sediment storage tanks.

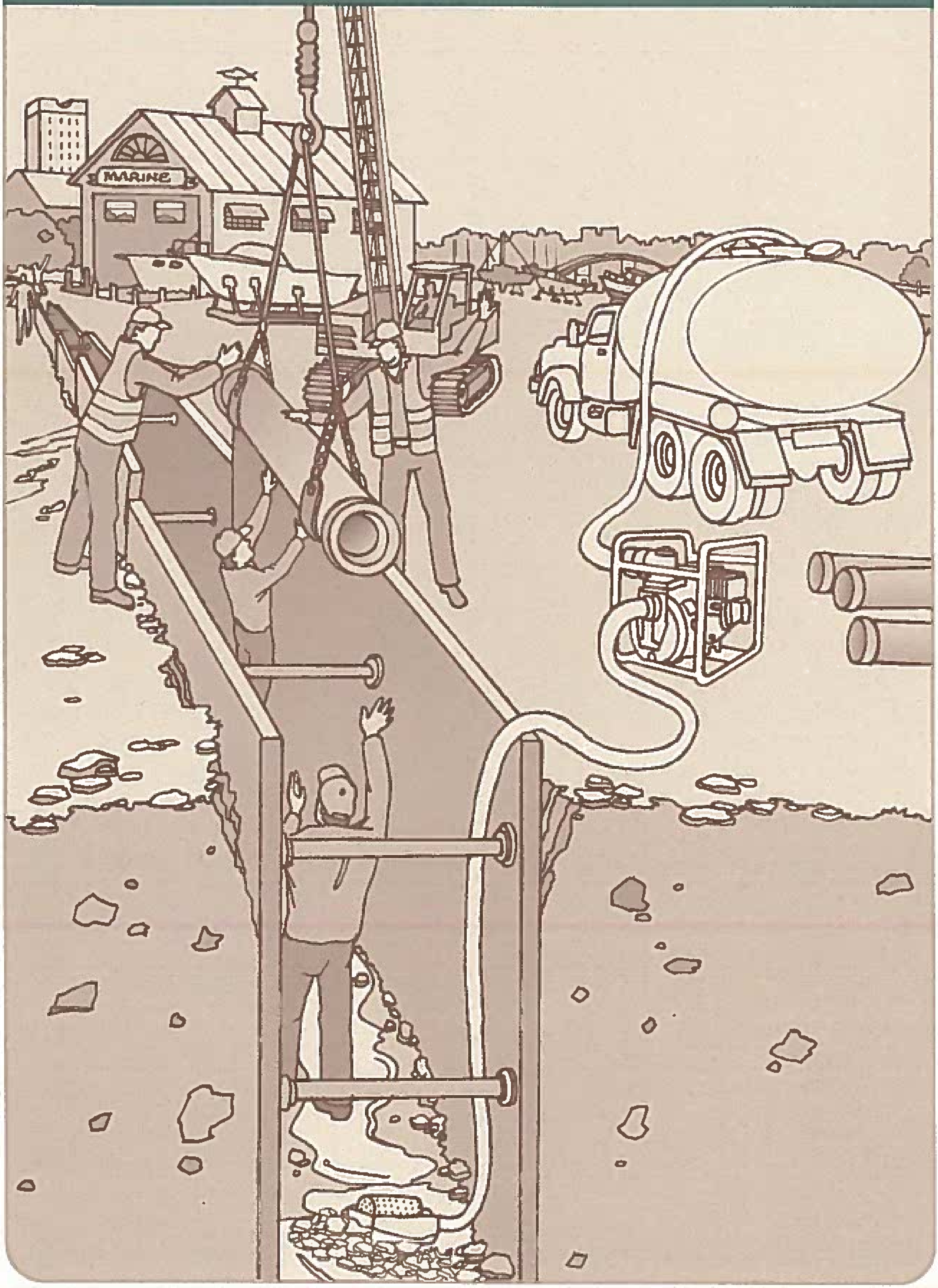
For dewatering trenches, cofferdams and foundation excavations the sump is typically excavated 2 feet or more below the grade of the proposed work.

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. 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 PuP-1** shows a typical sump and intake constructed of stone imbedded with a perforated stand pipe. 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. In some instances the prefiltration of discharge waters may be enough to reduce or eliminate the need for a dewatering basin or portable sediment tank. **Figure PuP-2** shows a typical sump and intake that calls for lining (rather than filling) the pumping

Figure PuP-2 Pump Intake Protection Using Sump with Strainer



Pump Intake and Outlet Protection (PuP)

13-Dewatering

Pumping Settling Basin (PSB)

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:

- *hay bale barriers shall meet those required in the* ***Hay Bale Barrier*** *measure.*
- *geotextile shall meet that required in the* ***Geotextile Silt Fence*** *measure, and*
- *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:

$$\text{Cubic feet of storage required} = \text{Pump Discharge Rate (g.p.m.)} \times 16$$

For sites where available storage is insufficient at the planned pumping rate, the maximum pumping rate is determined from the following formula:

$$\text{Pump Discharge Rate (g.p.m.)} = \frac{\text{Cubic feet of storage available}}{16}$$

In calculating the capacity, include the volume available from the floor of the basin to the crest of the outlet control.

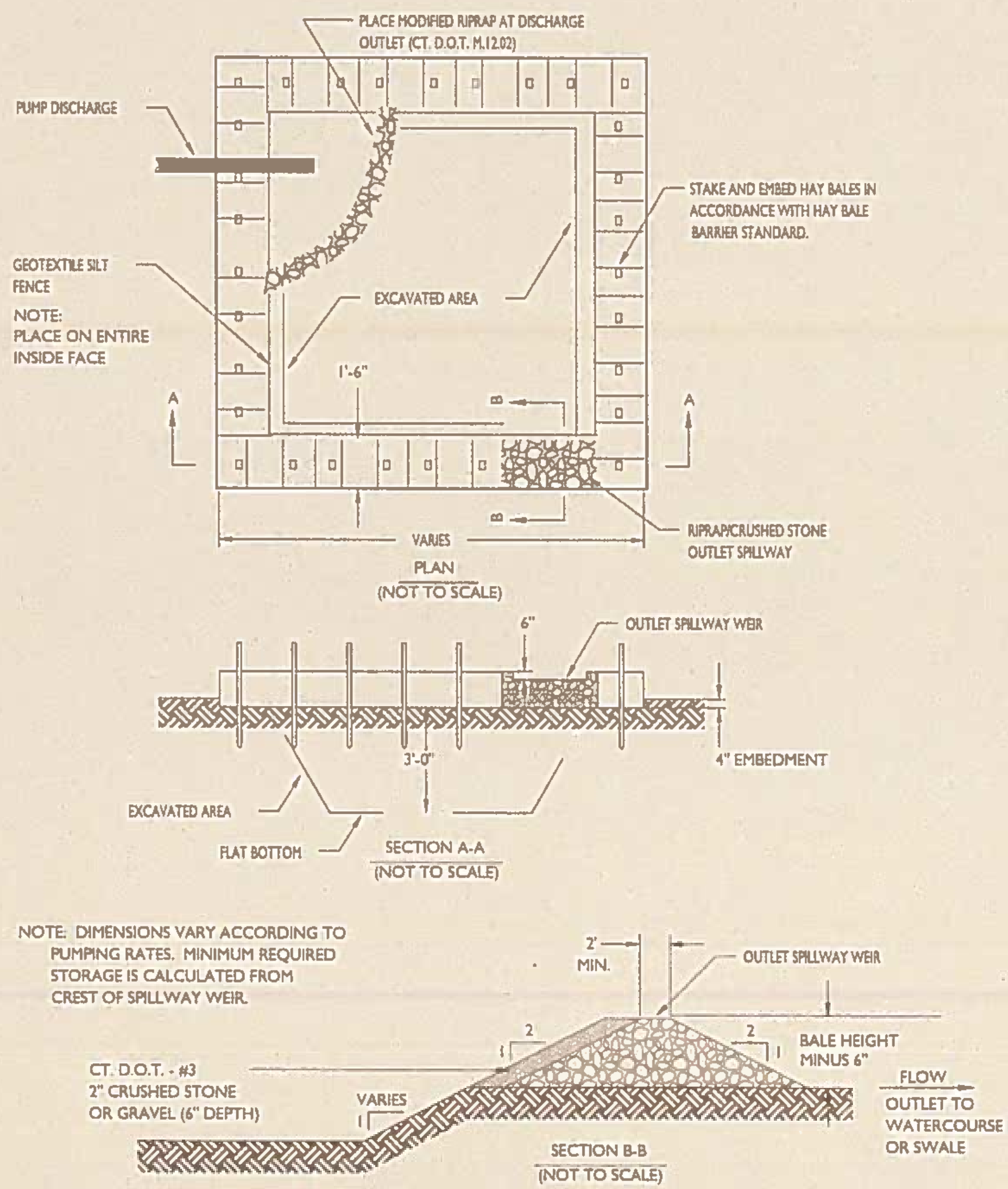
Location
Locate the pumping settling basin on the site such that surface water is directed away from the pumping settling basin (See **Temporary Water Diversion** measure).

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 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: Consist of an above ground enclosure created by a **Hay Bale Barrier**. See **Hay 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 hay 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 enter into critical area such as a wetland, watercourse, street or storm drainage system. (See **Figure PSB-1**).

Figure PSB-2 Example of Type II Dewatering Settling Basin



Source: USDA-NRCS

Portable Sediment Tank (PST)

Definition

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.

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 the sediment laden water to an approved location.

Planning Considerations

Typically used with cofferdam dewatering associated with bridge repair work, utility work or in the redevelopment of urban areas.

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. 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.

Location

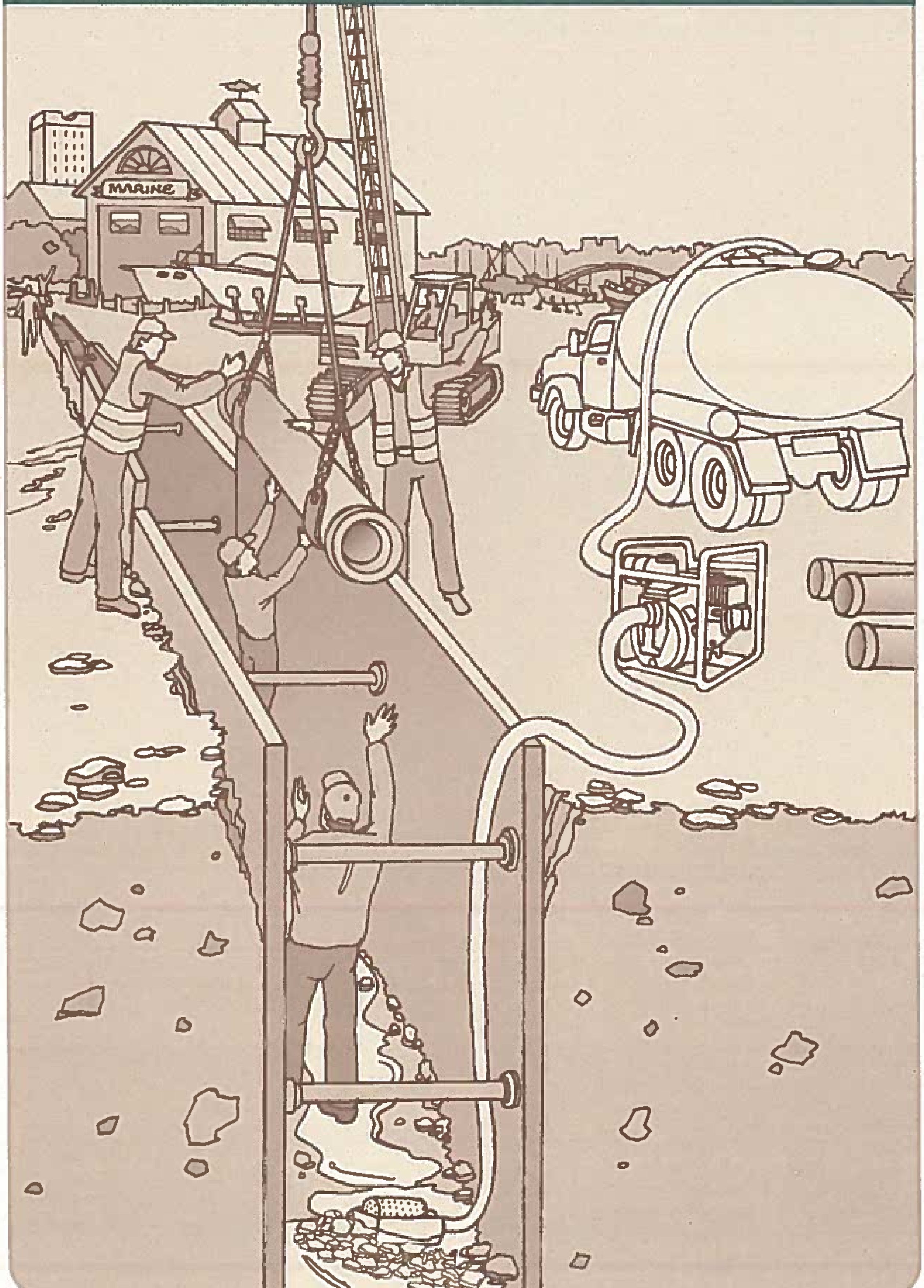
Locate non-portable sediment tanks for ease of clean-out and disposal of the trapped sediment, and to minimize the interference with construction activities and pedestrian traffic.

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 (g.p.m.) x 16*

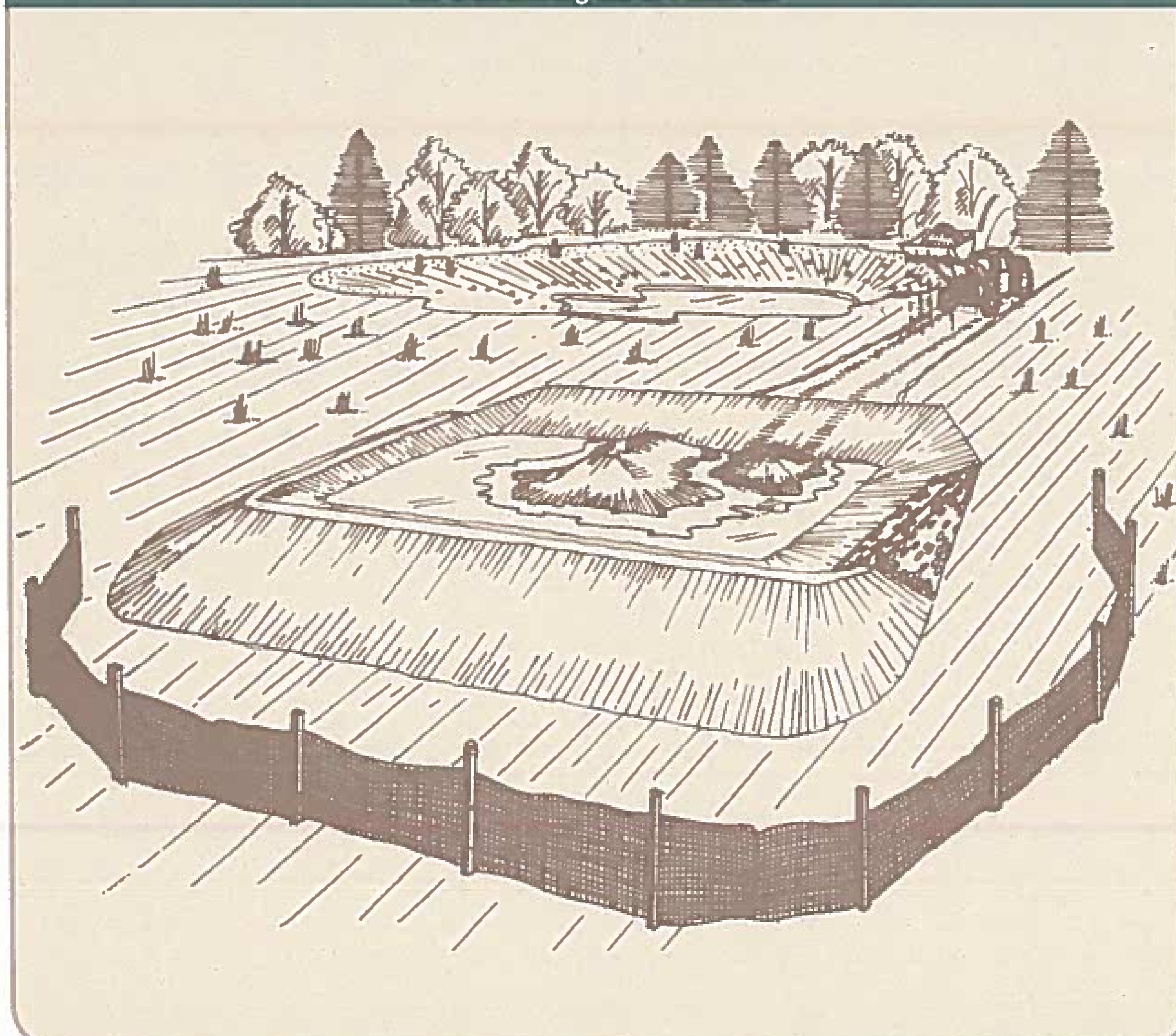
Figure PST-1 Portable Sediment Tank In Operation



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.

After dewatering operations are completed, regrade the containment area to a finished grade and stabilize in accordance with the planned use of the area .

Figure DW-1 Example of Non-Engineered Dewatering Containment Area for Dewatering Earth Materials



Appendices

Appendix A

Model Soil Erosion and Sediment Control Regulations for Land Development

Introduction

These are the same model regulations that were first prepared in 1985 by the Soil Erosion and Sediment Control Task Force's Model Regulations Subcommittee under the direction of the Connecticut Council on Soil and Water Conservation, to help municipalities comply with Public Act 83-388 entitled "An Act Concerning Soil Erosion and Sediment Control" now codified in sections 22a- 315 of the Connecticut General Statutes. This act amended sections 8-2, 8-13d and 8-25 of the Connecticut General Statutes. Connecticut towns were required to be in compliance with these amendments on or before July 1, 1985.

Although all towns have implemented changes to their regulations under the Act, these model regulations continue to be incorporated into these Guidelines to meet the requirements of the Act. Following the model regulations are the original notes provided with the model regulations to provide historical information as to the advice given at the time of enactment.

Model Soil Erosion and Sediment Control Regulations for Land Development

Section 1. Definitions

1.1. "Certification" means a signed, written approval by the ____________________ Commission (its designated agent or the ____________________ County Soil and Water Conservation District) that a soil erosion and sediment control plan complies with the applicable requirements of these regulations.

1.2. "Commission" means the ____________________ Commission of the Town (or City) of ____________________.

1.3. "County Soil and Water Conservation District" means the ________________ County Soil and Water Conservation District established under subsection (a) of section 22a-315 of the General Statutes.

1.4. "Development" means any construction or grading activities to improved or unimproved real estate.

1.5. "Disturbed area" means an area where the ground cover is destroyed or removed leaving the land subject to accelerated erosion.

1.6. "Erosion" means the detachment and movement of soil or rock fragments by water, wind, ice or gravity.

1.7. "Grading" means any excavating, grubbing, filling (including hydraulic fill) or stockpiling of earth materials or any combination thereof, including the land in its excavated or filled condition.

1.8. "Inspection" means the periodic review of sediment and erosion control measures shown on the certified plan.

1.9. "Sediment" means solid material, either mineral or organic, that is in suspension, is transported, or has been moved from its site of origin by erosion.

1.10. "Soil" means any unconsolidated mineral or organic material of any origin.

1.11. "Soil Erosion and Sediment Control Plan" means a scheme that minimizes soil erosion and sedimentation resulting from development and includes, but is not limited to, a map and narrative.

Section 2. Activities Requiring a Certified Erosion and Sediment Control Plan

A soil erosion and sediment control plan shall be submitted with any application for development when the disturbed area of such development is cumulatively more than one-half acre.

Section 3. Exemptions

A single family dwelling that is not a part of a subdivision of land shall be exempt from these soil erosion and sediment control regulations.

Section 4. Erosion and Sediment Control Plan

4.1. To be eligible for certification, a soil erosion and sediment control plan shall contain proper provisions to adequately control accelerated erosion and sedimentation and reduce the danger from storm water runoff on the proposed site based on the best available technology. Such principles, methods and practices necessary for certification are found in the <u>Connecticut Guidelines for Soil Erosion and Sediment Control</u> (1985) as amended. Alternative principles, methods and practices may be used with prior approval of the Commission.

4.2. Said plan shall contain, but not be limited to:

- A. A narrative describing:
  1. the development;
  2. the schedule for grading and construction activities including:
     - a. start and completion dates;
     - b. sequence of grading and construction activities;
     - c. sequence for installation and/or application of soil erosion and sediment control measures;
     - d. sequence for final stabilization of the project site;

Section 8. Inspection

Inspections shall be made by the Commission or its designated agent during development to ensure compliance with the certified plan and that control measures and facilities are properly performed or installed and maintained. The Commission may require the permittee to verify through progress reports that soil erosion and sediment control measures and facilities have been performed or installed according to the certified plan and are being operated and maintained.

Original Notes on Model Regulations

The purpose of these notes is to provide municipalities with further insight, explanation and guidance on the Model Regulations. The notes emphasize administrative procedures which can be helpful in implementing these regulations. These notes also focus on other important issues concerning management of erosion and sedimentation not specifically referred to within the state law. It may be prudent to discuss these issues with your town attorney prior to promulgation of the regulations by the town to ensure that the regulations conform with the Law. The notes first address the Model Regulations specifically by sections and then on a general basis.

Section 1. Definitions

Other definitions may be deemed appropriate to add to this section dependent on local circumstances.

If erosion and sediment control provisions are to be incorporated directly into the existing regulations (as compared to adoption of the "stand alone" document), then the definitions section in the existing regulations will require a revision to add the model's definitions. Remember to retain proper alphabetical order.

Also check for conflicting or inconsistent definitions in the existing and in the model regulations. Revise as needed.

Section 2. Activities Requiring a Certified Erosion and Sediment Control Plan and Section 3. Exemptions

Municipalities that already have existing erosion and sediment control regulations should review those regulations for conformity with the new law with special attention given to the requirements contained in Sections 2 and 3 of the Model Regulations.

It is suggested that the contents of these sections be included in any use and/or zone tables and in any descriptions of the permitted uses and/or various zones which may appear within the existing regulations.

Based upon the legislative history of PA 83-388, agricultural activities are deemed exempt from erosion and sediment control regulations.

The Law exempts the development of an individual residential building lot for residential purposes from the erosion and sediment control regulations. However, it is not the intent of the Law to allow a fragmented parcel- by-parcel development of a subdivision without the required erosion and sediment control provisions. Therefore, subdivision approvals should provide for erosion and sediment control during development.

Section 4. Erosion and Sediment Control Plan

4.1. (Basis for Plan)

The applicant has the responsibility to develop his control plan based on the best available technology. The Connecticut Guidelines for Soil Erosion and Sediment Control publication is specifically referenced as the current state-of-the-art source and readily available from the Department of Environmental Protection's Natural Resources Center. However, there are other acceptable publications which contain the principles, methods and practices for certified plans.

The phrase, "reduce the danger from storm water runoff" relates to erosion only, for example, downstream streambank conditions. Towns have always had the authority to require storm water management provisions. Some towns already do this and it may be the timely thing to do along with erosion and sediment control. However, PA 83-388 does not mandate storm water management. Agencies which can assist towns in developing storm water management regulations are the Department of Environmental Protection, county soil and water conservation districts, USDA Soil Conservation Service, University of Connecticut Cooperative Extension Service and regional planning agencies.

4.2.A (Narrative)

The narrative is extremely useful to the certifier, inspector, enforcer, developer and developer's contractor. Erosion and sediment control is a procedure often calling for written descriptions to explain the basis for any proposed plan, detailed control measures, and interactions such as timing of earth moving or stabilization.

The narrative is an appropriate place to include provisions for contingency plans if unforeseen erosion or sedimentation problems arise. Contingency plans may be handled by requiring statements within the narratives that identify the permittee's (and the contractor's) responsibilities to deal with unforeseen erosion and sedimentation problems as they arise. It is the developer's responsibility to anticipate unforeseen erosion or sedimentation problems and to have the capability to deal effectively with such problems.

Other components of a good narrative would include self-monitoring and active maintenance procedures. A good erosion and sediment control plan will identify someone (engineer, contractor, etc.) responsible for monitoring control measures with whom an inspector representing the town would be able to communicate routinely. On-site operational and maintenance procedures for erosion and sediment control measures should be required on a daily basis.

requirement provisions to be stated in the regulations. The one used depends upon the regulations being amended. The first, 7.1, is only legal for subdivision or planned unit development regulations. The second, 7.1, is only legal for zoning's site plan review regulations and is also conditional to that portion of the modified site plan.

Bonding should be effected according to the normal bonding procedures established by each municipality, but may not have to be implemented at the time of soil erosion and sediment control plan certification. Bonding at the time building permits are requested may be preferable.

Establishing who (i.e., town engineer) is to recommend "the estimated costs required to control soil erosion and sedimentation" may be stated in the regulations.

Section 8. Inspection

Although the inspection section is brief, it is very important. Inspection is mandated by state law and should be seriously accomplished to protect the town's liability.

The second sentence of 8.1, beginning with "The Commission may require ...", can be considered an "as-built" requirement that can be used on large, complex or sensitive developments. Progress reports are not necessary for all control plans, but in special instances can be used to guarantee compliance by the applicant. Normally, the applicant would be expected to pass this responsibility on to the consultant who prepared the control plan.

Inspection records or reports should be kept in the event of possible enforcement action. Types of information for such inspection records include: inspection dates, weather conditions, people spoken to on-site, what was looked at, discussed, and agreed upon. Additionally, inspection reports may include drawings, sketches, or photographs of relevant features or problem areas.

Check the existing regulations for inspection and investigation provisions which grant access to the development site. Consider such provisions here if they do not exist in the regulations.

Other Notes

Delegation of the certifying authority responsibilities may be possible for a municipality, especially where existing erosion and sediment control mechanisms are already in place. It is recommended to consolidate past mechanisms with new requirements, especially the certification and inspection responsibilities.

Any **Preapplication** process for development that may be ongoing between the town and the potential applicant should consider including the county soil and water conservation district as a source of resource information concerning soil erosion and sediment control.

Amendments to an existing certified soil erosion and sediment control plan may be sought at a later date. Adherence to the plan amendment provisions already appearing in existing regulations will need to be enforced. The Act does not contain provision for amendment to certified plans. It is recognized that municipalities already deal with minor technical changes to approved plans in a variety of ways. Each municipality should consider including in their regulations a formal erosion and sediment control amendment provision for substantive changes. However, experience will bear out that unforeseen circumstances during construction will necessitate technical changes and contingency measures.

Enforcement proceedings by a municipality can be kept to a minimum if the municipality insists that carefully prepared and well-thought-out soil erosion and sediment control plans be submitted, properly reviewed for certification and implemented. Substandard plans must be rejected or denied, and certified plans, when implemented, must be inspected periodically by the town enforcement agent. For significant development applications, bonding and the requirement for as-built soil erosion and sediment control measures have been shown to increase compliance with environmental laws.

Inland wetlands authorities can independently exercise enforcement action when soil erosion and sedimentation impacts upon their regulated areas. The State of Connecticut, Department of Environmental Protection can ultimately enforce situations that pollute the waters of the state.

Original Model Regulation Subcommittee

Tom Mocko, Chairman (Connecticut Council on Soil and Water Conservation)
Robert Fried, attorney (Connecticut Association of Soil and Water Conservation Districts) Geoffrey Colegrove (Connecticut Association of Regional Planning Agencies)
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James Gibbons (University of Connecticut, Cooperative Extension Service)
Katie Feidelson (Connecticut Conference of Municipalities)
David Russell (Council of Small Towns)
Barry Cavanna (U.S. Department of Agriculture, Soil Conservation Service)
Thomas Byrne, attorney (Connecticut Federation of Planning and Zoning Agencies)
Frank B. Connolly (Connecticut Town and City Management Association)
Barbara Johnston (Connecticut Association of Conservation and Inland Wetlands Commissions)
Tom Odell (Connecticut Association of Conservation and Inland Wetlands Commissions)

Appendix B

The Erosion and Sediment Control Act (Sections 22a-325 through 22a-329) Public Act 83-388

Summary

The Act establishes a public policy that recognizes soil erosion resulting from the development of land as a serious problem, and the sediment generated by this erosion as polluting the land, water and air. The policy requires improved and broadened erosion and sediment control activities that will consist of a coordinated control program to reduce the danger from storm runoff, minimize nonpoint sediment pollution, and conserve and protect land, water, air, and other environmental resources. (C.G.S section 22a-326.)

Definitions are provided for the terms Council, disturbed area, erosion, inspection, soil erosion and sediment control plan, regulations, sediment and soil. (C.G.S section 22a-327.)

The Council on Soil and Water Conservation is given the responsibility to develop and maintain guidelines that will outline methods and technology for controlling erosion and sedimentation. These guidelines are to be made available to the public by the Department of Environmental Protection and the Soil and Water Conservation Districts. (C.G.S section 22a-328.)

All municipalities are required to develop regulations that require erosion and sediment control plans for development projects which will disturb an area larger than one-half acre. Erosion and sediment control plans are not required for land disturbances of one-half acre or less, or for the construction of a single-family house that is not part of a subdivision. The regulations must provide for certification of the plans for adequacy and for inspection of the measures being installed. (C.G.S section 22a-329.)

Section 8-2 (Zoning), subsection (b) of section 8-13d (Planned Unit Development) and subsection (a) of section 8-25 (Municipal Planning Commission) of the General Statutes are revised by this act to make erosion and sediment control mandatory rather than optional. Municipalities are given an implementation dated of July 1, 1985. (C.G.S section 22a-329 .)

For further information see other statutes.

Connecticut General Statutes, Revised to 1997

Sec. 22a-325. Short title: Soil Erosion and Sediment Control Act. Sections 22a-325 to 22a-329, inclusive, shall be known and may be cited as the "Soil Erosion and Sediment Control Act".

(P.A. 83-388, S. 1.)

Sec. 22a-326. Legislative finding; policy of the state. The General Assembly finds that soil erosion on land being developed is a serious problem in Connecticut, that sediment is a source of pollution, that rapid changes in land use from agricultural and rural to nonagricultural and urban and the construction of residential, industrial and commercial development and land-disturbing activities associated with development have accelerated soil erosion and sediment deposition resulting in water pollution and damage to residential, agricultural, industrial and recreational land uses, to fish and wildlife and to other resources. It is, therefore, declared to be the policy of the state to strengthen and extend its erosion and sediment control activities and programs and to establish and implement, through the Council on Soil and Water Conservation, soil and water conservation districts, the municipalities and the Commissioner of Environmental Protection, a state-wide coordinated erosion and sediment control program which shall reduce the danger from storm water runoff, minimize nonpoint sediment pollution from land being developed and conserve and protect the land, water, air and other environmental resources of the state.

(P.A. 83-388, S. 2.)

Sec. 22a-327. Definitions. As used in sections 22a-325 to 22a-329, inclusive: (1) "Council" means the Council on Soil and Water Conservation established under subsection (c) of section 22a-315; (2) "Disturbed area" means an area where the cover is destroyed or removed leaving the land subject to accelerated erosion; (3) "Erosion" means the detachment and movement of soil or rock fragments by water, wind, ice and gravity; (4) "Inspection" means the periodic review of sediment and erosion control measures shown on the certified plan; (5) "Soil erosion and sediment control plan" means a scheme that minimizes soil erosion and sedimentation and includes, but is not limited to, a map and 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; (6) "Regulations" mean any regulations adopted by a municipality pursuant to sections 8-2 and 8-25; (7) "Sediment" means solid material, either mineral or organic, that is in suspension, is transported, or has been moved from its site of origin by erosion; (8) "Soil" means any unconsolidated mineral and organic material of any origin.

Appendix C

Definitions and Abbreviations

Abbreviation / Term	Definition
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 abreviated as Ac.).
access road	A vehicular travelway 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 DOT Standard Specification Section M.01.01 for gradation of aggregate.
ANSI	American National Standards Institute.
anti-seep collars	Collars around pipe conduits to inhibit seepage and piping of soils along the conduit.
aquifer	A porous water-bearing formation of permeable rock, sand or gravel capable of yielding economically significant quantities of groundwater.
apron	A lining extending downstream from a hydraulic structure to prevent erosion and scour.
artesian	A ground water condition where a confined aquifer transfers static water pressures over some distance and can be under pressure.
ASTM	American Standards of Testing and Materials.
auxiliary spillway	See emergency spillway.
balled & burlapped	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.
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 ground water 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.

Appendix C

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 hydraulic head, or for retention of soil, rock or other debris.
DEP	Connecticut Department of Environmental Protection.
deposition	Transported material deposited because of decreased transport capacity of water or wind.
detention basin	An impoundment made by constructing a dam or an embankment (embankment detention basin), or by excavating a pit or dugout (excavated detention basin) for the purpose of temporarily detaining stormwater runoff to control its rate of flow. Basins resulting from both excavation and embankment construction are classified as embankment detention basins where the depth of water impounded against the embankment at emergency spillway elevation is three feet or more.
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 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, 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.
DOT	Connecticut Department of Transportation.
DOT #3 stone	A gradation of aggregate found in DOT Standard Specifications Section M.01.01.
DOT <u>Drainage Manual</u>	Connecticut Department of Transportation <u>Hydraulics and Drainage Manual</u>, dated October 2000.
DOT Standard Specifications	Document entitled "State of Connecticut Department of Transportation, Standard Specifications for Roads, Bridges and Incidental Construction", as revised.
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.
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.

ment 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.

hay bale barrier A temporary sediment filter consisting of a row of entrenched and anchored bales of hay or straw used to intercept and detain small amounts of sediment from small disturbed areas.

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.

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.

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 An outlet for berms, diversions and other water conveyances consisting of an excavated depression with a broad stable point of discharge constructed at zero grade across a slope.

liming The application of lime to reduce soil acidity and to supply calcium for plant growth.

m Meters.

major storm A storm predicted by the National Office of Atmospheric Administration (NOAA) 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 (see permanent lined waterway, vegetated waterway and subsurface drain measures).

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.

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.

postconstruction stormwater management Controlling and providing 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.

principal spillway An earthen or concrete or pipe structure whose elevation determines the water level in an impoundment.

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 sediments 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 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 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.

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 surface water storage facility that retains stormwater and runoff and promotes ground water infiltration.

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.

riprap A permanent, erosion-resistant ground cover of large, loose, angular stone.

soil amendment	Any material, such as lime, compost or fertilizer, that is worked into the soil to make it more amenable to plant growth.
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.
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 ft^2	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.
stilling basin	An open structure or excavation at the foot of an overfall, drop or spillway to reduce the energy of the descending stream.
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 a fall of rain or snow; waters consisting of precipitation runoff.
stormwater runoff	The water and associated material draining into streams, lakes or sewers as a result of a rain storm.
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 ground water.
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 storm water run-off 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 across section and stays in suspension of 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 storm water. It is commonly heavily vegetated and is normally without flowing water.
SWCD	Soil and Water Conservation District.
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 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.

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 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 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 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.
watertable	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 conducting 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.
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).

Appendix D

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Appendix E

Directory of Related Agencies (Including Useful Internet Web Pages)

Federal Agencies

US Army Corps of Engineers, New England District
Attention: CENAE-OD-R, 696 Virginia Road, Concord, MA 01742-2751
Tel.: (978) 318-8502 and toll free (800) 343-4789, Fax: (978) 318-8303
Web Page: http://www.usace.army.mil/public.html (includes information on regulatory/permitting programs)

US Environmental Protection Agency, Region I
1 Congress Street Suite 1100, Boston, MA 02114-2023
Tel.: (617) 918-1111 and toll free within Region 1: (888) 372-7341, Fax: (617) 565-3660
Web Page: http://www.epa.gov/region01/

USDA Natural Resources and Conservation Service
Web Page: http://www.nrcs.usda.gov/,

NRCS CT State Office
344 Merrow Road Suite A, Tolland, CT 06084
Tel.: (860) 871-4011 or (860) 875-6928, Fax: (860) 871-4054

NRCS Brooklyn Service Center
Agricultural Center, 139 Wolf Den Road, Brooklyn, CT 06234
Tel.: (860) 774-8397, Fax: (860) 774-7009

NRCS Norwich Service Center
Yantic River Plaza, 238 West Town Street, Norwich, CT 06360
Tel.: (860) 887-3604, Fax: (860) 887-4082

NRCS Torrington Service Center
1185 New Litchfield Street, Torrington, CT 06790
Tel.: (860) 626-8258, Fax: (860) 626-8850

NRCS Wallingford Service Center
North Farms Executive Park, 900 Northrop Road, Wallingford, CT 06492
Tel.: (203) 269-7509, Fax: (203) 294-9741

NRCS Windsor Service Center
627 River Street, Windsor, CT 06095
Tel.: (860) 688-7725, Fax: (860) 688-0083

Connecticut State Agencies

Web Page: http://www.state.ct.us/ (Identifies a single point of entry for public access to all of the official information, programs and services provided on the Internet by the three branches of Connecticut state government: Executive, Judicial and Legislative, including search engines for licenses and permits issued by various state agencies and a telephone directory listing phone numbers by agency and staff name.)

CT Agricultural Experiment Station
Web Page: http://www.caes.state.ct.us/

New Haven Laboratories
123 Huntington Street, P.O. Box 1106, New Haven, CT 06540-1106
Tel.: (203) 974-8500, Toll Free in CT: 1-877-855-2237, Fax: (203) 974-8502

Valley Laboratory in Windsor
153 Cook Hill Road, P.O. Box 248, Windsor, CT 06095
Tel.: (860) 683-4977, Fax: (860) 683-4987

Lockwood Farm
890 Evergreen Avenue, Hamden, CT 06518
Tel.: (203) 974-8618

CT Council on Soil and Water Conservation
c/o DEP Bureau of Water Management Planning & Standards Division
79 Elm Street Hartford, CT 06106.

CT Department of Public Utility Control
10 Franklin Square, New Britain, CT 06051
Tel.: (860) 827-2801 and for Toll-Free in CT Consumer Assistance (1-800) 382-4586, Fax: (860) 827-2613
Web Page: http://www.state.ct.us/dpuc/

CT Cooperative Extension System
1380 Storrs Road, U-115, Storrs, CT 06269-4115
Tel.: (860) 486-6271, Fax.: (860) 486-6338, http://www.canr.uconn.edu/ces/

Fairfield County Extension Center
67 Stony Hill Road, Bethel, CT 06801-3056
Tel.: (203) 207-8440, Fax: (203) 207-3273

Windham County Extension Center
139 Wolf Den Road, Brooklyn, CT 06234-1729
Tel.: (860) 774-9600, Fax: (860) 774-9480

Middlesex County Extension Center
1066 Saybrook Road, P.O. Box 70, Haddam, CT 06438-0070
Tel.: (860) 345-4511, Fax: (860) 345-3357

New Haven County Extension Center
305 Skiff Street, North Haven, CT 06473-4451
Tel.: (203) 407-3161, Fax: (203) 407-3176

New London County Extension Center
562 New London Turnpike, Norwich, CT 06360-6599
Tel.: (860) 887-1608, Fax: (860) 886-1164

Litchfield County Extension Center
843 University Drive, Torrington, CT 06790-2635
Tel.: (860) 626-6240

Tolland County Extension Center
24 Hyde Avenue, Vernon, CT 06066-4599
Tel.: (860) 875-3331, Fax: (860) 875-0220

Hartford County Extension Center
1800 Asylum Avenue, West Hartford, CT 06117-2600
Tel.: (860) 570-9010, Fax: (860) 570-9008

CT Secretary of State
30 Trinity Street, Hartford CT 06106
http://www.sots.state.ct.us/

Concord – a computer program providing details on corporations registered to do business in Connecticut:
http://www.concord.state.ct.us/

State Register and Manual (known as the "Blue Book") containing many facts on state and local government:
http://www.sots.state.ct.us/#

CT Siting Council
10 Franklin Square, New Britain, CT 06051
Tel.: (860) 827-2935, Fax: (860) 827-2950
http://www.state.ct.us/csc/, e-mail address: siting.council@po.state.ct.us

CT State Library
http://www.cslib.org/psaindex.htm
Contains current copy of the Connecticut General Statutes, Public and Special Acts.

Non-State Agency Organizations
CT Soil and Water Conservation Districts

Fairfield County SWCD
69B Stony Hill Road, Bethel, CT 06801-9629
Tel.: (203) 774-6108.

Hartford County SWCD
627 River Street, Windsor, CT 06095-3003
Tel.: (860) 688-7725.

Litchfield County SWCD
1185 New Litchfield Street, Torrington, CT 06790
Tel: (860) 626-8258.

Appendix F

Matrix of Laws Which May Require Erosion and Sediment Control Implementation

Federal Authority	Threshold	Jurisdiction	Erosion and Sediment Control Requirements	Implementing Agency[1]
CLEAN WATER ACT, SECTION 404 of the FEDERAL CODE	Permit required for discharge of dredged or fill materials, including excavation activities, soil movement and placement of pilings.	Waters of the United States	Erosion and sediment control generally required as a condition of approval.	US Army Corps of Engineers
CLEAN WATER ACT, SECTION 401 of the FEDERAL CODE (Water Quality Certifications)	Any applicant for a federal license or permit for an activity which may result in a discharge into the navigable waters of the state, including all wetlands, watercourses, and natural and man-made ponds, must obtain a certification from DEP that such discharge will comply with the applicable provisions of the Federal Water Pollution Control Act and Connecticut's Water Quality Standards.	When federal 404 permits are required	Erosion and sediment control generally required as a condition of approval.	CTDEP
RIVERS AND HARBOR ACT, SECTION 10 of the FEDERAL CODE	Permit required for all activities that affect the course, location and capacity of navigable waters including all activities in, on, above or underneath navigable waters	Navigable waters[2] of the United States	Erosion and sediment control generally required as a condition of approval.	US Army Corps of Engineers
FEDERAL COASTAL ZONE MANAGEMENT ACT of 1972	Activities by federal agencies that directly affect the coastal zone, and activities affecting the coastal zone which require a federal license or permit are reviewed to ensure that they comply with and will be conducted in a manner consistent with Connecticut's federally approved Coastal Management Program.	The coastal zone is defined as the water within Connecticut's share of Long Island Sound and all of the land within the coastal communities.	Erosion and sediment control generally required to be incorporated into federal projects.	CTDEP
COASTAL ZONE ACT REAUTHORIZATION AMENDMENTS OF 1990 SECTION 6217 of the FEDERAL CODE	Specific management measures addressing soil erosion and sediment control which must be applied during the review of federal, state, municipal, and private development projects.	See Section 6217 Management Area[3]	Reduce erosion and, to the extent practicable, retain sediment onsite during and after construction, reduce the average annual total suspended solid (TSS) loadings by 80 percent, or reduce the postdevelopment loadings of TSS so that average annual TSS loadings are no greater than predevelopment loadings. erosion and sediment control plan required for all construction activities and activities on roads, highways, and bridges.	CTDEP, CTDOT, and municipal governments within the Section 6217 Management Area through their land use authorities
NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) of 1969	Requires full disclosure of potential environmental impacts associated with proposed federal actions.	Generally, the NEPA process occurs concurrently with the Section 404 reviews by the US Army Corps of Engineers	Soil erosion and sediment control plan may be required to avoid or minimize environmental impacts and/or may be a condition of approval.	Lead agency is usually the federal agency issuing the approval. Varies with the proposed action.

Appendix F

Matrix of Laws Which May Require Erosion and Sediment Control Implementation

State Authority	Threshold	Jurisdiction	Erosion and Sediment Control Requirements	Implementing Agency[1]
CONNECTICUT COASTAL MANAGEMENT ACT CGS § 22a-90 through 22a-112, inclusive	All regulatory programs of the DEP with permitting authority in the coastal area must be coordinated to ensure that the administration of those programs is consistent with the goals and policies contained in the CCMA. Each state department, institution, or agency responsible for the primary recommendation or initiation of actions within the coastal boundary which may significantly affect the environment shall ensure that such actions are consistent with the goals and policies contained in the CCMA.	The coastal area is defined as the water within Connecticut's share of Long Island Sound and all of the land within the coastal communities listed below. The coastal boundary is defined as a continuous line delineated within the coastal area on the landward side by the interior contour elevation of the one-hundred year frequency coastal flood zone, or a one thousand foot linear setback measured from the mean high water mark in coastal waters, or a one thousand foot linear setback measured from the inland boundary of tidal wetlands, whichever is farthest inland.	Erosion and sediment control plans generally required as a condition of approval.	CTDEP and local land use agencies
DIVERSION OF WATER CGS § 22a-365 through 22a-379	Prior to altering the flow of surface waters or withdrawing surface or ground water, a diversion permit must be obtained unless the activity is registered with Connecticut DEP or is exempted from diversion permit requirements. In general, any alteration of surface water flows from a watershed area of 100 acres or more and any withdrawal of water exceeding 50,000 gallons in a 24-hour period requires a permit.	Statewide	The owner/operator is required to employ best management practices to control storm water discharges, to prevent erosion and sedimentation, and to otherwise prevent pollution of wetlands and other waters of the State. Erosion and sediment control implementation generally required as condition of approval	CTDEP
AQUIFER PROTECTION AREAS ACT CGS § 22a-354b through 22a-354bb	Farm Resource Management Plans will be developed for farmland over major public water-supply aquifers.	Public water supply aquifers	Erosion control generally required as condition of approval	CTDEP
STREAM CHANNEL ENCROACHMENT LINE CGS § 22a-342 through 22a-349a	Prior to placing any encroachment or obstruction riverward of stream channel encroachment lines[5], a permit must be obtained.	Statewide - specific watercourses.	Erosion and sediment control implementation generally required as condition of approval.	CTDEP

Appendix F

Matrix of Laws Which May Require Erosion and Sediment Control Implementation

State Authority	Threshold	Jurisdiction	Erosion and Sediment Control Requirements	Implementing Agency[1]
PUBLIC UTILITY; CONTROL BY LOCAL AUTHORITIES, CGS § 16-235	Location approval of certain utility facilities not under the jurisdiction of the Connecticut Siting Council	Zoning commissions and inland wetland agencies may regulate and restrict the proposed location of certain public utility facilities	BMPs required, local review of site plans enabled	DPUC
JURISDICTION OF DPUC OVER ELECTRIC TRANSMISSION LINES CGS § 16-243	All electric line construction and reconstruction methods	Statewide	BMPs required	DPUC
MUNICIPAL & BUSINESS DEVELOPMENT PROJECTS CGS § 8-186 through 8-200b	Applications by towns for state financial assistance in economic development projects.	Statewide	All types of BMP's can be required, including erosion and sediment controls	Department of Economic & Community Development

Appendix G

Construction Network Scheduling

Background

A helpful tool to insure timely installation of sediment and erosion control measures on any construction project is a construction network schedule. There are basically two network scheduling systems.

PERT (Program Evaluation and Review Technique) was a program developed by the Navy for its Polaris development program. This Polaris program involved 250 prime contractors and 9000 subcontractors at one time. The primary thrust of PERT was toward time. In other words, "Getting the job done as fast as possible."

CPM (Critical Path Method) was developed by DuPont to combine money and time. This allowed the user to examine time - cost trade-offs to arrive at the fastest and most economical schedule.

Today these two programs have basically merged and are commonly referred to as CPM or Critical Path Method scheduling. There is no standardized format or program for CPM as yet, however, there is a generally accepted notation that is for the most part used by schedulers.

There are numerous computer programs available in the marketplace that range from use on mainframe to laptop computers. Since there is not a standardized program, there are currently no standardized computer programs. As a result, the reviewer may be subjected to a large variety of program outputs. If you understand the basic concepts of CPM scheduling, you can review and follow through almost all the various program outputs with a reasonable understanding of the proposed schedule.

Which Type of Scheduling to Use

Most contractors customarily use the bar (Gantt) chart, which is the forerunner of PERT and CPM. The Gantt chart was developed by scientist Henry Gantt around 1910, and is commonly referred to as the bar graph. The logic used to develop the bar chart is nearly the same logic used to develop a CPM chart. The method of displaying the logic is significantly different. Each chart, the bar chart and the CPM chart, has its application and its advantages and disadvantages.

The bar chart shows the schedule in a simple to understand format. It is usually developed to some scale which gives a visual impression of progress, although maybe not an accurate one. It is easy to determine what is to be done on a day-to-day- basis. Often milestones (completion targets) are shown on the bar chart. Milestones are an after the fact notice that you are behind schedule. On the bar chart, the items lying along the critical path are not readily apparent nor is the slack time. It is hard to judge the contractor's management effectiveness and schedule intent for items.

The CPM (Critical Path Method), though more complicated to the eye, is easy to adjust to after you have used it for a while. It normally does not have a scale. It provides a good overall management tool for the contractor. It provides a good visual of the critical path items and what items are being done concurrently. It allows the user to easily evaluate impact on other parts of the project if one item is delayed or accelerated.

Each scheduling method has its own application. For simple jobs with a small number of items and a simple straight forward construction sequence, the bar chart is adequate. For large jobs with numerous items that will be going on simultaneously, CPM scheduling is better. .

Remember that there is no one scheduling technique that is perfect for all occasions. Using more than one technique normally improves the management of the project. For example, a weekly CPM may be best for the overall management, while a daily CPM may be needed for the superintendent. For specific jobbers, a bar chart may be the best tool to use. Most computer programs have the capability to print out a CPM chart and a bar chart from the logic put into the program.

Construction Network Scheduling Using CPM

The CPM scheduling technique determines the critical path through the project. The critical path is the longest continuous path(s) along activity arrows through the project from beginning to end.

Consider CPM when:

- *Major expenditures of money, time, or materials are to be made.*
- *Project requires more than one department, company, or contractor.*
- *Project is subject to rigid time constraints.*
- *Close control is needed to ensure an orderly progress of the project.*
- *New type of work, or a project with some vaguely defined task is to be undertaken.*

What the CPM does for you:

- *Forces detailed planning, major decisions, and commitments at the beginning of the project.*
- *Provides a basis for logical and detailed planning.*
- *Provides a means to evaluate the project plan, to check for omissions, and to make improvements.*
- *Provides an extremely successful communication tool, and acts as a common point of reference.*
- *Points out possible problem areas in advance.*
- *Increases the probability of success in reaching the project objectives.*

Figure G-2 Sheet 2 of Critical Path Method Example

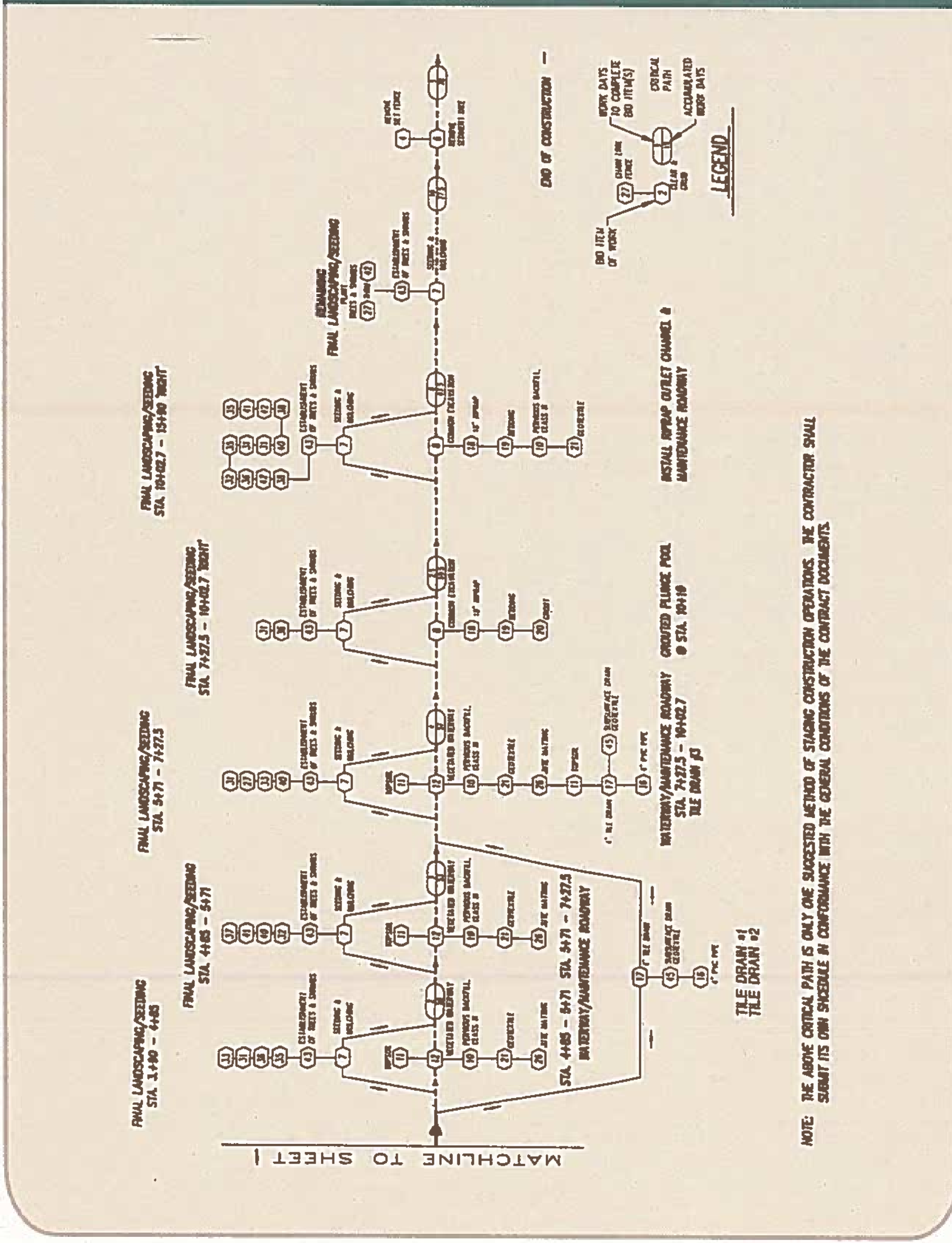
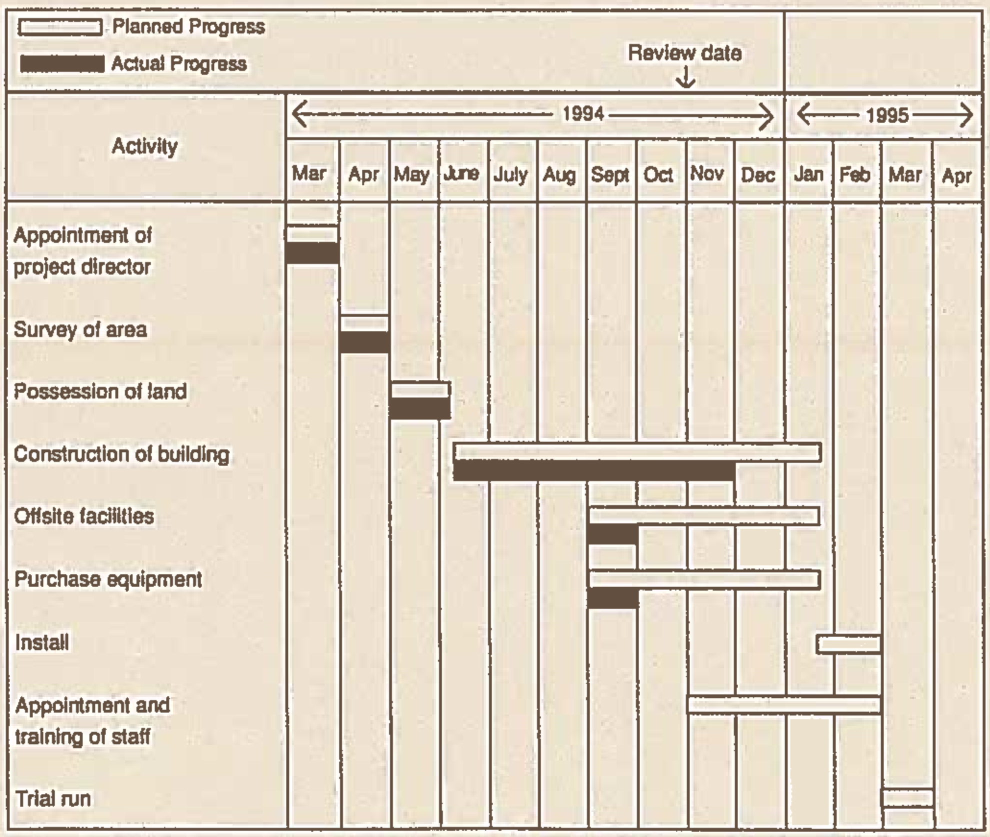


Figure G-3 Example of Gantt Chart



Appendix H
Soil Classification Systems

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 Appendix H-1**). 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.

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 in **Figure Appendix H-2**.

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 Appendix H-3** summarizes the classification description of each class.

Figure H-2 AASHTO Soil Classification System

Classification procedure: Using the test data, proceed from left to right in the chart. The correct group will be found by 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 A-7-5 or A-7-6 depending on the plastic limit. For plastic limit $w_p = w_l - I_p$ less than 30, the classification is A-7-6. For plastic limit $w_p = w_l - I_p$ greater than or equal to 30, it is A-7-5. NP means non-plastic.

	granular materials (35% or less passing no. 200 sieve)							silt-clay materials (more than 35% passing no. 200 sieve)				
	A-1		A-3	A-2				A-4	A-5	A-6	A-7	A-8
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 or A-7-6	
sieve analysis: % passing												
no. 10	50 max											
no. 40	30 max	50 max	51 min									
no. 200	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min	
characteristics of fraction passing no. 40:												
w_l: liquid limit				40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min	
I_p: plasticity index	6 max		NP	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min	
usual types of significant constituents	stone fragments gravel and sand		fine sand	silty or clayey gravel and sand				silty soils		clayey soils		peat, highly organic soils
general subgrade rating	excellent to good					fair to poor						unsatisfactory

Figure H-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% of Coarse Fraction Retained on No.4 Sieve	Clean Gravel	GW	Well-Graded Gravel, Fine to Coard 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 Sand
		Sand with Fines	SM	Silty Sand
			SC	Clayey Sand
Fine Grained Soils More Than 50% Passes 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 I
RUSLE

(Excerpted from USDA Agricultural Research Service National Sedimentation laboratory Web page http://www.sedlab.olemiss.edu/rusle/)

Introduction

The Revised Universal Soil Loss Equation (RUSLE) is an easily and widely used computer program that estimates rates of soil erosion caused by rainfall and associated overland flow.

This website is the "official" USDA-Agricultural Research Service (ARS) site for RUSLE. A copy of the current version of RUSLE, version 1.06b (Jan. 19, 2001), and associated data files can be downloaded from this site. Information is also provided on how to access RUSLE documentation, application guides for RUSLE, and help contacts. The current 1.06b version contains a calculation change for the soil moisture (SM) subfactor of the cover-management (C) factor. This change brings the SM calculation in line with that in the upcoming release of RUSLE 2.

RUSLE is used by numerous government agencies, and private organizations and individuals to assess the degree of rill and interrill erosion, identify situations where erosion is serious, and guide development of conservation plans to control erosion. RUSLE has been applied to cropland, rangeland, disturbed forest lands, landfills, construction sites, mining sites, reclaimed lands, military training lands, parks, land disposal of waste, and other land uses where mineral soil material is exposed to the erosive forces of raindrop impact and overland flow.

RUSLE has been developed and is maintained by the USDA-Agricultural Research Service (ARS) in cooperation with the USDA-Natural Resources Conservation Service (NRCS), USDI-Office of Surface Mining, Reclamation, and Regulation, USDI-Bureau of Land Management, Soil and Water Conservation Society, University of Tennessee, Purdue University, and University of Minnesota. Other users include the Department of Defense, U.S. Environmental Protection Agency, U.S. Department of Energy, USDA Forest Service, state agencies regulating land fills, surface mine companies, commercial firms that develop and retail erosion control products, private consultants that develop conservation plans and teach erosion control technology, and university faculty who teach RUSLE in the classroom. RUSLE is used in numerous foreign countries as well.

In the United States, the NRCS is the principal user of RUSLE and has implemented RUSLE in most of its local field offices. The NRCS is the major source for data needed to apply RUSLE and is the leading authority on field application of RUSLE.

About RUSLE

RUSLE uses a particular set of definitions, partly because the disciplines involved in soil erosion have not developed a standard set of definitions. Observance of RUSLE definitions is critical to getting accurate results.

RUSLE estimates average annual soil loss, expressed as mass per unit area per year, which is defined as the amount of sediment delivered from the slope length assumed in the RUSLE computation. RUSLE uses U. S., customary units and computes soil loss in units of tons/acre/year, which is the sediment load at the end of the slope length divided by the slope length. In that context, RUSLE is a sediment yield equation that describes sediment yield at the end of the RUSLE slope length.

The RUSLE slope length is defined according to the problem being addressed. The typical application for RUSLE is development of a conservation plan to protect the eroding portion of a landscape from being excessively degraded by soil erosion, that is, to protect the soil as a resource. In this application, slope length is defined as the distance from the origin of overland flow along the flow path to the point where deposition begins to occur on concave slopes or to a concentrated flow channel. In some cases, the slope can flatten to cause deposition and then steepen so that erosion occurs on the lower portion of the slope. Slope length passes through the depositional area when soil loss is being estimated on the lower portion of this slope.

Another application of RUSLE is to estimate the amount of sediment leaving a landscape that may cause off-site damages such as sedimentation in a road ditch. In this case, the slope length is the distance from the origin of overland flow through depositional overland flow areas to the first "concentrated flow" area that collects the overland flow to the point that the runoff can no longer be considered overland flow. Consideration outside of RUSLE must be given to deposition that occurs in concentrated flow areas, except terrace and diversion channels that are considered by RUSLE, to fully estimate sediment yield from a landscape area.

RUSLE also computes soil loss for individual slope segments. These soil loss values represent net sediment production for those segments, which is the net between detachment and deposition within the segment.

Detachment is the removal of soil particles from the soil mass, which adds sediment to the sediment load being transported downslope. Deposition is the transfer of sediment from the sediment load back to the soil mass. Local deposition is the deposition of sediment very near to the point where the sediment was detached. Deposition of sediment eroded from soil clods in nearby depressions formed by the clods is an example of local deposition. Remote deposition is the deposition of sediment far from its point of origin such as deposition in a terrace channel or on the toe of a concave slope.

Sediment load is a measure of the amount of sediment being transported downslope. Sediment yield, as used by RUSLE, is the sediment load at the end of the slope length, at the outlet of terrace diversion channels, or sediment basins that are considered by RUSLE.

The LS factor is a measure of sediment production. Deposition can occur on concave slopes where transport capacity of the runoff is reduced as the slope flattens. This deposition and its effect on sediment yield from the slope are considered in the supporting practices P factor.

C factor: The C factor for the effects of cover-management, along with the P factor, is one of the most important factors in RUSLE because it represents the effect of land use on erosion. It is the single factor most easily changed and is the factor most often considered in developing a conservation plan. For example, the C factor describes the effects of differences between vegetation communities, tillage systems, and addition of mulches.

The C factor is influenced by canopy (cover above but not in contact with the soil surface), ground cover (cover directly in contact with the soil surface), surface roughness, time since last mechanical disturbance, amount of live and dead roots in the soil, and organic material that has been incorporated into the soil. These variable change through the year as plants grow and senesce, the soil is disturbed, material is added to the soil surface, and plant material is removed. The C factor is an average annual value for soil loss ratio, weighted according to the variation of rainfall erosivity over the year.

The average annual distribution of erosivity during a year varies greatly with location. In the US, erosivity is nearly uniform throughout the year in the mid-south region, is concentrated in the late spring in the western corn belt, and is concentrated in late fall and early winter in the Pacific coast region.

Soil loss ratio is the ratio of soil loss from a given land use to that from the unit plot at a given time. RUSLE computes soil loss ratio values as they change through time with each half month period using equations for subfactors related to canopy, ground cover, roughness of the soil surface, time since last mechanical disturbance, amount of live and dead roots in the upper soil layer, amount of organic material incorporated into the soil, and antecedent soil moisture in the Northwest Wheat and Range Region.

P factor: The supporting practice P factor describes the effects of practices such as contouring, strip cropping, concave slopes, terraces, sediment basins, grass hedges, silt fences, straw bales, and subsurface drainage. These practices are applied to support the basic cultural practices used to control erosion, such as vegetation, management system, and mulch additions that are represented by the C factor.

Supporting practices typically affect erosion by redirecting runoff around the slope so that it has less erosivity or slowing down the runoff to cause deposition such as concave slopes or barriers like vegetative strips and terraces. The major factors considered in estimating a P factor value include runoff rate as a function of location, soil, and management practice; erosivity and transport capacity of the runoff as affected by slope steepness and hydraulic roughness of the surface; and sediment size and density.

Appendix J

Risk Assessment Adapted From CT DOT Drainage Manual (Section 6.15 Hydrology for Temporary Facilities and Appendix F)

Section 1: Introduction

Temporary hydraulic facilities include all channels, culverts or bridges which are required for haul roads, channel relocations, culvert installations, bridge construction, temporary roads or detours. They are to be designed with the same care which is used for the primary facility.

These designs are to be included in the plans for the project. Hydraulic approval is required from the Connecticut Department of Environmental Protection for those designs which they regulate.

Section 2: Detours and Temporary Roadways

Drainage systems for these are to be designed for a 2-year frequency if the roadway is required for a year or less and a 5-year frequency if required for longer than a year. All other temporary hydraulic facilities connected with these roads are to be designed for frequencies as determined by using the factors detailed below.

Section 3: Haul Roads

Hydraulic facilities for haul roads which cross or encroach into a watercourse are to be designed for a frequency as determined by using a Design Risk of 50% in **Figure J-2**, below. As a general rule, to avoid excess upstream flooding, the profile of the road should connect the tops of the channel embankments and the road designed to be overtopped by those events which exceed the design discharge. Sufficient cover must be provided over the temporary conduit to ensure structural integrity. The structural analysis of the conduit is to be included with the design.

The plan is to include a warning to the Contractor that this road is expected to be under water during certain rainfall events for undetermined lengths of time.

Section 4: Design Procedure

The selection of a design flood frequency for the remaining temporary hydraulic facilities involves consideration of several factors. These factors are rated considering their severity as 1, 2, or 3 for low, medium or high conditions (see **Figure J-1**).

Factors

Potential Loss of Life: If inhabited structures, permanent or temporary, can be inundated or are in the path of a flood wave caused by an embankment failure, then this item will have a multiple of 15 applied. If no possibility of the above exists, the loss of life will be the same as the severity used for the A.D.T.

Property Damages: Private and public structures (houses, commercial, or manufacturing), appurtenances such as sewage treatment and water supply (public and private well heads and reservoirs), utility structures either above or below ground, trout management areas, streams stocked by DEP, ponds located immediately downstream before the confluence with other watercourses, and wetlands greater than 5 acres in size are to have a multiple of 10 applied. Active cropland, parking lots, recreational areas are to have multiple of 5 applied. All other areas shall use the severity determined by site conditions.

Traffic Interruption: Includes consideration for emergency supplies and rescue; delays; alternate routes; busses; etc. Short duration flooding of a low volume roadway might be acceptable. If the duration of flooding is long (more than a day), and there is nearby good quality alternate route, then the flooding of a higher volume highway might also be acceptable. The severity of this component is determined by the detour length multiplied by the average daily traffic projected for bi-directional travel.

Detour Length: The length in miles of an emergency detour by other roads should the temporary facility fail.

Height Above Streambed: The difference in elevation in feet between the traveled roadway and the bed of the waterway.

Drainage Area: The total area contributing runoff to the temporary facility, in acres.

Average Daily Traffic: The average amount of vehicles passing through the area both ways in a 24-hour period.

Figure J-2 Design Frequency Risk Analysis

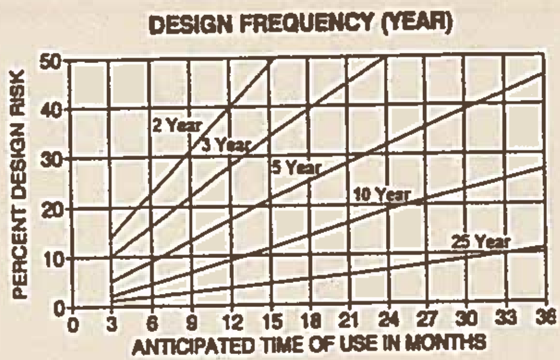
IMPACT RATING TABLE

Loss of Life Rating X 15 =	________
Property Damage Rating X 10 or X 5 =	________
Traffic Interruption Rating =	________
Detour Length Rating =	________
Height Above Streambed Rating =	________
Drainage Area Rating =	________
Average Daily Traffic Rating =	________

Total Impact Rating = (sum of the above) = ________

Step 2: Determine risk percentage

Step 3: Determine Temporary Design Frequency



Note: If sufficient discharges have been developed either by the designer or a Flood Insurance Study then a frequency curve should be plotted to determine the Design Discharge instead of the final formula using the ratio.

Design Frequency = __________ years

Step 4: Determine Multiplying Ratio

Year	Ratio	Year	Ratio
2.0	0.8	5.0	1.4
3.0	1.2	10.0	1.9
4.0	1.3	25.0	2.7

Step 5: Determine Temporary Flow Rate (Select the higher flow rate)

Ratio = _____ × 0.27 (Q_{50} _____) = _____ m^3/s (cfs)

Ratio = _____ × 0.20 (Q_{100} _____) = _____ m^3/s (cfs)

Source: DOT Drainage Manual

Appendix K

Conversion Factors for Select English/Metric Measurements

Length

Unit of Measure	Abbreviation	mm	cm	m	km	in	ft	mi
millimeter	mm	1	011	01001	-	0.0394	0.003	-
centimeter	cm	10	1	0.01	-	0.394	0.033	-
meter	m	1000	100	1	0.001	39.37	3.281	621
kilometer	km	-	100000	1000	1	-	3281	0.621
inch	in	25.4	2.54	0.0254	-	1	0.083	-
foot	ft	304.8	30.48	0.3048	0.0003	12	1	0.0002
mile	mi	-	-	1609	1.609	-	5280	1

Area

Unit of Measure	Abbreviation	m^2	ha	km2	ft^2	acre	mi^2
square meter	m^2	1	-	-	10.76	-	-
hectare	ha	10000	1	0.01	107600	2.471	0.00386
square kilometer	km^2	$1x10^6$	100	1	-	247.1	0.386
square foot	ft^2	0.093	-	-	1	-	-
acre	acre	4047	0.4047	-	43560	1	0.00156
square mile	mi^2	2590000	259	2.59	-	640	1

Volume

Unit of Measure	Abbreviation	km^3	m^3	L	Mgal	acre-ft	ft3	gal
cubic kilometer	km3	1	$1x10^9$	-	-	811000	-	-
cubic meter	m^3	-	1	1000	-	-	35.3	264
liter	L	-	0.001	1	-	-	0.0353	0.264
million U.S. gallons	Mgal	-	-	-	1	3.07	14000	$1x10^6$
acre-foot	acre-ft	-	1233	-	0.3259	1	43560	325848
cubic foot	ft^3	-	0.0283	28.3	-	-	1	7.48
gallon (U.S.)	gal	-	0.0038	3.785	-	-	0.134	1

Flow Rate

Unit of Measure	Abbreviation	km^3/yr	m^4/sec	L/sec	mgd	gpm	cfs	acre-ft/day
cubic kilometers/year	km^3/yr	1	31.7	-	723	-	1119	2220
cubic meters/second	m^3/sec	0.0316	1	1000	22.8	15800	35.3	70.1
liter/second	L/sec	-	0.001	1	0.0228	15.8	0.0353	0.070
million U.S. gallons/day	mgd	-	0.044	43.8	1	694	1.547	3.07
U.S. gallons/min	gpm (gal/min)	-	-	0.063	-	1	0.0022	0.0044
cubic feet/second	cfs (ft^3/sec)	-	0.0283	28.3	0.647	449	1	1.985
acre-feet/day	acre-ft/day	-	-	14.26	0.326	226.3	0.504	1

Temperature

Unit of Measure	Abbreviation	F	C
Fahrenheit	F	-	0.56 (after subracting 32)
Celsius	C	1.8 (then add 32)	-

Appendix M

Index – Concurrences

Appendix M