Chapter 3 – Erosion and Sediment Control Plans

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

This chapter is divided into three parts:

Part I – General Guidelines

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

Part II – Planning Process

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

Part III – Plan Requirements and Preparation

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

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

Part I – General Guidelines

Definition of an E&S Plan

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

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

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

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

Plan Adequacy

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

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

The length and complexity of the plan is directly related to the size of the project, the severity of site conditions, and the potential for off-site damage (see Table 3. 1) E&S plans 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. The procedure outlined in this chapter is recommended for the development of all plans.

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

Table 3. 1 E&S Plan Complexity

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

Minimum Standards and Specifications

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

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

Part II– Selection & Planning Process

LID Site Selection

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

Review of Available Information

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

These information sources include but are not limited to:

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

[4] See Appendix C- Agency Contact Information

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

Site Investigations and Limitations

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

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

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

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

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

The combined data is used to develop the following maps:

Site Locus Map

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

Detailed Existing Conditions Map

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

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

Topography

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

Drainage Patterns

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

Soils

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

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

Wetlands

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

Vegetation

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

Bedrock

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

Coastal Resources and Other Sensitive Areas

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

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

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

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

Adjacent Areas

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

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

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

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

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

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

Fit the Development to the Site – Determination of Developable Area

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

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

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

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

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

Keep Land Disturbance to a Minimum

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

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

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

Reduce Runoff and Slow the Flow

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

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

Keep Clean Runoff Separated

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

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

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

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

Use Distributed Controls

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

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

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

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

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

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

Implement a Thorough Maintenance and Follow up Program

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

Select Erosion and Sediment Control Measures

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

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

Step 1 – Identify Problem Areas and Ecological Needs

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

Step 2 – Identify Control Problems

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

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

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

Step 3 – Identify Control Strategies

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

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

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

Step 4 – Select the Appropriate Measures from the Control Groups

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

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

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

Table 3. 2 Measures Selection Matrix

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

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

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

Part III – E&S Plan Requirements

Plan Format

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

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

I. Place the information needed for construction on the construction drawings or in the specifications package.
II. Make all construction drawings for a specific project the same size sheet.
III. Make the soil erosion and sediment control drawings a part of the overall construction drawings for the project.
IV. For larger projects, show the installation requirements and specifications for measures to be used on a separate sheet from the plan view sheets. For small

projects, if room allows for details to be clearly shown, placing details on the plan view sheet can be advantageous.

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

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

Monitoring and Maintenance

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

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

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

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

E&S Plan Checklists

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

Narrative

i. A narrative description of the nature of the construction activity including the project purpose. An estimate of the total area of the project site and the total area of the site that is expected to be disturbed by construction activities.

ii. An estimate of the average runoff coefficient of the site after construction activities are completed.

iii. The name of the immediate receiving water(s) and the ultimate receiving water(s) of the discharges.

iv. Identification of site-specific erosion or sediment control concerns and issues.

v. The expected sequence of all construction activities on the site and corresponding erosion and sediment controls, including phases of development if more than one phase is planned.

vi. The approximate planned start and completion dates for each phase of the project.[8]

vii. Either provide or identify where in the E&S plan the following information is found:
   a. the design criteria, construction details, and maintenance program for the erosion and sediment control measures to be used,
   b. the sequence of major operations within each phase, such as installation of erosion control measures, clearing, grubbing, excavation, grading, drainage and utility installation, temporary stabilization, road base, paving for roadways and parking areas, building construction, permanent stabilization, removal of temporary erosion control measures
   c. The approximate duration (in calendar days) required for the major operations identified in the sequence

viii. Identify other possible local, state, and federal permits required.

ix. Identify the Low Impact Development (LID) site planning and design strategies to be used.

x. A listing of all other documents to be considered part of the E&S plan (e.g., reports of hydraulic and hydrologic computations, boring logs, test pit logs, field infiltration testing results, soils reports, etc.)

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

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

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

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

ii. Post-construction Stormwater Management Calculations (refer to the Connecticut Stormwater Quality Manual for specific requirements)
iii. Boring logs, test pit logs, field infiltration testing results, soils reports, etc.

Site Drawing(s) Checklist

Jurisdictional Features Required on All Maps or Drawings

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

Site Locus Map

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

Topography, Natural Features and Regulatory Boundaries

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

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

Drainage Patterns

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

Road and Utility Systems

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

Clearing, Grading, Vegetation Stabilization

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

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

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

Chapter 4 – Construction Phasing and Sequencing and Special Treatments

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

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

Part I – Construction Phasing and Sequencing

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Building Sites and Parking Lots

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

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

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

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

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

Limitations of Sequence

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

New Roadway Construction and Roadway Reconstruction or Widening

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

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

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

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

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

Limitations of Sequence

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

Underground Utility Projects

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

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

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

Limitations of Sequence

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

Solar Array Projects

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

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

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

21. Conduct equipment testing, inspections, and commissioning of the system.

Limitations of Sequence

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

Part II – Special Treatments

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

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

Water Management and Slope Stability

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

Cut Slopes or Cuts into Existing Slopes

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

- **Visually assess the undisturbed slope if one exists.**
  - Look for signs of sloughing, sliding, and seepage. This information may prove important in determining the reaction of the slope to the proposed changes. With an undisturbed slope, determine the degree of slope. It may also prove helpful to determine the type of vegetation growing on the existing slope.
- **Investigate the underlying material.**

- This could be done by using existing soil surveys or existing borings or test pits in the area. If this information does not exist, then information should be gathered through borings or test pits. Keep in mind that the extent of the information should not stop at the proposed toe of slope but should extend below the proposed bottom of the excavation.

➢ **Evaluate the soil layers for engineering characteristics.**

- This can be performed in the field but is more likely to be performed through laboratory analysis of samples collected from borings or test pits to determine soil properties such as composition, permeability, and friction angle. These properties should be evaluated for each different type of soil encountered in the borings.

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

Slope of Placed Fill

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

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

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

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

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

Failure of an Existing Slope

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

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

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

Possible Slope Repairs

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

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

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

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

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

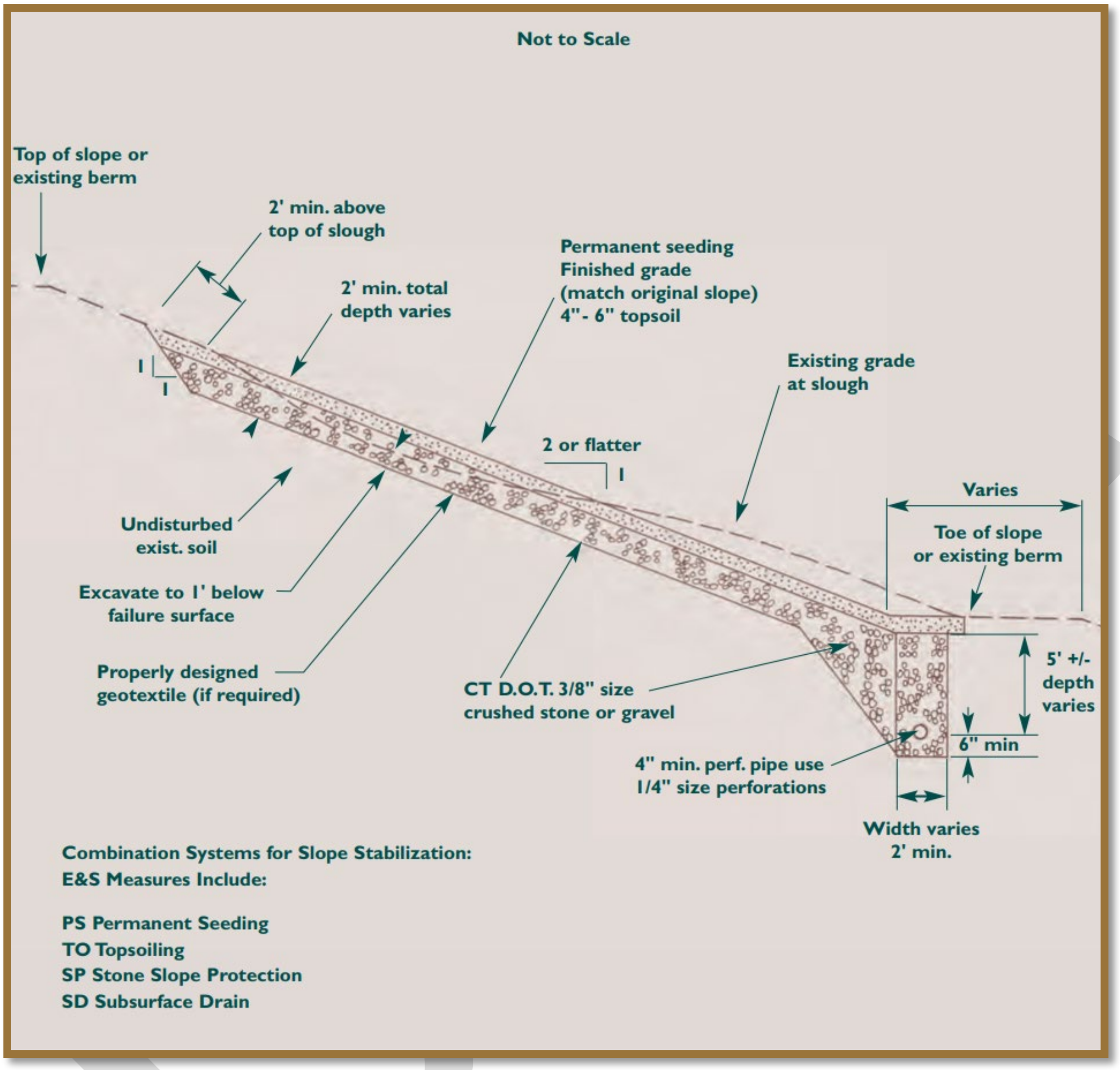


Figure 4- 2 Slope Repair Example 2: Using A Gabion Blanket, Source: USDA-NRCS

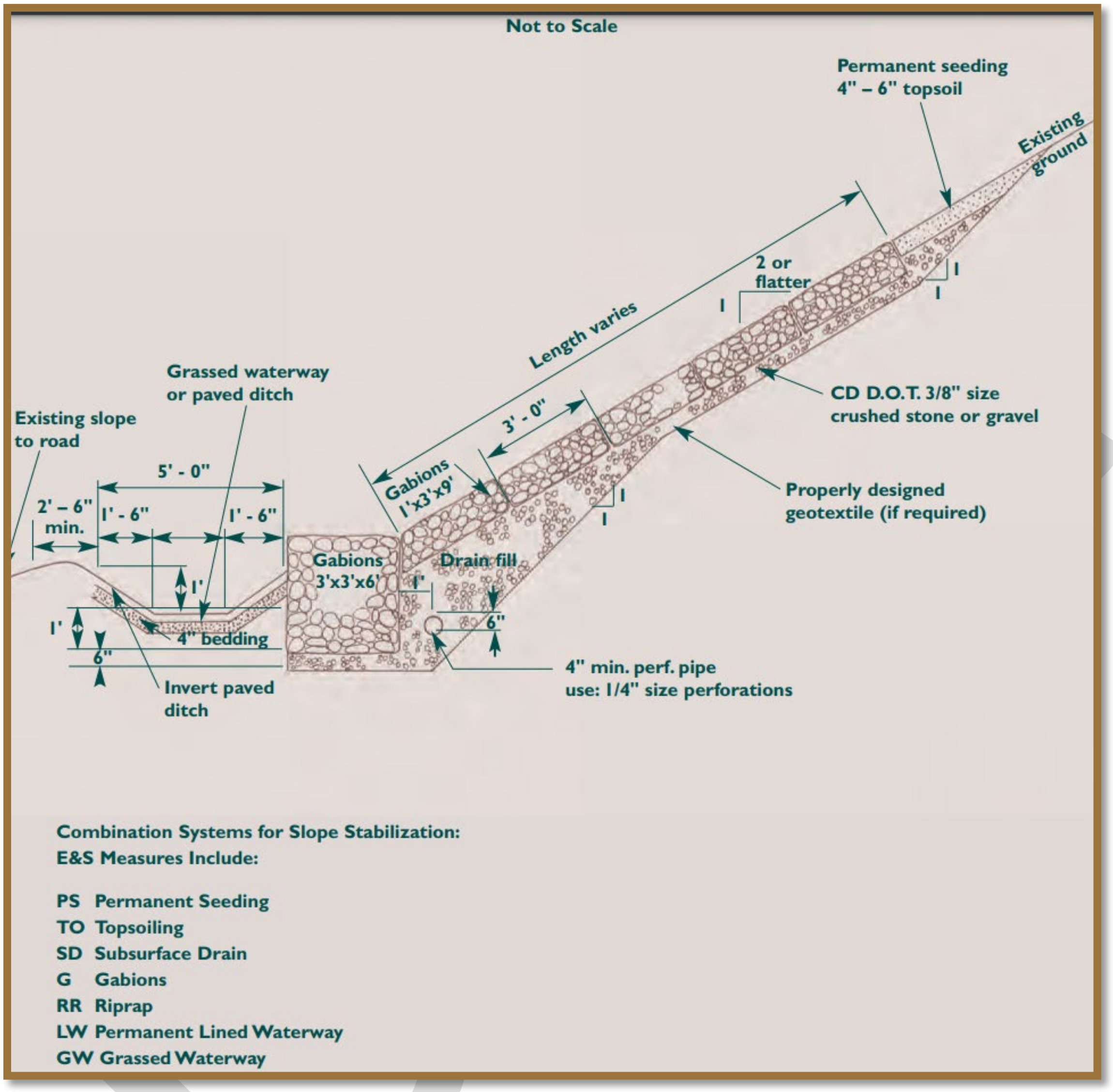


Figure 4- 3 Slope Repair Example 3: Using Multiple Subsurface Drains, Source: USDA-NRCS

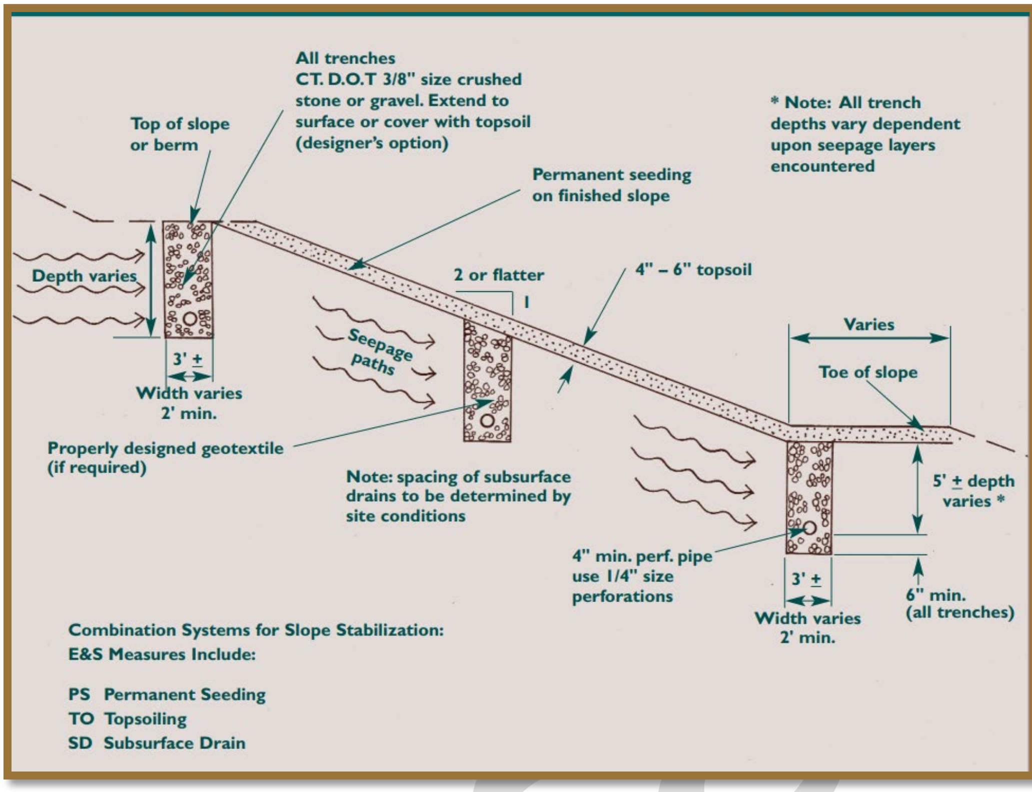
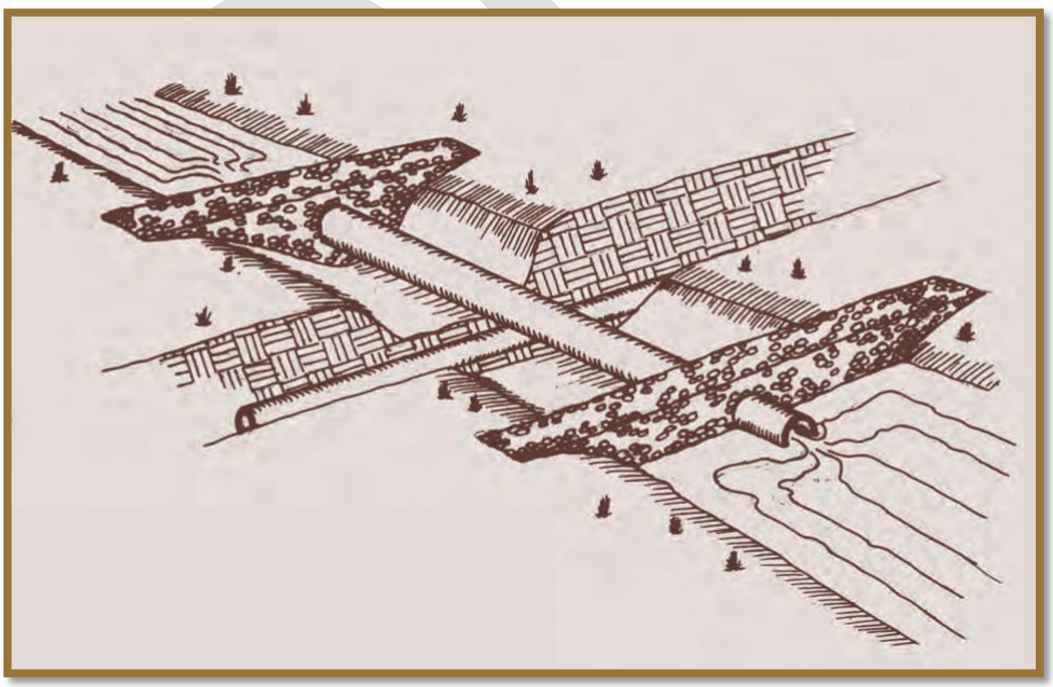


Figure 4- 4 Pipe Flume Crossing Illustration, Source: Adapted from Virginia Erosion and Sediment Control Handbook. 1992.



Stream Deflectors

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

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

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

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

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

Construction Access Roads

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

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

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

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

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

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

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

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

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

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

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

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

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

Utility Watercourse Crossings

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

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

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

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

Pipe Flume Crossing

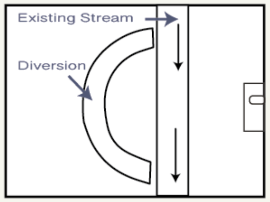
Used when in-stream construction will last less than 72 hours, and the contributing drainage area is less than 100 acres. It consists of a pipe and cofferdams of sandbags or gravel at each end of the pipe placed within the channel. The pipe is sized to handle the anticipated flow during the construction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

Diversion Channel Crossing

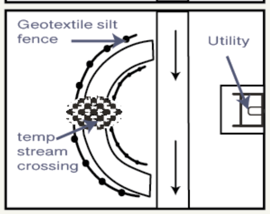
Used when in-stream construction will last longer than 72 hours. It consists of the construction of a temporary diversion channel (stabilized as needed with a channel lining to prevent erosion) with associated cofferdams and riprap to divert water flows around the stream, and a temporary stream crossing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

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

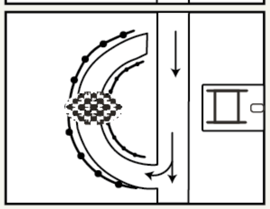
Figure 4- 5 Diversion Channel Crossing Sequence, Source: Adapted from "Damming by the Numbers" Erosion Control. July/August, 1995.



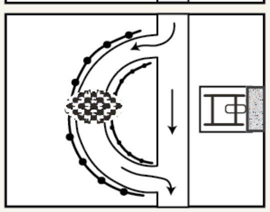
1. Excavate diversion channel with ends blocked. Install temporary channel lining.



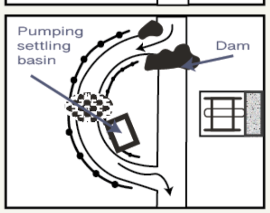
2. Install temporary stream crossing andperimeter E&S controls for diversion channel.



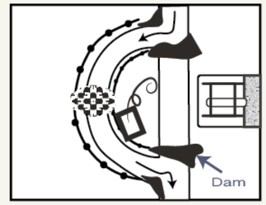
3. Open downstream end of diversion allowing water pressure to equalize in diversion.



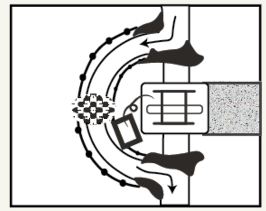
4. Open upstream end of diversion. Some sedimentation will occur.



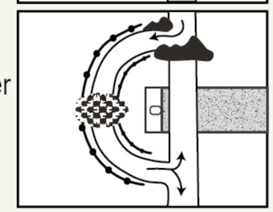
5. Construct non-erodable dam in the upstream end of the existing stream channel. Construct pumping settling basin.



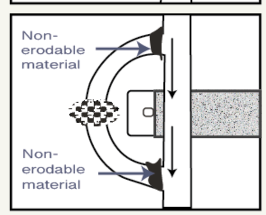
6. Construct non-erodable dam in the downstream end of the existing stream channel. Dewater blocked stream channel.



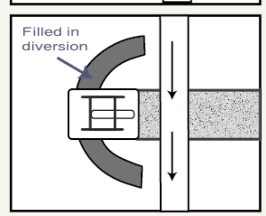
7. Construct utility across blocked streambed, detwatering as necessary.



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



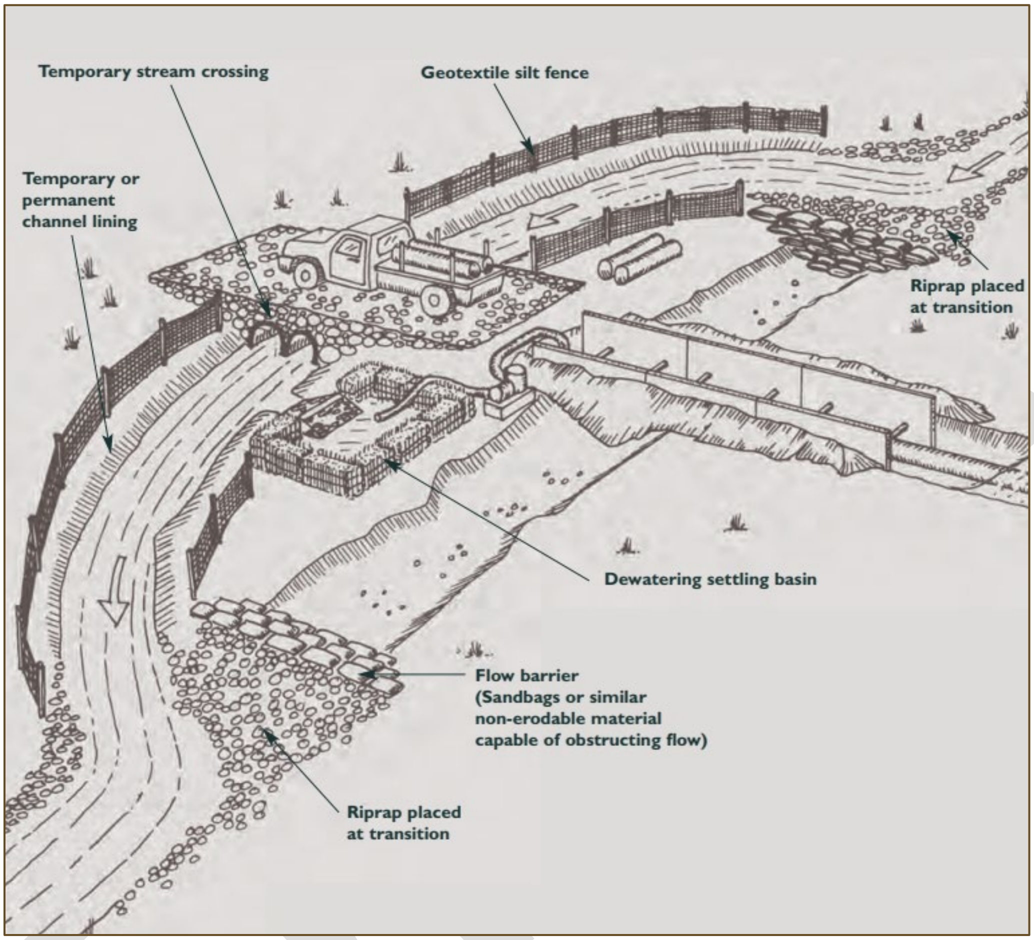
9. Remove dam from upstream end of existing channel. Fill in downstream and upstream end of diversion with non-erodable material.



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

Figure 4- 6 Diversion Channel Crossing Illustration,

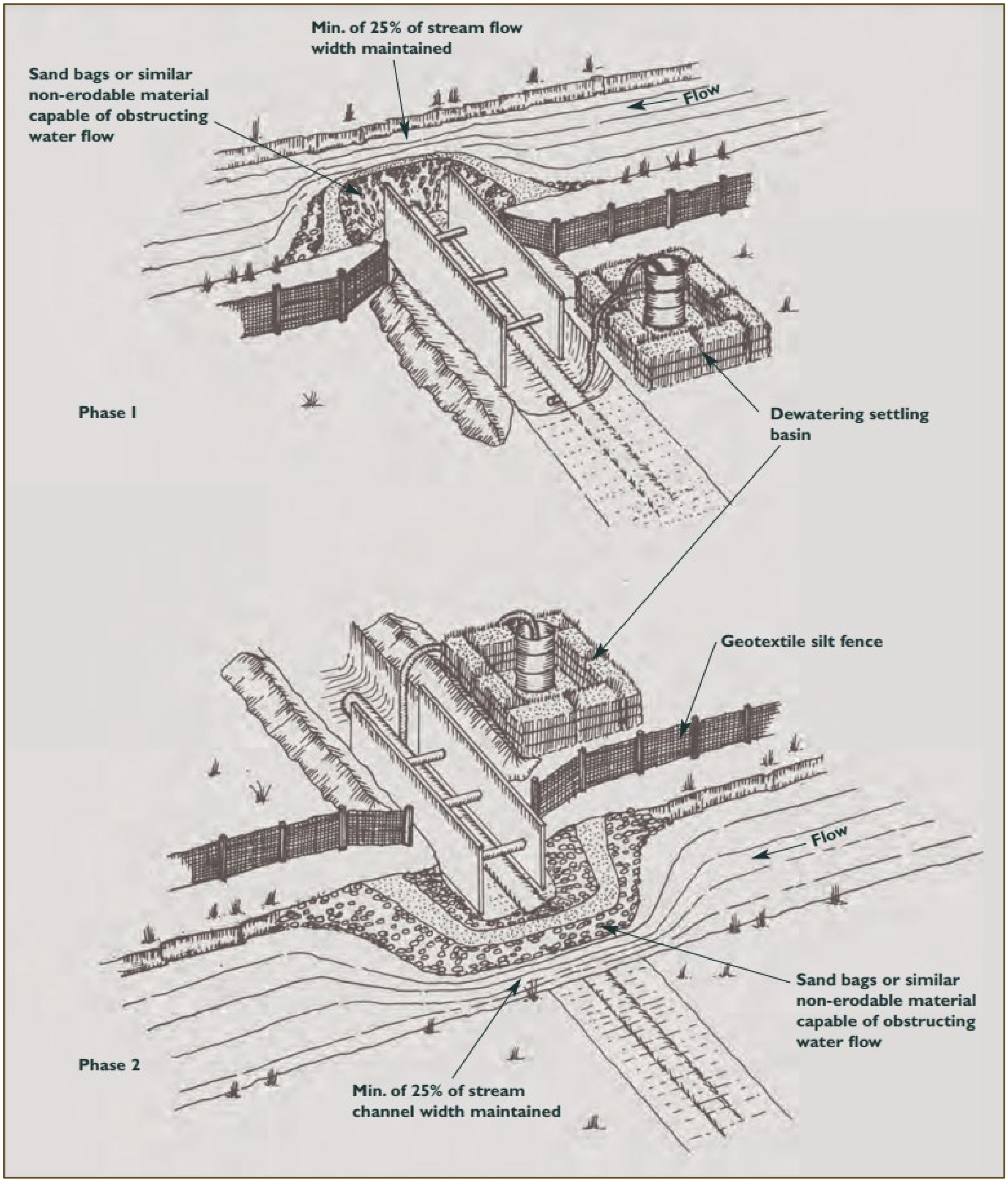
Adapted from Virginia Erosion and Sediment Control Handbook. 1992



Sequential Cofferdams

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

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



Soil Bioengineering

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Solar Array Projects

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

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

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

Erosion and Sediment Control in Coastal Shoreline Environments

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

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

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

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

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

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

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

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

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

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

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

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