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*Division of Land Resources  
Land Quality Section*

# *Erosion and Sediment Control*

## *Field Manual*



## *Disclaimer*

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The contents of this publication were prepared by the authors and should not be interpreted as necessarily representing the policies or recommendations of other referenced agencies or organizations. Additional information is available in the *North Carolina Erosion and Sediment Control Planning and Design Manual*.

The mention of trade names, products, or companies does not constitute an endorsement.

This manual is intended for periodic update. Sections may be changed as practices for erosion and sedimentation control evolve.

## Acknowledgements

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## Table of Contents

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- 1 North Carolina Sedimentation Control Law**  
*Review of the Law as it affects the developer/contractor*
  - 2 Principles of Erosion and Sediment Control**  
*Protecting the land surface, managing runoff, retaining sediment, scheduling, inspection, and maintenance*
  - 3 Vegetation for Erosion Control**  
*Planning considerations for use of vegetation in erosion control*
  - 4 The Erosion and Sedimentation Control Plan**  
*Working with an approved erosion and sedimentation control plan*
  - 5 Inspection for Sediment Control**  
*The preconstruction conference, checklist for site evaluation, reporting deficiencies*
  - 6 Practice Installation**  
*Specifications, installation instructions, trouble points, and maintenance for standard erosion and sediment control practices*
- SITE PREPARATION
- 6.06 Temporary Gravel Construction Entrance/Exit
- SURFACE STABILIZATION
- 6.10 Temporary Seeding
- 6.11 Permanent seeding
- 6.12 Sodding
- 6.14 Mulching
- 6.15 Riprap
- 6.16 Vegetative Dune Stabilization

## *Table of Contents*

---

### RUNOFF CONTROL

- 6.20 Temporary Diversions
- 6.21 Permanent Diversions
- 6.22 Diversion Dike (Perimeter Protection)
- 6.23 Right-of-Way Diversions (Water Bars)

### RUNOFF CONVEYANCE

- 6.30 Grass-lined Channels
- 6.31 Riprap-lined Channels
- 6.32 Temporary Slope Drains

### OUTLET PROTECTION

- 6.41 Outlet Stabilization Structure

### INLET PROTECTION

- 6.50 Excavated Drop Inlet Protection (Temporary)
- 6.51 Fabric Drop Inlet Protection (Temporary)
- 6.52 Block and Gravel Inlet Protection (Temporary)

### SEDIMENT TRAPS AND BARRIERS

- 6.60 Temporary Sediment Trap
- 6.61 Sediment Basin
- 6.62 Sediment Fence (Silt Fence)
- 6.63 Rock Dam

### RELATED PRACTICES

- 6.70 Temporary Stream Crossing
- 6.85 Sand Fence (Wind Fence)

### 7 Related References

### 8 Where to Go for Help

# List of Figures

*NOTE: All figures in this Erosion Control Field Manual are located in Chapter 5, Practice Installation.*

Chapter Section & Figure Number	Figure Title	Page
<b>SITE PREPARATION</b>		
6.06a	Gravel entrance/exit keeps mud off public roads.	6.06.1
6.06b	Plan of temporary construction entrance/exit.	6.06.2
6.06c	Temporary gravel construction entrance/exit with diversion ridge where grade exceeds 2%.	6.06.2
6.06d	Trouble point: Inadequate runoff control—sediment washes onto public road.	6.06.4
<b>SURFACE STABILIZATION</b>		
6.10a	Temporary seeding of Sudangrass controls erosion until permanent ground cover can be applied.	6.10.1
6.10b	Calendar for scheduling temporary seedings.	6.10.2
6.11a	Permanent cover protects slopes after grading.	6.11.1
6.11b	Calendar for permanent seeding recommendations by region.	6.11.3
6.12a	Installing grass sod.	6.12.1
6.12b	Detailed installation of grass sod.	6.12.2
6.12c	Installation of sod in waterways.	6.12.3
6.14a	Erosion-control matting protects channel until grass becomes established.	6.14.1
6.14b	Installation of nets and mats.	6.14.4
6.15a	Riprap provides immediate protection of disturbed slopes.	6.15.1
6.15b	Riprap slope protection.	6.15.3
6.15c	Placement of channel riprap.	6.15.4
6.15d	Slumping of riprap where filter is omitted.	6.15.5
6.16a	Dune grasses hold dune and collect blowing sand.	6.16.1
6.16b	Graduated row spacing, closer in the center, wider at the edges.	6.16.2

## List of Figures

Chapter Section & Figure Number	Figure Title	Page
<b>RUNOFF CONTROL MEASURES</b>		
6.20a	Temporary earthen diversion.	6.20.1
6.20b	Temporary diversion cross section.	6.20.2
6.20c	Trouble point: Sedimentation in channel results in overflow and erosion.	6.20.3
6.21a	Permanent diversion is located to prevent slope erosion and reduce flooding in lower area.	6.21.1
6.21b	Typical cross section of permanent diversion.	6.21.2
6.22a	Diversion dike on low side of work area prevents sediment from leaving the site.	6.22.1
6.22b	Perimeter dikes prevent surface runoff from entering construction sites.	6.22.2
6.22c	Cross section of diversion dike above area to be protected.	6.22.3
6.23a	Right-of-way diversions (water bars) prevent erosion in utility access routes.	6.23.1
6.23b	A system of water bars reduces runoff accumulation on long, sloping rights-of-way.	6.23.2
6.23c	Cross section of a water bar.	6.23.3
<b>RUNOFF CONVEYANCE MEASURES</b>		
6.30a	Wide, shallow grass-lined channel carries non-erosive flow.	6.30.1
6.30b	Overcut channel and grade approach for unrestricted flow.	6.30.2
6.30c	Protect seeded channel with temporary liner or well-anchored mulch as specified in plan.	6.30.2
6.30d	Installation of temporary channel liner.	6.30.3
6.31a	A filter cloth foundation prevents piping of the riprap channel.	6.31.1
6.31b	Increased volume of excavation required for riprap and filter in channel.	6.31.2
6.31c	Finished riprap surface should blend with surrounding land surface.	6.31.3
6.31d	Riprap not smoothly blended to ground surface.	6.31.4
6.32a	Temporary slope drain conveys concentrated flow safely down steep slope.	6.32.1
6.32b	Compact fill over inlet section, creating an <i>island</i> to prevent overtopping.	6.32.2
6.32c	Cross section of temporary slope drain and detail of inlet.	6.32.3

Chapter Section & Figure Number	Figure Title	Page
<b>OUTLET PROTECTION</b>		
6.41a	Riprap outlet stabilization structure prevents erosion by reducing velocity of concentrated flow.	6.41.1
6.41b	Pipe outlet to flat area with no well-defined channel.	6.41.3
6.41c	Pipe outlet to well-defined channel.	6.41.3
<b>INLET PROTECTION</b>		
6.50a	Excavation around inlet creates an effective settling pool.	6.50.1
6.50b	Perspective of excavated drop inlet protection.	6.50.2
6.50c	Cross section of excavated drop inlet protection.	6.50.3
6.51a	Fabric inlet with excavated approach.	6.51.1
6.51b	Prevent bypass flow with a dike on the downslope side.	6.51.2
6.51c	Recommended installation of fabric with supporting frame around stormwater inlet.	6.51.3
6.52a	Block and gravel inlet protection forms low dam, creating a temporary settling pool.	6.52.1
6.52b	Perspective of block and gravel drop inlet protection.	6.52.2
6.52c	Detail of block and gravel drop inlet.	6.52.3
6.52d	Detail of gravel drop inlet protection (gravel donut).	6.52.4
<b>SEDIMENT TRAPS AND BARRIERS</b>		
6.60a	Temporary settling pool traps sediment.	6.60.1
6.60b	Construction detail of sediment trap.	6.60.3
6.61a	A compacted earth dam across a low area forms the sediment basin.	6.61.1
6.61b	Section through embankment of sediment basin.	6.61.4
6.61c	Plan, profile, and cross section of emergency spillway excavated in undisturbed soil.	6.61.6
6.62a	Sediment trapped behind well supported sediment fence.	6.62.1
6.62b	Level fence line with room for temporary pool.	6.62.3
6.62c	Perspective of reinforced, stabilized outlet for sediment fence.	6.62.4
6.62d	Detail of sediment fence installation.	6.62.5
6.63a	Wide spillway keeps discharge velocity low.	6.63.1

## *List of Figures*

---

<b>Chapter Section &amp; Figure Number</b>	<b>Figure Title</b>	<b>Page</b>
6.63b	Rock dam cross section.	6.63.3
6.63c	Plan view of rock dam with spillway detail.	6.63.4
<b>STREAM PROTECTION</b>		
6.70a	Bridges must be designed and built to support expected loads.	6.70.1
6.70b	Ford stabilized with stone over stabilization fabric.	6.70.3
<b>OTHER RELATED PRACTICES</b>		
6.85a	Fences trap sand to build up eroded dune.	6.85.1
6.85b	Typical sand fence material.	6.85.2
6.85c	Location of sand fences to trap sand and build up a dune.	6.85.3

# List of Tables

*NOTE: All tables in this Erosion Control Field Manual are located in Chapter 6, Practice Installation.*

Chapter Section & Table Number	Table Title	Page
<b>SURFACE STABILIZATION</b>		
6.11a	Tolerance, Maintenance, and Propagation Characteristics of Erosion Control Plants	6.11.6
6.11b	Low-maintenance Mixtures—Mountains	6.11.7
6.11c	High-maintenance Mixtures—Mountains	6.11.8
6.11d	Low-maintenance Mixtures—Piedmont	6.11.8
6.11e	High-maintenance Mixtures—Piedmont	6.11.9
6.11f	Low-maintenance Mixtures—Coastal Plain	6.11.9
6.11g	High-maintenance Mixtures—Coastal Plain	6.11.10
6.14a	Typical Mulching Materials and Application Rates	6.14.2
6.15a	NC DOT Classes of Riprap and Erosion Control Stone	6.15.2
6.16a	Dune Fertilization Schedule	6.16.3
<b>RUNOFF CONTROL MEASURES</b>		
6.23a	Spacing of Water Bars	6.23.1
6.32a	Pipe Size for Slope Drain	6.32.1
<b>SEDIMENT TRAPS AND BARRIERS</b>		
6.60a	Minimum Spillway Design	6.60.2
6.62a	Maximum Land Slope and Distance for Which Sediment Fence is Applicable	6.62.1
6.62b	Specifications for Sediment Fence Fabric	6.62.2



**1** North Carolina  
Sedimentation Control Law



## North Carolina Sedimentation Control Law

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This section highlights portions of the North Carolina Sedimentation Pollution Control Act of 1973 that affect contractors and developers involved in land-disturbing activities other than agriculture, mining, and forestry operations that follow best management practices.

### The Performance Standard

The Sedimentation Pollution Control Act is performance oriented. This means that for each land-disturbing activity, the approved system of erosion and sedimentation control measures must work. It permits the owner or developer to use innovative practices if they are effective, but it also demands that the system perform as designed.

The contractor is extremely important to performance of an erosion and sedimentation control plan. Careful installation and maintenance of erosion and sedimentation controls and coordination with construction activities make all the difference.

### What does the law require?

The law has three general requirements:

- For areas larger than one contiguous acre, an erosion and sedimentation control plan must be approved before any clearing or grading may occur;
- Surfaces on the construction site must be stabilized; and
- Sediment must be retained on site.

Starting work before the plan is approved is a particularly serious violation. **The law requires that the plan be submitted at least 30 days before the start of clearing or grading.**

Any changes to the approved erosion and sedimentation control plan must be approved by the authorized agency before they are implemented.

In addition, there are the following mandatory standards:

- A sufficient buffer zone must be retained along any natural water course or lake to contain all visible siltation within the 25 percent of the buffer nearest the disturbed land (25 ft undisturbed buffer is the minimum for trout waters).<sup>1</sup>
- Sediment control practices must be installed properly as specified in the approved plan.
- The angle of cut or fill slopes must be limited to that which can be properly stabilized.
- The surfaces of graded slopes and fills must be stabilized with ground cover within 30 working days after any phase of grading is completed.
- A permanent ground cover, sufficient to control erosion, must be installed within 30 working days or 120 calendar days, whichever is less, after completion of construction or development.

**Who is responsible?**

The person financially responsible for the land-disturbing activity is responsible for erosion and sedimentation control. If this person is not the landowner, the landowner may also be held responsible. Responsibility includes installation and maintenance of all sediment control structures and surface stabilization measures.

If any modification is required in the approved plan, the change must be initiated by the person who is financially responsible.

Responsibility for maintenance and future compliance is that of the landowner after construction is complete.

**Who enforces the law?**

The Sedimentation Pollution Control Act provides authority to the North Carolina Department of Environment, Health, and Natural Resources, Land Quality Section to approve erosion and sedimentation control plans, inspect land-disturbing activities, and take enforcement actions. Citizens affected by sedimentation from a disturbed site may also take action through the courts.

Authorized local governments or agencies may adopt, administer, and enforce their own ordinances, with the approval of the Sedimentation

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<sup>1</sup>There is an exception, where approved, for construction on, over, or under a lake or natural watercourse [North Carolina G. S. 113A-57 (1)].

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Control Commission. Local ordinances, however, must meet or exceed the minimum State standards. The Department of Environment, Health, and Natural Resources reviews local programs periodically to ensure uniform enforcement of the Act.

**What are the penalties?**

Failure to submit an erosion and sedimentation control plan carries a single, noncontinuing penalty up to \$1000.

Other civil penalties assessed by the State or authorized locality carry a maximum fine of \$500/day per violation for each day that the site is in violation. Existing violations or unpaid fines may be grounds for disapproval of subsequent erosion and sedimentation control plans.

Criminal penalties for knowing and willful violation may be imposed to a maximum of 90 days in jail and a \$5000 fine.

Injunctions that may stop work until the site is brought into compliance may be issued by the courts.

**Where can a copy of the law be obtained?**

The Sedimentation Control Commission has developed a set of rules for sedimentation and erosion control, adopted as Title 15, Chapter 4 of the North Carolina Administrative Code. The complete text of these rules and the Sedimentation Pollution Control Act of 1973 can be obtained from:

Land Quality Section  
Division of Land Resources  
Department of Environment, Health, and Natural Resources  
Archdale Building  
512 N. Salisbury St.  
P.O. Box 27687  
Raleigh, NC 27611

Specific requests regarding interpretation of this law should be addressed to your regional office of the Land Quality Section of the Department of Environment, Health, and Natural Resources (addresses are shown in Chapter 8).



**2** Principles of Erosion and  
Sediment Control



## *Principles of Erosion and Sediment Control*

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Severe erosion is caused by the action of wind, rainfall, and runoff on bare soil. Clearing, grading, and other construction activities remove vegetation and compact the soil, increasing both runoff and erosion. Excessive runoff erodes deep gullies, attacks channels, and causes off-site erosion, sedimentation, and flooding problems. Effective erosion and sedimentation control can be achieved by careful attention to the following principles:

- Protect the land surface from erosion.
- Manage runoff and keep velocities low.
- Capture sediment near the source.
- Integrate sediment control with the construction schedule.
- Inspect and maintain the erosion and sediment control system.

### **Protect the Land Surface**

The contractor can control erosion most effectively by making sure the soil surface is protected from the action of rain, runoff, and wind. Attention to the following concerns will limit erosion and reduce the burden of maintaining sediment control practices in proper working order.

- Schedule construction activities to minimize the duration of exposure.
- Limit the area disturbed. Grade no larger an area than necessary at any one time and leave an undisturbed buffer.
- Divert runoff away from exposed slopes.
- Stabilize and maintain construction roads, parking areas, and the construction entrance. Use the designated routes to limit the development of ruts and erosion.
- Stabilize channels immediately.
- Protect graded surfaces with temporary vegetation and mulch whenever work is interrupted for an extended period.

Key control practices are: *Temporary Seeding*, 6.10; *Permanent Seeding*, 6.11; *Mulching*, 6.14; and *Riprap*, 6.15. Additional specialized practices include *Temporary Gravel Construction Entrance/Exit*, 6.06; *Construction Road Stabilization*, 6.80<sup>1</sup>; *Sodding*, 6.12; *Trees, Shrubs, Vines, and Ground Covers*, 6.13<sup>1</sup>; *Temporary Diversions*, 6.20; *Grass-lined Channels*, 6.30; and *Dust Control*, 6.84<sup>1</sup>.

### **Keep Runoff Velocities Low**

Erosion can be reduced and sediment controlled by timely installation of runoff control measures. The superintendent or project foreman is essential in making the water disposal system work. The foreman can handle day-to-day on-site details such as excluding runoff water from the work site and protecting highly erodible areas such as fill slopes and channels. Attention should be given to the following points:

- Protect the work area from off-site water with perimeter dikes or temporary diversions.
- Provide stable outlets to dispose of runoff water.
- Divert all runoff from disturbed areas to sediment traps or basins.
- Divert runoff from undisturbed areas to stable or protected outlets.
- Break long slopes with temporary diversions.
- Install the permanent water conveyance system early in the construction sequence and protect all inlets with inlet protection measures.
- Protect the work area from unexpected rain by putting up temporary diversions at the end of the work day.

Key practices are: *Temporary Diversions*, 6.20; *Permanent Diversions*, 6.21; *Diversion Dike (Perimeter Protection)*, 6.22; *Right-of-way Diversions (Water Bars)*, 6.23, and outlet protection practices such as *Level Spreader*, 6.40<sup>1</sup> and *Outlet Stabilization Structure*, 6.41. Supporting practices include *Temporary Slope Drains*, 6.32; *Riprap*, 6.15; *Grass-lined Channels*, 6.30; and *Riprap-lined Channels*, 6.31.

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<sup>1</sup>See *North Carolina Erosion and Sediment Control Planning and Design Manual* (1988) for practice specifications.

**Capture  
Sediment  
Near the  
Source**

Sediment is controlled most easily and effectively near the source. Several sediment traps or barriers located at the edge of a graded area are more effective and less hazardous than a single large sediment basin near the site boundary.

Sediment traps, basins, and barriers, such as sediment fences, operate by reducing runoff velocity to allow deposition—not by filtering. Filtering runoff with fabric or gravel is not effective because filters clog too rapidly to remove much sediment. Therefore, the practices described here are designed to reduce flow velocity and form shallow pools for settling.

The contractor can make sediment control more effective by providing access to traps and barriers for maintenance. Anticipate where sediment will accumulate behind sediment fences, and plan to provide access for cleanout and maintenance. Traps and barriers must be inspected and cleaned frequently.

Key practices are: *Temporary Sediment Trap*, 6.60; *Sediment Basin*, 6.61; *Sediment Fence (Silt Fence)*, 6.62; and *Inlet Protection*, practices 6.50-6.53. Supporting practices include: *Temporary Diversions*, 6.20 and *Diversion Dike (Perimeter Protection)*, 6.22.

**Scheduling**

Erosion and off-site sediment problems are controlled most effectively by coordinating the construction sequence and the installation of erosion and sediment control measures. Key sediment control practices must be in place before any site disturbance occurs. A carefully planned construction access route with well-drained, stabilized surfaces improves erosion and sediment control and promotes efficient site development.

**Inspection  
and  
Maintenance**

Inspection and maintenance are vital to performance of the erosion and sediment control system. Lack of maintenance is the most common reason for failure. Low points in dikes or diversions can cause major gullies to form. A collapsed sediment fence or fabric inlet protection device can deliver large amounts of sediment off-site, and failure of a large sediment basin could have severe consequences. Inspect and repair all erosion and sediment control practices frequently.

Maintenance requirements for erosion and sediment control practices are contained in Section 6, *Practice Installation*.



**3** Vegetation for  
Erosion Control



## *Vegetation for Erosion Control*

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Vegetative cover is the principal method for stabilizing disturbed sites throughout North Carolina. It is relatively inexpensive, tends to be self-healing, and is often the only practical, long-term solution to site stabilization and erosion control.

Site factors must be considered in planning site preparation and choosing plants and vegetative practices to fit a given site. Disturbed sites vary widely in soils, slope, orientation, and proposed use. There is also unusually wide variation in climate across the state.

Plant selection is based largely on the site's intended use. Under low maintenance, plants must persist without regular fertilization and liming. Turf grasses and ornamentals are typically used on high-maintenance sites with regular mowing and fertilization.

### **Plant Materials**

Plant selection is made early in the development of a site so that the seedbed can be prepared to fit requirements of the plants. A large number of plant species and varieties can be grown in North Carolina and many have been used for soil stabilization. However, only a few have really stood the test of time. These are the plants emphasized in this manual; they were chosen for their wide adaptation and high degree of dependability. Others may be preferable for special applications.

### **Soil Amendments**

Following cut-and-fill operations, disturbed soils in this state typically end up with a surface consisting of acid, infertile subsoil material with little or no organic matter. They may also contain compounds toxic to plants. Construction activities may further increase problems by compacting the rooting zone, steepening slopes, and altering drainage patterns. Therefore, the essentials for plant growth—an adequate nutrient supply, water, and air in the root zone—are frequently lacking in disturbed soils.

Fertilizer, lime, and special care in seedbed preparation are almost always required when seeding disturbed sites. Since each site has unique requirements, the best way to determine lime and fertilizer rates is by using soil tests. Although it is difficult to generalize about soil requirements, the

manual presents recommendations for lime and fertilizer that are adequate in many common situations. Topsoiling can be used to overcome the worst soil problems, and it is usually a necessity for establishing high-maintenance turf. Care should be taken to ensure that topsoil is free of weed seeds and is of sufficient thickness to provide an adequate rooting depth.

**Mulching** Mulching is usually necessary to establish erosion control vegetation. The functions of mulch are to:

- hold seeds and fertilizer in place,
- protect the soil,
- reduce evaporation,
- prevent soil crusting,
- insulate the soil against abrupt temperature changes, and
- encourage rapid seed germination.

The steeper the slope and the poorer the soil the more important it is to mulch. A number of mulching materials, both natural and synthetic, can be used. Grain straw (wheat, oats, barley, or rye) is the most widely used mulching material and one of the most effective. Anchoring mulch is important.

**Maintenance** Maintenance is a key factor in stabilization and is particularly critical in the early stages. Heavy downpours, coming before new seedlings can get a foothold, are a major hazard. Damage from erosion usually begins where cover is weakest and can worsen rapidly if not corrected. Repairs should be made immediately, with seed, fertilizer, and well-anchored mulch.





## *The Erosion and Sedimentation Control Plan*

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### **The Approved Plan**

The approved erosion and sedimentation control plan is an agreement between the owner or developer of a construction site and the state or local sedimentation control authority. It specifies the minimum level of erosion and sediment control that may be installed on the site during each phase of development. **On sites where disturbance will exceed one acre, work may not begin without an approved plan.**

The approved plan designates a system to prevent erosion and off-site sedimentation during all phases of construction and after development. The plan specifies the erosion and sediment control practices to be used, construction specifications, where practices will be located, and at what point in the construction schedule they must be installed. It also specifies who is responsible for maintenance.

The contractor should review the plan carefully to understand what is required. Installing the erosion and sedimentation control plan and assuring its performance may involve significant expense that should be recognized as a line item in the contractor's bid.

The approved plan includes:

- topo and vicinity maps
- site development plan
- construction schedule
- erosion and sedimentation control plan drawings
- detailed drawings and specifications for practices
- design calculations
- vegetation plan

The plan should also include a brief narrative describing any unique site characteristics or special considerations. Sufficient detail should be provided to implement the plan properly and control erosion and sedimentation during each of phase of site development.

**Modifying  
the Plan**

The approved erosion and sedimentation control plan should be viewed as an open-ended document, subject to approved adjustments and modifications, if necessary. Contingencies such as changes in the construction schedule or unexpectedly severe weather frequently call for changes or adjustments to the plan. In addition the contractor is expected to monitor the performance of all erosion and sediment control practices and make minor adjustments as needed on a day-to-day basis. Major modifications, on the other hand, must be approved before they are implemented.

The sediment control inspector can help determine which problems may be corrected in the field and which require modification of the plan. The contractor should accompany the sediment control inspector during inspections to discuss any performance problems. Anticipating changes and discussing them with the inspector can avoid major delays.

**Performance  
Requirement**

Erosion and sediment control practices specified in the approved plan are designed to control erosion and prevent off-site sedimentation from storms up to and including the 10-yr storm event. Dust control may also be required.

The developer's responsibility does not end with installation and maintenance of designated practices—the plan must also work effectively. Excessive erosion on the site or off-site damage from sediment are not acceptable. If performance of the sediment control system is not adequate, the plan must be revised, approved as modified, and implemented.

**5** Inspection for  
Sediment Control



## *Inspection for Sediment Control*

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Inspection of land-disturbing activities for sediment control is required by the North Carolina Sediment Pollution Control Act. The inspector's job is to determine that the approved erosion and sedimentation control plan is installed as approved, that erosion is being controlled, and that off-site sedimentation is prevented. If the inspector finds deficiencies, he or she must take appropriate action to secure compliance. A cooperative working relationship between the contractor and the inspector can be highly beneficial. Continued or willful violation of sediment control rules can result in civil penalties or injunctions to stop work.

### **Preconstruction Conference**

The preconstruction conference provides an opportunity for the contractor and developer to discuss the plan with the inspector and to learn which elements of the plan deserve the most attention. Adjustments to improve performance or make installation easier and maintenance more reliable may also be discussed.

The preconstruction conference is also an opportunity to discuss the inspection schedule and procedures. The inspector will encourage the developer to be present at the time of inspections so that any deficiencies may be addressed quickly.

Key points to consider in the preconstruction conference are:

- Adjacent areas that need special protection from sedimentation, particularly environmentally sensitive areas such as wetlands and highly valued resource areas.
- Critical areas with high erosion potential such as steep cut-and-fill slopes, highly erodible soils, construction access routes, stream crossings, channels, and water disposal outlets.
- Location of erosion and sediment control practices and their implementation.
- Sequence of practice installation with respect to the construction schedule.

- Surface stabilization plans, temporary and permanent seeding.
- The construction schedule and any anticipated shut-down periods.
- Maintenance plans and the contractor's procedure for monitoring performance.
- Location of off-site borrow and waste areas.

### **The Inspection**

During the inspection, the contractor has the opportunity to discuss any problems or concerns that affect the performance or maintenance of the erosion and sediment control practices. Such discussion may identify areas where field adjustments can improve performance, make maintenance easier, or reduce cost. It may also identify points where modifications of the approved plan are needed. Coordination with the inspector at this point can avoid costly delays.

The inspector is concerned with two things: (1) Is the sediment control system installed as specified in the approved plan? and (2) Are erosion and sedimentation being adequately controlled? The inspector will compare the installed measures with those specified and check to determine if erosion is being held to a minimum and off-site sedimentation is prevented.

The inspector will determine if the measures are sufficient to retain sediment on site and if ground cover is installed properly and performs as specified. He or she will check buffer zones, check the steepness and stability of graded cuts and fills, determine if there is adequate protection for adjacent property from the 10-yr storm, and ensure that erosion and sediment control practices are properly maintained.

When there are violations, the inspector will seek to determine the amount of off-site sedimentation and what water resources or adjacent properties are being damaged. Necessary corrective measures will be identified and noted in the inspection report.

The following points are usually checked during an erosion and sedimentation control inspection:

- Are all the practices specified in the approved plan installed in the proper location and in accordance with the minimum requirements?
- Are all practices performing adequately and is the perimeter protected?

- 
- Do any practices require repair or cleanout?
  - Are there any bare areas that require temporary or permanent stabilization?
  - Do seeded areas require maintenance, reseeding, or mulching?
  - Are cut-and-fill slopes stable and adequately protected from erosion?
  - Are channels and outlets stable?
  - Are storm inlets protected from sediment?
  - Are stream banks and stream crossings stable?
  - Are utility installations properly protected?
  - Are construction roads and right-of-way access routes stable?
  - Is there evidence of sediment leaving the site or entering streams on the site through construction entrances/exits, channel outlets, storm drains, or by washing off slopes?
  - Is dust control needed?
  - Is there an adequate buffer zone between the construction site and any water resource?

### **The Inspection Report**

If significant problems or violations are found during an inspection, the owner or developer will be notified promptly in writing. The inspector prepares a report describing the problems and noting what corrective actions are needed. The inspector keeps a file with documentation and pictures to describe accurately any problems or deficiencies noted. The inspection report is mailed to the developer shortly after the inspection is completed. Continued serious violation may result in civil penalties or court injunction that can stop work on the site.



**6 Practice Installation**



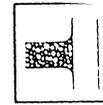
## *Practice Installation*

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This section gives instructions for installation and maintenance of the most commonly used erosion and sediment control practices. Each practice is presented with a list of its minimum requirements for proper installation and a compilation of common trouble points. Additional information on these and other practices can be found in the *North Carolina Erosion and Sediment Control Planning and Design Manual*.

Contractors are encouraged to install and maintain practices carefully, in a workmanlike manner. Minor adjustments should be anticipated to assure proper performance. Intensive maintenance and extensive use of vegetation, mulch, and other ground covers may be required to achieve the performance required by law. Because the cost of field adjustments, maintenance, and ground covers can be substantial, they must be approved by the person financially responsible. We recommend very strongly, therefore, that such erosion and sediment control efforts be specified clearly in the general construction contract and that any unexpected expenses be approved before they are incurred.

Any modification to the approved erosion and sedimentation control plan must be initiated by the person financially responsible—the developer or contractor—and must be approved by the authorized erosion and sedimentation control agency before it is implemented.

**TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT**

**Purpose** To provide a stable entrance/exit condition from the construction site and keep mud and sediment off public roads (Figure 6.06a).

Figure 6.06a  
Gravel entrance/  
exit keeps mud off  
public roads.

**Minimum Requirements**

- **Material:** 2-3-inch washed stone over a stable foundation as specified in the plan.
- **Thickness:** 6 inches minimum (Figure 6.06b).
- **Width:** 12 ft minimum or full width of exit roadway, whichever is greater.
- **Length:** 50 ft minimum.
- **Washing facility (if required):** level area with 3-inch washed stone minimum, or a commercial rack. Divert waste water to a sediment trap or basin.

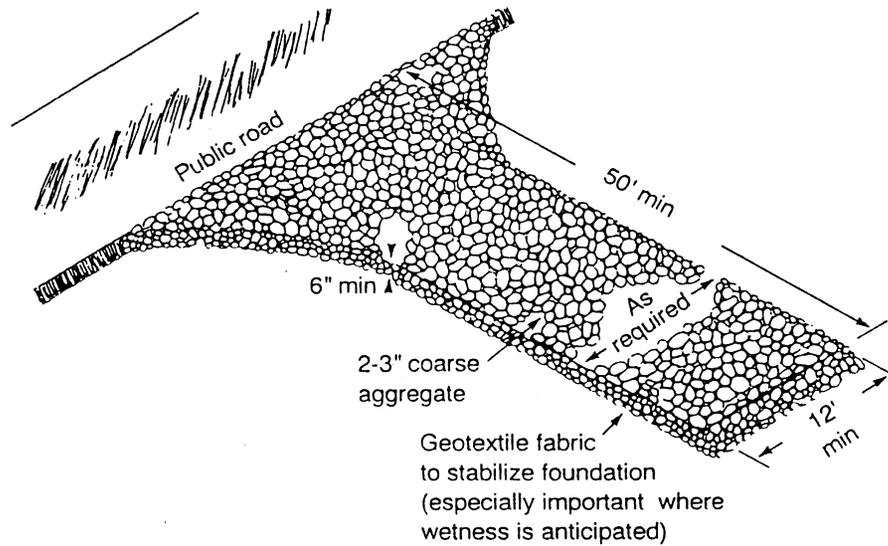


Figure 6.06b Plan of temporary construction entrance/exit.

**Installation** Avoid curves in public roads and steep slopes. Remove all vegetation and other objectionable material from the foundation area. Grade and crown foundation for positive drainage.

If the slope toward the road exceeds 2%, construct a ridge, 6 to 8 inches high with 3:1 side slopes, across the foundation approximately 15 ft from the entrance to divert runoff away from the public road (Figure 6.06c).

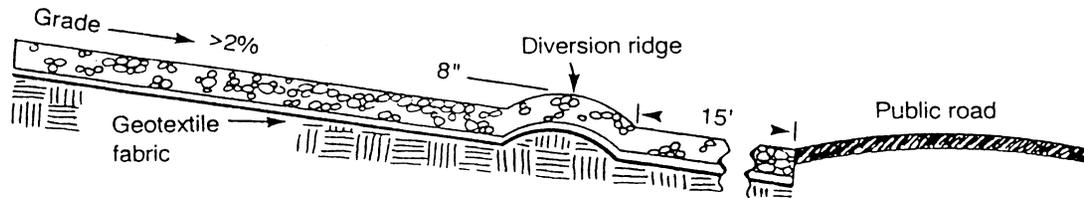


Figure 6.06c Temporary gravel construction entrance/exit with diversion ridge where grade exceeds 2%.

Place geotextile fabric on graded foundation to improve stability, especially where wet conditions are anticipated.

Place stone to dimensions and grade shown on plans. Leave surface smooth and sloped for drainage.

Divert all surface runoff and drainage from the stone pad to a sediment trap or basin.

Install pipe under pad if needed to maintain proper public road drainage.

**Common  
Trouble  
Points**

- Inadequate runoff control—sediment washes onto public road (Figure 6.06d).
- Stone too small, pad too thin, or geotextile fabric absent—results in muddy condition as stone is pressed into soil.
- Pad too short for heavy construction traffic—extend pad beyond the minimum 50-ft length as necessary.
- Pad not flared sufficiently at road entrance—results in mud being tracked onto road and possible damage to road edge.
- Unstable foundation—use geotextile fabric under pad and/or improve foundation drainage.

Figure 6.06d  
Trouble point:  
Inadequate runoff  
control—sediment  
washes onto  
public road.



- Maintenance** Inspect entrance/exit pad and sediment disposal area weekly and after heavy rains or heavy use.
- Reshape pad as needed for drainage and runoff control.
  - Topdress with clean stone as needed.
  - Immediately remove mud and sediment tracked or washed onto public road.
  - Repair any broken road pavement immediately.

**TEMPORARY SEEDING**

**Purpose** To stabilize disturbed areas before final grading or in a season not suitable for permanent seeding (Figure 6.10a).

Figure 6.10a  
Temporary  
seeding of  
Sudangrass  
controls erosion  
until permanent  
ground cover can  
be applied.

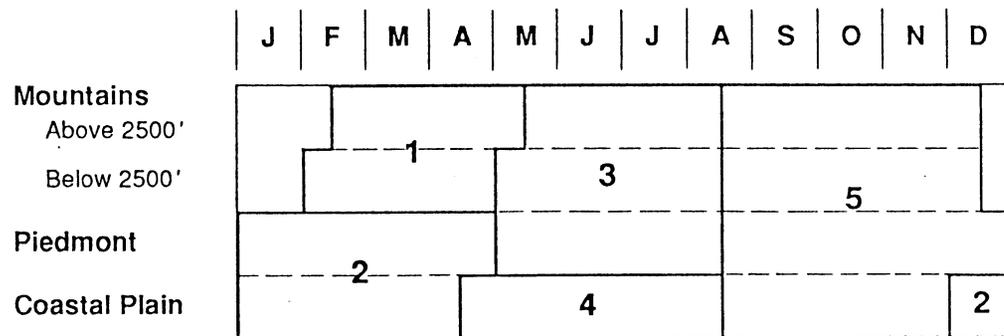
**Minimum  
Requirements**

- **Seedbed preparation:** lime and fertilizer incorporated 4-6 inches, where conditions allow, steep slopes roughened by tracking.
- **Plant selection:** temporary species appropriate for season and region (Figure 6.10b).
- **Seed quality:** North Carolina certified seed, tested within the past 9 months.
- **Mulch:** effective mulch such as clean grain straw, tacked and/or tied down with netting to protect seedbed and encourage plant growth (reference Practice 6.14, *Mulching*).

**Installation**

**Seedbed Preparation** Apply soil amendments evenly and incorporate to a depth of 4-6 inches, if possible. Follow recommendations of soil tests or apply 2000 lb/acre ground agricultural limestone and 700-1000 lb/acre 10-10-10 fertilizer. Loosen surface just before broadcasting seed (reference Practice 6.11, *Permanent Seeding*).

**Plant Selection** Select an appropriate temporary species based on the calendar in Figure 6.10b. Avoid seeding in December or January. If necessary to seed at these times, use rye grain and a securely tacked mulch.



**Recommended Plantings**

**Legend**

1	Korean Lespedeza with .....	50 lb/acre
	Rye Grain .....	120 lb/acre
2	Kobe Lespedeza with .....	50 lb/acre
	Rye Grain .....	120 lb/acre
3	German Millet or .....	40 lb/acre
	Sudangrass .....	50 lb/acre
4	German Millet .....	40 lb/acre
5	Rye Grain .....	120 lb/acre

Figure 6.10b Calendar for scheduling temporary seedings.

Apply seed evenly using a cyclone seeder, rotary-spreader, drop-spreader, cultipacker seeder, or hydroseeder. Hand broadcasting is not recommended because it is difficult to achieve a uniform stand.

Cover broadcast seed by raking or by dragging a chain. Firm lightly with a roller or cultipacker.

When drill-seeding, plant small grains no more than 1 inch deep, and grasses and legumes no more than 1/2 inch deep.

Mulch all seedings to reduce erosion and encourage seedling growth. Straw mulch is commonly used on gently sloping areas. Spread evenly at a rate of 2 tons/acre and anchor securely with tackifier, asphalt, or netting. Netting is the most effective method on steep slopes and in channels (reference Practice 6.14, *Mulching*).

### Common Trouble Points

- Lime and fertilizer not incorporated to at least 4 inches—may be lost to runoff or remain concentrated near the surface where they may inhibit germination.
- Mulch rate inadequate or straw mulch not tacked down—results in poor germination or failure, and erosion damage. Repair damaged areas, reseed and mulch.
- Annual ryegrass used for temporary seeding—ryegrass reseeds itself and makes it difficult to establish a good cover of permanent vegetation.
- Seed not broadcast evenly or rate too low—results in patchy growth and erosion.

### Maintenance

Inspect within 6 weeks of planting to see if stands are adequate. Check for damage after heavy rains. Stands should be uniform and dense. Fertilize, reseed, and mulch damaged and sparse areas immediately. Tack or tie down mulch as necessary.

Topdress fall plantings with 50 lb/acre nitrogen in February or March.





## PERMANENT SEEDING

**Purpose** To stabilize disturbed areas with vegetation for periods longer than 12 months (Figure 6.11a).

Figure 6.11a  
Permanent cover  
protects slopes  
after grading.



### Minimum Requirements

- **Surface roughening:** slopes steeper than 3:1 should be roughened by tracking, grooving, or furrowing.
- **Amendments:** lime and fertilizer, incorporated 4-6 inches where conditions allow (refer to *Seedbed Preparation*, below).
- **Seed quality:** North Carolina certified seed, tested within the past 9 months.
- **Planting date:** appropriate for region and species (Figure 6.11b).
- **Plants:** recommended erosion control plants are listed in Table 6.11a. Select a seeding mixture from those shown in Tables 6.11b-g.
- **Mulch:** 75% of the ground surface covered with approved material (reference Practice 6.14, *Mulching*).
- **General:** inspect seeded areas 2-4 weeks after seeding. Repair and reseed as necessary.

- Definitions**
- Certified seed:** seed that has been inspected and tested according to official North Carolina standards and is labeled with information on germination, purity, and contaminating species.
- High maintenance:** (as used in Tables 6.11b-g) plantings that require frequent mowing, fertilizer, and pest control.
- Hulled seed:** seed that has its outer protective covering, or hull, removed to speed germination. It is also called "clean" seed. Hulled seed is not always scarified (see below).
- Inoculant (for legume seed):** nitrogen-fixing bacteria, sold in air-tight plastic bags. The bacteria colonize roots of the legume, providing nitrogen to the plant and soil.
- Legume:** members of the pea family such as lespedeza or crown vetch. Legumes are particularly suited for erosion control because they add nitrogen to the soil by means of bacteria that live on their roots (see *Inoculant*, above).
- Nurse crop or nurse plant:** an annual species such as rye grain, Sudan grass, or German millet that germinates rapidly. Nurse plants are included in mixtures to prevent erosion while slower-growing permanent plants are developing.
- Scarified seed:** seed that has been treated by scratching the hard seed coat after any hull has been removed. Scarified legume seeds germinate rapidly. Most unscarified seeds lie dormant until the following spring.
- Sprigs:** fragments of spreading grasses that include at least one node (joint). Planting sprigs is an alternative to seeding; it is the only means of establishing hybrid Bermudagrass, which cannot be seeded.

- Installation**
- During final grading, take soil samples from the top 6 inches in each area to be seeded. Sample containers and directions are available from the North Carolina Department of Agriculture (NCDA) soil testing lab, or through county Agricultural Extension offices.
- Submit samples to the NCDA or a commercial laboratory for liming and fertilizer recommendations.\*

\*Agronomic Division, NC Department of Agriculture, Blue Ridge Rd. Center, Raleigh, NC.

6.11

Seedbed Preparation

- Apply ground agricultural limestone, unless a soil test indicates pH 6.0 or greater. If a soil test is not available, use a rate based on soil texture:

Coarse textured: 1-1 1/2 tons/acre

Fine textured: 2-3 tons/acre

- Apply a complete fertilizer at rates recommended by soil tests. In the absence of soil test, use the following as a guide:

Grasses: 800-1200 lb/acre of a 10-10-10 analysis fertilizer (or equivalent)

Grass-legume mixtures: 800-1200 lb/acre of a 5-10-10 fertilizer (or equivalent)

- Incorporate lime and fertilizer to a depth of 4-6 inches by disking or chiseling on slopes up to 3:1. Do not mix lime and fertilizer prior to application.

- Fill in depressions that can collect water. Where mowing is planned, continue tillage until a uniform, finely pulverized seedbed is achieved.

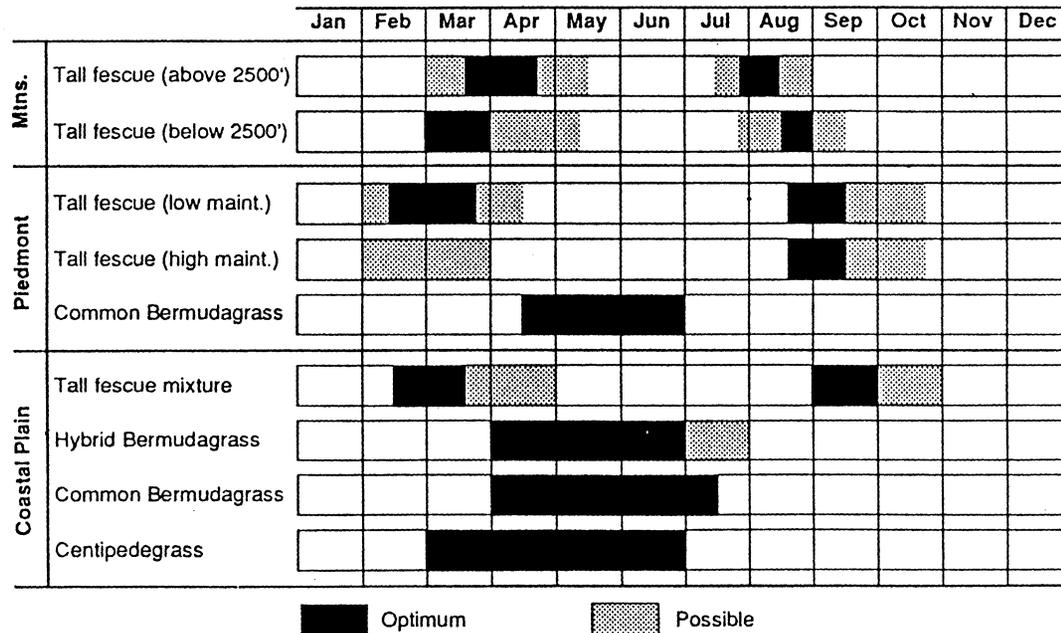


Figure 6.11b Calendar for permanent seeding recommendations by region.

- Seeding** **Seeding dates:** Use the seeding calendar shown in Figure 6.11b. As you vary from the recommended dates, the probability of failure increases rapidly. If scheduled outside these dates, use temporary seeding until preferred date for permanent seeding (reference Practice 6.10, *Temporary Seeding*).
- Select a seeding mixture** from Tables 6.11b-g based on region (Mountains, Piedmont, Coastal Plain), soil characteristics, slope, and level of maintenance. Table 6.11a lists characteristics and applications of grasses and legumes used in the mixtures.
- Inoculate legume seed** to ensure good growth. Cut-and-fill soils are likely to be deficient in the appropriate bacteria.
- Seeding rates** in Tables 6.11b-g are based on poor growing conditions that typically exist, and a need for dense growth. **Higher seeding rates will not substitute for good seedbed preparation.**
- Apply seed uniformly**, using a cyclone seeder, drop-type spreader, drill, cultipacker seeder, or hydroseeder. When using a drill seeder, plant rye or other grains no more than 1 inch deep, grasses and legumes no more than 1/2 inch. Calibrate equipment in the field.
- Cover seed** by raking, chain-dragging, or dragging a brush or mat, then firm the soil lightly with a roller. Seed can also be covered with hydro-mulched wood fiber and tack. Do not roll hydro-mulched seed.
- Sprigging** Sprigs are sold by the bushel, and can be broadcast or planted in furrows using a vegetable transplanter.
- Make furrows 4-6 inches deep and 2 ft apart. Place sprigs about 2 ft apart with one end at or above surface.
- If broadcast, select rate from Table 6.11g. Press into top 1/2-2 inches of soil with a cultipacker or mulch crimper.
- Mulching** Cover area evenly with approved mulch (75% cover minimum). Crimp, tack, or tie mulch with netting. **Mulching is extremely important for successful seeding** (reference Practice 6.14, *Mulching*).

### Common Trouble Points

- Inadequate seedbed preparation—a well-tilled, limed, and fertilized seedbed is the most important step in vegetative establishment.
- Unsuitable choice of plant materials—do not plant Bermudagrass in the fall, Kentucky bluegrass in the Coastal Plain, or annual ryegrass in a permanent seeding mixture.
- Nurse crop rate too high in mixture—competes with perennial; limit rates to those shown in Tables 6.11b-g.
- Seeding at the wrong time of year—consult Figure 6.11b. If timing is not right, use temporary seeding to stabilize soil until preferred seeding dates.
- Inadequate mulching—cover area evenly and tack or tie down well, especially on slopes, ridges, and in channels.

### Maintenance

Expect emergence of grasses within 4-28 days and legumes 5-28 days after seeding, with legumes following grasses. A successful stand should exhibit the following:

- vigorous dark green or bluish green seedlings—not yellow
- uniform density, with nurse plants, legumes, and grasses well inter-mixed
- green leaves. Perennials should remain green throughout the summer, at least at the plant bases.

For at least a year, inspect stands for erosion or die-out. Repair damaged, bare, or sparse areas by filling any gullies, refertilizing, reseeding, and mulching.

### Reseeding

If plant cover is sparse or patchy, re-evaluate the choice of plant materials and quantities of lime and fertilizer. Depending on the condition of the stand, repair by overseeding or reseeding after complete seedbed preparation. If timing is bad, overseed with rye grain or German millet to thicken the stand until a suitable time for seeding perennials.

If vegetation fails to grow, have the soil tested to determine whether acidity or nutrient deficiency is a problem.

- Fertilization** Satisfactory establishment may require refertilizing the stand in second growing season.
- Do not fertilize cool season grasses in late May through July.
  - Grass that looks yellow may be nitrogen deficient.
  - Do not use nitrogen fertilizer if stand contains more than 20% legumes.

**Table 6.11a**  
Tolerance, Maintenance, and Propagation Characteristics of Erosion Control Plants

	Region			Drainage				Planting	Tolerance			Maintenance								
	Temporary	Permanent	Warm season	Cool season	Mountains	Piedmont	Coastal Plain	Dry	Well	Moder. well	Somewhat poor	Poor	Seed	Sprigs/sod	Days to germination <sup>1</sup>	Shade	Drought	Flooding	High	Low
<b>Grasses</b>																				
Bahiagrass		●	●		●	●		●	●	●	●		●	●	14-28		●	●		●
Bermudagrass (common)		●	●		●	●		●	●	●	●		●	●	21		●	●		●
Bermudagrass (hybrid)		●	●		●	●		●	●	●	●		●	●	—		●			●
Centipedegrass		●	●		●	●		●	●	●	●		●	●	28		●			●
Fescue, tall		●		●	●			●	●	●	●		●		5-14	●		●		●
Fescue, red	●	●	●		●			●	●	●	●		●		7-28	●		●		●
German millet <sup>2</sup>	●		●		●	●		●	●	●	●		●		4-14					●
Kentucky bluegrass		●	●		●	●		●	●	●	●		●	●	10-28			●		●
Redtop		●	●		●	●		●	●	●	●		●		5-10		●	●		●
Rye grain	●		●		●	●		●	●	●	●		●		4-7					●
Sudangrass	●		●		●	●		●	●	●	●		●		4-10					●
<b>Legumes</b>																				
Crown vetch		●	●		●			●	●	●	●		●	●	14-21		●			●
Kobe lespedeza	●		●		●	●		●	●	●	●		●		5-14		●			●
Korean lespedeza	●		●		●	●		●	●	●	●		●		5-14					●
Sericea lespedeza		●	●		●	●		●	●	●	●		●		7-28		●			●

<sup>1</sup>Number of days required for majority of seeds to germinate under favorable conditions.

<sup>2</sup>Also "Foxtail millet."

## 6.11

Table 6.11b Low-maintenance Mixtures — Mountains

Seeding No. <sup>1</sup>	Site	Plants	lb/acre
1M	Steep slopes, average soils	Tall fescue	100
		Sericea lespedeza <sup>2</sup>	20
		Korean lespedeza	10
		Redtop	5
		Kentucky bluegrass	5
		Nurse plant <sup>3</sup>	
2M	Gentle or steep slopes with stony, dry soils	Tall fescue	40
		Crown vetch	10
		Korean lespedeza	10
		Redtop	5
		Nurse plant <sup>3</sup>	
(If occasional mowing is desired, substitute 20 lb/acre sericea lespedeza for crown vetch.)			
3M	Gentle slopes, average soils	Tall fescue	60
		Kentucky bluegrass	10
		Sericea lespedeza <sup>2</sup>	15
		Korean lespedeza	10
		Nurse plant <sup>3</sup>	
7M	Gentle or steep slopes with stony, dry soils (trees)	Black locust (tree)	3
		Korean lespedeza	10
		Winter rye (grain)	15
		Weeping lovegrass	2
		Redtop	1
8M	Channels	Tall fescue	175-200
		Kentucky bluegrass	20
		Nurse plant <sup>3</sup>	

<sup>1</sup> Seeding numbers refer to seeding specifications in the *N.C. Erosion and Sediment Control Planning and Design Manual* (1988); "M" indicates Mountain region.

<sup>2</sup> After Aug. 15 use unscarified seed for sericea lespedeza.

<sup>3</sup> Between May 1 and Aug. 15, add 10 lb/acre German millet or 15 lb/acre Sudangrass. Prior to May 1 or after Aug. 15, add 40 lb/acre rye grain.

**Table 6.11c High-maintenance Mixtures — Mountains**

Seeding No. <sup>1</sup>	Site	Plants	lb/acre
4M	Soils with average or better moisture retention	Kentucky bluegrass (three improved varieties)	75-100
	(Shady locations: substitute 40% by weight fine fescue — hard, red or chewings.)		
5M & 6M	Full sun or semi-shade including drought-prone soils — minimum-care lawns	Tall fescue blend (two or three turf types)	200
		Kentucky bluegrass (50:50 mix of two improved varieties)	30-50

<sup>1</sup> Seeding numbers refer to seeding specifications in the *N.C. Erosion and Sediment Control Planning and Design Manual* (1988); "M" indicates Mountain region.

**Table 6.11d Low-maintenance Mixtures — Piedmont**

Seeding No. <sup>1</sup>	Site	Plants	lb/acre
1P	Steep slopes or poor soils	Tall fescue	100
		Sericea lespedeza <sup>2</sup>	30
		Kobe lespedeza	10
		Nurse plant <sup>3</sup>	
	(Eastern Piedmont: add 25 lb/acre Pensacola Bahiagrass or 10 lb/acre common Bermudagrass.)		
2P	Gentle slopes, average soil	Tall fescue	80
		Sericea lespedeza <sup>2</sup>	20
		Kobe lespedeza	10
		Nurse plant <sup>3</sup>	
	(Fall plantings: Kobe is best overseeded in late winter.)		
5P	Channels	Tall fescue	200
		Nurse plant <sup>3</sup>	

<sup>1</sup> Seeding numbers refer to seeding specifications in the *N.C. Erosion and Sediment Control Planning and Design Manual* (1988); "P" indicates Piedmont.

<sup>2</sup> After Aug. 15 use unscarified seed for sericea lespedeza.

<sup>3</sup> Between May 1 and Aug. 15, add 10 lb/acre German millet or 15 lb/acre Sudangrass. Prior to May 1 or after Aug. 15, add 40 lb/acre rye grain.

**Table 6.11e High-maintenance Mixtures — Piedmont**

Seeding No. <sup>1</sup>	Site	Plants	lb/acre
3P	Soils with average or better moisture retention — cool sites	Tall fescue (two turf types)	200
		Kentucky bluegrass (two or more improved varieties)	20
4P	Dry soils, soils with physical limitations, or warm sites	Tall fescue blend (three or more varieties — turf types or KY-31)	200-250

<sup>1</sup> Seeding numbers refer to seeding specifications in the *N.C. Erosion and Sediment Control Planning and Design Manual* (1988); "P" indicates Piedmont.

**Table 6.11f Low-maintenance Mixtures — Coastal Plain**

Seeding No. <sup>1</sup>	Site	Plants	lb/acre
1CP	Well- to poorly-drained soils with good moisture retention	Tall fescue	80
		Pensacola Bahiagrass	50
		Sericea lespedeza <sup>2</sup>	30
		Kobe lespedeza	10
		Nurse plant <sup>3</sup>	
	(Poorly drained sites: omit sericea and increase Kobe to 30 lb/acre.)		
5CP	Dry to well-drained soils	Pensacola Bahiagrass	50
		Sericea lespedeza <sup>2</sup>	30
		Common Bermudagrass	10
		German millet	10
	(Bermudagrass may be replaced with 5 lb/acre centipedegrass.)		
7CP	Channels	Common Bermudagrass	40-80

<sup>1</sup> Seeding numbers refer to seeding specifications in the *N.C. Erosion and Sediment Control Planning and Design Manual* (1988); "CP" indicates Coastal Plain.

<sup>2</sup> From Sept. 1 to March 1, use unscarified seed for sericea lespedeza. Where a neat appearance is required omit sericea and increase Kobe to 40 lb/acre.

<sup>3</sup> Between April 15 and Aug. 15, add 10 lb/acre German millet or 15 lb/acre Sudangrass. Prior to April 15 or after Aug. 15, add 40 lb/acre rye grain.

**Table 6.11g High-maintenance Mixtures — Coastal Plain**

Seeding No. <sup>1</sup>	Site	Plants	Rate/acre
2CP	Well- to poorly-drained soils with good moisture retention	Tall fescue blend (two or three improved varieties)	200 lb
		Rye grain	25 lb
3CP	Well-drained sandy loam to sand	Hybrid Bermudagrass (Tifway or Tifway II)	130-140 bu
4CP	Well-drained, sandy loam to sand — minimum care lawns	Centipedegrass	33 bu (sprigs)
			10-20 lb (seed)

<sup>1</sup> Seeding numbers refer to seeding specifications in the *N.C. Erosion and Sediment Control Planning and Design Manual* (1988); "CP" indicates Coastal Plain.

**SODDING**

**Purpose** To provide immediate vegetative cover of critical areas, channels, and sediment control structures (Figure 6.12a).

Figure 6.12a  
Installing  
grass sod.

**Minimum  
Requirements**

- **Plant material:** high-quality, healthy, vigorous sod. Select a variety that is well-adapted to the region and expected level of maintenance.
- **Soil amendments:** lime and complete fertilizer, incorporated to a depth of 4-6 inches.
- **Surface:** smooth and firm; not compacted clay or pesticide-treated soil.
- **Irrigation:** required to ensure rooting of sod.

**Installation****Site  
Preparation**

Apply amendments according to soil test recommendations. In the absence of a soil analysis, apply amendments at the following rates:

- Ground agricultural limestone—100 lb/1000 ft<sup>2</sup>
- Fertilizer (10-10-10 in fall, 5-10-10 in spring)—25 lb/1000 ft<sup>2</sup>

Incorporate amendments to a depth of 4-6 inches with a disk or chisel plow.

Rake or harrow to achieve a smooth, final grade. Roll or cultipack to create a smooth, firm surface on which to lay the sod.

**Laying Sod** Install sod within 36 hrs of harvest. Store rolls of sod in shade during installation.

Rake soil surface to break crust just before laying sod, or irrigate soil lightly if weather is hot. Do not install on hot, dry soil, compacted clay, frozen soil, gravel, or soil that has been treated with pesticides.

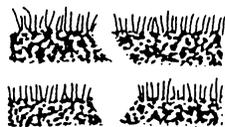
Install strips of sod with their longest dimension perpendicular to the slope, and stagger in a brick-like pattern. Do not stretch or overlap. All joints should butt tightly against each other. Match angled ends correctly to prevent voids (Figure 6.12b). Use a knife or mason's trowel to trim and fit irregularly shaped areas.

Roll sod lightly after installation to make a firm soil contact.

Irrigate sod until soil is wet to a depth of 4 inches, and keep moist until grass takes root.



Lay sod in a staggered pattern with strips butted tightly against each other. A sharpened mason's trowel can be used to tuck down the ends and trim pieces.



Correct

Incorrect

Angled ends must be matched correctly.

Figure 6.12b Detailed installation of grass sod.

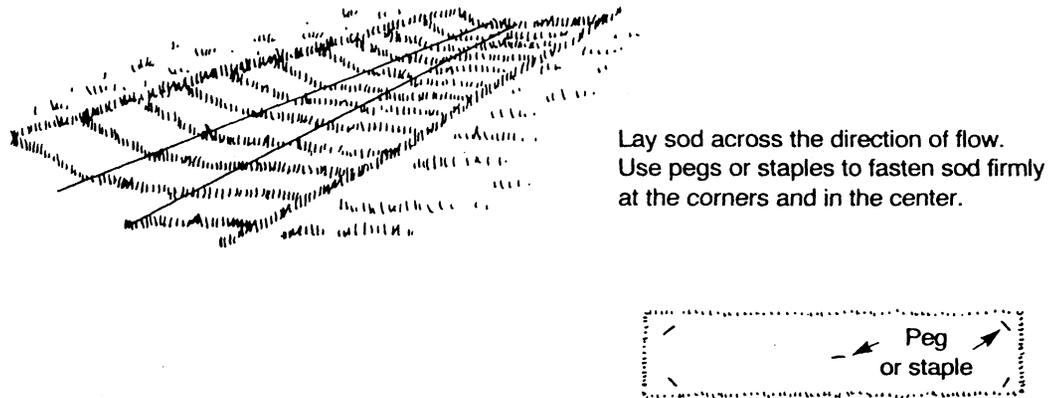


Figure 6.12c Installation of sod in waterways.

**Sodded Waterways** Sod provides quicker protection than seeding and may reduce the risk of early washout.

When installing sod in waterways:

- Use the type of sod specified in the channel design.
- Lay sod strips perpendicular to the direction of waterflow and stagger in a brick-like pattern (Figure 6.12c).
- Staple firmly at the corners and middle of each strip. Jute or plastic netting may be pegged over the sod for further protection against washout during establishment.

---

**Common  
Trouble  
Points**

- Sod laid on poorly prepared soil or unsuitable surface—grass dies because it is unable to root.
- Sod not adequately irrigated after installation—may cause root die-back; grass does not root rapidly and is subject to drying out.
- Sod not anchored properly—may be loosened by runoff.

**Maintenance**

Keep sod moist until it is fully rooted.

Mow to a height of 2-3 inches after sod is well-rooted (2-3 weeks). Do not remove more than one-third of the shoot in any mowing.

Permanent, fine turf areas require yearly maintenance fertilization. Fertilize warm-season grass in late spring to early summer, cool-season grass in late winter and again in early fall.

**MULCHING**

**Purpose** To provide temporary erosion protection and promote growth of vegetation. *This is one of the most important, effective, and economical erosion-control practices (Figure 6.14a).*

Figure 6.14a  
Erosion-control  
matting protects  
channel until  
grass becomes  
established.

**Minimum  
Requirements**

- **Material:** as specified in the approved plan, or an equivalent mulch selected from Table 6.14a. On steep slopes and in channels, install and anchor matting, geofabric, or netting-over-straw.
- **Coverage:** at least 75% of the soil surface.
- **Anchoring method:** straw or hay mulch should be anchored by applying tackifier, stapling netting over the top, or crimping with a mulch crimping tool. Materials that are heavy enough to stay in place do not need anchoring (for example, bark or wood chips).

Table 6.14a  
Typical Mulching  
Materials and  
Application Rates

Material	Rate Per Acre	Requirements	Notes
<b>ORGANIC MULCHES</b>			
Straw	1-2 tons	Dry, unchopped, unweathered; avoid weeds.	Spread by hand or machine; must be tacked or tied down.
Wood fiber or wood cellulose	1/2-1 ton		Use with hydro-seeder; may be used to tack straw. Do not use in hot, dry weather.
Wood chips	5-6 tons	Air dry. Add fertilizer N, 12 lb/ton.	Apply with blower, chip handler, or by hand. Not for fine turf areas.
Bark	35 yd <sup>3</sup>	Air dry, shredded or hammermilled, or chips.	Apply with mulch blower, chip handler, or by hand. Do not use asphalt tack.
<b>NETS AND MATS</b>			
Jute net	Cover area	Heavy, uniform; woven of single jute yarn. Used with organic mulch.	Withstands water flow.
Excelsior (wood fiber) mat	Cover area		
Fiberglass roving	1/2-1 ton	Continuous fibers of drawn glass bound together with a non-toxic agent.	Apply with compressed air ejector. Tack with emulsified asphalt at rate of 25-35 gal/1000 ft <sup>2</sup> .
<b>CHEMICAL STABILIZERS (Soil binders)*</b>			
Aquatain Aerospray Curasol AK Petroset SB Krete Crust 500	Follow manufacturer's specifications.		Not beneficial to plant growth. Do not attempt to seed/mulch over the soil binder.

\*Use of trade names does not imply endorsement of product.

**Installation** Spread mulch uniformly, by hand, with a mulch blower, or with a hydro-mulcher. After spreading, no more than 25% of the ground surface should be visible.

**Straw mulch:** apply 1-2 tons/acre (use the higher rate on steeper slopes).

**Anchor organic mulch** (other than wood or bark chips) by one of the following means, to resist runoff and wind:

- Crimping with a mulch anchoring tool or with a weighted farm disk set nearly straight.
- Applying a liquid tackifier—apply emulsified asphalt 0.1 gal/yd<sup>2</sup>, heavier at edges of area and at crests of ridges and banks. Apply other tackifiers according to manufacturers' specifications.
- Stapling netting securely over straw mulch (Figure 6.14b). Netting may be the only effective anchoring method for steep slopes and channels.

**Installing Netting and** Bury upslope end of net in a trench 6 inches deep and unroll downgrade (Figure 6.14b). Allow netting to lay loosely on the surface—**do not stretch**.

**Matting** Staple strips every 1 ft across the top, and every 3 ft around the edges, bottom, and down the middle. In channels, staple every 2 ft down the edges and middle.

Overlap adjacent strips 3 inches and staple, every 3 ft, on the overlap.

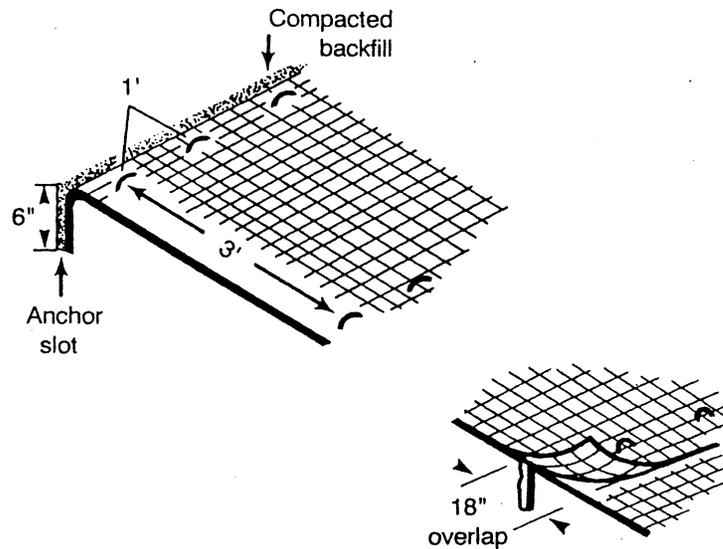
To join ends of strips: overlap 18 inches and staple every 1 ft on the overlap. An anchor slot is recommended to secure mats in channels with unstable soils. Backfill must be well compacted.

On slopes steeper than 3:1, make a 6-inch check slot every 15 ft, insert a fold of net into slot, backfill with soil and compact firmly.

**Installing Fiber Glass** Roving is applied with a compressed air ejector, alone or over straw.

- Apply uniformly at a rate of 0.25 - 0.35 lb/yd<sup>2</sup>.
- Anchor with emulsified asphalt at a rate of 0.25 - 0.35 gal/yd<sup>2</sup>.
- On steep slopes and in channels, bury upslope end of roving and anchor with stakes on 10-ft centers.

Figure 6.14b  
Installation of nets  
and mats.



### Common Trouble Points

- Inadequate coverage—results in erosion, washout, and poor plant establishment.
- Appropriate tacking agent not applied, or applied in insufficient amount—mulch is lost to wind and runoff.
- Channel grade and liner not appropriate for amount of runoff—results in erosion of channel bottom. Plan modification may be required.
- Hydromulch applied in winter—results in deterioration of mulch before plants can become established.

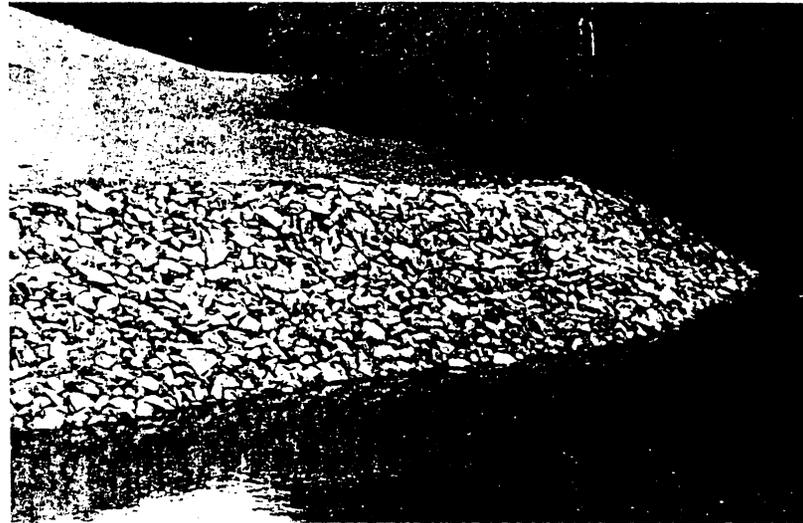
### Maintenance

Inspect after rainstorms to check for movement of mulch or erosion. If washout, breakage, or erosion occurs, repair surface, reseed, remulch, and install new netting. Continue inspections until vegetation is firmly established.

**RIPRAP**

**Purpose** To protect slopes, streambanks, channels, or areas subject to erosion by wave action (Figure 6.15a).

Figure 6.15a  
Riprap provides  
immediate protec-  
tion of disturbed  
slopes.

**Minimum  
Requirements**

- **Stone:** hard, angular, weather-resistant; specific gravity at least 2.5.
- **Gradation:** well-graded stone, 50% by weight larger than the specified  $d_{50}$ . The largest stones should not exceed 1.5 times the  $d_{50}$  specified (Table 6.15a).
- **Filter:** heavy-duty filter fabric or aggregate layer as specified in the plan is required under all permanent riprap installations.
- **Slope:** 2:1 or flatter, unless approved in plan.
- **Thickness:** 1.5 times the maximum stone diameter, minimum, or as specified in the plan.

Table 6.15a  
NC DOT Classes  
of Riprap and  
Erosion Control  
Stone

Riprap		Erosion Control Stone	
Class 1	Class 2	Class A	Class B
5 to 200 lb	25 to 250 lb	2" to 6"	5" to 15"
30% shall weigh a minimum of 60 lb each	60% shall weigh a minimum of 100 lb each		
No more than 10% shall weigh less than 15 lb each	No more than 5% shall weigh less than 50 lb each	10% tolerance top and bottom sizes	
		Equally distributed, no gradation specified	Equally distributed, no gradation specified

*Source: NC Aggregates Association*

**Installation**

**Subgrade Preparation**

Remove brush, trees, stumps, and other objectionable materials.  
Excavate deep enough for both filter and riprap. Compact any fill material to the density of surrounding undisturbed soil.  
**NOTE:** Over-excavation to allow for riprap and filter increases the amount of spoil considerably (reference Practice 6.31, *Riprap-lined Channels*).  
Cut a keyway in stable material at base of slope to reinforce the toe. Keyway depth should be 1.5 times the design thickness of riprap and should extend a horizontal distance equal to the design thickness (Figure 6.15b).

**Filter**

Install synthetic filter fabric or a sand/gravel filter on subgrade as specified in plans.

- **Synthetic filter fabric**—Place filter fabric on a smooth foundation. Overlap edges at least 12 inches, with anchor pins spaced every 3 ft along overlap. For large stones, a 4-inch layer of sand may be needed to protect filtercloth.
- **Sand/gravel filter**—Spread well-graded aggregate in a uniform layer to the required thickness (6 inches minimum). If two or more layers are specified, place the layer of smaller stones first and avoid mixing the layers.

### Stone Placement

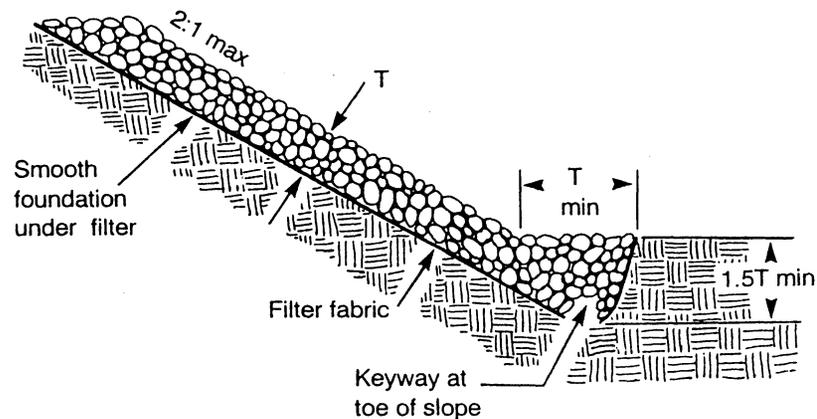
Place riprap immediately after installing filter.

Install riprap to full thickness in one operation. Do not dump through chutes or use any method that causes segregation of stone sizes. Avoid dislodging or damaging underlying filter material when placing stone.

If fabric is damaged, remove riprap and repair fabric by adding another layer, overlapping the damaged area by 12 inches.

Place smaller stones in voids to form a dense, uniform, well-graded mass. Selective loading at the quarry and some hand placement may be necessary to obtain an even distribution of stone sizes.

Figure 6.15b  
Riprap slope protection.



Blend the stone surface smoothly with the surrounding area allowing no protrusions or overfall (Figure 6.15c).

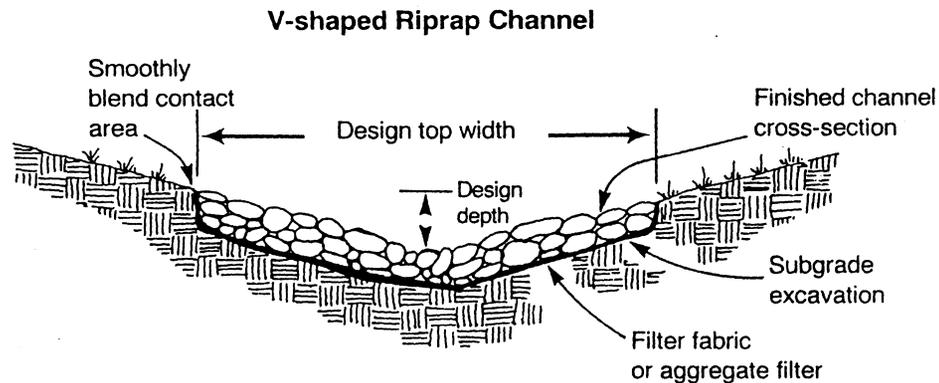


Figure 6.15c Placement of channel riprap.

- Common Trouble Points**
- Excavation not deep enough—riprap blocks channel, resulting in erosion along edges.
  - Slope too steep—results in stone displacement. **Do not use riprap as a retaining wall.**
  - Foundation not properly smoothed for filter placement—results in damage to filter.
  - Filter omitted or damaged—results in piping or slumping (Figure 6.15d).

Figure 6.15d  
Slumping of riprap  
where filter is  
omitted.



- Riprap not properly graded—results in stone movement and erosion of foundation.
- Foundation toe not properly reinforced—results in undercut riprap slope or slumping.
- Fill slopes not properly compacted before placing riprap—results in stone displacement.

**Maintenance** Inspect periodically for displaced stones, slumping, and erosion at edges, especially downstream or downslope. Properly designed and installed riprap usually requires very little maintenance if repaired promptly.



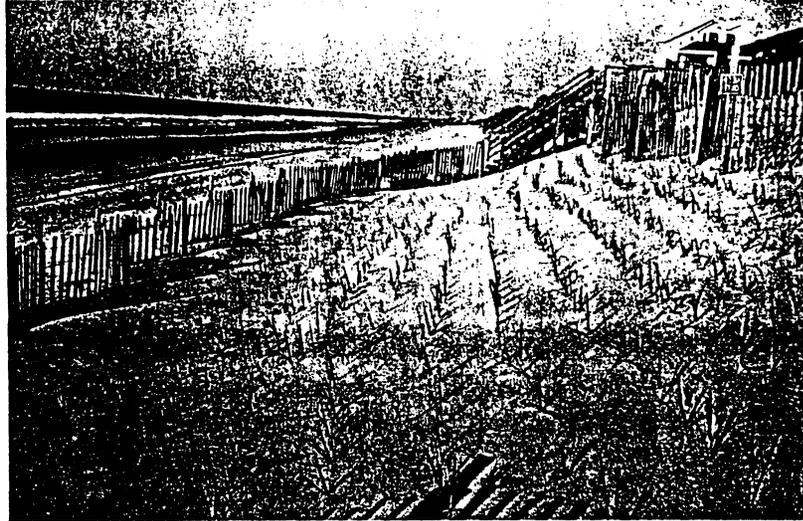




## VEGETATIVE DUNE STABILIZATION

**Purpose** To build or repair dunes that protect backshore areas and to stabilize sandy, coastal sites disturbed by construction activities (Figure 6.16a).

Figure 6.16a  
Dune grasses hold dune and collect blowing sand.



### Minimum Requirements

- **Plant materials:** Hatteras American beachgrass, with 5-10% sea oats and/or bitter panicum.
- **Planting dates:** American beachgrass — November-March  
Sea oats and bitter panicum — March-June
- **Planting depth:** American beachgrass and sea oats — 8-10 inches  
Bitter panicum — 6-8 inches
- **Spacing:** To repair or maintain existing dunes, plant on 1.5-ft centers. To build dunes, use the graduated spacing pattern shown in Figure 6.16b. Place plants 1.5 ft apart in each row.
- **Fertilization:** 15 lb/1000 ft<sup>2</sup> of 10-10-10 fertilizer applied after root growth begins. Maintenance as shown in Table 6.16a.
- **Do not mulch.**

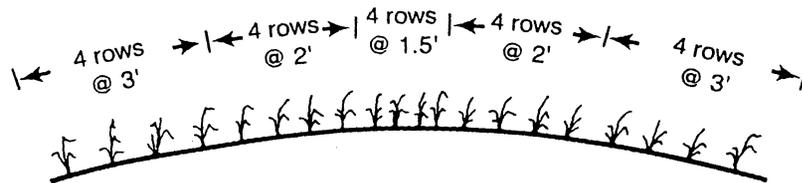


Figure 6.16b Graduated row spacing, closer in the center, wider at the edges.

## Installation

**Site Preparation** Install sand fences as described in Practice 6.85, *Sand Fence (Wind Fence)*. Tillage and liming are not required for planting on beach sand.

**Planting** Graduate row spacing as shown in Figure 6.16b, closely spaced at center of dune, wider toward the edges. When repairing a planting, space rows 1.5 ft on center.

**American beachgrass and sea oats:** Plant small areas and steep slopes by hand. Dig a hole with a shovel or dibble bar, insert a single, healthy plant (sprig), and firm sand around plant.

Large, flat areas may be planted with a tractor-drawn transplanter. Set furrow depth to 8-10 inches.

**Bitter panicum:** roots from every node on its stem. Place stems in a trench and cover, leaving 6-8 inches sticking out of the sand.

**Fertilization** Do not apply fertilizer until you are certain that root growth has begun, or the fertilizer may leach out before it can be taken up.

Apply 15 lb/1000 ft<sup>2</sup> of 10-10-10 fertilizer in April or May. Follow with 4 lb/1000 ft<sup>2</sup> of ammonium nitrate in June and again in early September (Table 6.16a).

Table 6.16a  
Dune Fertilization  
Schedule

Date	First Year	Second Year	Subsequent Years (if needed)
<b>American Beachgrass</b>			
(lb/1000 ft <sup>2</sup> )			
March 15	—	10 lb 10-10-10	10 lb 10-10-10
April 15	15 lb 10-10-10	—	—
June 15	4 lb ammonium nitrate	—	—
Sept. 1	4 lb ammonium nitrate	3 lb ammonium nitrate	—
<b>Sea Oats and Bitter Panicum</b>			
(lb/1000 ft <sup>2</sup> )			
April 15	—	10 lb 10-10-10	10 lb 10-10-10
May 1	15 lb 10-10-10	—	—
June 15	4 lb ammonium nitrate	—	—
July 1	—	3 lb ammonium nitrate	—
August 1	4 lb ammonium nitrate	—	—

*Source: S.W. Broome et al., 1982.*

### Common Trouble Points

- Planting too late in the year—high probability of plants dying from drought and heat stress.
- American beachgrass is planted in pure stands—stands are susceptible to die-out from insects and disease; weak areas erode rapidly from wind action.
- Maintenance fertilization not carried out, resulting in poor growth and weak stand. Rapid and vigorous spreading of plants is required to hold and collect sand.
- Planting too close to beachfront. Even well-vegetated dunes can be eroded by wave action during storms.

**Maintenance** Replant weak areas. Fertilize twice during the second growing season and once each year thereafter as needed (Table 6.16a). When American beachgrass dies out, replace it with sea oats, bitter panicum, or seashore elder.

Do not mow.

## TEMPORARY DIVERSIONS

**Purpose** To protect work areas from runoff and divert water to sediment traps or stable outlets (Figure 6.20a).

Figure 6.20a  
Temporary  
earthen  
diversion.



### Minimum Requirements

- **Drainage area:** limited to 5 acres.
- **Capacity:** peak runoff from 10-yr storm.
- **Ridge cross section** (Figure 6.20b):
  - Side slopes—2:1 or flatter (3:1 or flatter where vehicles cross)
  - Top width—2 ft minimum
  - Freeboard—0.3 ft minimum
- **Channel cross section:**
  - Shape—parabolic, trapezoidal, or V-shaped
  - Side slopes—2:1 or flatter (3:1 or flatter where vehicles cross)
- **Grade:** uniform or gradually increasing toward outlet, generally not exceeding 2.0%.
- **Outlet:** must be nonerosive for design flow. Divert flow containing sediment to a sediment trap.

- **Stabilization:** ridge must be stabilized with vegetation if in place longer than 30 working days. Channel must be stable for design flow.

**Installation**

**Site Preparation** Mark diversion location and remove trees, brush, stumps, and other objectionable material.

Set grade and alignment to fit site needs and topography. Maintain constant or gradually increasing grade. Realign or elevate ridge as needed to avoid reverse grade. Deviation from the plan may require prior approval.

**Construction** Construct diversion to dimensions and grades shown in plan (Figure 6.20b).

Build ridge higher than design and compact with wheels of construction equipment. Compacted ridge must be at or above design grade at all points. Channel must be constructed on design grade.

Leave sufficient area along diversion to permit cleanout and regrading.

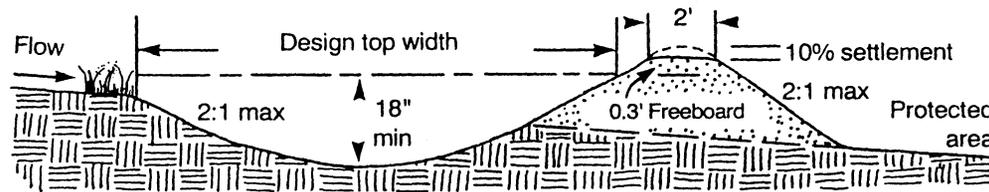


Figure 6.20b Temporary diversion cross section.

**Outlets** Stabilize outlets during installation of diversion.

Where temporary diversions are constructed above steep slopes, install temporary slope drains for outlets (reference Practice 6.32, *Temporary Slope Drains*).

Flow containing sediment must be diverted to a sediment trap.

Stabilization Vegetate ridge immediately after construction unless diversion will be in place less than 30 working days.

### Common Trouble Points

- Sedimentation where channel grade decreases or reverses causes overtopping—realign or deepen channel to maintain grade (Figure 6.20c).
- Low point in ridge often occurs where diversion crosses a natural depression—build up ridge.
- Vehicle crossing point—maintain ridge height, flatten side slopes, and protect ridge with gravel at crossing point.
- Excessive grade in channel—requires liner or realignment to reduce grade (reference Practices 6.30, *Grass-lined Channels*, and 6.31, *Riprap-lined Channels*).
- Excessive velocity at outlet—install outlet stabilization structure (reference Practice 6.41, *Outlet Stabilization Structure*).
- Ridge not compacted—attack by storm flow may cause failure.

Figure 6.20c  
Trouble point:  
Sedimentation in  
channel results in  
overflow and  
erosion.



---

**Maintenance** Inspect once a week and following each rainfall event. Remove sediment from channel and reinforce ridge as needed. Check outlets, remove sediment from traps when they are 50% full, and make necessary repairs immediately.

When watershed area has been stabilized, remove ridge and fill channel to blend with natural ground. Remove temporary slope drains. Stabilize all disturbed areas.

## PERMANENT DIVERSIONS

**Purpose** To divert water from areas where it is in excess to locations where it can be used or released without causing erosion or flood damage (Figure 6.21a).

Figure 6.21a  
Permanent diversion is located to prevent slope erosion and reduce flooding in lower area.



- Minimum Requirements**
- **Capacity:** peak runoff from 10-yr storm. Use higher capacity where safety is a concern or flood damage cannot be tolerated.
  - **Ridge cross section (Figure 6.21b):**
    - Side slopes—2:1 or flatter (3:1 or flatter if mowed)
    - Top width—2 ft minimum
    - Freeboard—0.5 ft minimum
    - Settlement—10% of fill height
  - **Channel:** Lining—to meet velocity requirements and site aesthetics  
Side slopes—2:1 or flatter (3:1 or flatter if mowed)
  - **Grade:** uniform or gradually increasing as shown on plan.
  - **Outlet:** must be nonerosive for design flow.
  - **Stabilization:** ridge and channel must be stabilized with vegetation or other appropriate measures.

**Installation**

**Site Preparation** Set grade and alignment to fit site conditions and maintain constant or gradually increasing grade. Avoid reverse grade. **Deviation from the plan may require prior approval.**

Remove and properly dispose of all trees, brush, stumps, or other objectionable material. Fill and compact all ditches, swales, or gullies to be crossed. Final foundation elevation must be at or above surrounding ground level.

Disk the base of ridge before placing fill.

**Construction** Excavate, fill, shape, and stabilize the diversion to line, grade, and cross section shown in the approved plan (Figure 6.21b).

Overfill and compact ridge, allowing 10% for settlement. Settled ridge top must be at or above design elevation at all points. Compaction may be achieved by driving wheeled equipment along the ridge as lifts are added.

Shape ridge and channel to blend with surrounding landscape.

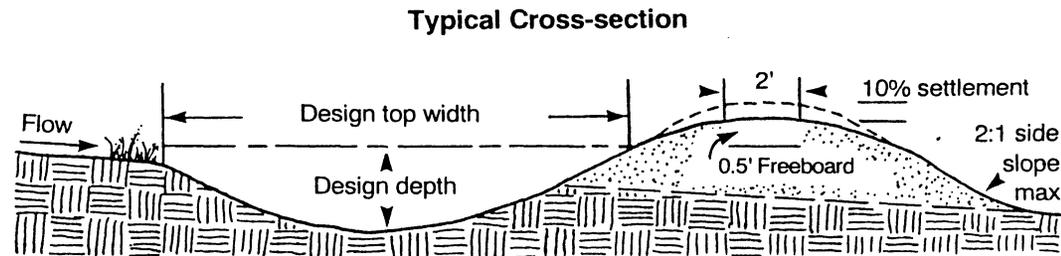


Figure 6.21b Typical cross section of permanent diversion.

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Stabilize outlets when installing diversions. Diversions carrying sediment must empty into sediment traps.

Stabilize permanent diversions with vegetation, riprap, or paving immediately after installation. If vegetation is used, protect seeding with properly anchored mulch or install sod (reference Practices 6.12, *Sodding*, and 6.30, *Grass-lined Channels*).

**Common  
Trouble  
Points**

- Sedimentation where channel grade decreases or reverses. Realign or deepen channel to maintain grade.
- Low point in ridge resulting from negative grade in channel and ridge where diversion crosses a natural depression. Build up ridge to maintain positive ridge grade.
- Vehicle crossings—build up ridge and protect with gravel at crossing points.
- Erosion occurs in channel before vegetation is fully established. Install sod or use a temporary liner to protect vegetation (reference Practices 6.12, *Sodding*, and 6.30, *Grass-lined Channels*).
- Erosion in vegetated channel bottom—grade too steep for vegetation. Install riprap or a paved liner (reference Practice 6.31, *Riprap-lined Channels*).
- Erosion damage at outlet due to excessive velocity. Install outlet stabilization structure (reference Practice 6.41, *Outlet Stabilization Structure*).

**NOTE:** Subsurface drains or stone channel bottoms may be needed where permanent vegetation cannot be established because of seepage or poor drainage.

**Maintenance**

Inspect once a week and following each rainfall event, until diversion is vegetated. After vegetation is fully established, inspect periodically and after major storms.

---

Remove debris and sediment from channel and rebuild ridge to design elevation where needed.

Check outlets and make timely repairs to prevent erosion. Remove sediment from sediment traps when 50% full.

Maintain vegetation in a vigorous, healthy condition.

When watershed area has been stabilized, remove sediment traps and repair bare or damaged areas in the vegetation. Stabilize all disturbed areas.

## DIVERSION DIKE (Perimeter Protection)

**Purpose** To prevent storm runoff from entering the work area or sediment from leaving the construction site (Figures 6.22a and 6.22b).

Figure 6.22a  
Diversion dike on  
low side of work  
area prevents  
sediment from  
leaving the site.



### Minimum Requirements

- **Drainage area:** limited to 5 acres.
- **Capacity:** peak runoff from 10-yr storm.
- **Ridge cross section (Figure 6.22c):**
  - Side slopes—2:1 or flatter (3:1 or flatter where vehicles cross)
  - Top width—2 ft minimum
  - Height—1.5 ft minimum from channel bottom
  - Freeboard—0.5 ft minimum
  - Settlement—10% of fill height
- **Channel cross section (Figure 6.22c):**
  - Side slopes—2:1 or flatter (3:1 or flatter where vehicles cross)
  - Depth and grade—as shown on plans
- **Outlet:** must be stable. Divert sediment-laden water to sediment trap; divert runoff from undisturbed areas to a stable natural outlet or outlet stabilization structure.

- **Stabilization:** ridge must be stabilized with vegetation immediately after construction and flow area stabilized according to design requirements.

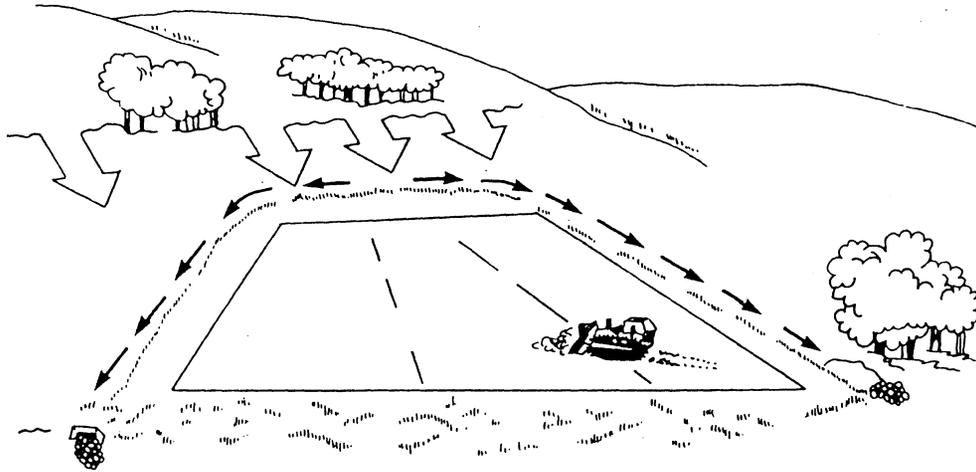


Figure 6.22b Perimeter dikes prevent surface runoff from entering construction sites.

### Installation

**Site Preparation** Remove all trees, brush, stumps, or other objectionable material and dispose of properly.

Fill and compact all ditches or gullies to be crossed. Foundation elevation must be at or above surrounding ground level.

Disk base of dike before placing fill.

**Construction** Fill dike higher than design elevation and compact with wheels of construction equipment to design height plus 10% (Figure 6.22c).

Construct channel to dimensions and elevations shown on plans.

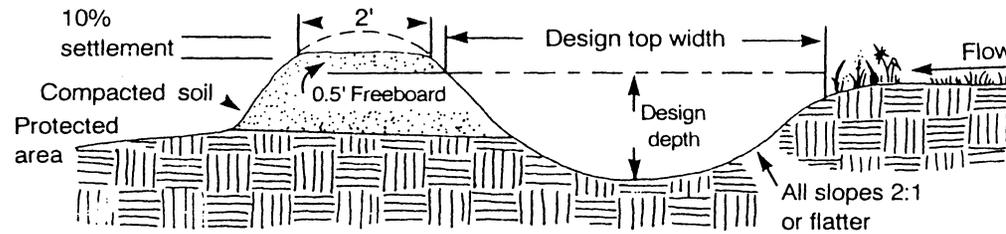


Figure 6.22c Cross section of diversion dike above area to be protected.

Leave sufficient area along diversion dike to permit access by machines for cleanout and maintenance.

**Outlets** Install outlet protection and sediment traps as part of diversion dike installation. All outlets must be stable.

**Stabilization** Stabilize channel as shown in plans. Use temporary liners to protect vegetation. Steep slopes may require riprap linings. Seed and mulch dike immediately following construction.

**Common  
Trouble  
Points**

- Erosion in channel from excessive grade—install a temporary liner in channel.
- Overtopping caused by sediment deposition in channel where grade decreases or reverses—deepen channel or realign grade.
- Overtopping at low point in ridge where diversion crosses shallow draw—reconstruct ridge with positive grade at all points.
- Erosion at outlet—install outlet stabilization structure.
- Sedimentation at diversion outlet—install sediment trap (reference Practice 6.60, *Temporary Sediment Trap*).

**CAUTION:** Water diverted from the construction site must not damage adjacent property.

---

**Maintenance** Inspect diversion dikes periodically and after every rainfall event.

Remove sediment from the channel immediately and repair dike to original height and cross section where needed.

Check outlets and make timely repairs to prevent gully formation.

Clean out sediment traps when 50% full.

When the work area has been stabilized, inspected, and approved, remove the diversion ridge and fill and compact channel to blend with the surrounding area. Remove sediment traps and dispose of unstable sediment in a designated disposal area.

Stabilize disturbed areas as shown in the vegetation plan.

## RIGHT-OF-WAY DIVERSIONS (Water Bars)

**Purpose** To prevent erosion on long, sloping right-of-way routes by diverting runoff at selected intervals (Figure 6.23a).

Figure 6.23a  
Right-of-way  
diversions (water  
bars) prevent  
erosion in utility  
access routes.



### Minimum Requirements

- **Height:** 18 inches minimum from channel bottom to top of settled ridge.
- **Side slope:** 2:1 or flatter (3:1 or flatter where vehicles cross).
- **Spacing:** for right-of-way widths less than 100 ft, spacing is given in Table 6.23a.
- **Base width of ridge:** 6 ft minimum (Figure 6.23c).

Table 6.23a  
Spacing of  
Water Bars

Slope (%)	Diverslon Spacing (ft)
< 5	125
5 to 10	100
10 to 20	75
20 to 35	50
> 35	25

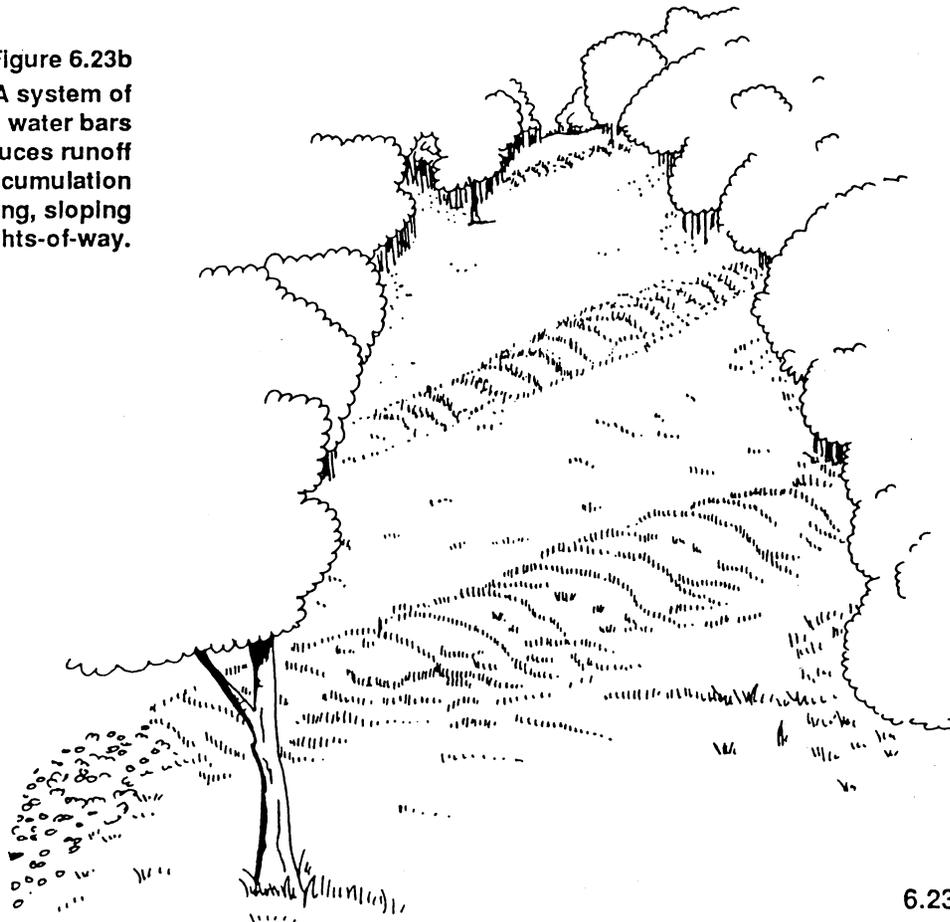
- **Grade:** constant or slightly increasing, not to exceed 2%.
- **Outlet:** diversion must cross the full access width and extend to a stable outlet.

**Installation** Construct the diversion system as soon as the access right-of-way has been cleared and graded (Figure 6.23b).

Locate first diversion at required distance from the slope crest depending on steepness of right-of-way slope (Table 6.23a). Set crossing angle to keep positive grade less than 2% (approximately 60-degree angle preferred).

Mark location and width of ridge and disk the entire length.

Figure 6.23b  
A system of water bars reduces runoff accumulation on long, sloping rights-of-way.



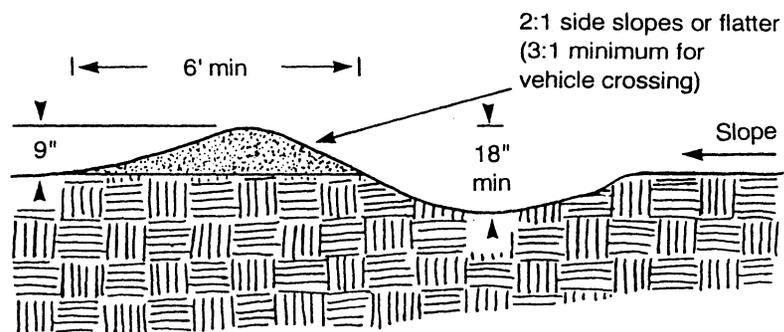
Fill and compact ridge above design height and compact with wheeled equipment to the design cross section (Figure 6.23c).

Construct diversions on constant or slightly increasing grade not to exceed 2%. **Avoid reverse grades.**

Set direction of water bars to utilize the most stable outlet locations. If necessary, adjust length of water bars or make small adjustments to spacing. Do not allow runoff from upslope water bars to converge with downslope water bar outlets. Construct sediment traps or outlet stabilization structures as needed.

Seed and mulch the ridge and channel immediately.

Figure 6.23c  
Cross section of  
a water bar.



### Common Trouble Points

- Overtopping ridge where diversion crosses low areas. Build water bars to grade at all points.
- Erosion between water bars—spacing too wide for slope (Table 6.23a). Install additional water bars.
- Ridge worn down and channel filled where vehicles cross—surface not stable or side slopes too steep; may need gravel.
- Erosion at outlets—install outlet stabilization structure or extend upslope water bar so runoff will not converge on lower outlets.
- Erosion in channel—grade too steep. Realign water bar.

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**Maintenance** Inspect water bars periodically for vehicle wear. Inspect for erosion and sediment deposition after heavy rains.

Remove debris and sediment from diversion channel and sediment traps, repair ridge to positive grade and cross section. Add gravel at crossing areas and stabilize outlets as needed.

Repair and stabilize water bars immediately if right-of-way is disturbed by installation of additional utilities.

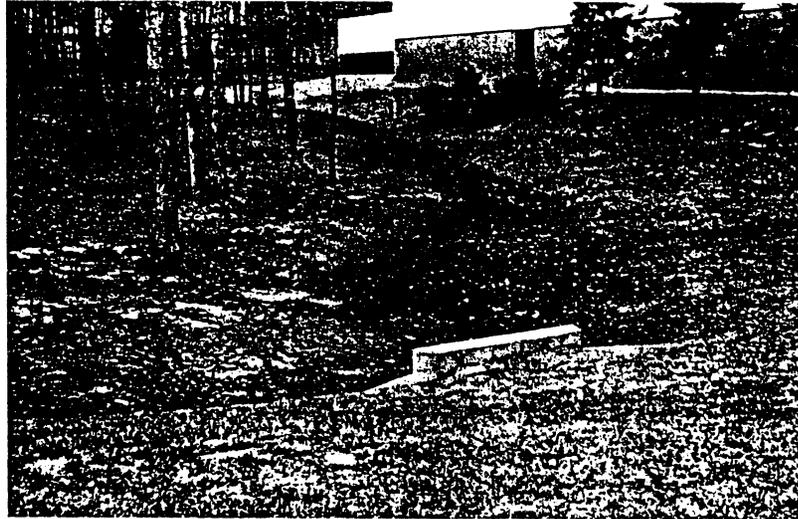
In removing temporary water bars, grade ridge and channel to blend with natural ground. Compact channel fill and stabilize disturbed areas with vegetation. Water bars should not be removed until all disturbed areas draining to them have been stabilized, inspected, and approved.

If water bars are designed for permanent use, correct any erosion problems, stabilize outlets, and apply permanent seeding.

## GRASS-LINED CHANNELS

**Purpose** To carry concentrated runoff to a stable outlet without damage from erosion or flooding (Figure 6.30a).

Figure 6.30a  
Wide, shallow  
grass-lined  
channel carries  
non-erosive flow.



### Minimum Requirements

- **Capacity:** peak runoff from 10-yr storm without erosion.
- **Cross section:** triangular “V”, parabolic, or trapezoidal.
- **Grade:** generally restricted to slopes 5% or less.
- **Side slopes:** generally 3:1 or flatter to establish and maintain vegetation and facilitate mowing.
- **Channel size:** as specified in approved plan.
- **Temporary liner:** straw and netting, excelsior mat, fiber glass mat, or similar material must be tacked, anchored, stapled, or tied firmly in place.
- **Outlet:** channels carrying sediment must empty into sediment traps. Outlet must be stable.

### Installation

Remove all trees, brush, stumps, and other objectionable material from the foundation area and dispose of properly. Install traps or other measures to protect grass-lined channels from sediment.

Excavate and shape channel to dimensions shown on plans. Overcut entire channel 0.2 ft to allow for bulking during seedbed preparation and growth of vegetation (Figure 6.30b). If installing sod, overcut channel the full thickness of the sod. Remove and properly dispose of excess soil so that surface water may enter the channel freely.

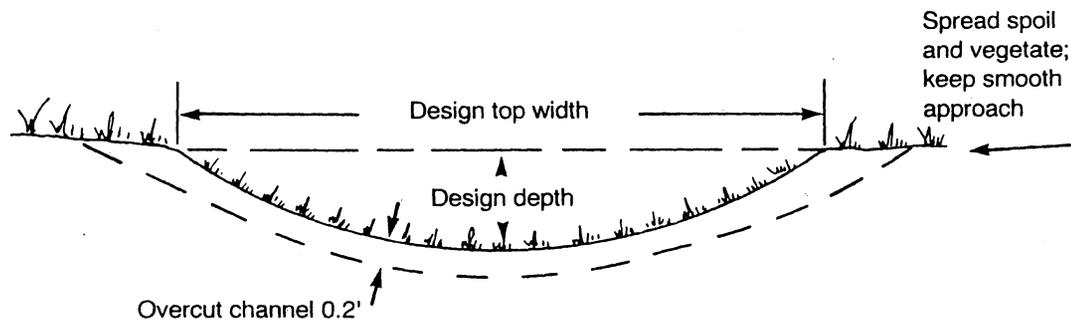


Figure 6.30b Overcut channel and grade approach for unrestricted flow.

Protect all concentrated inflow points along channel by installing a temporary liner, riprap, sod, or other appropriate measures.

Vegetate the channel immediately after grading (reference Practices 6.11, *Permanent Seeding*, and 6.14, *Mulching*). Smooth slopes facilitate maintenance.

Protect seeding with well-anchored mulch or a temporary liner (Figures 6.30c and 6.30d).

**NOTE:** Install sod instead of seeding in critical areas, particularly where slopes approach 5% (reference Practice 6.12, *Sodding*).

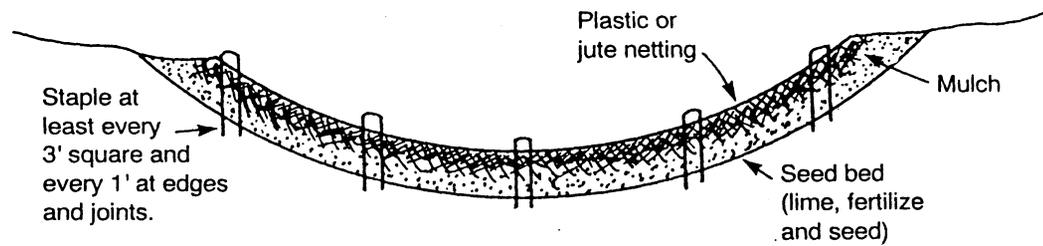
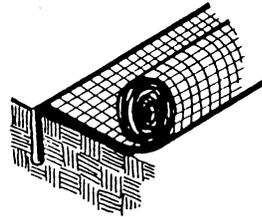


Figure 6.30c Protect seeded channel with temporary liner or well-anchored mulch as specified in plan.

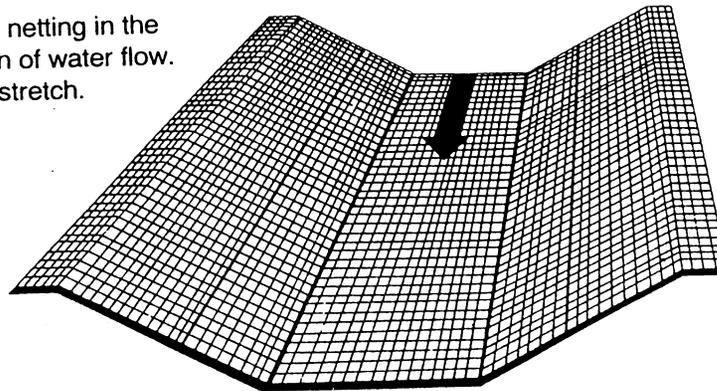
Apply a good coverage of straw mulch before installing netting.

Figure 6.30d  
Installation  
of temporary  
channel liner.

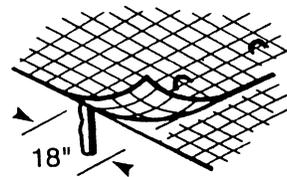


Anchor netting or matting in a 6-inch trench at upper end of channel. Compact soil firmly and staple every 1 ft, just below anchor slot.

Roll out netting in the direction of water flow. Do not stretch.



Staple each strip every 3 ft around the edges and down the center. Overlap adjacent strips 3 inches and staple.



Join ends of strips by overlapping 18 inches and stapling every 1 ft through both layers. Anchor upper end of each strip in 6-inch trench.

Stabilize outlets and install sediment traps as needed during channel installation.

### Common Trouble Points

- Erosion occurs in channel before vegetation is fully established—repair, reseed, and install temporary liner.
- Gullyng or head cutting in channel—grade too steep for grass lining (steep grade produces excessive velocity). Channel and liner should be redesigned.
- Sideslope caving may result from any of the following: 1) channel dug in unstable soil (high water table), 2) banks too steep for site conditions, or 3) velocity too high, especially on outside of channel curves.
- Overbank erosion, spot erosion, channel meander, or flooding—avoid debris and sediment accumulation. Stabilize trouble spots and revegetate. Riprap or other appropriate measures may be required.
- Ponding along channel—approach not properly graded, surface inlets blocked.
- Erosion at channel outlet—install outlet stabilization structure (reference Practice 6.41, *Outlet Stabilization Structure*).
- Sediment deposited at channel outlet—indicates erosion in channel or watershed. Find and repair any channel erosion. Stabilize watershed, or install temporary diversions and sediment traps to protect channel from sediment-laden runoff.

### Maintenance

During the establishment period, inspect grass-lined channels after every rainfall. After grass is established, check channel periodically and after heavy rainfall. Make all repairs immediately.

It is particularly important to check the channel outlet and all road crossings for blockage, sediment, bank instability, and evidence of piping or scour holes. Remove any blockage and make repairs immediately.

Remove all significant sediment and debris from channel to maintain the design cross section and grade and prevent spot erosion.

**RIPRAP-LINED CHANNELS**

**Purpose** To carry concentrated runoff to a stable outlet without erosion (Figure 6.31a).

Figure 6.31a  
A filter cloth  
foundation pre-  
vents piping of the  
riprap channel.

**Minimum  
Requirements**

- **Capacity:** peak runoff from 10-yr storm.
- **Side slopes:** 2:1 or flatter unless slope stability has been checked and approved.
- **Stone:** size and gradation as shown in approved plans and specifications. Do not use broken concrete.
- **Riprap thickness:** 1.5 times maximum stone diameter or as shown on plans.
- **Foundation:** filter fabric or aggregate filter layer is required under riprap.
- **Channel cross section:** as shown in the plans and specifications.

### Installation ■ Outlet: must be stable.

Remove all trees, brush, stumps, and other objectionable material from channel and spoil areas and dispose of properly.

Excavate cross section to the lines and grades shown in plans. Overcut for thickness of riprap and filter.

**NOTE:** Overcut for riprap and filter increases excavation and spoil disposal significantly. For example, for the channel in Figure 6.31b (3 ft deep, 4-ft bottom width, 2:1 side slope,  $d_{50}$  8-inch riprap with synthetic filter fabric), excavation doubles from, 1.1 yd<sup>3</sup>/ft of channel to 2.2 yd<sup>3</sup>/ft of channel. An aggregate filter layer would require even more excavation and disposal.

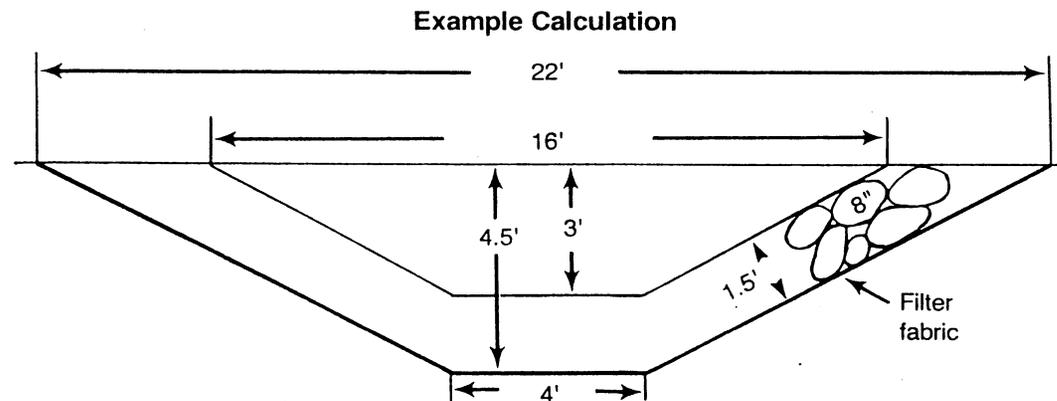


Figure 6.31b Increased volume of excavation required for riprap and filter in channel.

Install filter fabric or gravel layer as specified in the plan. Place riprap as soon as foundation is prepared.

Place riprap to the thickness, depth and elevation shown on plans. Riprap should form a dense uniform, well-graded mass with few voids. Selective loading at the quarry and some hand placement may be necessary to obtain good distribution of stone sizes.

Blend the finished stone surface with surrounding land surface (Figure 6.31c). No overfall or channel constriction should exist. Grass-lined channels with riprap bottoms must have smooth contact between riprap and vegetation.

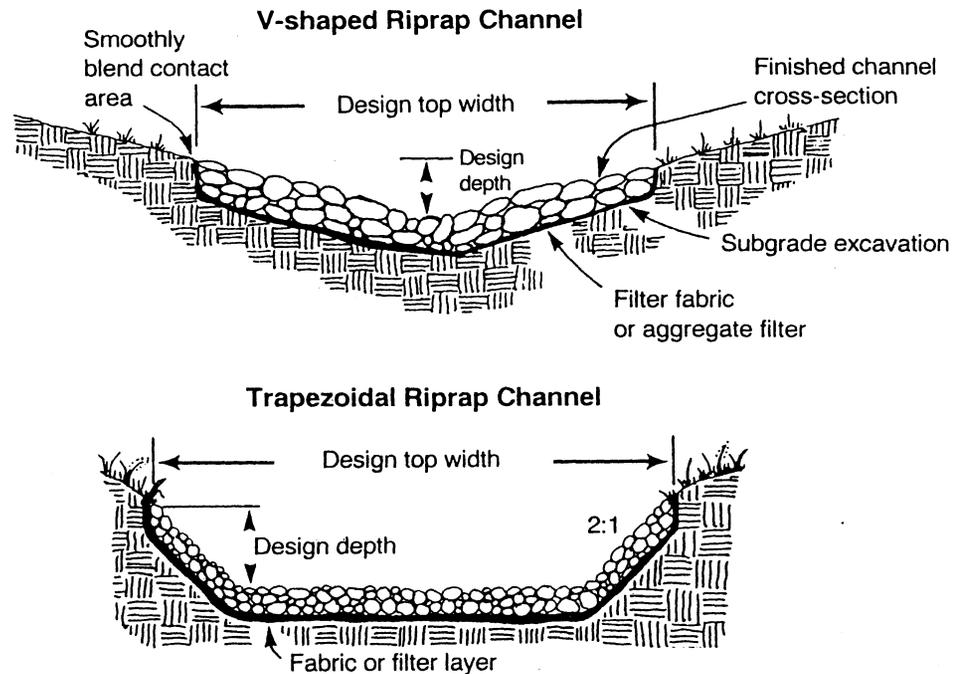


Figure 6.31c Finished riprap surface should blend with surrounding land surface.

Stabilize channel inlet points and install needed outlet protection during channel installation.

Keep erosion and water pollution to a minimum during channel construction. Stabilize all disturbed areas immediately.

#### Common Trouble Points

- Foundation not excavated deep enough or wide enough—riprap restricts channel flow, resulting in overflow and erosion.
- Side slopes too steep—causes instability, stone movement, and bank failure.

- Filter omitted or damaged during stone placement—causes piping and bank instability.
- Riprap poorly graded or stones not placed to form a dense, stable channel lining—results in stone displacement and erosion of foundation.
- Riprap not extended far enough downstream—causes undercutting. Outlet must be stable.
- Riprap not blended to ground surface—results in gullying along edge of riprap (Figure 6.31d).

Figure 6.31d  
Riprap not smoothly blended to ground surface.



**Maintenance** Inspect channels at regular intervals and after major storms. Remove debris and make needed repairs where stones have been displaced. Take care not to restrict flow area when stones are replaced.

Give special attention to outlets and points where concentrated flow enters channel. Repair eroded areas promptly.

Check for sediment accumulation, piping, bank instability, and scour holes. Repair promptly.

**TEMPORARY SLOPE DRAINS**

**Purpose** To convey runoff water down the face of a cut or fill slope without causing erosion (Figure 6.32a).

Figure 6.32a  
Temporary slope  
drain conveys  
concentrated  
flow safely down  
steep slope.



**Minimum Requirements**

- **Capacity:** peak runoff from 10-yr storm.
- **Pipe size:** based on drainage area (Table 6.32a).
- **Material:** strong, flexible pipe such as heavy duty, non-perforated, corrugated plastic.

Table 6.32a  
Pipe Size for  
Slope Drain

Maximum Drainage Area Per Pipe (Acres)	Minimum Pipe Diameter (Inches)
0.5	12
0.75	15
1.0	18
>1.0	Individually designed

- **Inlet section:** standard “T”-section or “L”-section, flared-end section with metal toe plate.
- **Connection to diversion ridge at top of slope:** compacted fill over pipe with minimum dimensions 1.5-ft depth, 4-ft top width, and 0.5 ft higher than diversion ridge (Figures 6.32b and 6.32c).
- **Outlet:** slope drain must extend beyond toe of slope, and should discharge to a sediment trap unless contributing drainage area is stable.

**Installation** Place slope drains on undisturbed soil or well-compacted fill at locations and elevations shown in plans. Set inlet of slope drain at the bottom of the diversion channel.

Slope the inlet section slightly toward the pipe outlet.

Place fill over pipe in 6-inch lifts, maximum. Compact each lift by hand-tamping under and around the inlet and along the pipe.

Connect pipe to diversion ridge at top of slope by covering with compacted fill material where it passes through the diversion ridge. Fill over pipe should be at least 1.5 ft deep, with top width of 4 ft, and 3:1 side slopes. Top of fill should be 0.5 ft higher than the adjoining diversion ridge creating an *island* over the pipe to prevent washout (Figures 6.32b and 6.32c).

Figure 6.32b  
Compact fill  
over inlet section,  
creating an *island*  
to prevent  
overtopping.

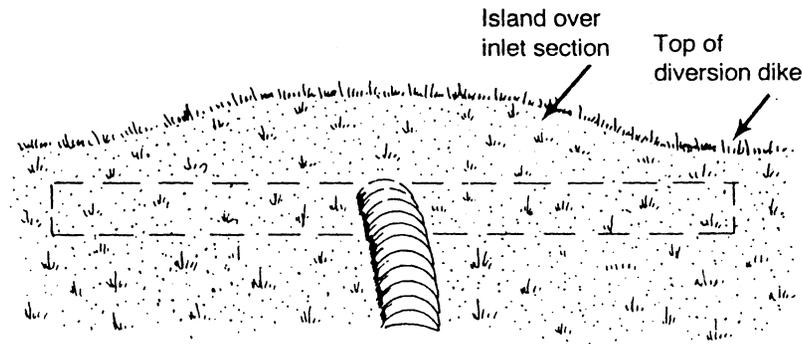
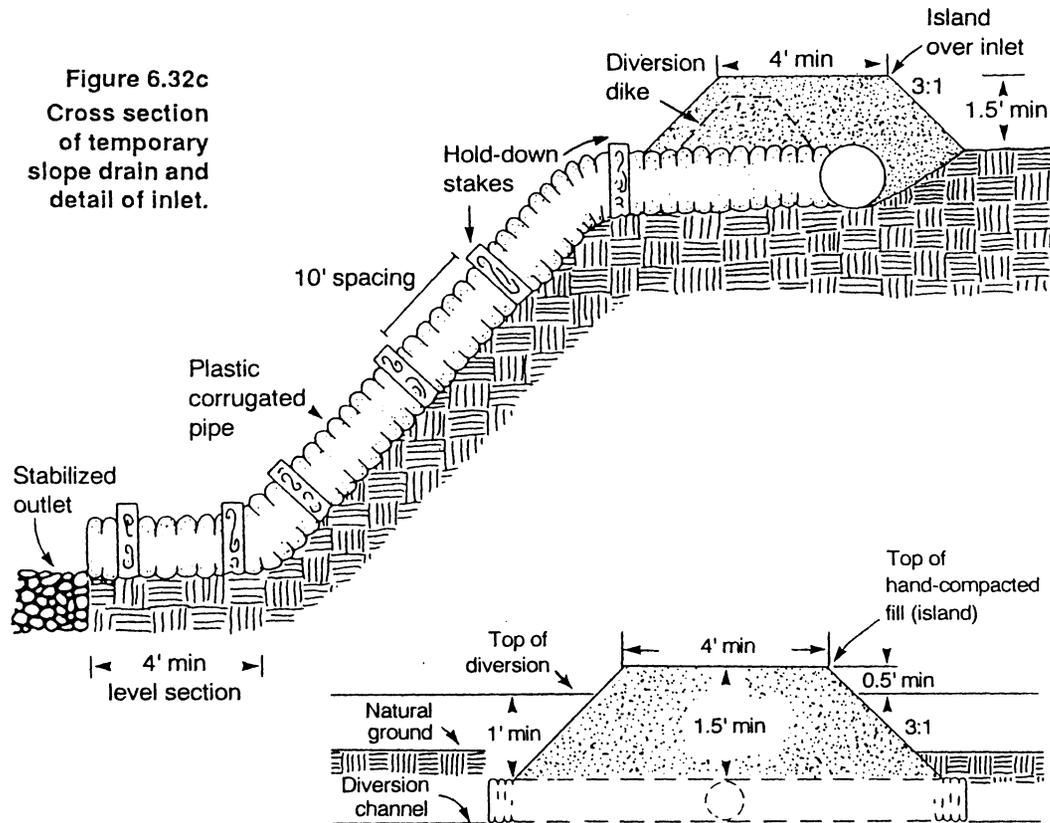


Figure 6.32c  
Cross section  
of temporary  
slope drain and  
detail of inlet.



**Make all pipe connections watertight** and secure so that joints will not separate in use.

Secure pipe to face of slope with grommets or stakes spaced no more than 10 ft apart.

Extend drain beyond the toe of the slope to stable grade, and protect outlet from erosion. Terminate drain in a 4-ft level section where practical.

Grade the diversion channel at the top of the slope toward the temporary slope drain. Positive grade is important.

Compacted diversion ridge must be at least 1 ft higher than the top of the drain pipe at all points and 1.5 ft higher directly over the inlet section.

Stabilize all disturbed areas immediately following installation.

**Common  
Trouble  
Points**

- Washout along the pipe due to seepage and piping—inadequate compaction, insufficient fill, or installation too close to edge of slope.
- Overtopping of diversion caused by undersized or blocked pipe—drainage area may be too large.
- Overtopping of diversion caused by improper grade of channel and ridge. Maintain positive grade.
- Overtopping due to poor entrance conditions and trash build up at pipe inlet. Deepen and widen channel at pipe entrance; inspect and clear inlet frequently.
- Erosion at outlet—pipe not extended to stable grade or outlet stabilization structure needed (reference Practice 6.41, *Outlet Stabilization Structure*).
- Displacement or separation of pipe. Tie pipe down and secure joints.

**CAUTION:** Do not divert more water to the slope drain than it was designed to carry.

**Maintenance**

Failure of a temporary slope drain can cause severe erosion damage. This practice requires intensive maintenance. Inspect slope drains and supporting diversions once a week and after every rainfall event.

- Check inlet for sediment or trash accumulation. Clear inlet and restore proper entrance condition.
- Check fill over pipe for settlement, cracking, or piping holes. Repair immediately.
- Check for seepage holes at point where pipe emerges from dike. Repair immediately.
- Check conduit for evidence of leaks or inadequate lateral support. Repair immediately.
- Check outlet for erosion or sedimentation. Clean, repair, or extend as needed.

When slopes have been stabilized, inspected, and approved, remove temporary diversions and slope drains and stabilize all disturbed areas.



## OUTLET STABILIZATION STRUCTURE

**Purpose** To reduce velocity and prevent erosion at the outlet of channel, culvert, or other high-velocity section (Figure 6.41a).

Figure 6.41a  
Riprap outlet  
stabilization  
structure prevents  
erosion by reduc-  
ing velocity of  
concentrated flow.



### Minimum Requirements

- **Capacity:** peak runoff from 10-yr storm.
- **Apron:** as shown in plans, set on zero grade, aligned straight, with sufficient length to dissipate energy (Figures 6.41b and 6.41c).
- **Foundation:** extra-strength filter fabric or well-graded gravel filter layer, 6 inches thick, minimum.
- **Material:** hard, angular, and highly weather-resistant stone (riprap) with specific gravity at least 2.5. Stone size as specified in plans.
- **Thickness:** as shown in plans, at least 1.5 times the maximum stone diameter.

**Installation** Excavate subgrade below design elevation to allow for thickness of filter and riprap. Install riprap to minimum thickness of 1.5 times maximum stone diameter. Final structure should be to lines and elevations shown in plans.

**NOTE:** Over-excavation to allow for riprap and filter increases the amount of spoil considerably (reference Practice 6.31, *Riprap-lined Channels*).

Construct apron on zero grade. If there is no well-defined channel, cross section may be level or slightly depressed in the middle (Figure 6.41b). In a well-defined channel, extend riprap and filter to the top of the bank or as shown on plans (Figure 6.41c). Blend riprap smoothly to the surrounding land.

Apron should be straight and properly aligned with the receiving stream. If a curve is necessary to fit site conditions, curve the apron near the upstream end.

Compact any fill used in the subgrade to the density of the surrounding undisturbed material. Subgrade should be smooth enough to protect fabric from tearing.

Install a continuous section of extra-strength filter fabric on smooth, compacted foundation.

Protect filter fabric from tearing while placing riprap with machinery. Repair any damage immediately by removing riprap and installing another section of filter fabric. Upstream section of fabric should overlap downstream section a minimum of 1 ft.

Make sure top of riprap apron is level with receiving stream or slightly below it. Riprap should not restrict the channel or produce an overfall.

Immediately following installation, stabilize all disturbed areas with vegetation as shown in plans.

Figure 6.41b  
Pipe outlet to flat area with no well-defined channel.

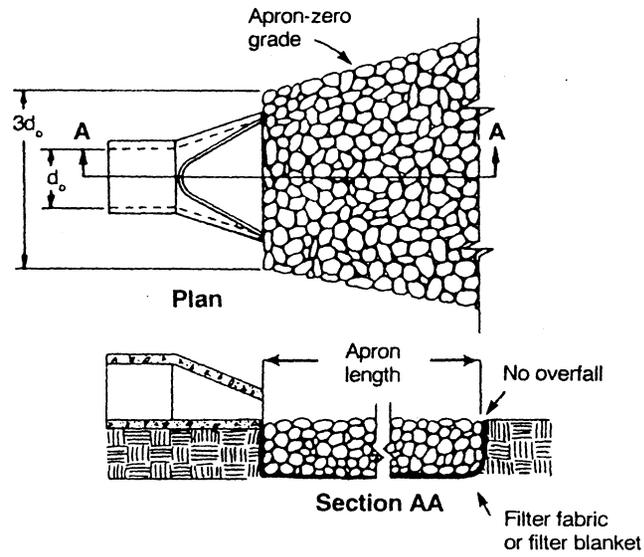
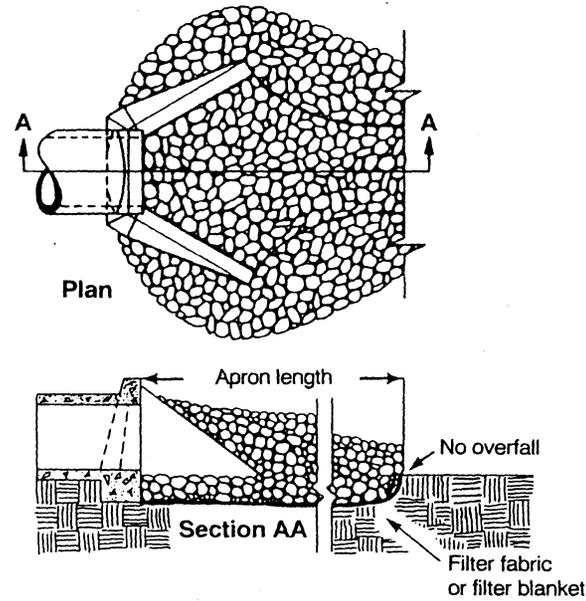


Figure 6.41c  
Pipe outlet to well-defined channel.



Note: In both figures, the thickness of riprap is as shown in plans (minimum thickness is 1.5 times maximum stone diameter).

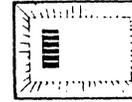
**Common  
Trouble  
Points**

- Foundation not excavated deep enough or wide enough—riprap restricts flow cross section, resulting in erosion around apron and scour holes at outlet.
- Riprap apron not on zero grade—causes erosion downstream.
- Stones too small or not properly graded—results in movement of stone and downstream erosion.
- Riprap not extended far enough to reach a stable section of channel — results in downstream erosion.
- Appropriate filter not installed under riprap—results in stone displacement and erosion of foundation.

**Maintenance**

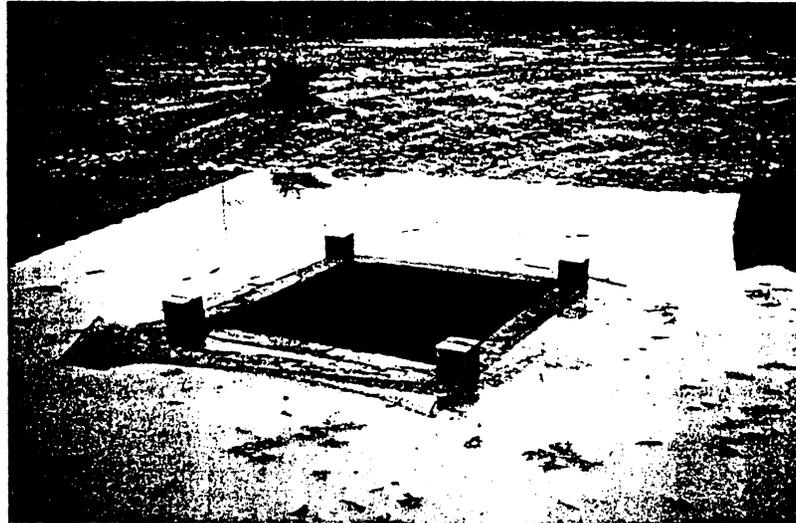
Inspect riprap outlet structures after heavy rains for erosion at sides and ends of apron and for stone displacement.

Make repairs immediately using appropriate stone sizes. Do not place stones above finished grade.

**EXCAVATED DROP INLET PROTECTION (Temporary)**

**Purpose** To trap sediment at the approach to a storm drain inlet. *This practice allows use of the storm drain system during the construction period (Figure 6.50a).*

Figure 6.50a  
Excavation around  
inlet creates an  
effective settling  
pool.

**Minimum  
Requirements**

- Drainage area: limited to 1 acre.
- Excavated depth: 1-2 ft, measured from crest of inlet structure.
- Excavated volume: 35 yd<sup>3</sup>/acre disturbed, minimum.
- Side slopes: 2:1 or flatter.
- Dewatering: weep holes in drop inlet, covered with wire screen (hardware cloth) and gravel.
- Capacity: runoff from 10-yr storm must enter storm drain without bypass flow.

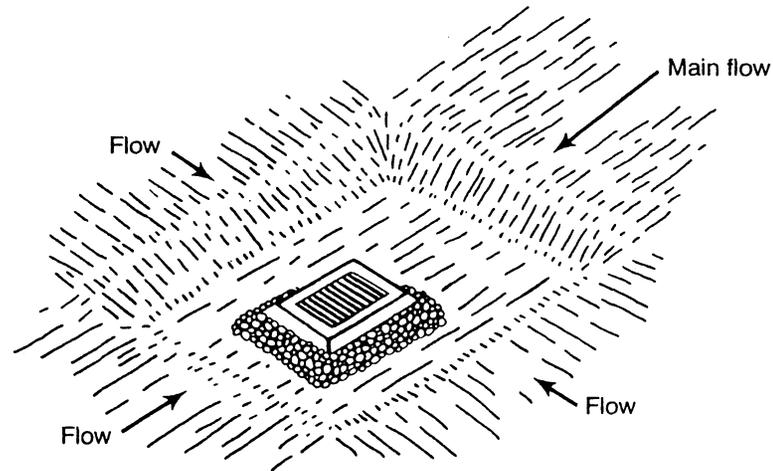
**Installation** Clear area of all debris. Remove and stockpile or spread soil so that it will not block flow or wash back into the excavation.

Excavate basin to the depth, side slopes, and dimensions shown in plans.

Shape basin to fit site conditions with longest dimension oriented toward the largest inflow (Figure 6.50b).

**NOTE:** This practice may be used to improve the effectiveness and reliability of other sediment traps and barriers such as fabric, or block and gravel inlet protection.

Figure 6.50b  
Perspective of  
excavated drop  
inlet protection.



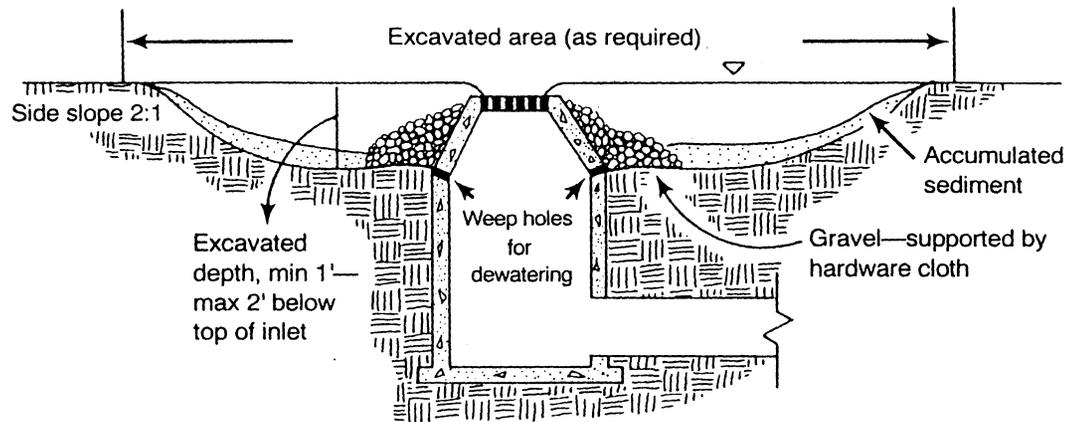


Figure 6.50c Cross section of excavated drop inlet protection.

Install weep holes in drop inlet to drain pool slowly. Cover holes with wire screen (hardware cloth) and gravel to hold sediment in place (Figure 6.50c). Gravel to be 1/2- to 3/4- inch washed aggregate (NC DOT #57 or #5), 1 ft thick, minimum.

Excavate minimum depth 1 ft and the maximum depth at 2 ft as measured from the crest of the inlet structure.

Maintain side slopes around the excavation no steeper than 2:1.

When necessary, spoil may be placed to form a dike on the downslope side of the excavation to prevent bypass flow.

Stabilize all disturbed areas, except the excavated pool bottom, in accordance with vegetation plan.

**Common  
Trouble  
Points**

- Sediment fills excavated basin and enters storm drain—sediment-producing area too large for basin design or inlet not properly maintained.
- Excessive ponding—gravel over weep holes may be plugged with sediment. Remove debris, clear sediment, and replace gravel.
- Flooding and erosion due to blockage of storm drain. Install trash guard.

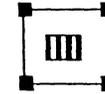
**Maintenance**

Inspect, clean, and properly maintain the excavated basin after every rainfall until contributing drainage area has been permanently stabilized.

Remove sediment when the excavated volume is approximately one-half full.

Remove and replace gravel over weep holes when drainage stops.

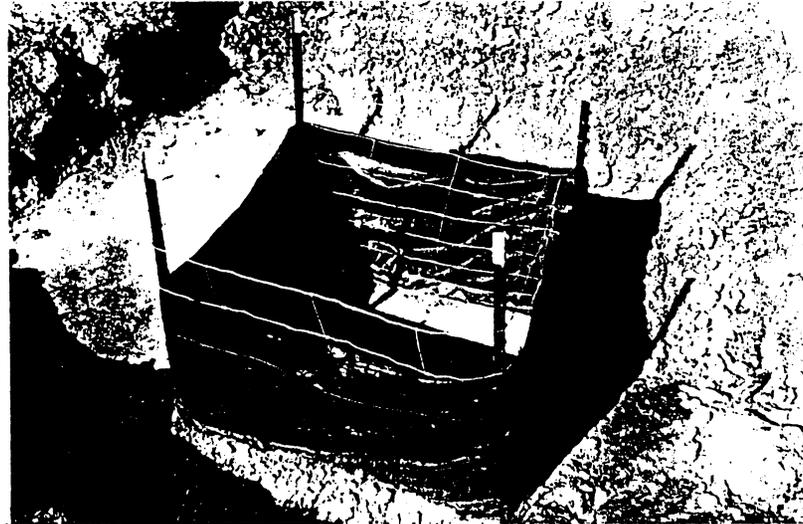
When the contributing drainage area has been permanently stabilized, inspected, and approved, seal weep holes, remove sediment, and fill basin with stable soil. Compact and grade to final elevation. Stabilize all disturbed areas immediately as shown in plans.



## FABRIC DROP INLET PROTECTION (Temporary)

**Purpose** To capture sediment at the entrance to a storm drain. This practice allows full use of the storm drain system during the construction period (Figure 6.51a).

Figure 6.51a  
Fabric inlet  
with excavated  
approach.



### Minimum Requirements

- **Drainage area:** 1 acre maximum.
- **Capacity:** runoff from 10-yr storm must enter storm drain without bypass flow (Figure 6.51b).
- **Height of fabric:** 1.5 ft maximum, 1 ft minimum, measured from top of inlet.
- **Approach:** pool area should be flat, < 1% slope, with sediment storage 35 yd<sup>3</sup>/acre disturbed.
- **Stability:** structure must withstand 1.5-ft head of water and sediment without collapsing or undercutting.
- **Support posts:** steel fence posts or 2 x 4-inch wood, length 3 ft minimum, spacing 3 ft maximum; top frame support recommended (Figure 6.51c).
- **Fabric material:** synthetic, extra-strength fabric. Burlap acceptable for short-term use only (60 days or less).

**Installation** Set top of fabric at least 6 inches below downslope ground elevation to prevent runoff from bypassing the inlet. If necessary, build a temporary dike on the low side of the inlet. Dike should be compacted to 6 inches higher than fabric (Figure 6.51b).

Cut fabric from a single roll to eliminate joints.

Space support posts evenly against the perimeter of the inlet a maximum distance of 3 ft apart. Drive them securely into the ground approximately 18 inches. Overflow must fall directly into the inlet and not on unprotected soil.

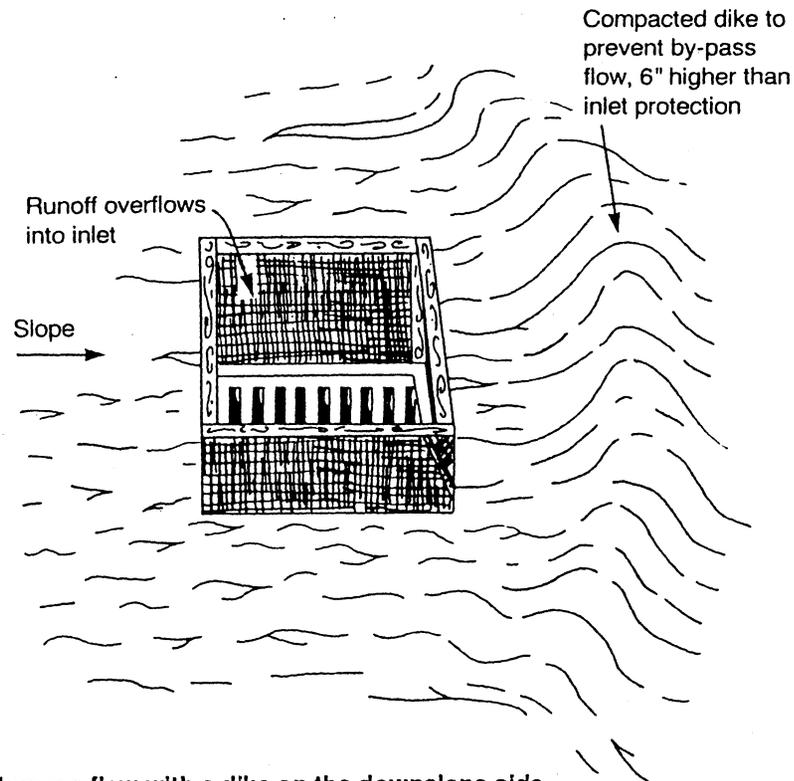


Figure 6.51b Prevent bypass flow with a dike on the downslope side.

Build a supporting frame of 2 x 4-inch lumber as shown in Figure 6.51c, maximum height 1.5 ft above the drop inlet crest. The frame adds stability and serves as a weir to control storm overflow into the drop inlet.

Alternatively, use wire fence (14 gauge minimum, with a maximum mesh spacing of 6 inches) to support fabric. Stretch fence with top level to provide uniform overflow. Extend wire 6 inches below ground.

Place bottom 12 inches of fabric in trench adjacent to the drop inlet.

Backfill and compact with soil or crushed stone.

Fasten fabric securely to the posts and frame or support fence, if used. Overlap joints to the next post.

A combination of excavated sediment pool and a low fabric height prevents bypass flow and provides sediment storage capacity.

Stabilize disturbed areas immediately after construction.

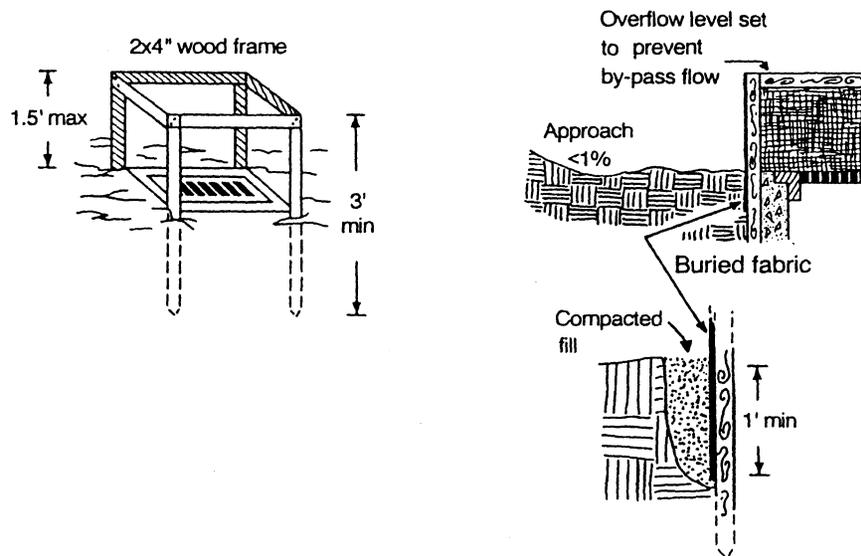


Figure 6.51c Recommended installation of fabric with supporting frame around stormwater inlet.

**Common  
Trouble  
Points**

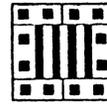
- Posts and fabric not supported at the top—results in collapse of the structure.
- Fabric not properly buried at bottom—results in undercutting.
- Top of fabric barrier set too high—results in flow bypassing the storm inlet or collapsing structure.
- Temporary dike below the drop inlet not maintained—results in flow bypassing storm inlet.
- Sediment not removed from pool—results in inadequate storage volume for next storm.
- Fence not erected against drop inlet—results in erosion and undercutting.
- Land slope at storm drain too steep—results in high flow velocity, poor trapping efficiency, and inadequate storage volume. Excavation of sediment storage area may be necessary.

**Maintenance**

Inspect fabric barrier after each rainfall event and make needed repairs immediately.

Remove sediment from pool area to provide storage for the next rain. Avoid damaging or undercutting the fabric during sediment removal.

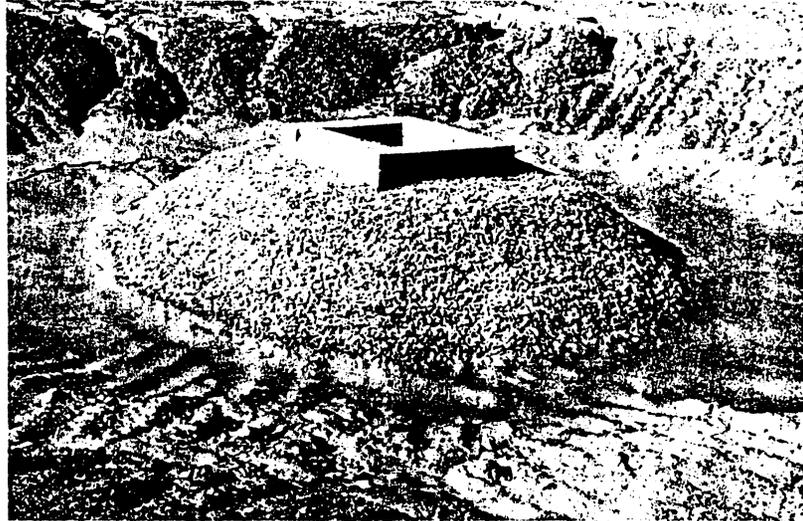
When the contributing drainage area has been stabilized, inspected, and approved, remove all construction material and any unstable sediment, and dispose of them properly. Grade the disturbed area to the elevation of the drop inlet crest. Stabilize all bare areas immediately.



## BLOCK AND GRAVEL INLET PROTECTION (Temporary)

**Purpose** To trap sediment at the approach to a storm drain inlet. (*This practice allows use of the storm drain system during the construction period. See Figure 6.52a).*

Figure 6.52a  
Block and gravel  
inlet protection  
forms low dam,  
creating a tempo-  
rary settling pool.



- Minimum Requirements**
- **Drainage area:** limited to 1 acre.
  - **Capacity:** runoff from 10-yr storm must enter storm drain without bypass flow.
  - **Height of barrier:** 2 ft maximum, 1 ft minimum, measured from bottom of sediment pool.
  - **Sediment pool dewatering:** one or more blocks in the bottom row, placed with holes horizontal and covered with wire screen (hardware cloth) and gravel (Figure 6.52b).
  - **Gravel:** 1 inch diameter or smaller, on outside face of blocks, to control drainage rate.
  - **Side slopes:** 2:1 or flatter, with gravel 2-4 inches lower than gravel and top of block structure (Figure 6.52c).

**Installation** To prevent bypass flow, top of structure should be 6 inches minimum below ground elevation on the downslope side. Otherwise, construct a temporary dike to prevent bypass flow. The dike should be compacted and at least 6 inches higher than the structure and stabilized appropriately (Figure 6.52b).

Excavated inlet protection may be used with structural inlet protection to prevent bypass flow, improve trap efficiency, and provide sediment storage capacity (reference Practice 6.50, *Excavated Drop Inlet Protection*).

Excavate foundation for the blocks on level grade at least 2 inches below the top of the storm drain.

Place bottom row of blocks against edge of storm drain. Butt blocks firmly against concrete and let blocks extend as necessary at edges. Storm drain provides lateral support and prevents undercutting. Support blocks laterally with 2x4-inch wood studs through block openings if necessary. Do not use mortar.

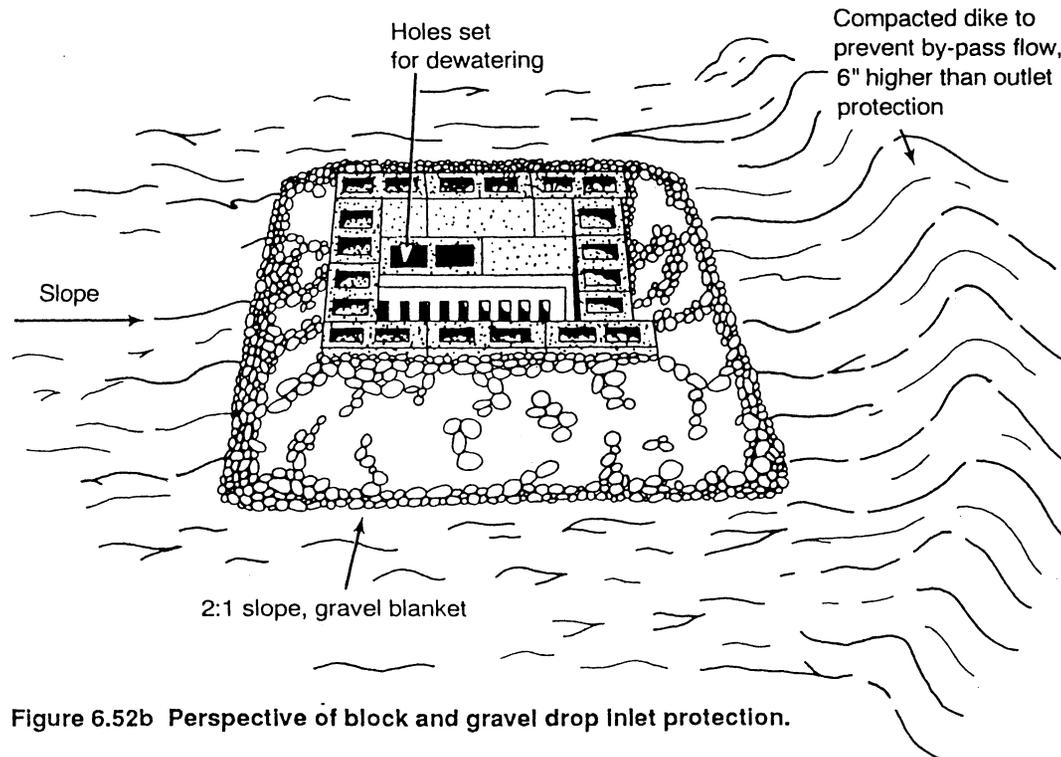
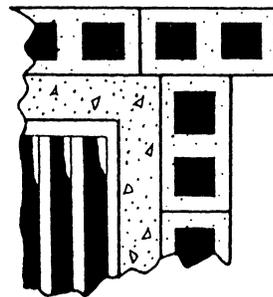
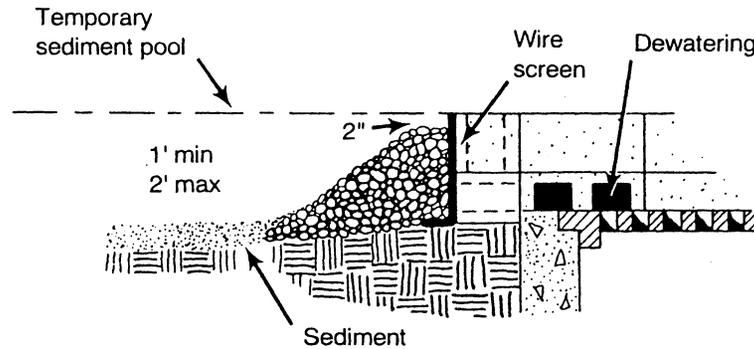


Figure 6.52b Perspective of block and gravel drop inlet protection.

Lay one block on its side in each side of the bottom row to drain the pool. Place wire screen (hardware cloth) over block openings to hold gravel in place.

Place gravel around blocks on a 2:1 slope or flatter, allowing 2-4 inches between top of gravel and top of blocks.

Figure 6.52c  
Detail of block and gravel drop inlet.



Butt blocks firmly against concrete and let blocks extend as necessary at edges.

Gravel Donut Structure

Encircle the storm drain with a donut-shaped structure of 3-inch stone minimum. Construct the inside slope 3:1 or flatter (Figure 6.52d). Top of structure should be 1 ft minimum to 2 ft maximum above top of inlet and 6 inches minimum below ground elevation on the downslope side.

Place gravel (NC DOT #57 or #5 washed stone) on the outside face, 1 ft thick minimum on a 2:1 or flatter slope. Leave a level recessed area of stone, 1 ft wide, minimum, between the toe of the structure and the inlet to keep stone out of storm drain.

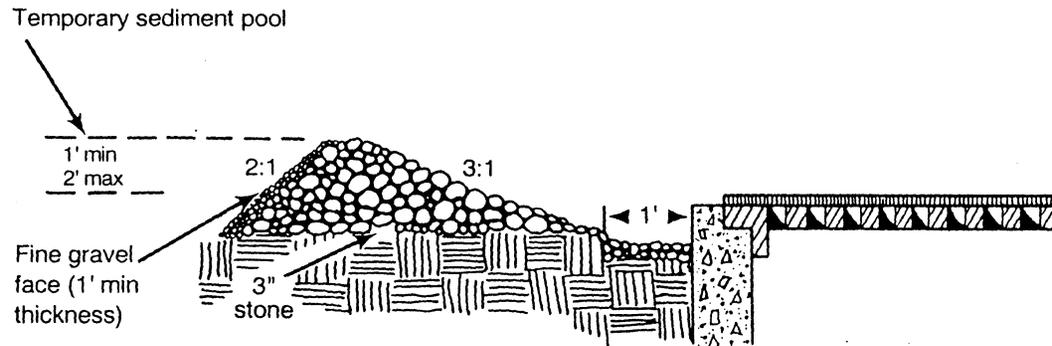


Figure 6.52d Detail of gravel drop inlet protection (gravel donut).

### Common Trouble Points

- Top of structure too high—bypass storm flow causes severe erosion.
- Blocks not placed firmly against storm drain inlet—scour holes develop.
- Drainage area too large—poor trap efficiency and/or sediment overload.
- Approach to drain too steep—causes high flow velocity and poor trap efficiency. Install excavated basin in the approach (reference Practice 6.50, *Excavated Drop Inlet Protection*).
- Sediment not removed following a storm—sediment enters storm drain.
- Stone in gravel donut not large enough or inside slope too steep—stone washes into inlet.

### Maintenance

Inspect structure after each rainfall event, remove sediment, and make needed repairs immediately.

When the contributing drainage area has been stabilized, inspected, and approved, remove all construction material and any unstable sediment and dispose of them properly. Stabilize as shown in plans.



## TEMPORARY SEDIMENT TRAP

**Purpose** To trap sediment at designated locations accessible for cleanout. Prevents off-site sedimentation (Figure 6.60a).

Figure 6.60a  
Temporary settling  
pool traps  
sediment.



### Minimum Requirements

- **Drainage area:** limited to 5 acres.
- **Structure life:** limited to 2 yrs.
- **Sediment storage:** 1800 ft<sup>3</sup>/acre disturbed, minimum.
- **Embankment:** machine-compacted earth fill (Figure 6.60b).
  - Height—5 ft maximum
  - Side slopes—2:1 or flatter
  - Top width—5 ft minimum
- **Spillway outlet section:**
  - Capacity—10-yr peak storm
  - Freeboard—0.5 ft minimum
- **Stone:** a hard, angular, well-graded mixture with  $d_{50}$  of 9 inches minimum. Inside facing is lined with a 1-ft thick layer of 1/2- to 3/4-inch washed aggregate (NC DOT #57 or #5 washed stone).
- **Side slopes:** spillway and excavated basin, 2:1 or flatter.

- **Protection from piping:** filter fabric or cut-off trench is required between the stone spillway outlet section and the compacted embankment.
- **Spillway depth:** 1.5 ft minimum below design, settled top of embankment.
- **Spillway width:** based on drainage area as shown in Table 6.60a. Any change must be approved as a modification of the plan.

Table 6.60a  
Minimum Spillway  
Design

Drainage Area (acres)	Minimum Bottom Width (ft)
1	4.0
2	6.0
3	8.0
4	10.0
5	12.0

- **Outlet apron:** 5-ft long, minimum, on level grade with filter fabric foundation. Exit velocity must be nonerosive for receiving stream.
- **Stabilization:** embankment and all disturbed areas should be stabilized with vegetation immediately following installation.

### Installation

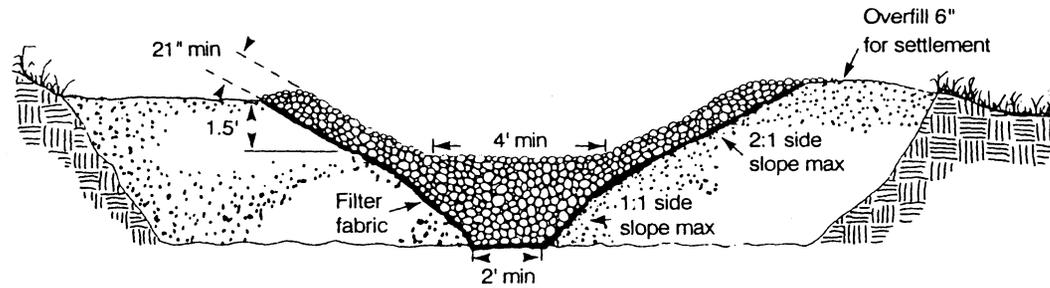
**Embankment** Locate sediment trap as near the sediment source as topography allows.

Divert runoff from all undisturbed areas away from sediment trap.

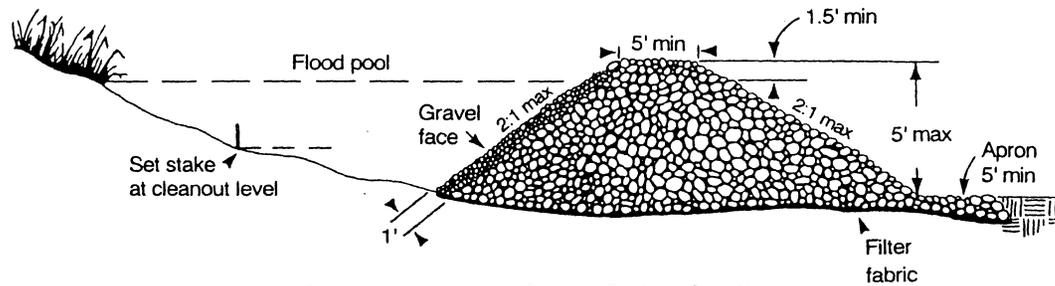
Clear, grub, and strip all vegetation and root mat from area of embankment. Use stable mineral soil free of roots, rocks, debris, and other objectionable material.

Place fill in 9-inch lifts, maximum. Machine compact each lift. Construct side slopes 2:1 or flatter (3:1 recommended for backslope to improve stability of stone spillway).

Overfill embankment to 6 inches above design elevation to allow for settlement.



**Earth Embankment and Stone Outlet Section**



**Cross-section of Stone Outlet Section**

**Figure 6.60b Construction detail of sediment trap.**

**Outlet Section** Excavate trapezoidal stone outlet section from compacted embankment (Figure 6.60b). Allow for thickness of stone side slopes (21 inches minimum).

Install filter fabric under riprap. Extend fabric up the sides to top of embankment.

Place specified stone to lines and grades shown on plans, working the smaller stones into the voids to achieve a dense mass. Spillway crest must be level with minimum inside dimension specified in plan. Measure spillway depth from the highest stones in the spillway to the design elevation of dam. Minimum depth is 1.5 ft.

Keep sides of the stone outlet section at least 21 inches thick through the level section and the downstream face of dam.

Extend outlet apron below toe of dam on level grade until stable conditions are reached (5 ft minimum). Edges and end of the stone apron section must be flush with surrounding ground. No overfall should exist.

Cover inside face of stone outlet section with a 1-ft thick layer of 1/2- to 3/4-inch aggregate (NC DOT #57 or #5 washed stone).

Vegetate the embankment in accordance with the vegetation plan.

Set a stake at one-half the design depth. This will be the “cleanout level.”

**Common  
Trouble  
Points**

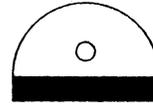
- Inadequate spillway size—results in overtopping of dam, poor trap efficiency and possible failure of the structure. Modification of the plan may be required.
- Omission or improper installation of filter fabric—results in washout under sides or bottom of the stone outlet section (piping).
- Low point in embankment caused by inadequate compaction and settling—results in overtopping and possible failure.
- Stone outlet apron does not extend to stable grade—results in erosion below the dam.
- Stone size too small or backslope too steep—results in stone displacement.
- Inadequate vegetative protection—results in erosion of embankment.
- Inadequate storage capacity—sediment not removed from basin frequently enough.
- Contact slope between stone spillway and earth embankment too steep—piping failure is likely.

- Maintenance** Inspect temporary sediment traps after each significant rainfall event. Repair any erosion and piping holes immediately.
- Remove sediment when it has accumulated to one-half the design depth; a stake set at the cleanout level is helpful. Clean or replace spillway gravel facing if clogged.
- Inspect vegetation; reseed and mulch if necessary.
- Check spillway depth periodically to ensure minimum of 1.5 ft depth from lowest point of the settled embankment to highest point of spillway crest. Fill any low areas of the embankment to maintain design elevation.
- Promptly replace any displaced riprap, being careful that no stones in the spillway are above design grade.
- After all sediment-producing areas have been stabilized, inspected, and approved, remove the structure and all unstable sediment. Smooth site to blend with adjoining areas and stabilize in accordance with vegetation plan.





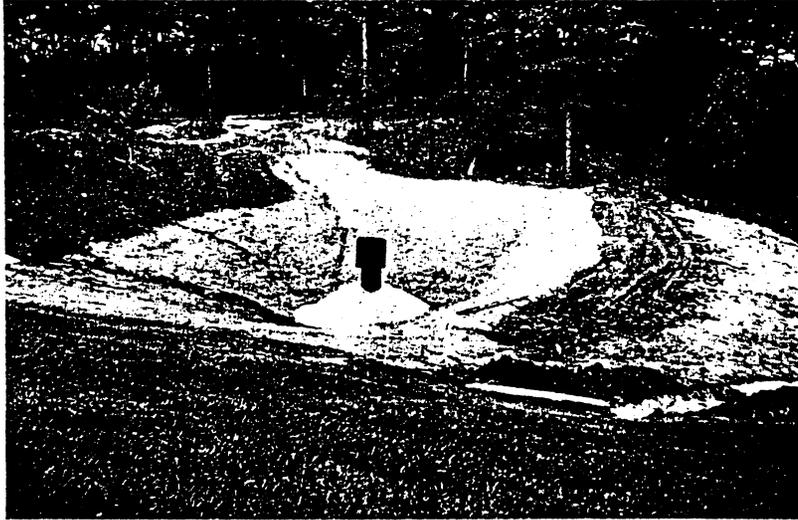




## SEDIMENT BASIN

**Purpose** To retain sediment on the construction site and prevent off-site sedimentation (Figure 6.61a).

Figure 6.61a  
A compacted earth dam across a low area forms the sediment basin.



### Minimum Requirements

Dams 15 ft or higher and storage volume of 10 acre-ft or more must meet requirements of the NC Dam Safety Act. Height of dam is measured from top to lowest point at downstream toe. Volume is measured to top of the dam.

- **Drainage area:** limited to 100 acres.
- **Structure life:** limited to 3 yrs.
- **Sediment storage:** 1800 ft<sup>3</sup>/acre disturbed min.
- **Trap efficiency:** Length-to-width ratio should be 2:1 or greater; divert inflow to upper end of basin to avoid short-circuiting flow.
- **Dewatering:** perforate riser and cover holes with gravel.
- **Total spillway capacity:** 10-yr peak flow with 1 ft freeboard.

- 
- Emergency Spillway**
- **Capacity:** 10-yr peak flow with 1 ft freeboard minus flow in principal spillway.
  - **Location:** construct in undisturbed soil — not fill.
  - **Cross section:** trapezoidal with side slopes 3:1 or flatter.
  - **Control section:** level and straight, at least 20 ft long.
  - **Inlet section:** may be curved if necessary to improve alignment.
  - **Outlet section:** must be straight.
- Principal Spillway**
- **Riser and barrel:** usually vertical pipe riser with horizontal pipe barrel; must withstand the maximum external loading without yielding, buckling, or cracking.
    - Capacity minimum—0.2 cfs/acre of drainage
    - Barrel diameter—8-inch corrugated pipe minimum or 6-inch smooth-wall pipe minimum
    - Riser cross-sectional area—1.5 x barrel area minimum
  - **Top of spillway:** 1 ft minimum below elevation of emergency spillway crest.
  - **Pipe connections:** must be watertight.
  - **Antiseep collars:** at least one watertight antiseep collar with a minimum projection of 1.5 ft is required around barrel of pipes 8 inches in diameter or larger. A drainage diaphragm may be used where appropriate.
  - **Antiflotation block:** riser must be held in place with an anchor having buoyant weight greater than 1.1 times the weight of water displaced by riser and any exposed portion of barrel.
  - **Trash guard:** required at top of riser.
  - **Outlet:** must be stable for design pipe discharge. Install riprap outlet apron unless foundation is rock.

Embankment

- Dams 15 ft or higher and storage volume of 10 acre-ft or more must meet requirements of the NC Dam Safety Act. Height of dam is measured from top to lowest point at downstream toe. Volume is measured to top of the dam.
- **Top width:** 8 ft minimum for dam height less than 10 ft  
10 ft minimum for dam height 10-15 ft
- **Side slopes:** 2.5:1 or flatter.
- **Settlement allowance:** 10% of design height.
- **Cutoff trench:** required under centerline of dam, depth 2 ft minimum into undisturbed firm mineral soil. Extend trench up each abutment to elevation of emergency spillway crest.
- **Fill material:** stable mineral soil compacted in 8-inch lifts while moist.
- **Freeboard:** 1 ft minimum between top of settled dam and elevation of water surface at 10-yr peak flow in the emergency spillway.

All disturbed areas except the lower one-half of sediment pool must be stabilized immediately following construction.

Installation

Site Preparation

The sediment basin should be as close to the sediment source as site conditions allow considering soils, pool area, dam length, and spillway conditions. Delay clearing pool until dam is complete to reduce erosion and off-site sedimentation.

Clear, grub, and strip dam location. Excavate area for the outlet apron.

Remove surface soil containing high amounts of organic matter and stockpile for later use. Clear sediment pool to facilitate sediment cleanout.

Dispose of trees, limbs, logs, and other debris in designated disposal areas.

Cutoff Trench

Excavate cutoff trench along dam centerline extending up both abutments to elevation of principal spillway crest.

Cut trench into stable soil material, at least 2 ft wide and at least 2 ft deep with side slopes 1:1 or flatter (Figure 6.61b).

Keep trench dry during backfilling; backfill with clayey soil if available.

## Principal Spillway

Use only approved watertight assemblies as shown in the plans for all pipe connections. Rod and lug connector bands with gaskets are recommended for corrugated pipe. **Do not use dimple (universal) connector bands.** Connection between pipe and antiseep collar must be watertight.

Perforate lower half of riser in each outside valley with 1/2-inch holes spaced approximately 3 inches; cover with 2 ft of 1/2- to 3/4-inch aggregate (NC DOT # 57 or #5 washed stone).

Place barrel and riser on firm, even foundation. Install anti-seep collar(s) slightly downstream of dam centerline.

Place moist, clayey, workable soil around pipe and antiseep collars. Do not use pervious material such as sand, gravel, or silt. Compact 4-inch layers of soil, by hand, under and around pipe and collars to at least the density of foundation soil. **Avoid raising pipe from firm contact with foundation while compacting material under pipe haunches.**

Cover pipe to a depth of 2 ft minimum of hand-compacted backfill before crossing it with construction equipment.

Anchor riser in place with concrete to prevent flotation. Embed riser at least 6 inches into concrete.

Install trash guard with bars spaced 2-3 inches apart.

Install riprap apron at pipe outlet, width 5 ft minimum. Extend apron to stable grade (length 10 ft minimum). Use well-graded stone with  $d_{50}$  of 9 inches minimum.

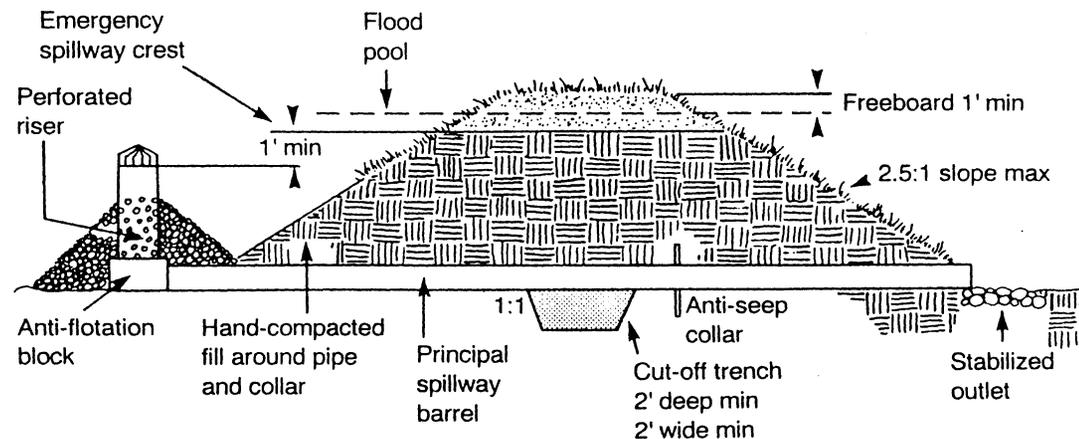


Figure 6.61b Section through embankment of sediment basin.

**Embankment** Scarify base of dam before placing fill.

Take fill from approved borrow areas shown on plans. It should be clean, stable mineral soil free of roots, woody vegetation, rocks, and other objectionable material. Save the least permeable soil for center portion of dam. Place the most permeable soil in downstream toe.

Fill material must contain sufficient moisture that it can be formed by hand into a ball without crumbling. **If water can be squeezed out of the ball, it is too wet for proper compaction.**

Construct dam to lines and grades shown in plan. Side slopes must be 2.5:1 or flatter.

Compact fill material in 6- to 8-inch continuous layers over length of dam. Compaction may be obtained by routing construction equipment over fill so that the entire surface of each layer is traversed by at least one wheel of compacting equipment. Protect spillway barrel with 2 ft of hand-compacted fill before traversing with equipment.

Construct embankment 10% higher than design height to allow for settlement.

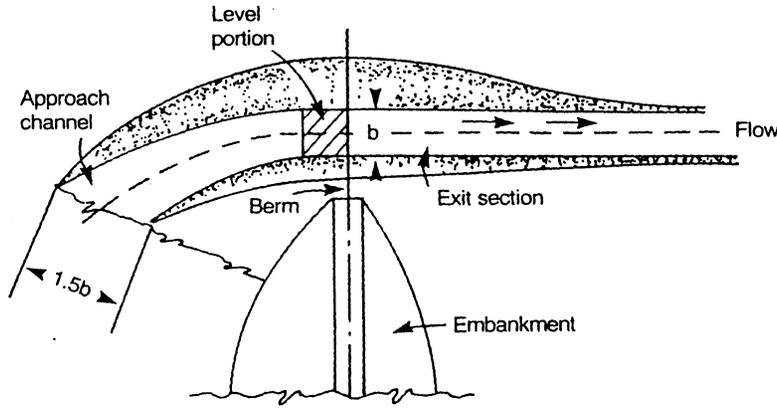
**Emergency Spillway** Cut emergency spillway in undisturbed soil to lines and grade shown in the approved plan. Side slopes must be 3:1 or flatter.

Control section must be level and straight, 20 ft long minimum. Inlet may be curved to improve alignment (Figure 6.61c). Exit section must be straight.

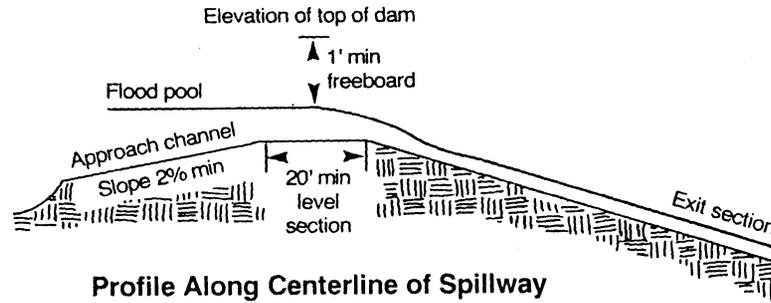
Vegetate spillway as soon as grading is complete, following all requirements in vegetation plan. Anchor mulch in spillway with netting.

Install paving material to finished grade if spillway is not to be vegetated.

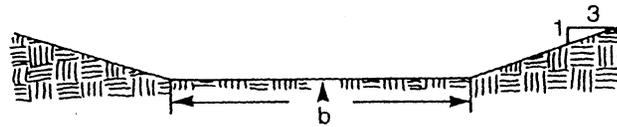
**Figure 6.61c**  
 Plan, profile, and  
 cross section of  
 emergency  
 spillway excavated  
 in undisturbed  
 soil.



**Plan view**



**Profile Along Centerline of Spillway**



**Cross-section at Control Section**

- 
- Diversions** Divert sediment-laden water to upper end of sediment pool to improve trap effectiveness. Bring all water into the basin at low velocity to prevent erosion.
- Divert runoff from undisturbed areas away from basin.
- Cleanout** Place reference stake at sediment cleanout elevation (50% of design volume).
- Erosion Control** Minimize the area disturbed and time of exposure.
- Excavate the outlet apron area first, to use as a sediment trap during construction of dam.
- Use temporary diversions to prevent surface water from running onto disturbed areas.
- Construct embankment before clearing the sediment pool.
- Stabilize all disturbed areas except lower one-half of sediment basin immediately after construction, in accordance with vegetation plan.
- Safety** Keep sediment pool dewatered between storms.
- Construct side slopes 2:1 or flatter in pool area.
- Fence area and post warning signs if trespassing is likely.
- Follow all state and local requirements.
- Common Trouble Points**
- Piping failure along conduit due to lack of proper compaction, omission of anti-seep collar, or leaking pipe joints.
  - Erosion of spillway or embankment slopes due to inadequate vegetation or improper grading and sloping.
  - Slumping and/or settling of embankment due to inadequate compaction and/or use of poor-quality fill material.
  - Slumping failure due to steep side slopes.
  - Erosion and caving below pipe due to inadequate outlet protection.

- Basin not located properly for access—makes maintenance difficult and costly.
- Sediment not properly removed—leaves inadequate storage capacity.
- Lack of anti-flotation—pipe damage from uplift.
- Lack of trash rack—barrel and riser blocked with debris.
- Elevations of principal spillway and emergency spillway too high relative to top of dam—potential failure from overtopping.
- Sediment disposal area not designated on plans—results in improper disposal of accumulated sediment.
- Safety and/or health hazard due to clogged gravel in dewatering system.

**Maintenance** Inspect sediment basins after each significant rainfall.

Remove and properly dispose of sediment when it accumulates to one-half design volume (level marked by reference stake). Check embankment, emergency spillway, and outlet for erosion damage.

Check embankment for: settlement, seepage, or slumping along the toe or around pipe. Look for signs of piping. Repair immediately. Remove trash and other debris from riser, emergency spillway, and pool area.

Clean or replace gravel when sediment pool does not drain properly.

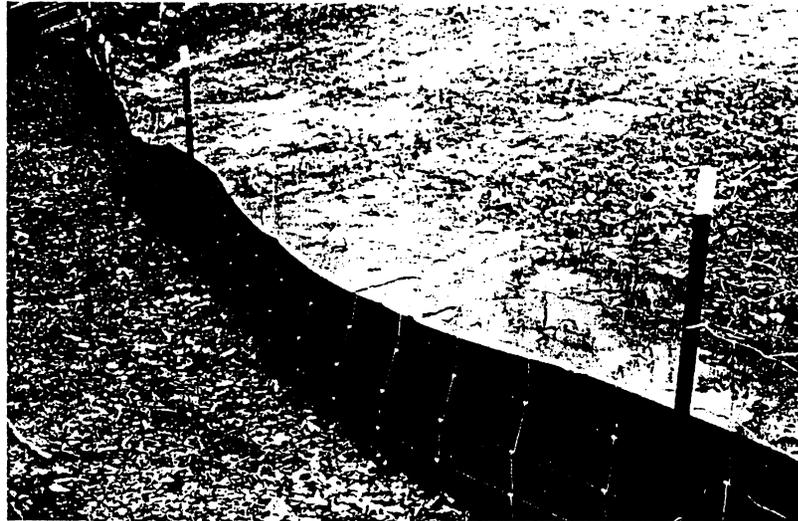
Remove basin after drainage area has been permanently stabilized, inspected, and approved. Before removing dam, drain water and remove sediment; place waste material in designated disposal areas. Smooth site to blend with surrounding area and stabilize as shown in vegetation plan.



**SEDIMENT FENCE (Silt Fence)**

**Purpose** To retain sediment from small, sloping disturbed areas by reducing the velocity of sheet flow (Figure 6.62a).

Figure 6.62a  
Sediment trapped behind well supported sediment fence.



**Minimum Requirements**

- **Drainage area:** limited to 1/4 acre per 100 ft of fence. Area is further restricted by slope steepness as shown in Table 6.62a.

Table 6.62a  
Maximum Land Slope and Distance for Which Sediment Fence is Applicable

Land Slope (%)	Maximum Slope Distance Above Fence (ft) <sup>1</sup>
< 2	100
2 to 5	75
5 to 10	50
10 to 20	25
> 20	15

<sup>1</sup>Slope distance may be increased if design is supported by appropriate runoff calculations.

- **Location:** Fence should be nearly level and at least 10 ft from the toe of slopes to provide a broad, shallow sediment pool (Figure 6.62b).
- **Spacing of support posts:** 8 ft maximum if fence is supported by wire, 6 ft maximum for extra-strength fabric without support-wire backing.
- **Trench:** bottom 1 ft of fence must be buried 8 inches deep minimum.
- **Fence height:** depth of impounded water should not exceed 1.5 ft at any point along the fence.
- **Support posts:** 4-inch diameter pine or 1.33 lb/linear ft steel, buried or driven to depth of 18 inches. Steel posts should have projections for fastening fabric.
- **Support wire:** wire fence (14 ga with 6-inch mesh) is required to support standard-strength fabric.
- **Reinforced, stabilized outlets (Figure 6.62c):** located to limit water depth to 1.5 ft measured at lowest point along fenceline. Outlet allows safe storm flow bypass.
  - Crest height—1 ft maximum
  - Width of splash pad—5 ft minimum
  - Length of splash pad—5 ft minimum
- **Fence fabric:** synthetic filter fabric conforming to specifications in Table 6.62b, and containing UV inhibitors and stabilizers to provide a life of 6 months minimum at temperatures from 0° to 120° F. (Burlap may be used for short periods, not exceeding 60 days.)

Table 6.62b  
Specifications  
for Sediment  
Fence Fabric

Physical Properties	Minimum Requirements
Filtering efficiency	85%
Tensile strength at 20% (max) elongation:	
Standard strength	30 lb/linear inch
Extra strength	50 lb/linear inch
Slurry flow rate	0.3 gpm/ft <sup>2</sup>

**Installation** NOTE: Sediment fence captures sediment by backing up water to allow deposition. It is relatively ineffective for filtration because it clogs too rapidly. The sedimentation pool behind the fence is very effective and may reduce the need for expensive sediment basins and traps.

To use sediment fence effectively, provide access to the locations where sediment accumulates and provide reinforced, stabilized outlets for emergency overflow (Figure 6.62c).

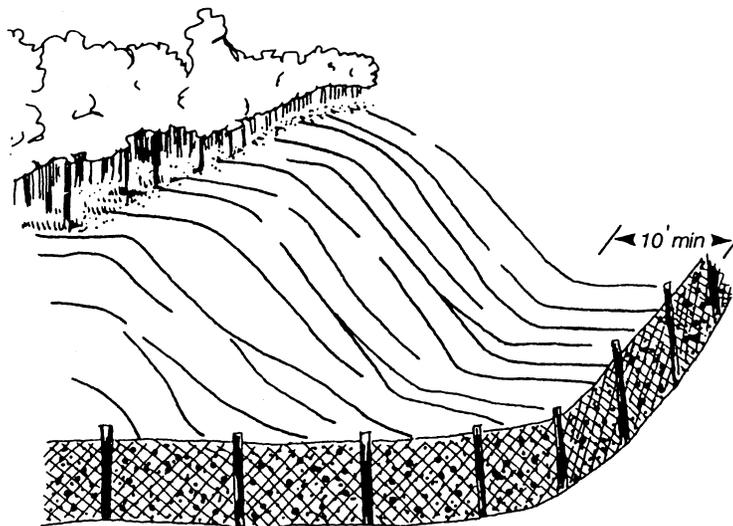
Sediment fence is most effective when used in conjunction with other practices such as perimeter dikes or diversions.

**Location** Locate the fence at least 10 ft from the toe of steep slopes to provide sediment storage and access for cleanout (Figure 6.62b).

The fence line should be nearly level through most of its length to impound a broad, temporary pool. Stabilized outlets are required for bypass flow, unless fence is designed to retain all runoff from the 10-yr storm (Figure 6.62b).

The fence line may run slightly off level (grade less than 1%) if it terminates in a level section with a stabilized outlet, diversion, basin, or sediment trap. There must be no gullying along the fence or at the ends. Sediment fence should not be used as a diversion.

Figure 6.62b  
Level fence line  
with room for  
temporary pool.



### Reinforced, Stabilized Outlets

Any outlet where storm flow bypass occurs must be stabilized against erosion.

Set outlet elevation so that water depth cannot exceed 1.5 ft at the lowest point along the fenceline (Figure 6.62c).

Set fabric height at 1 ft maximum between support posts spaced no more than 4 ft apart. Install a horizontal brace between the support posts to serve as an overflow weir and to support top of fabric. Provide a riprap splash pad as shown in Figure 6.62c.

Excavate foundation for the splash pad a minimum 5 ft wide, 1 ft deep, and 5 ft long on level grade. The finished surface of the riprap should blend with surrounding area, allowing no overfall. The area around the pad must be stable.

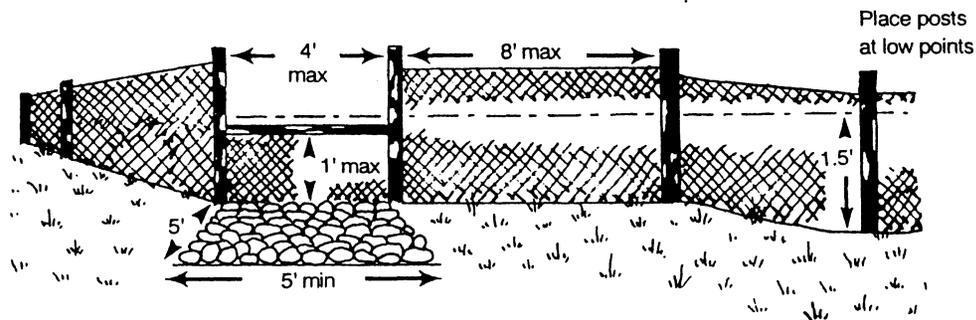


Figure 6.62c Perspective of reinforced, stabilized outlet for sediment fence.

### Construction

Dig a trench approximately 8 inches deep and 4 inches wide, or a V-trench, in the line of the fence as shown in Figure 6.62d.

Drive posts securely, at least 18 inches into the ground, on the downslope side of the trench. Space posts a maximum of 8 ft if fence is supported by wire, 6 ft if extra-strength fabric is used without support wire. Adjust spacing to place posts at low points along the fenceline.

Fasten support wire fence to upslope side of posts, extending 6 inches into the trench as shown in Figure 6.62d.

Attach continuous length of fabric to upslope side of fence posts. Avoid joints, particularly at low points in the fence line. Where joints are necessary, fasten fabric securely to support posts and overlap to the next post.

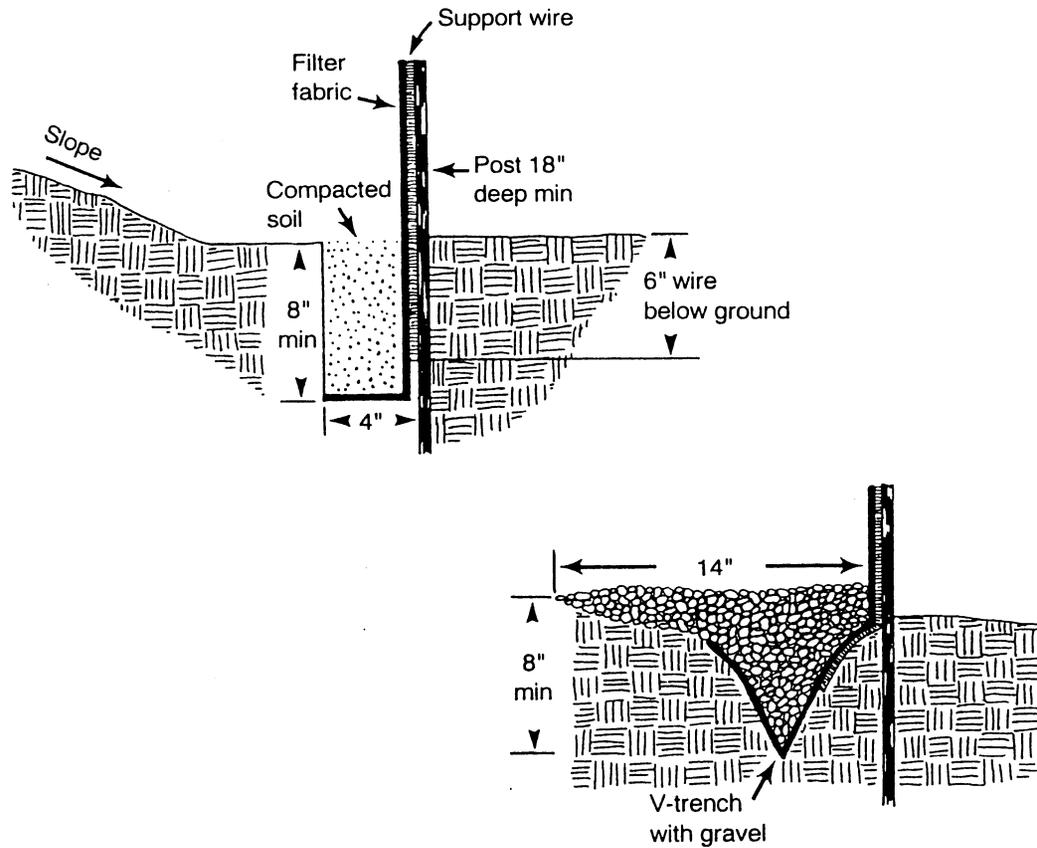


Figure 6.62d Detail of sediment fence installation.

Place the bottom 1 ft of fabric in 8-inch deep trench lapping toward the upslope side. Backfill with compacted earth or gravel as shown in Figure 6.62d.

To reduce maintenance, excavate a shallow sediment storage area on upslope side of fence where sedimentation is expected. Provide good access to deposition areas for cleanout and maintenance.

Allow for safe bypass of storm flow to prevent overtopping failure of fence.

**DO NOT** install sediment fence across intermittent or permanent streams, channels, or any location where concentrated flow is anticipated.

**Common  
Trouble  
Points**

**Fence sags or collapses**—common causes are:

- drainage area too large,
- too much sediment accumulation allowed before cleanout,
- approach too steep, or
- fence not adequately supported.

**Fence fails from undercutting**—common causes are:

- bottom of fence not buried at least 8 inches at all points,
- trench not backfilled with compacted earth or gravel,
- fence installed on excessive slope, or
- fence located across drainageway.

**Fence is overtopped**—common causes are:

- storage capacity inadequate, or
- no provision made for safe bypass of storm flow.
- **Do not locate fence across drainage way.**

**Erosion occurs around end of fence**—common causes are:

- fence terminates at elevation below the top of the temporary pool,
- fence terminates at unstabilized area, or
- fence located on excessive slope.

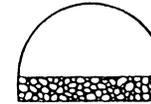
**Maintenance**

Sediment fence requires a great deal of maintenance. Inspect sediment fences periodically and after each rainfall event.

Should fabric tear, decompose, or in any way become ineffective, replace it immediately. Replace burlap at least every 60 days.

Remove sediment deposits promptly to provide adequate storage volume for the next rain and to reduce pressure on fence. Take care to avoid undermining fence during clean out.

Remove all fencing materials and unstable sediment deposits after the contributing drainage area has been properly stabilized, inspected, and approved. Bring the disturbed area to grade and stabilize as shown in the vegetation plan.



## ROCK DAM

**Purpose** To trap sediment on the construction site and prevent off-site sedimentation. Useful where earth fill material is not readily available (Figure 6.63a).

Figure 6.63a  
Wide spillway  
keeps discharge  
velocity low.



### Minimum Requirements

- **Drainage area:** limited to 50 acres.
- **Design life:** limited to 3 yrs.
- **Sediment storage:** 1800 ft<sup>3</sup>/acre disturbed minimum, measured 1 ft below spillway crest.
- **Dam crest height:** limited to 8 ft.
- **Basin area and shape:** the largest surface area gives the greatest trapping efficiency. Basin length-to-width ratio should be 2:1 minimum.
- **Spillway capacity:** 10-yr peak runoff, at maximum flow depth of 1 ft and minimum freeboard of 1 ft. Entire length of dam between rock abutments may serve as spillway.

- **Rock embankment** (Figure 6.63b):
  - Top width—5 ft minimum
  - Side slopes—upstream, 2:1 or flatter
  - downstream, 3:1 or flatter
- **Earth abutments:** smooth, stable slopes, 2:1 or flatter.
- **Rock abutments:** must protect earth abutments and extend along downstream face to toe of dam. Abutments must be at least 1 ft higher than the spillway face at all points.
  - Height—2 ft minimum above spillway crest
  - Width—2 ft thick, minimum
  - Side slopes—2:1 or flatter
- **Outlet protection:** rock apron, 1.5 ft thick, minimum, zero grade, length equal to height of dam or extended to stable grade, whichever is greater.
- **Rock material:** well graded, hard, angular, weather-resistant stone with a  $d_{50}$  of 9 inches minimum.
- **Protection from piping:** extra-strength filter fabric covers entire foundation including earth abutments and apron (Figure 6.63b).
- **Basin dewatering:** through 1 ft thick minimum layer of 1/2- to 3/4-inch aggregate on upstream face of dam (NC DOT #57 or #5 washed stone).

**Installation** Divert runoff from undisturbed areas away from the basin (reference Practice 6.20, *Temporary Diversions*). Delay clearing pond area until dam is in place.

Excavate foundation for apron and use it as a temporary sediment basin during construction of dam.

Clear and grub area under dam, removing all root mat and other objectionable material. Grade earth abutments no steeper than 1:1. Dispose of material in approved location.

If cutoff trench is required, excavate at center line of dam, extending all the way up earth abutments.

## 6.63

**Protection from Piping** The entire foundation including both earth abutments must be covered by filter fabric. Overlap 1 ft at all joints, upstream strip over downstream strip (Figure 6.63b).

Smooth the foundation area before placing filter fabric. Be careful placing rock on fabric. It may be helpful to place a 4-inch layer of sand over fabric before placing rock.

**Embankment and Pool** Construct embankment to dimensions shown on plans. Use well-graded, hard, angular, weather-resistant rock. Rock abutments must be at least 2 ft higher than the spillway crest and at least 1 ft higher than the downstream face of dam at all points (Figure 6.63c).

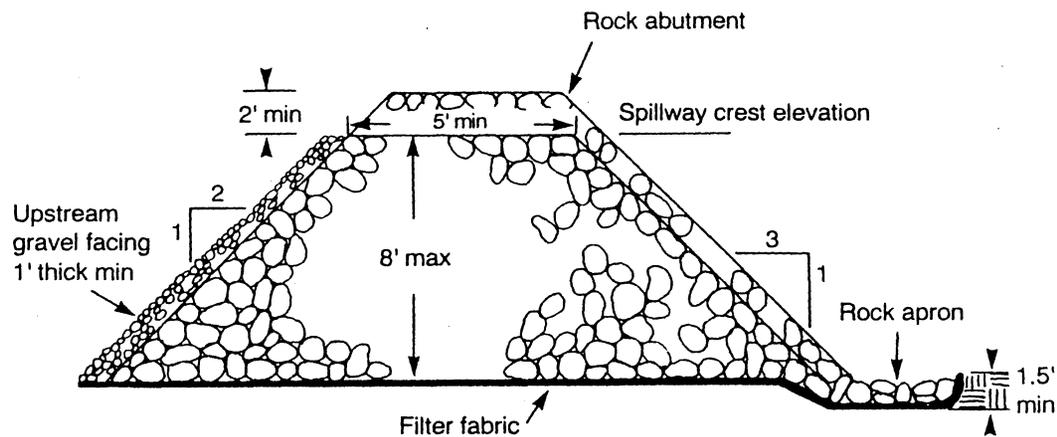


Figure 6.63b Rock dam cross section.

Divert sediment-laden flow to upper end of basin.

Set marker stake to indicate clean out elevation where sediment pool is 50% full.

Stabilize all disturbed areas except the lower one-half of sediment pool as shown in the vegetation plan.

**Safety** Sediment basins that impound water are hazardous. Basin should be dewatered between storms. Avoid steep side slopes. Fences with warning signs may be necessary if trespassing is likely. State and local requirements must be followed.

### Spillway Detail

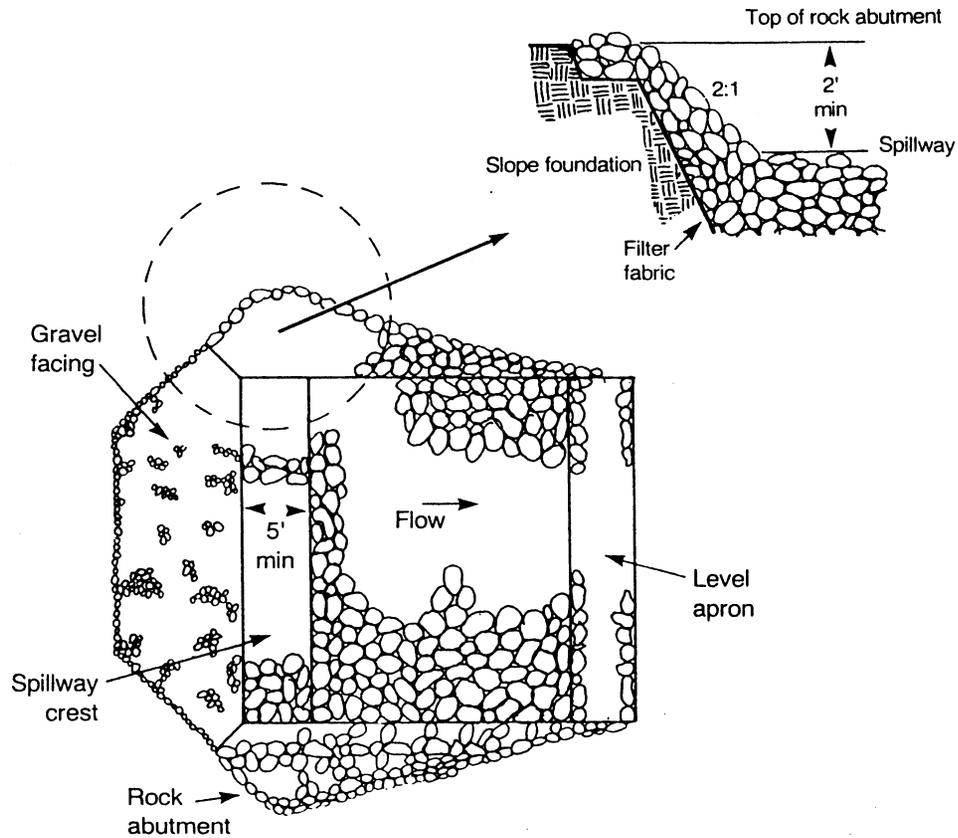


Figure 6.63c Plan view of rock dam with spillway detail.

**Common  
Trouble  
Points**

- Failure from piping along abutments—filter material not properly installed, or earth abutments too steep.
- Stone displaced from face of dam—stone size too small and/or face too steep.
- Erosion below dam—apron not extended to stable grade.
- Erosion of abutments during spillway flow—rock abutment height inadequate.
- Sediment carried through spillway—drainage area too large. Divert runoff from undisturbed area away from basin.
- Sediment loss through dam—inadequate layer of aggregate on inside face or aggregate too coarse to restrict flow through dam.

**Maintenance**

Inspect rock dam and pool after each rainfall event.

Remove sediment when it accumulates to one-half design volume (marked by stakes).

Check structure and abutments for erosion, piping, or rock displacement. Repair immediately.

Replace aggregate on inside face of structure when sediment pool does not drain between storms.

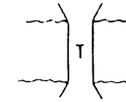
Add fine gravel to upstream face of dam if sediment pool drains too rapidly (less than 6 hrs) following a storm.

Remove rock dam after the contributing drainage area has been permanently stabilized, inspected, and approved. Remove all water and sediment prior to removing dam. Dispose of waste materials in designated disposal areas. Smooth site to blend with surrounding area and stabilize according to vegetation plan.









## TEMPORARY STREAM CROSSING

**Purpose** To provide a means of moving construction vehicles across a stream with minimal streambank erosion (Figure 6.70a).

Figure 6.70a  
Bridges must be designed and built to support expected loads.



### Minimum Requirements

A stream crossing must be non-erosive and structurally stable, and must not introduce any flooding or safety hazard. Bridge design in particular should be undertaken only by a qualified engineer. The following standards apply only to erosion and sediment control aspects of bridges, culverts, and fords.

- **Anticipated life:** generally less than 1 year.
- **Flow capacity:** must carry bankfull flow or 2-yr peak discharge, whichever is less, without overflow. Overflow areas must be protected from erosion from 10-yr peak flow.
- **Velocity control:** the design discharge velocity at the crossing outlet must be nonerosive for the stream channel.

## Installation

- Planning and Site Preparation** Construct crossing when stream flow is low. Have all necessary materials and equipment on site before work begins.
- Minimize clearing and excavation of streambanks, bed, and approach sections. Plan work to minimize crossing the stream with equipment. If possible, complete all work on one side of the stream before crossing to work on other side.
- Install stream crossing at right angle to the stream. Limit surface runoff by installing diversions (Figure 6.70b; reference Practice 6.20, *Temporary Diversions*).
- Align road approaches with center line of crossing for a distance of 30 ft minimum.
- Where required, install an in-stream sediment trap before excavating or grading the approaches to a ford. Excavate trap 2 ft minimum below stream bottom and approximately twice the channel width for a minimum distance equal to one-half the length of crossing. Remove all spoil to an area outside the flood plain. Stabilize spoil appropriately.
- Avoid diverting stream out of its natural channel by working on one-half of the installation at a time.
- Temporary Stream Diversion** If stream must be diverted, select most appropriate location considering extent of clearing, channel grade, amount of cut, and spoil disposal.
- Excavate diversion channel starting at the lower end. If stream velocity exceeds that allowable for the temporary channel, stabilize with riprap (reference Practice 6.15, *Riprap*). Temporary bypass channel must be stable for flows up to and including the 10-yr storm.
- The crossing site should be built in the dry streambed and stabilized before the stream is redirected to its normal course.
- Fords** Fords are effective for infrequent crossing of wide, shallow streams.
- Where required, install in-stream sediment trap before excavating approach to the ford.
- Install diversions in road approach sections to divert surface runoff (reference Practice 6.20, *Temporary Diversions*).

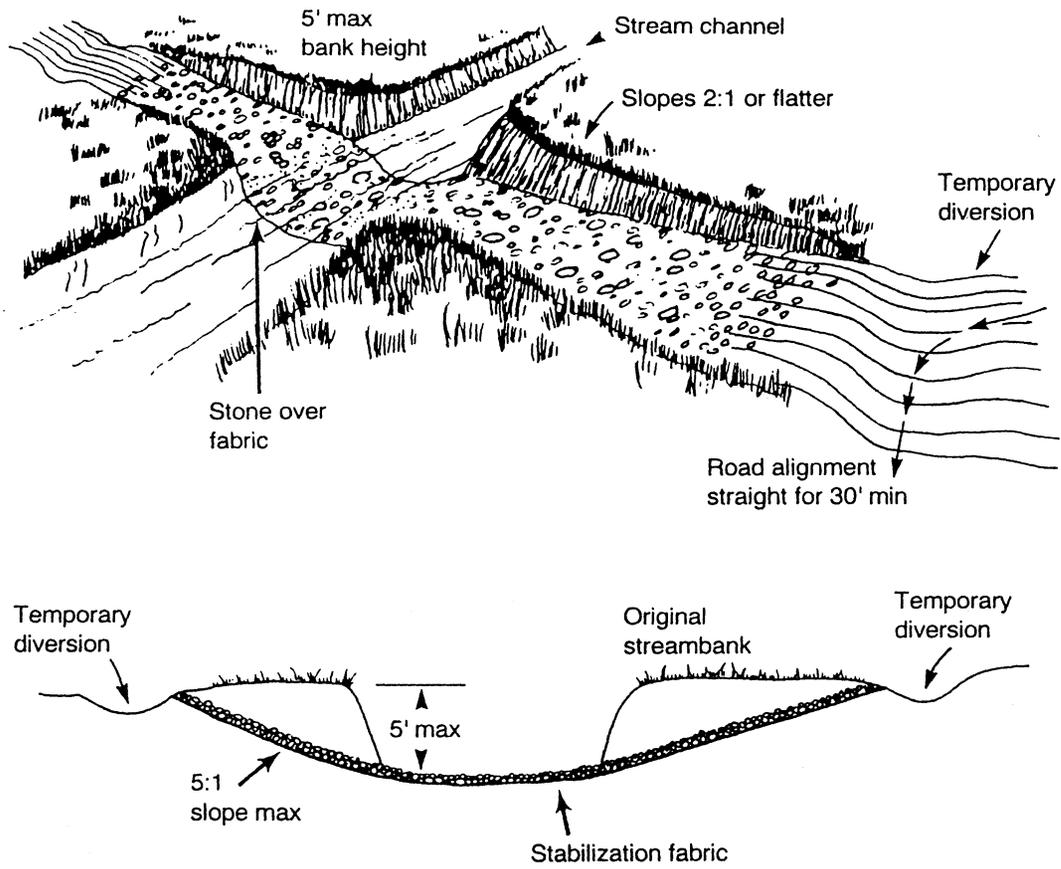


Figure 6.70b Ford stabilized with stone over stabilization fabric.

Install geotextile fabric in channel to stabilize foundation, then apply well-graded, weather-resistant stone (3-6 inch) over fabric (Figure 6.70b). Use only stabilization fabric, not filter fabric.

**Bridges and Culverts** Elevate bridge abutments or culvert fill 1 ft minimum above the adjoining streambank to allow storm overflow to bypass structure without damage. Culvert pipe should extend well beyond fill side slopes.

Protect disturbed streambanks, fill slopes and overflow areas with riprap or other suitable methods (reference Practice 6.15, *Riprap*). Stabilize other disturbed areas as specified in the vegetation plan. Good surface stabilization is especially important at stream crossings as all eroded material directly enters the stream.

**Removal** Remove temporary stream crossings as soon as they are no longer needed. Restore stream channel to original cross section and stabilize all disturbed areas. Fords may be left in place if site conditions allow.

Temporary bypass channels should be permanently stabilized or removed. If removed, overfill 10%, compact, and stabilize appropriately.

**Leave in-stream sediment traps in place.**

**Common  
Trouble  
Points**

- Inadequate flow capacity and/or lack of overflow area around structure—results in washout of culverts or bridge abutments.
- Inadequate stabilization of overflow area—results in severe erosion around bridges and culverts.
- Exit velocity from culvert or bridges too high—causes stream channel erosion and may eventually cause erosion of bridge or culvert fill.
- Debris not removed after a storm—clogging may cause washout of culverts or bridges.
- Inadequate compaction under or around culvert pipe—culverts wash out due to seepage and piping.
- Stone size too small—ford washes out.
- Culvert pipes too short—results in a crossing supported by steep, unstable fill slopes.

**Maintenance** Inspect temporary crossing after each rainfall event for accumulation of debris, blockage, erosion of abutments and overflow areas, channel scour, riprap displacement, or piping along culverts.

Remove debris; repair and reinforce damaged areas immediately to prevent further damage to the installation.

**SAND FENCE (Wind Fence)**

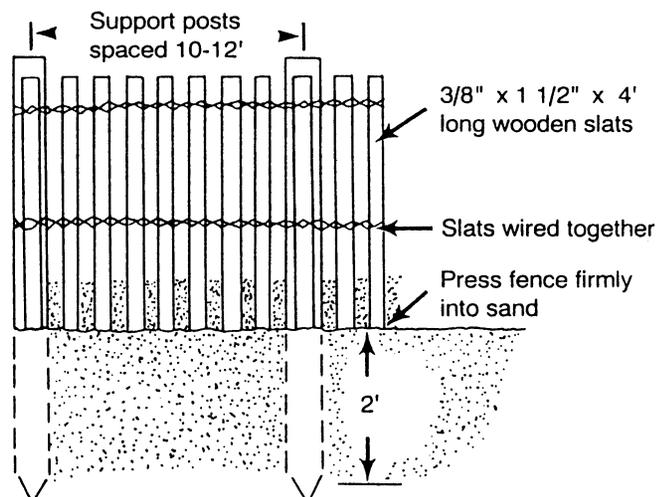
**Purpose** To reduce wind velocity at the ground surface and trap blowing sand. Typically used for rebuilding frontal dunes along coastal areas (Figure 6.85a).

Figure 6.85a  
Fences trap  
sand to build up  
eroded dune.



**Materials** Commercial sand fences usually consist of 4-ft wooden slats wired together with spaces between the slats (Figure 6.85b). The distance between slats is approximately equal to the slat width (about 1 1/2 inches). Synthetic fencing fabric is available for this use.

Figure 6.85b  
Typical sand fence  
material.



### Installation

Install sand fences in spring or early summer and seed selected permanent vegetation in November and the following spring (reference Practices 6.11, *Permanent Seeding*, and 6.16, *Vegetative Dune Stabilization*).

Erect a windward fence parallel to existing dune (generally perpendicular to the prevailing on-shore wind), at least 1 ft above the maximum annual high water elevation. Locate a second fence generally parallel to the first at the top edge of the eroded dune bank. Space additional parallel fences 20 - 40 ft apart as needed over the area to be built up (Figure 6.85c).

A second set of fences may be erected perpendicular to the first to protect captured dune sand from cross winds. Space perpendicular fences a greater distance apart (50-75 ft).

Support fencing material with 2 x 4-inch or 3-inch round posts, 6 ft long minimum, driven firmly into the ground at least 2 ft and spaced approximately 12 ft apart. Alter spacing so that posts are placed at all low points. Secure fencing to windward side of posts by tying or nailing. Press bottom of fencing material firmly into the ground at all points.

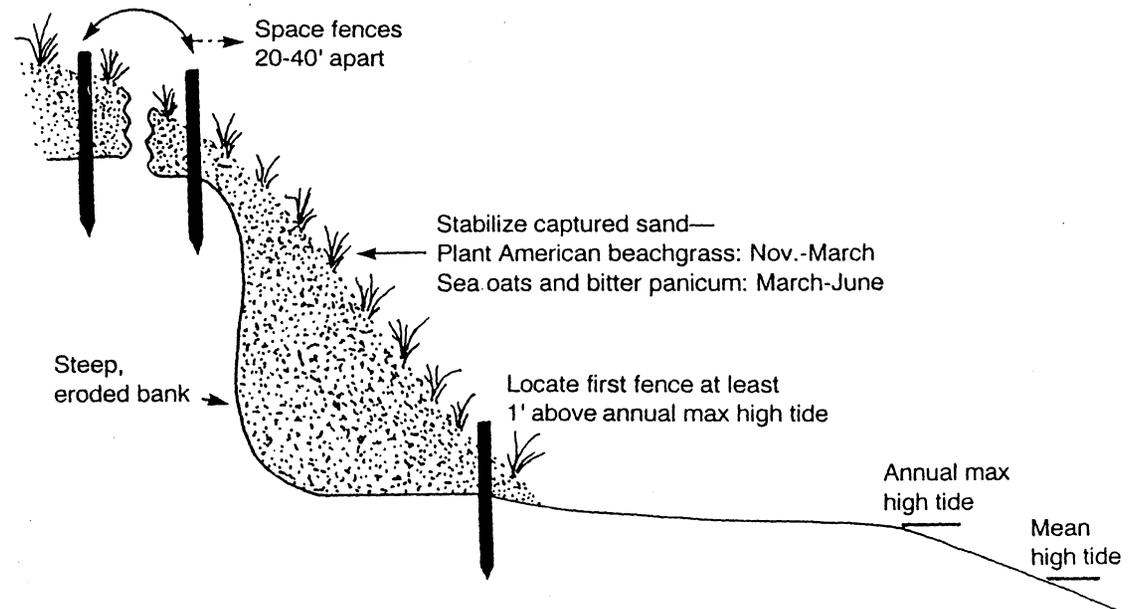


Figure 6.85c Location of sand fences to trap sand and build up a dune.

**Raising the Dune** When the fence system is approximately two-thirds filled with sand, erect another series of fences until desired dune height is reached.

**Final Stabilization** When the dune-building process slows significantly, the dune must be permanently stabilized. Planting should begin in November and be completed the following spring even if the dune has not reached the desired height. Vegetation hastens the building process. Maintain fences until vegetation is well established.

**Common  
Trouble  
Points**

- Bottom fence located too low—fence washes out.
- Fences not maintained long enough. Some seasons provide little opportunity for dune building and fences may have to be maintained for longer periods.
- Dune not adequately stabilized with permanent vegetation—dune is subject to erosion during storms, even with sand fences in place.
- Fencing material placed on leeward side of posts or not adequately secured—sections of fence collapse.
- Posts not driven deep enough—fence collapses.
- Fence system located too near the ocean—not enough sand source for dune building.

**Maintenance**

Inspect sand fences periodically, and immediately following storms. Repair damaged sections of fence promptly.

Maintain fences until vegetation is well established.

## **7** Related References



## *Related References*

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Few references deal specifically with the construction and installation of erosion and sediment control practices. There are, however, many handbooks, technical guides, and manufacturers' product publications that contain illustrations and other information that may be useful in the field. The following references were selected from those used in preparing this Field Manual and the *North Carolina Erosion and Sediment Control Planning and Design Manual*.

### **Erosion and Sediment Control Design Manuals**

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North Carolina Sedimentation Control Commission. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Department of Environment, Health, and Natural Resources. Division of Land Resources. Raleigh, N.C. 1988.

Land Quality Section and USDA Soil Conservation Service. *Guide for Sediment Control on Construction Sites in North Carolina*. North Carolina Department of Environment, Health, and Natural Resources Division of Land Resources. Raleigh, N.C. 1979.

Soil Conservation Committee. *Standards for Soil Erosion and Sediment Control in New Jersey*. Division of Rural Resources. New Jersey Department of Agriculture. Trenton, N.J. 1982.

Department of Transportation. *Guidelines for Control of Erosion and Sediment During Construction*. North Carolina Department of Transportation. Raleigh, N.C. 1979.

Land Resources Conservation Commission. *Erosion and Sediment Control Practices for Developing Areas*. South Carolina Erosion and Sediment Control Division. Columbia, S.C. 1985.

Department of Natural Resources. *Construction Best Management Practice Manual*. West Virginia Division of Water Resources. Morgantown, W. Va. 1983.

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## Energy Dissipating Devices

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Federal Highway Administration. Hydraulic Design of Energy Dissipators for Culverts and Channels. Hydraulic Engineering Circ. No. 14. U.S. Department of Transportation. Washington, D.C. 1983.

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## Vegetation Guides

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Broome, S.W., E.D. Seneca, W.W. Woodhouse, Jr. Building and Stabilizing Dunes with Vegetation. University of North Carolina Sea Grant Publication 82-05. Raleigh, N.C. 1982.

North Carolina Agricultural Extension Service. Carolina Lawns. North Carolina Agricultural Extension Service Publication AG-69. Raleigh, N.C. 1985.

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## Construction Materials<sup>1</sup>

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National Stone Association. Quarried Stone for Erosion and Sediment Control. N.C. Aggregates Association. Raleigh, N.C. 1987.

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## Soils Information

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Daniels, R.B., H.J. Kleiss, S.W. Buol, H.J. Byrd, J.A. Phillips. Soil Systems in North Carolina. Agricultural Extension Service Bulletin 467. North Carolina State University. Raleigh, N.C. 1984.

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<sup>1</sup>Manufacturers often provide details on proper installation of their products.





## *Where to Go for Help*

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The Land Quality Section of the North Carolina Department of Environment, Health, and Natural Resources employs qualified engineers, geologists, and technicians to implement laws pertaining to the safety of non-federal dams, erosion and sediment control on construction sites, and responsible operation and reclamation of mines in North Carolina. There are seven regional field offices across the state and a central administrative office in Raleigh that provides specialized technical and legal support (Figure 8.1).

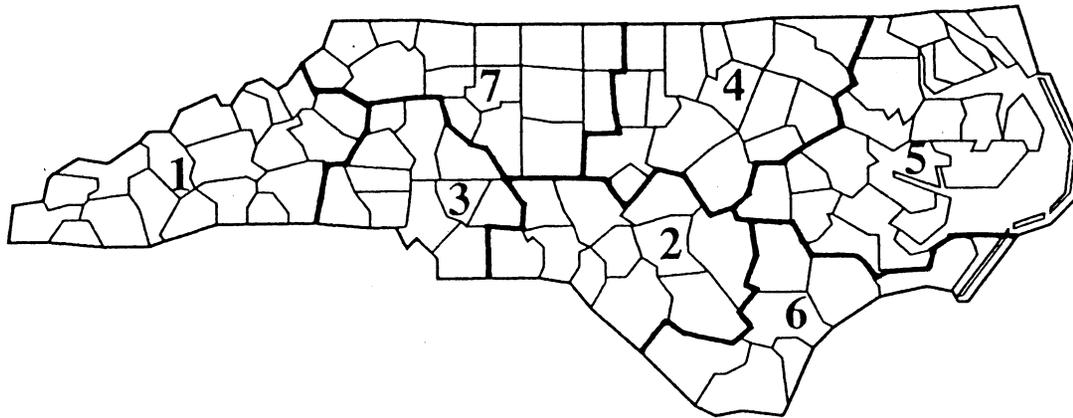


Figure 8.1 NC Department of Environment, Health, and Natural Resources Regions.

**Local Ordinances**

The North Carolina Sedimentation Control Commission has approved a number of local erosion and sediment control programs for administration by county and municipal governments. For information concerning a specific local ordinance, contact the appropriate office listed below:

*Revised 10/23/89*

ASHEBORO	City Engineer 146 N. Church St. Asheboro, NC 27203	(919) 625-6131
ASHEVILLE	City Engineer P.O. Box 7148 Asheville, NC 28807	(704) 259-5617
BEECH MOUNTAIN	Building Inspector 510 Beech Mountain Parkway Beech Mountain Banner Elk, NC 28604	(704) 387-4236
BOONE	Planning Director P.O. Drawer 192 Boone, NC 28607	(704) 262-4540
BUNCOMBE CO.	Dept. of Planning and Development 46 Valley St. Asheville, NC 28801	(704) 255-5777
BURLINGTON	City Engineer P.O. Box 1358 Burlington, NC 27215	(919) 222-5050
CARY	Stormwater Management Engineer Dept. of Construction Management P.O. Box 1147 Cary, NC 27511	(919) 469-4038 (919) 469-4076
CASWELL CO.	County Building Inspector P.O. Box 204 Yanceyville, NC 27370	(919) 694-4193

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HAYWOOD CO.	Environmental Specialist Haywood County Annex 2 1600 N. Main St., Suite I-45 Waynesville, NC 28786	(704) 452-6706
HENDERSON	City Inspector P.O. Box 1434 Henderson, NC 27536	(919) 492-6111
HIGHLANDS	Zoning Administrator and Town Planner P.O. Box 460 Highlands, NC 28741	(704) 526-2118
HIGH POINT	Planning Department Central Engineering P.O. Box 230 High Point, NC 27261	(919) 887-2511
JACKSONVILLE	Director of Public Works City of Jacksonville P.O. Box 128 Jacksonville, NC 28541	(919) 455-2600
KERNERSVILLE	Forsyth Erosion Control Officer Inspections Department 810 NCNB Plaza Winston-Salem, NC 27102	(919) 727-2494
KITTY HAWK	Town Planner P.O. Box 549 Kitty Hawk, NC 27949	(919) 261-3552
MECKLENBURG CO.	County Engineer 700 N. Tryon St. Charlotte, NC 28202	(704) 336-3731
NAGS HEAD	Town Manager P.O. Box 99 Nags Head, NC 27959	(919) 441-5508

