GUAM

EROSION & SEDIMENT CONTROL

FIELD GUIDE

Version 1.0 for Contractors and Site Inspectors

Purpose

This field guide was designed specifically for contractors in Guam involved in clearing, grading, stockpiling, and other earth-moving activities at all construction sites. Its requirements will be administered and enforced pursuant to the Guam Water Quality Standards (GWQS) and the Guam Soil Erosion and Sediment Control (GSESC) Regulations (22GAR-2 Chapter 10). Also to help contractors implement 11 Erosion and Sediment Control (ESC) Standards of the 2006 CNMI/Guam Stormwater Management Manual, this field guide:

- Explains why ESC is an important part of the construction process
- Summarizes ESC practice design, installation, and maintenance tips
- Outlines inspection and project closeout considerations
- Serves as a reference for use in the field
- Relies primarily on graphical illustrations for multi-lingual users
- Is not a substitute for more detailed practice design or technical specifications

Prepared for:

Guam Coastal Management Program (GCMP) and
Guam Environmental Protection Agency (GEPA)

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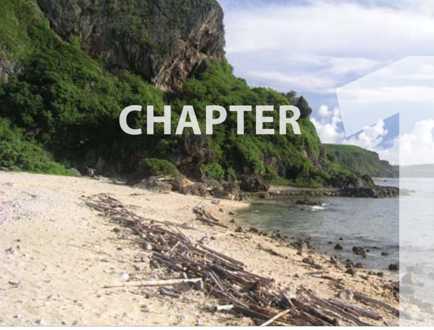
Adapted from:

2009 CNMI Erosion and Sediment Control Field Guide, CNMI DEQ



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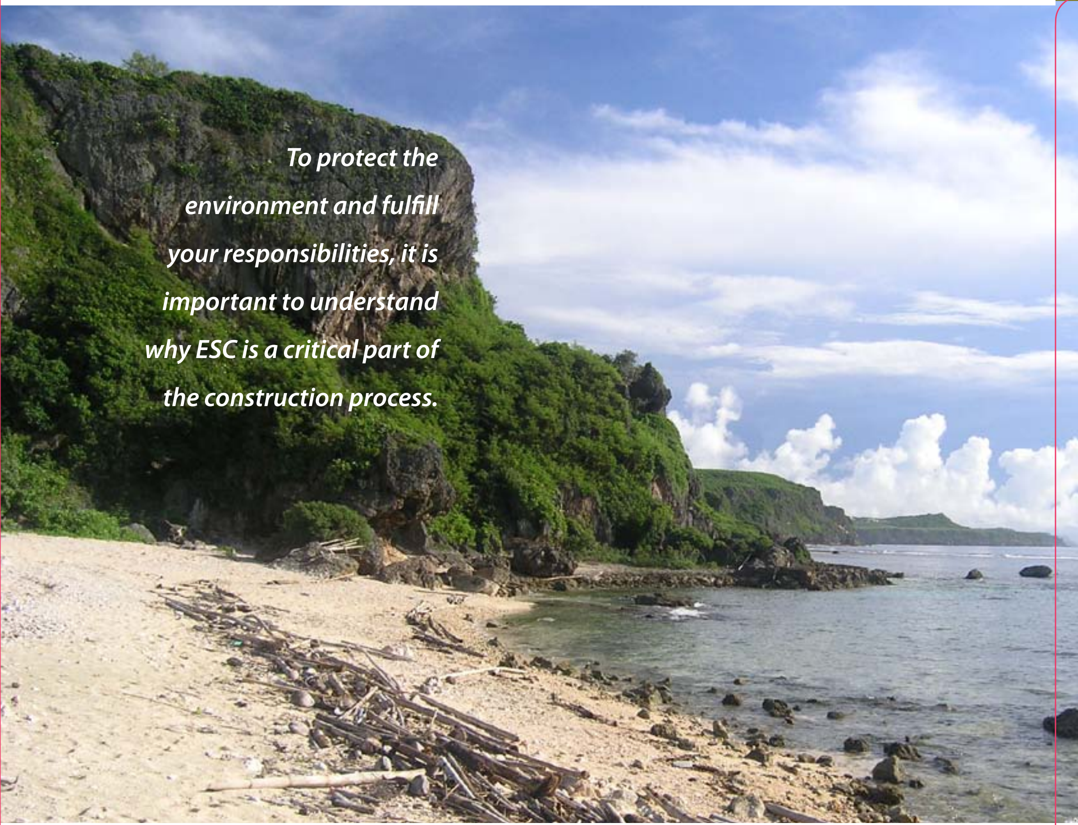
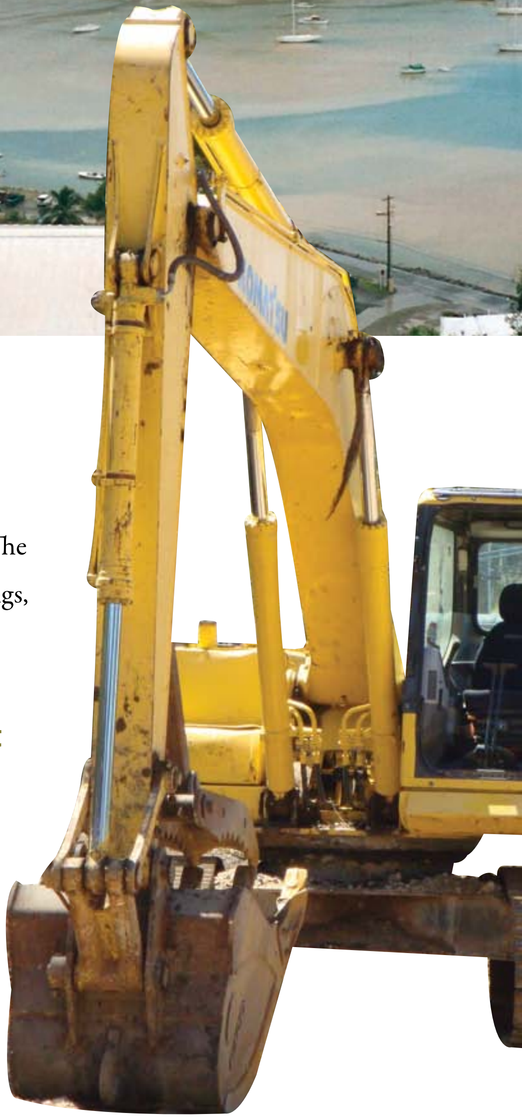
WHY EROSION AND SEDIMENT CONTROL?



To protect the environment and fulfill your responsibilities, it is important to understand why ESC is a critical part of the construction process.

Impacts of Construction

There is a direct link between land alteration and the health of streams, wetlands, coastal waters, and aquifers. The conversion of vegetated areas to buildings, roads, and parking lots changes surface and groundwater drainage processes, which can have a **negative impact on our local environment and economy.** These impacts begin during construction and are influenced by rainfall, site conditions, and our ability to apply proper erosion and sediment control (ESC) practices.



Before clearing and grading, native **vegetation absorbs rainfall,** slows runoff velocities, protects soil from erosion, and allows for infiltration into the ground.

Land cleared for new development **involves removal of vegetation, exposure of valuable soil, and compaction by heavy equipment**. These factors result in more surface runoff and less recharge to important aquifers.

Sediment buildup can clog drainage systems and lead to **flooding** of roadways and properties.

Sediment-laden runoff ultimately **discharges** into streams, wetlands, and marine waters. Sediment particles carry toxic **pollutants** and nutrients that can **reduce water quality**.

When it rains on construction sites, unprotected slopes and **exposed soils can erode.** If ESC practices are not properly installed or maintained on site, sediment runoff can wash into roads, adjacent properties, and waterways.

Runoff from steep or highly **erodible roads** can add to the sediment load from construction sites during typical storm events.

Sediment deposition can damage nearshore ecosystems by filling shallow wetlands and smothering benthic habitats such as **coral reefs**.

Turbidity **reduces oxygen** and **light** necessary for marine life.

Site Factors Contributing to Erosion

Several factors contribute to increased erosion at construction sites (Figure 1.1). Erosion and sediment loss is more likely to occur when:

- Native **vegetation is removed,** and soils are exposed to erosive rainfall and surface runoff.
- **Erodible soils are present.** Most soils in Southern Guam are classified as volcanic rock that have a higher erosion potential and are less permeable than limestone in Northern Guam.
- **Steep slopes** exist on site. Unlike flat terrain, water concentrates and travels faster down steep slopes. Sediment on cut and fill slopes is particularly vulnerable to erosion.
- ESC practices are not properly installed or maintained. **This field manual describes appropriate techniques to prevent erosion and control sediment.**
- Average annual rainfall on Guam ranges from ~85-115 inches (Figure 1.2). **Heavy rainfall occurs** during the wet season (July through October).

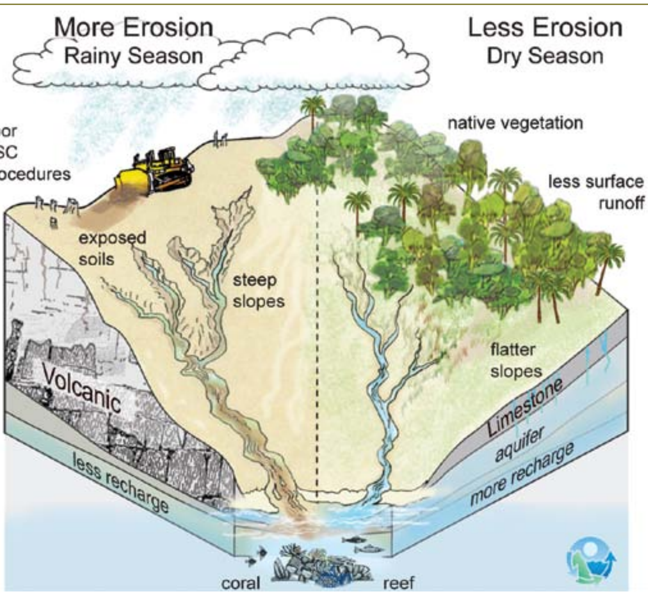


Figure 1.1. Factors contributing to construction site erosion (Adapted from: Tetra Tech).

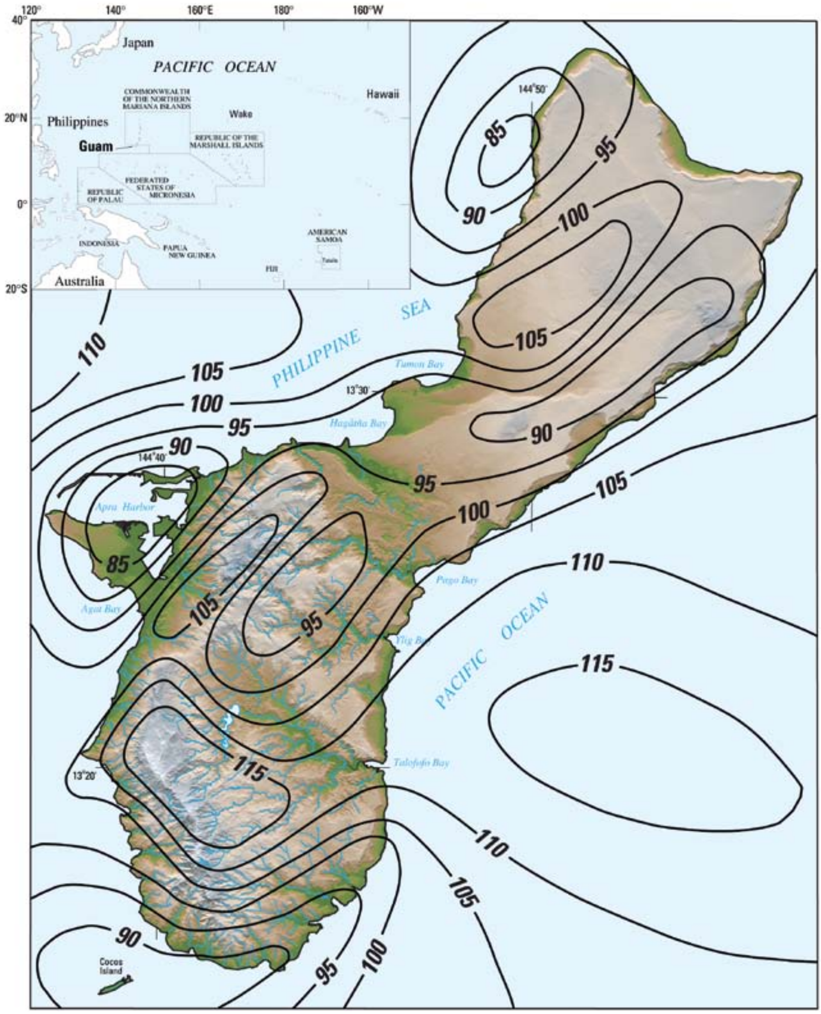


Figure 1.2. Annual Rainfall in inches per year for Guam (Adapted from Gingerich's 2003 USGS Report WRIR 03-4126, Hydrologic Resources of Guam).

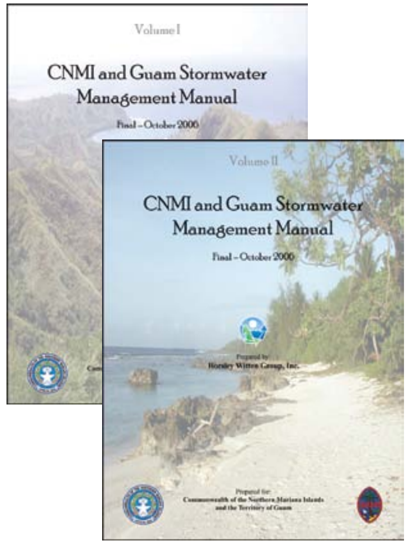
ESC Regulations

In Guam, the U.S. Environmental Protection Agency administers the National Pollutant Discharge Elimination System (NPDES), which was established under the federal Clean Water Act to address stormwater runoff from construction sites and other sources.

The Guam Soil Erosion and Sediment Control Regulation (22GAR-2 Chapter 10) is available for download at **www.epa.guam.gov**.

In Guam, all **government construction sites are subject to ESC and post-construction stormwater criteria** described in the 2006 CNMI/Guam Stormwater Management Manual (available at **www.epa.guam.gov**). Volume I provides design guidance, construction details, and specifications for common ESC practices. Additional ESC guidance can be found in the Guam Transportation Stormwater Drainage Manual.

The following conditions must be met unless, a waiver is granted by approved authority:



- ☑ All sites over 1 acre must submit an NOI to EPA for coverage under the general NPDES permit and furnish a copy to GEPA.
- ☑ All sites **disturbing over 1 acre** must prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) in accordance with the NPDES Phase II Stormwater Program.
- ☑ Measures must safely convey the **10-year storm** (10 inches) with non-erosive velocities and temporary sediment trapping devices must retain a minimum of the **1 ½ inch storm**.

Once final ESC and Stormwater Management Regulations are adopted, projects will need to comply with 11 ESC standards (see page 9).

Contents of an ESC Plan

Plan Components	Description
A. Description of the project	Location, water courses, 25-ft buffers and flood plains, flow direction of stormwater runoff, and vegetation
B. Soil map and description	Soil permeability, erodibility factor, percolation rate, runoff coefficient, and depth to groundwater
C. Protection and removal of native vegetation	Location of existing trees/vegetation; identification of trees to be preserved and removed; tree protection details; and clear limits of disturbance
D. Construction schedule	Sequencing of construction activities/phases and construction notes
E. Stockpile and staging plan	Source of materials, location, slope and height of stockpile, and measures to prevent erosion
F. Plan for spoil materials	Proper on- and off-site disposal procedures
G. Grading plan	Contours, cross sections, spot elevations and the condition of the land before and after construction
H. ESC practices	Locations, details, and design calculations for proposed ESC measures
I. Temporary stabilization	Procedures for stabilizing unworked soils and slopes
J. Maintenance procedures	Routine and scheduled maintenance for each ESC measure, including responsible party
K. Permanent vegetation establishment	Planting plans, proposed species used, procedures for ensuring growth (e.g., watering, inspecting, re-planting)
L. Certification	Plans to be stamped and signed by an engineer

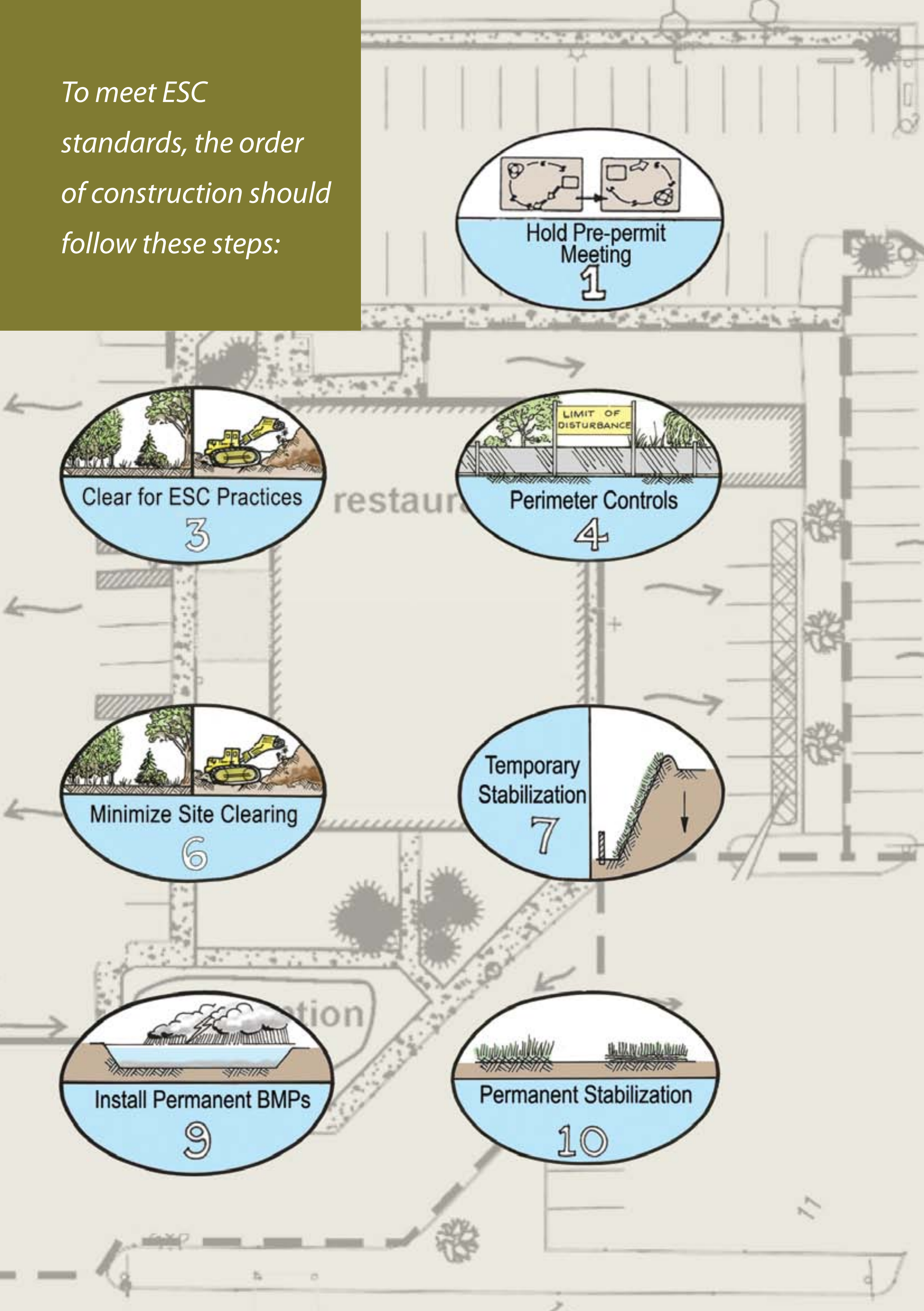
* See GEPA for additional information on plan requirements.

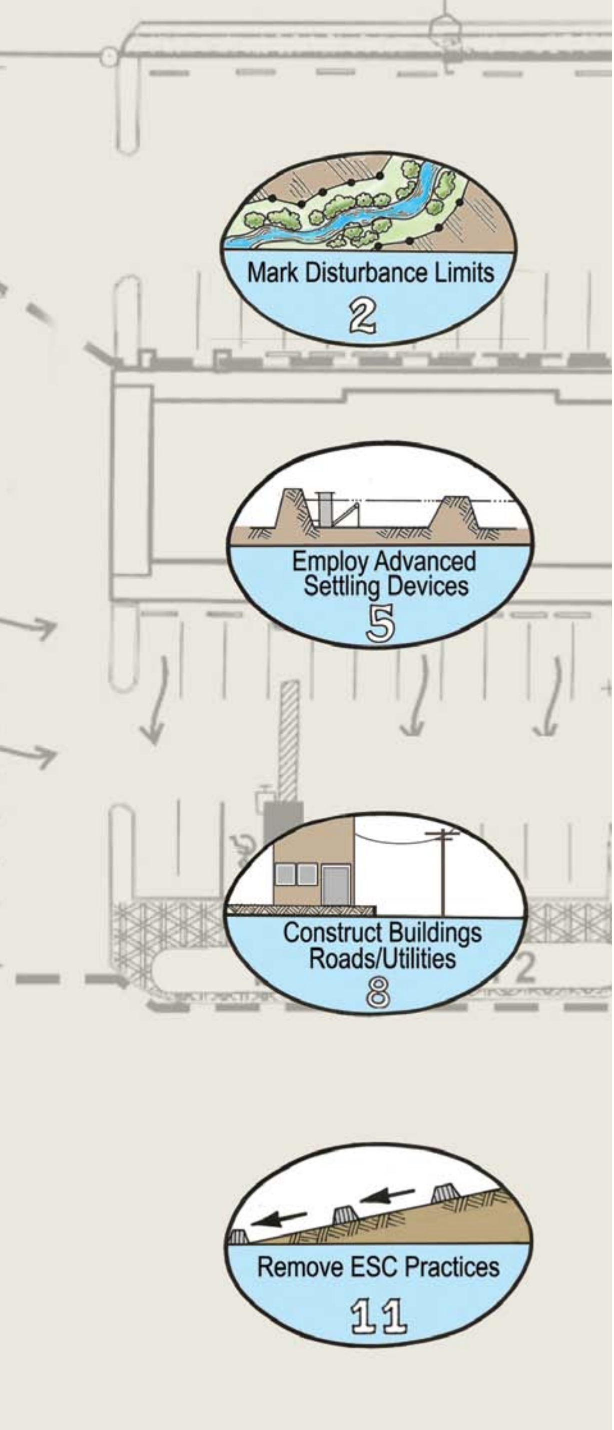
Projects must show compliance with 11 ESC standards

ESC Standards

1. Minimize unnecessary clearing and grading to preserve existing natural areas
2. Protect waterways (minimum 25-foot buffer) and stabilize drainage ways
3. Phase construction to limit soil exposure
4. Stabilize exposed soils immediately (~14 days)
5. Protect steep slopes and cuts from erosion
6. Install perimeter controls to keep sediment on site
7. Employ advanced sediment settling control devices
8. Train and certify contractors on ESC plan implementation
9. Conduct a pre-permit site meeting and adjust plan if necessary
10. Where feasible, schedule construction during dry season
11. Maintain ESC controls throughout the entire construction process

To meet ESC standards, the order of construction should follow these steps:





(Adapted from: Center for Watershed Protection)

Proper Construction Sequencing

1. Hold pre-permit meeting
2. Mark limits of disturbance to protect waterway buffer, existing vegetation, and other resources
3. Clear/grub areas necessary to construct ESC practices
4. Stabilize construction entrance and install necessary perimeter controls and diversions
5. Install temporary sediment trapping devices and runoff conveyance systems
6. Complete clearing and rough grading where necessary (minimized and phased)
7. Provide temporary stabilization with vegetation or mulch for inactive, disturbed areas
8. Construct utilities, roads, and buildings
9. Convert/install permanent stormwater practices
10. Stabilize with permanent vegetation
11. Remove temporary ESC devices

Contractor Responsibilities

It is the job of the contractor to:

- ☑ Be trained in ESC standards, practice installation, and maintenance procedures.
- ☑ Install ESC practices according to the ESC plan.
- ☑ Follow appropriate construction sequencing.
- ☑ Educate operators and site workers on the importance of proper ESC practices.
- ☑ Protect waterways, trees, and other natural areas from construction activities.
- ☑ Inspect ESC practices routinely, especially after rainfall events.
- ☑ Make sure practices are maintained, repaired, and reinstalled when necessary.
- ☑ Communicate with supervisor and/or inspector any concerns related to ESC.
- ☑ Properly remove practices at end of construction only after site is permanently stabilized.

Inspector Responsibilities

It is the job of the site inspector to:

- ☑ Understand regulations affecting construction site activities and proper ESC practice application.
- ☑ Be familiar with the approved ESC plan, construction sequencing, and specifications.
- ☑ Communicate expectations for cooperative ESC implementation.
- ☑ Inspect site weekly, within 24 hours of major rainfall event, and at critical points during the construction process.
- ☑ Anticipate where ESC problems may occur.
- ☑ Ensure ESC practices are properly installed, maintained, and performing adequately. Provide input for improvement or minor modifications in the field.
- ☑ Maintain detailed records of inspections with reports, photos, and rainfall records.
- ☑ Establish clear time frames for corrective actions to be completed. Follow up.
- ☑ Initiate any enforcement actions.

CHAPTER 2 SEDIMENT BARRIERS

Before extensive clearing and grading occurs, barriers should be installed at vehicle entrances and at key perimeter locations to keep sediment from leaving the site.

BUFFER AND TREE PROTECTION

Definition

During construction activities, measures should be taken to ensure natural areas remain undisturbed. Where possible, clearing should be limited to areas needed to construct buildings, roadways, septic systems, and utilities. Preservation of natural vegetation, steep slopes, and buffers helps minimize erosion, protects water quality, and is cost-effective.

Design & Installation

- Before clearing, mark areas to be preserved. Use temporary wood fencing, plastic construction fencing, flagging, and/or signage.
- Install fencing outside of the 25-foot buffer zone and outside of tree dripline to protect roots.
- Locate temporary roadways, stockpiles, and layout areas to avoid stands of trees, shrubs, and grass.
- Instruct all workers to honor protective devices.
- Prohibit heavy equipment, vehicular traffic, or storage of construction materials within the protected area.
- Consider the impact of grade changes to vegetation and roots.
- Do not remove until site cleanup and final stabilization is complete.

Maintenance Required

During construction, the limits of disturbance should remain clearly marked at all times. Verify that protective measures remain in place. Restore damaged protection measures immediately. Serious tree injuries shall be attended to by a tree specialist.

Common Problems

- **Protected areas not clearly marked.** Use construction fencing and signage.
- **Sediment discharges into protected area.** Remove deposited sediment and install proper ESC practices.
- **Large tree roots cut or exposed.** Extend fencing beyond dripline to protect roots. Remove the ends of damaged roots with a smooth cut. Cover exposed roots with soil.
- **Soil compacted over roots.** Aerate soil by punching holes 12 inches deep, 18 inches apart.

Good use of highly visible construction fencing to mark limit of disturbance. Additional bilingual signage installed to identify area as protected.

Failure to adequately maintain/protect a 25- foot buffer zone between the stream and construction activities. Encroachment reduces buffer filtering capacity and can lead to in-stream sediment deposition.

Good combination of a double row of silt fence, brush berm, and temporary seeding to protect buffer area from construction site erosion.

Although the wooden frame with construction fence protects tree from heavy equipment and debris, the fence does not fully extend beyond tree dripline in this example, leaving roots unprotected.

✓ = *good use of practice* ✗ = *poor use of practice*

STABILIZED CONSTRUCTION ENTRANCE

Definition

Stabilized construction entrances are temporary crushed rock pads located at all points where vehicles enter or leave a construction site. The purpose of a stabilized entrance is to reduce the tracking of sediment/mud from the site onto paved roads and parking lots.

Design & Installation

- Locate entrance to provide for maximum use by all construction vehicles.
- Place woven or non-woven geotextile fabric over entire area to be covered with rock (see CNMI/Guam Stormwater Manual for fabric specifications for heavy duty vs. light duty roads).
- Spread minimum 6-inch thick layer of 1- to 4-inch rock , or reclaimed/recycled concrete equivalent on top of fabric.
- Minimum width of entrance should be 12 feet (24 feet if only access point), but not less than the full width of access point. Ends should be tapered to meet street.
- Minimum length of 50 feet (30 feet on single residential lots).
- Piping of surface water under entrance or a moundable berm shall be provided as required (Figure 2.1).
- When necessary, wheels shall be cleaned to remove sediment prior to leaving site. If a washing area is required, drainage should be directed to a sediment trap rather than storm drains, ditches, or watercourses.

Use available crushed rock or recycled concrete equivalent for temporary construction entrance.

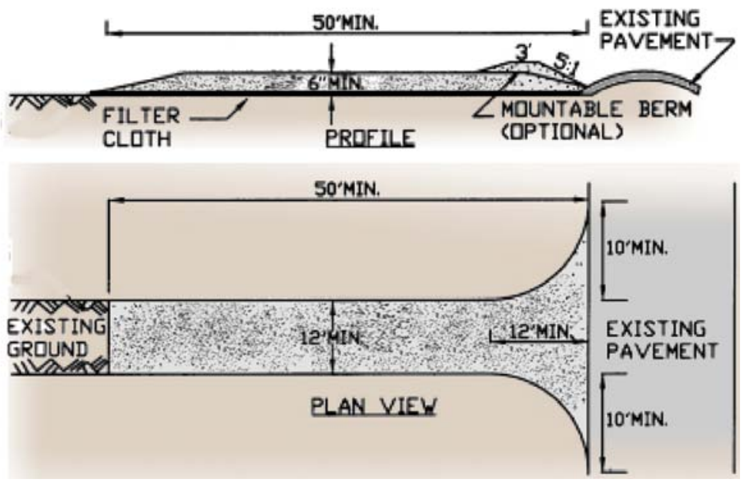


Figure 2.1. Stabilized construction entrance with optional mountable berm.

Maintenance Required

The condition of crushed rock should be monitored periodically and maintained after heavy use or heavy rainfall to prevent tracking or flowing of sediment onto rights-of-way. This may require periodic top dressing with additional rock.

All sediment spilled, dropped, or washed onto public rights-of-way must be removed immediately and more rock added as needed.

Common Problems

- **Crushed rock compacted into ground.** Install layer of fabric underneath and reapply rock.
- **Crushed rock full of sediment.** Top-dress with additional rock or wash and drain to sediment trapping device.
- **Vehicles going around stabilized entrance.** Be sure to taper edges to street. Expand entrance width or install barriers to direct traffic to entrance.

Good example of a stabilized entrance pad. Fabric is installed beneath rock layer. Fencing used to keep traffic on pad and block sediment from surrounding area (Source: University of Illinois).

Entrance is paved and slopes back towards site. Hoses (on left) are provided for washing tires; however, tracks indicate infrequent compliance. Stabilized entrances are supposed to be temporary. Drainage should be directed to a sediment trapping device.

Sediment accumulation shows that entrance has not been maintained. Fabric was not used beneath rock layer to prevent sinking. Rock should be washed or re-applied.

SILT FENCING

Definition

A temporary barrier of geotextile fabric, silt fencing is installed across a slope, around stockpiles, or along a perimeter. The purpose of a silt fence is to intercept sediment-laden runoff from small drainage areas of disturbed soil, slow runoff velocity, and allow sediment to settle out.

Design & Installation

- Install before extensive land clearing activities begin.
- Place fencing close to disturbed area, but ~10 feet from toe of slope to allow for sediment build up and maintenance access. The area beyond the fence should be undisturbed or stabilized.
- Install perpendicular to flow direction. Turn ends uphill to prevent bypass of water around fence.
- On long slopes, install multiple rows of fencing at separation distances based on slope steepness (Table 2.1 and Figure 2.3).
- **Silt fence should receive only sheet flow, not concentrated flow.**

Table 2.1. Distance Between Rows

Slope Steepness	Maximum Length (ft)
2:1	25
3:1	50
4:1	75
5:1 or flatter	100

Silt fences often fail due to poor installation or lack of maintenance.

- Dig 4-inch wide by 6-inch deep trench. Install posts every 5-10 feet on downhill side of trench at least 16 inches deep. Use "T" or "U" type steel or sturdy wooden posts (3 square inch cross section).
- Place fabric along bottom of trench. Attach to posts with wire or plastic ties every ½ foot. Fold and tie posts together to overlap fabric at ends.
- Backfill trench with soil and compact.
- Reinforce fabric with heavy wire support fencing to prevent collapse where necessary (Figure 2.2).

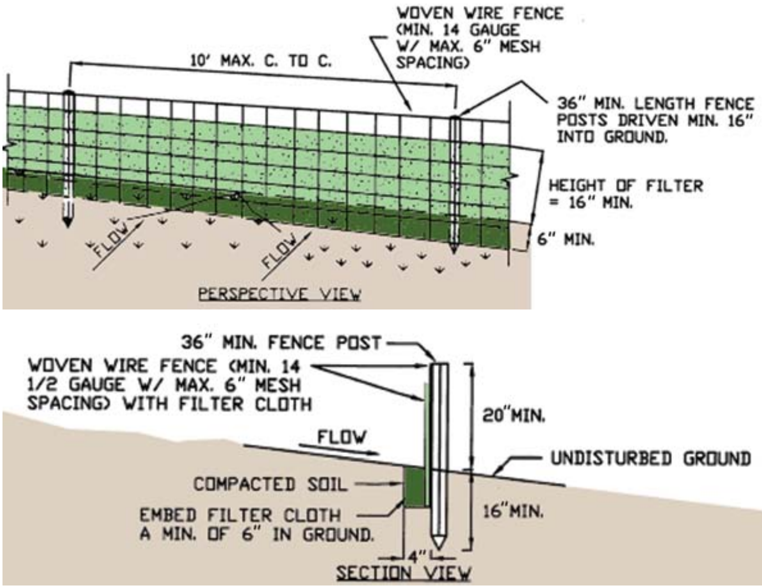


Figure 2.2. Silt fence installation with wire mesh support.

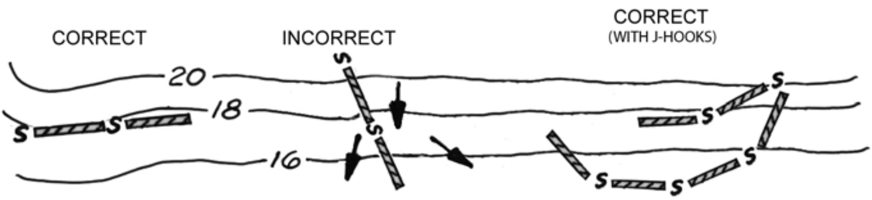
Maintenance Required

Inspect daily. Repair if sagging, flapping, or bulging is noticeable, or if erosion or spillover is observed. Remove sediment and debris when build up reaches ⅓ height of fencing. If site is inactive, continue to inspect after every rain event.

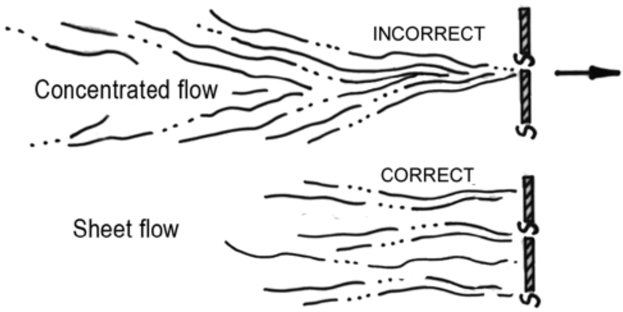
Common Problems

- **Not maintained.** Should be inspected daily. Remove accumulated sediment when buildup is ⅓ height of fence, and replace torn fabric immediately.
- **Not trenched properly.** Reinstall to prevent flow from going underneath.
- **Stakes placed on uphill side of fence.** Reinstall stakes 5-10 feet apart on downhill side.
- **Installed across concentrated flow path** (i.e., swale or stream). Identify source of concentrated flow and re-evaluate placement of silt fence. Use different ESC practice.
- **Flow overtops or bypasses fencing.** Add uphill row of fencing, add wire support, or turn ends uphill.

Figure 2.3. Reasons Silt Fences Fail (Adapted from: Center for Watershed Protection)

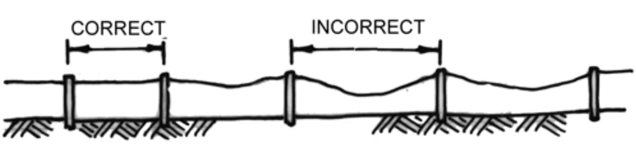


Silt fence is **not aligned parallel** to slope contours.



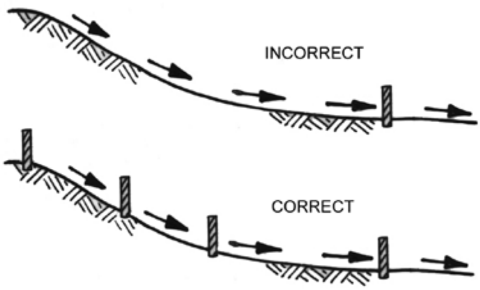
Fence receives **concentrated flow**.

Fence **not properly trenched** into ground.

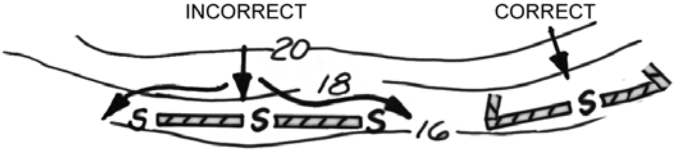


Spacing between posts is too great.

Fence placed **uphill** of disturbed area.



Slope and/or length of slope too great for fence.



Ends do not **curve uphill** to prevent bypass.

Sediment deposits behind fence not removed in time to prevent failure.

Good use of fencing around stockpile. Area outside of fencing is stabilized with grass. Leave enough space behind fence for maintenance access.

Workers installing silt fence along the perimeter of construction area. Be sure to locate fencing based on ESC needs, not just placed around the property boundary.

The bottom of silt fencing should be securely trenched, not covered with a thin layer of dirt. Trench should be at least 6-8 inches deep, back-filled, and compacted.

Concentrated flow down this slope and improper use/installation of the silt fence have resulted in practice failure and sediment discharge beyond the site. Install multiple rows of fence on slopes.

SILT FENCE ALTERNATIVES

Definition

Because of the high failure rate and extensive maintenance burden of silt fences, consider using some of these alternatives:

Berms: Linear barrier of compacted soil or sand/gravel bags used to block or divert runoff (see Chapter 3, Diversion Berms).

Compost socks: Mesh tubes (also called filter socks or wattles) filled by blower with organic or wood mulch. These flow through filters can be used around site perimeters, as check dams, and as inlet protection (Figure 2.4).

Silt dikes: Reusable, triangular, foam product covered in geotextile used along perimeters, curbs, and as check dams.

Design, Installation, & Maintenance

Follow manufacturer's installation and maintenance instructions.

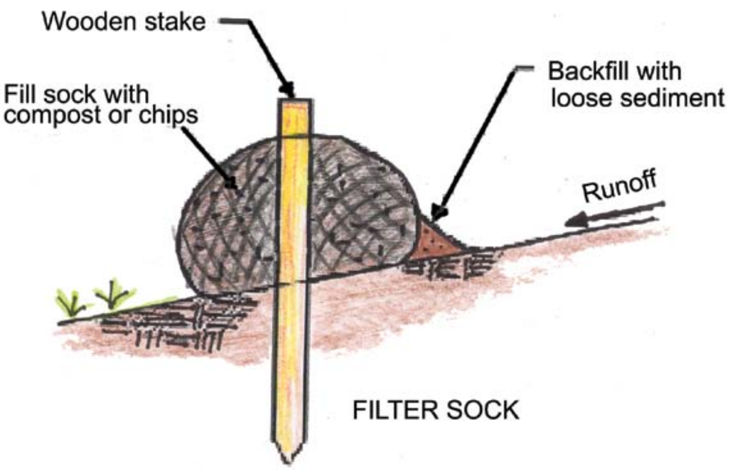
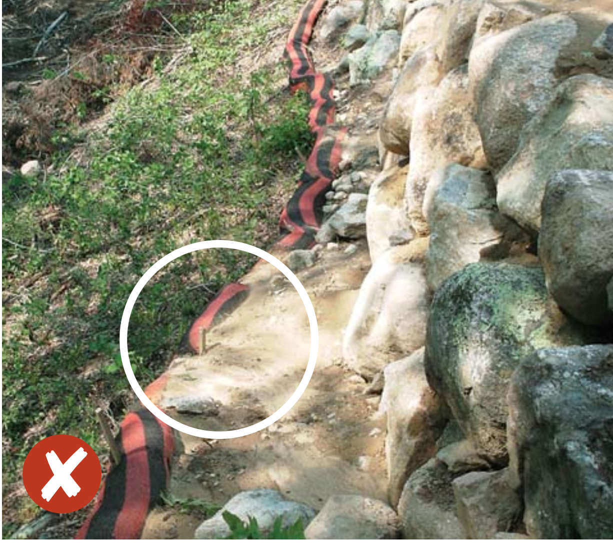


Figure 2.4. Typical filter sock installation (Adapted from: Iowa Statewide Urban Design and Specifications Manual).

An alternative for small sites, silt dikes are relatively easy to install, are resistant to drive-overs, and are potentially reusable. Note sediment line on backside of dike.



Socks can be used on slopes, but remember to properly maintain practice by removing excessive sediment that has built up behind it.

Construction fencing is not an approved alternative to silt fence.

Earth berms can be effective sediment barriers and diversion practices when installed correctly (see Chapter 3 on Diversion Berms). Berms should only be used on flat or shallow slopes if used as a "trap."

TURBIDITY CURTAIN

Definition

A turbidity curtain is a flexible, floating barrier used to contain suspended sediment along a shoreline or within a waterbody for a short period of time. This curtain has a flotation system at the top and is weighted or anchored at the bottom.

Design & Installation

- Various types are available, see manufacturer's instructions for your application.
- Do not use across flowing waters. Use in calm water surfaces.
- Curtain height shall be 20% greater than current water depth to allow for changing water levels.
- Remove obstacles and debris from area prior to installation.
- Locate around perimeter of construction site and firmly anchor in place. Place shoreline anchors outside of areas to be disturbed by construction equipment (Figure 2.5).
- For shallow installations, curtain can be secured by staking rather than using flotation system.
- Anchor curtain toe as needed depending on wave action and boat traffic.

Maintenance Required

Inspect curtain weekly, and check anchors and attachments after heavy winds or wave action. All floating debris shall be removed to prevent damage to the curtain. Any problem or failure of the curtain must be repaired immediately.

When removal of sediment deposited behind curtain is necessary, remove by hand. Allow 24 hours for sediment to settle before removing the curtain. Remove curtain by carefully pulling it towards shoreline to minimize the release of remaining sediment. All removed silt should be disposed of properly.

The turbidity curtain is the last line of defense for land-based construction runoff, and is used in conjuction with other ESC practices on site .

Turbidity curtain being used to protect waterway during shoreline stabilization projects. See manufacturer's instructions for installation and design specifications.

While this is a good use of curtain to contain erodible stockpile along shoreline, erodible materials should not be stored in waterway regardless of ESC practice usage. Be sure to firmly anchor ends of curtain to shoreline.

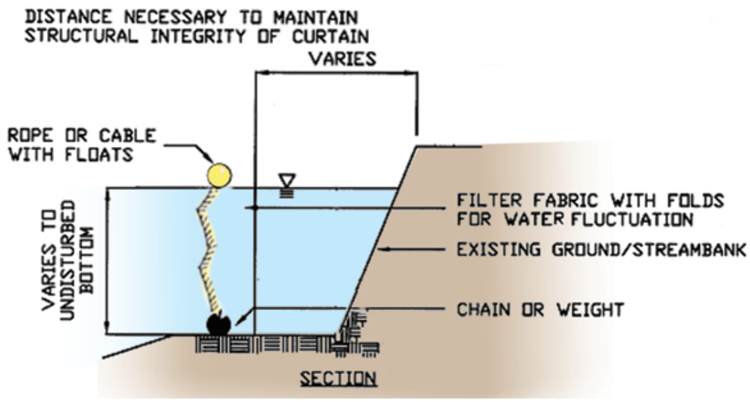


Figure 2.5. Typical turbidity curtain with flotation and anchoring devices.

Stabilized conveyance systems can be used to divert runoff into trapping devices or around distrubed areas. Ponding of runoff behind dams allows sediment to drop out before discharge.

CHAPTER 3

DIVERSIONS AND TRAPS

DIVERSION BERMS AND SWALES

Definition

Berms and swales, depending on their location, can be used to divert "clean" runoff around disturbed areas, or to move "dirty" runoff to sediment traps.

Berms (also called earth berms or diversion dikes) are mounds of compacted soil placed at the top or base of slopes, along the site perimeter, or across exposed areas (Figure 3.1).

Swales are temporary channels used to convey runoff to a sediment trapping device (Figure 3.2).

Design & Installation

- **Do not** construct diversion practices outside the site boundary without legal permission.
- **Do not** install diversions to redirect existing streams around your site.
- All berms should be compacted by heavy equipment, except for the combined dike/swale (Figure 3.3).
- Berms and swales should be **stabilized** within 1 week of installation.
- All berms and swales must have a positive, uninterrupted grade to a stabilized outlet. Typically minimum of 0.5% to 20% maximum slope (8% max on combined berm/swales, or if not using ESC matting or riprap).
- Outlets must slow runoff velocity to prevent erosion. Convey "dirty" runoff to a sediment trap.
- The flow of any existing natural drainage shall not be impeded or changed without a written waiver from the Administrator.

Maintenance Required

Full length of berms and swales should be inspected weekly and after every rain event in case of damage.

Common Problems

1. **Drainage area too large.** Install additional practices to reduce contributing drainage area and prevent erosion and overtopping.
2. **Berms not stabilized.** Stabilize exposed soils with temporary seeding, mulch, matting, or rock.
3. **Erosion at outlets.** Relocate or redesign outlet to slow runoff velocity and dissipate flow.
4. **Too steep.** Install matting or riprap to reduce erosion.

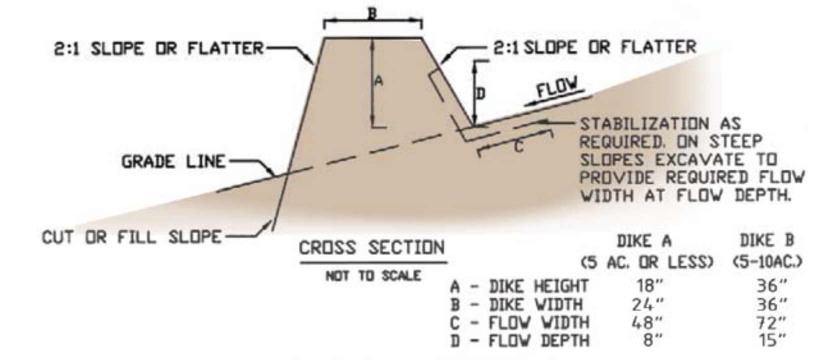


Figure 3.1. Earth berm cross section for different sized drainage areas.

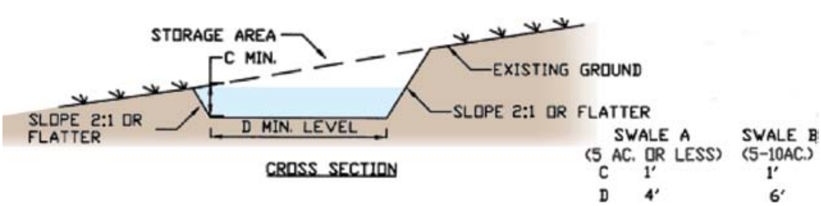


Figure 3.2. Diversion swale cross section with 2:1 side slopes.

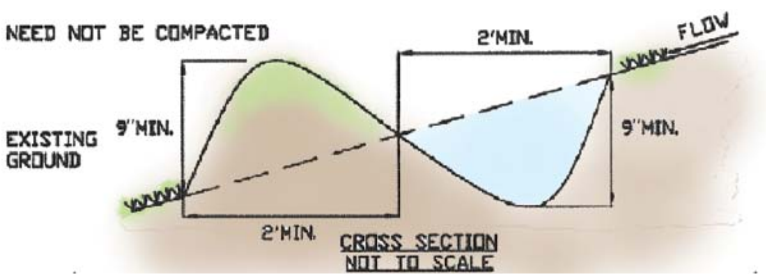
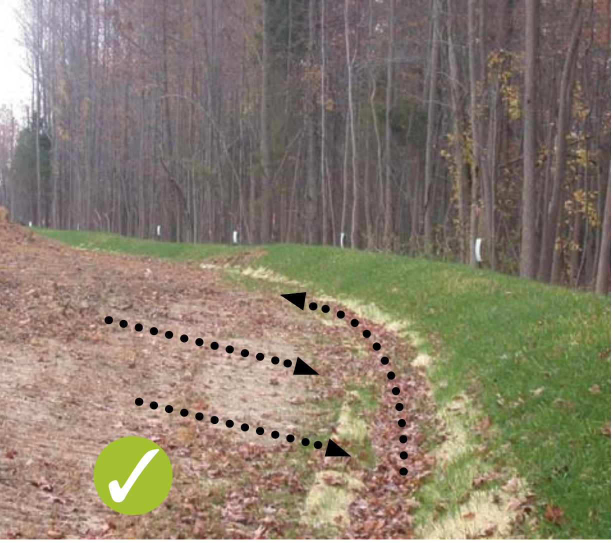


Figure 3.3. Combined berm/swale cross section.



Good use of a diversion berm at the base of a slope and along the perimeter to protect adjacent natural areas from construction site runoff. The berm was stabilized with erosion control matting and grass seed.

This diversion swale directs flows to a sediment trap. The slopes and surrounding area should be stabilized. Do not use swales to divert streams.

Great use of an earth berm to collect and divert runoff from the site into a stabilized outlet at the top of a ponding basin (behind chain fence on right). The berm should be stabilized with erosion control blankets or vegetation.

CHECK DAMS

Definition

Small check dams constructed of rock, sand bags, compost socks, or other durable materials are placed across an open drainage channel to reduce erosive runoff flows and allow sediment to settle out.

Design & Installation

- Maximum 2 acres drainage to the dam.
- Anchor check dams in the channel by a cutoff trench 1 ½ feet wide by ½ foot deep and lined with filter fabric.
- Use a well-graded rock matrix 2 to 9 inches in size. For other materials, follow manufacturer's specifications.
- Height of check dam less than 2 feet. Center shall be 9 inches lower than sides at natural ground elevation (Figure 3.4). Side slopes shall be 2:1 or flatter. Be sure to tie into banks.
- Space dams as directed in site plan. The top of the downstream dam should be at the same elevation as the toe of the upstream dam (Table 3.1).

Table 3.1. Standard spacing (MDE, 1994).

Slope	Spacing (ft)
< 2%	80
2.1–4%	40
4.1–7%	25
7.1–10%	15
>10%	lined waterway

Maintenance Required

The check dams should be inspected after each runoff event. Correct all damage immediately. Replace rocks as needed. Make sure culverts or other structures are not blocked by displaced check dam rocks.

Common Problems

- **Erosion occurring between structures.** Evaluate spacing. Install erosion control liner.
- **Sediment accumulation behind dams.** Remove sediment behind dam to allow channel to drain and prevent overtopping.
- **Dams dislodged by heavy flow.** Reduce drainage area or install additional check dams. Use larger size rock. Better anchoring.

Do not use silt fence for check dams, which should extend fully across ditch to prevent erosive bypass and have a lower center to allow for controlled spillover.

Good example of rock check dams that are lower in the center and extend fully across the channel to avoid run around.

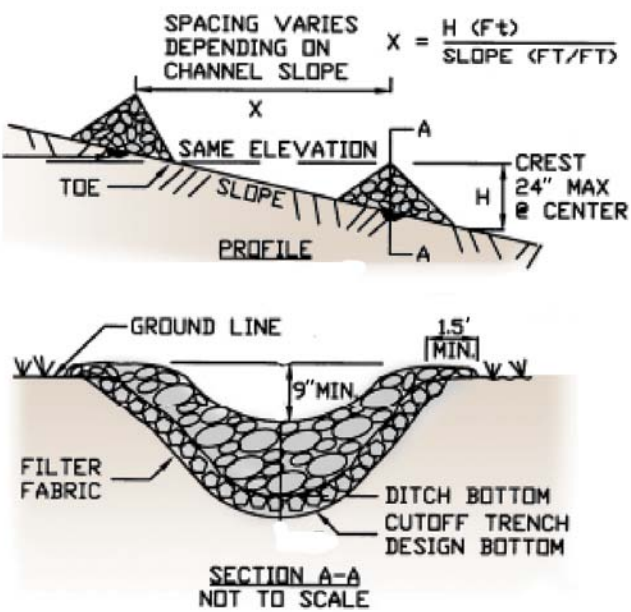


Figure 3.4. Proper spacing and cross section of rock check dam.

VEGETATED AND LINED WATERWAYS

Definition

Vegetated or lined channels are used to safely convey flows from stabilized areas or outlets without damage from erosion. Waterways are typically stabilized with grass, erosion control matting, rock rip rap, gabions, or concrete depending on slope, soil, and runoff velocity.

Table 3.2 summarizes some key features of vegetated versus lined waterways.

Design & Installation

- Clear foundation of trees, stumps, roots, loose rock, or other objectionable material.
- Excavate and install as shown on the plans (Figure 3.5). Backfill over-excavated areas with moist soil compacted to the density of the surrounding material.
- Do not allow abrupt deviations from design grade or horizontal alignment.
- Stabilize channels according to specifications.

Table 3.2. Features of Various Waterways

Vegetated Waterways	Lined Waterways
▪ May require subsurface drainage or additional outlets to reduce wet spots. ▪ Seed with grass as soon as practical if low gradient (<3% slope). ▪ Use sod and erosion control matting, particularly along centerline at moderate gradient (3-6% slope). ▪ Vegetation must be established before use.	▪ Used when vegetation will not prevent erosion (>6% slopes). ▪ Steepness of side slopes based on liner type (see 2006 CNMI/Guam Stormwater Manual). ▪ Minimum lining thickness of 4 inches for concrete lining, or 1½ times the maximum rock size for rip rap. ▪ Weep holes and underdrains should be provided for concrete.

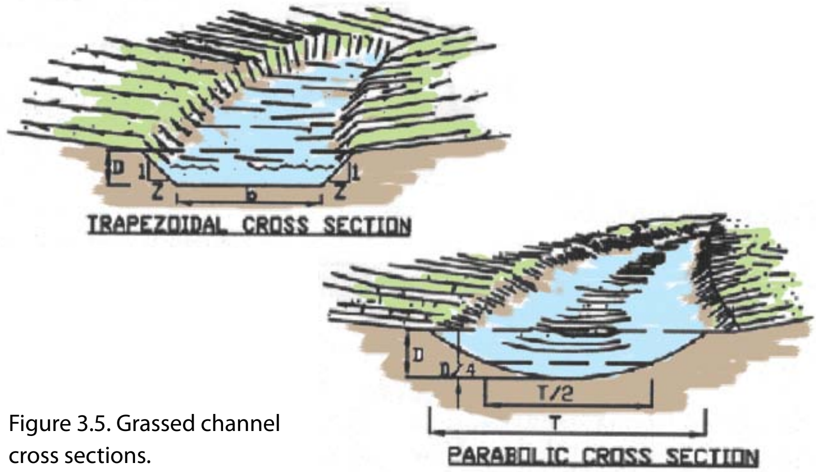


Figure 3.5. Grassed channel cross sections.

- Follow manufacturer's instructions for installing erosion control matting in channels (Figure 3.6).
- Hard linings shall be installed as shown on the plans. Non-woven geotextiles and cutoff walls may be used to prevent undermining.
- Do not use until fully stabilized.
- Requires a stable outlet that does not cause erosion at discharge.

Maintenance Required

Pavement or lining should be maintained as built to prevent undermining and deterioration. Existing trees next to pavements should be removed, as roots can cause uplift damage. Vegetation next to pavement should be maintained in good condition to prevent scouring if overtopped.

Common Problems

- **Vegetation not establishing.** Use erosion control matting or sod. Install additional outlets or underdrain system.
- **Out-of-bank flows are problematic.** Reduce flows to channel, or redesign.
- **Gullies forming in vegetated channel.** Use liner in centerline of vegetated channel.
- **Erosion beneath rock channels.** Make sure filter fabric was installed.

Concrete-lined waterways are effective for steep slopes and can be used as permanent drainage features.

Erosion control matting liner used in centerline of channel to prevent erosion and help establish vegetation.

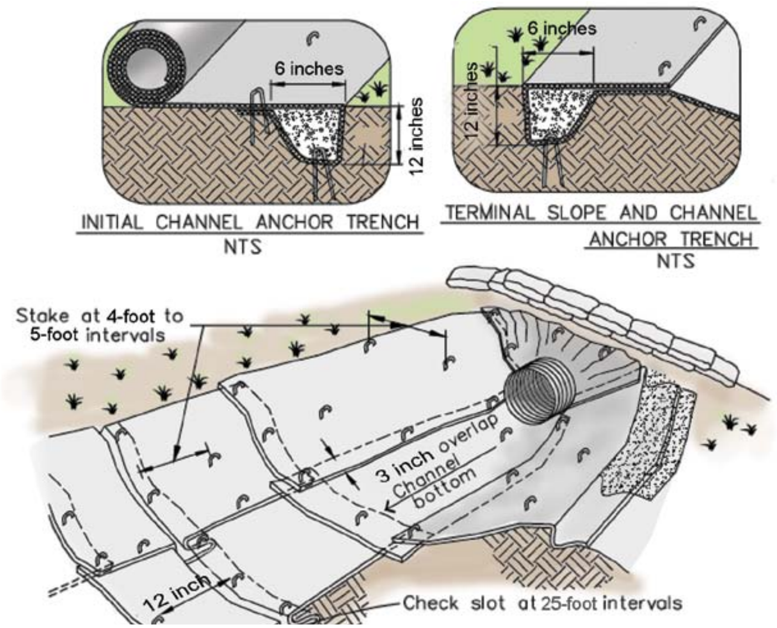


Figure 3.6. Diagram of erosion control matting used to line channel. (Adapted from State of California DOT Construction Site BMPs Manual, 2003)

SEDIMENT TRAPS AND BASINS

Definition

Large basins and small traps are temporary ponding structures used to collect runoff and allow sediment to settle out before runoff leaves the site. Basins and traps are formed by an embankment and/or excavation.

Design & Installation

- Construct before earth-moving activities begin. Clear embankment area of all vegetation and debris.
- Design and construction of embankments, basins, and traps must comply with all engineering specifications (Table 3.3).
- Locate traps (Figure 3.7) and basins (Figure 3.8) to obtain maximum storage, ease cleanout, and minimize interference with construction activities.
- Where outlets required, maximize distance between inlet and outlet.
- All pipe connections should be watertight.
- Install water-permeable covers on basins to prevent trash and debris from clogging pipe. Dewatering holes in base of riser should be covered by filter fabric or rock. No holes allowed in outflow pipe.

Table 3.3. Differences Between Basins and Traps

	Basins	Traps
Max Drainage Area	100 acres	5 acres
Size	5,500 cubic ft/acre of drainage; >2:1 length to width	
Dam Height	10-15 ft max.	5 ft max.
Dam Width	8-10 ft min.	4 ft min.
Dam Side Slopes	2.5:1 or flatter	2:1 or flatter
Outlet, if needed	Riser with spillway	Riser or grass/rock outlet
Riser Height, if needed	2 ft below top of dam, 1 ft below spillway.	1 ½ ft below top of dam
Status	Temporary or Permanent	Temporary

a)

b)

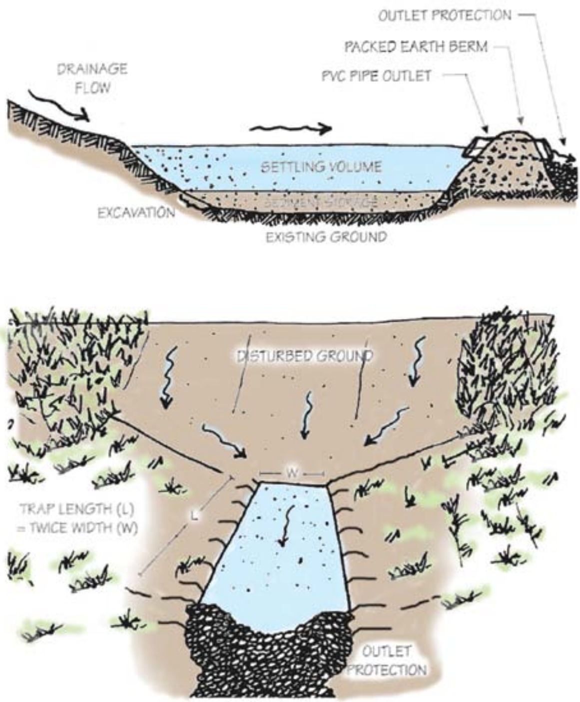


Figure 3.7. Examples of excavated traps with (a) pipe or (b) rock outlet (AS-EPA Guidance Manual for Runoff Control, 2001). Traps located in limestone may not need an outlet.

- Perforated risers should be wrapped in wire and filter cloth. Do not cover top of riser. No perforation within 6 inches of outflow pipe allowed.
- Outlets should be constructed and maintained to prevent sediment from leaving the trap and erosion from occurring below dam.
- Stabilize all side slopes, inlets and basin outlets (including spillway/ energy dissipater).

** If basin is permanent, temporary riser will need to be replaced with permanent water quality control outlet structure.*

Maintenance Required

Repair any damage daily. Remove sediment to original design volume when reduced by half (e.g., mark height on riser or sediment marker). Dispose of sediment according to approved site plan. In no case should removed sediments be disposed of in streams or other natural areas.

Do not remove basin until site has been fully stabilized for at least 30 days. Remove water by pumping or cutting riser prior to removing dam. Do not allow sediment to flush into a stream or drainage way. Basin sediments must be removed, safely disposed of, and backfilled with a structural fill.

**If converting to permanent practice, basin should be cleaned of deposited sediment and re-graded to meet new design specifications.*

Common Problems

- **Outlet pipe clogged with debris.** Clean pipe, install filter fabric or trash rack cover.
- **Basin slopes eroding.** Stabilize slopes with rock, vegetation, or matting. Pay close attention to inlets.
- **Excessive sediment buildup.** Remove sediment to retain holding capacity. Do not allow sediment to build up higher than 1 foot below spillway.
- **Upstream drainage too large.** Have engineer check drainage area calculations. Use other or additional practices.

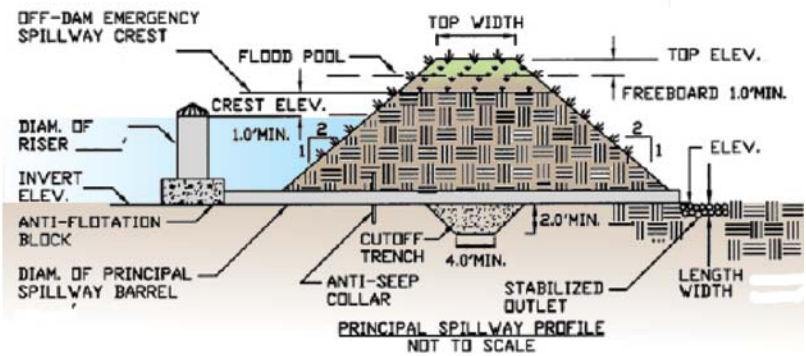
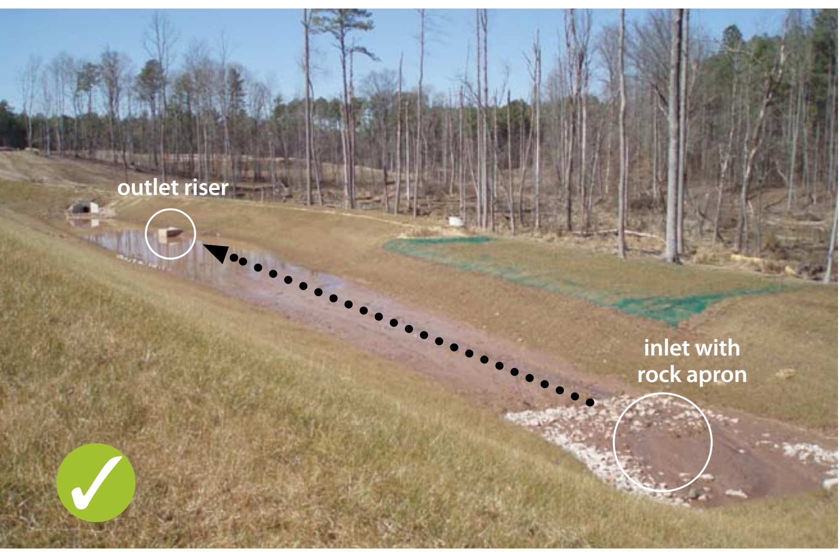


Figure 3.8. Sediment basin spillway profile. Basins located in limestone may not need an outlet.

This sediment trap has a perforated riser with no filter cloth protection to filter out sediment and trash before water is discharged. Side slopes are not stabilized with vegetation, and there is erosion occurring at the inlet point (not shown).



Large sediment basin to be converted to permanent stormwater practice once construction complete and accumulated sediment is removed. Good distance from inlet to outlet riser. Good stabilization of side slopes and spillway.

DEWATERING DEVICES

Definition

Sometimes there is the need to pump "dirty" water out of excavations or from construction projects along shorelines and stream crossings. Dewatering devices should be used to remove sediment before that water is discharged. Typical devices include:

Sump pits are holes dug into and area that requires dewatering into which a perforated vertical standpipe wrapped in gravel is inserted. Water is pumped from the center of the pipe and filtered through gravel (Figure 3.9).

Bag Filters are square or rectangular bags made of non-woven geotextile fabric that trap sand, silt, and fines inside the bag as water flows through the fabric (Figure 3.10). Bags come in many sizes.

Weir Tanks are containers with a series of baffles that create compartments.

Containment Areas are excavated areas surrounded by gravel, silt fence and/or other sediment barriers used for secondary dewatering treatment (Figure 3.11).

Design & Installation

- Size devices and pumps based on expected volumes and flow rates. Table 3.4 has sizing guidance for containment areas. Storage for tanks (Cu. Ft.) is equal to the pump discharge (GPM) x 16, assuming 2 hrs of residence time.
- Discharge from pits, filters, and tanks should be directed to another dewatering device, sediment basin, or stabilized containment area.
- Follow manufactures installation and maintenance instructions.
- Do not use in place of sediment traps or other ESC practices.
- Locate dewatering devices for ease of clean-out and to minimize the interference with construction and pedestrian activities.

Sump pits are used to filter out coarse particles during dewatering.

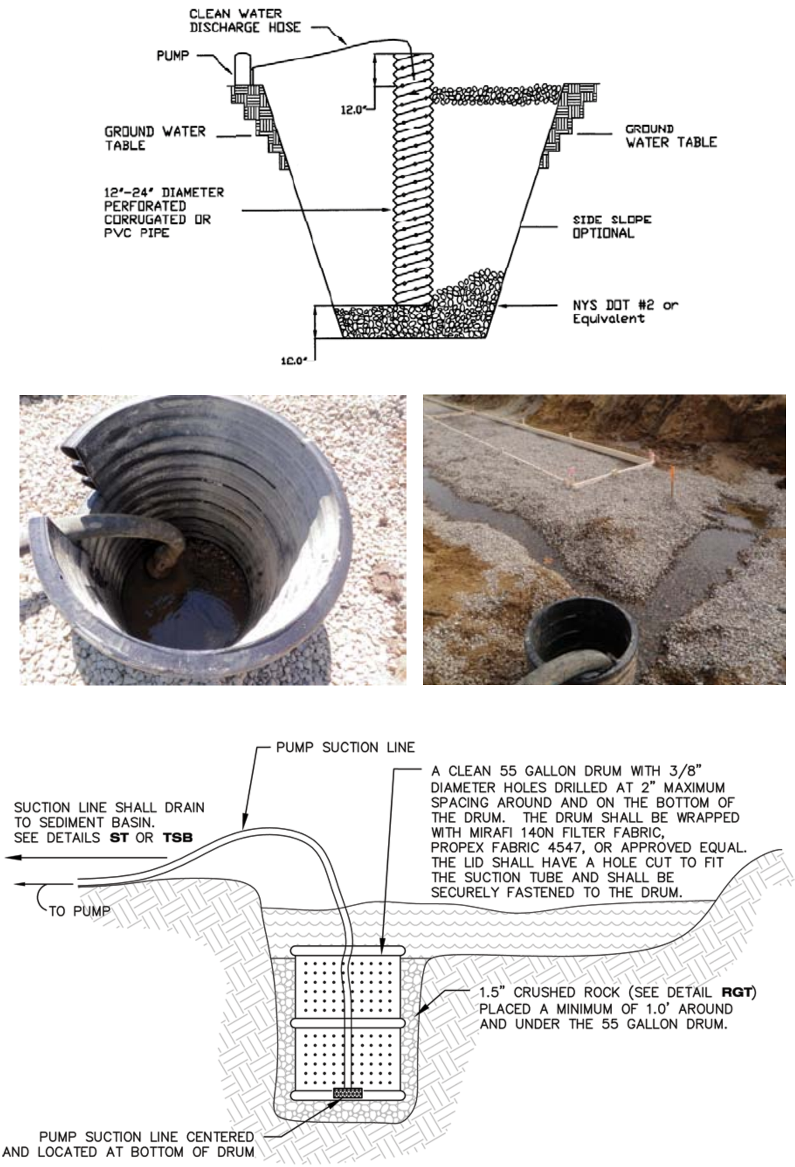


Figure 3.9. Sump pit schematic showing use of a perforated standpipe (top). An alternative design using a 55-gallon drum is shown below (Source:Town of Parker, Colorado).

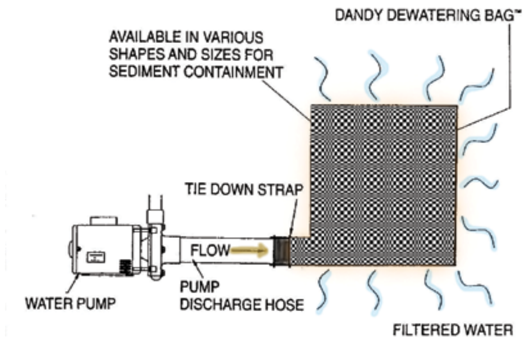


Figure 3.10. Example schematic of Dandy Dewatering Bag™. Bags should be placed on stabilized area or within a proper containment area.

Table 3.4. Sizing of Containment Area

Flow Rate		**Required Surface Area**	**Length/Width=2.1**	
Q (gpm)	Q (ft^3/s)	As (ft^2)	L (ft)	W (ft)
25	0.0565	131.86	16.24	8.14
50	0.1130	263.82	22.97	11.48
100	0.2225	527.54	32.48	16.24
200	0.4450	1055.19	45.93	22.97
300	0.6674	1582.73	56.27	28.12
400	0.8899	2110.09	64.96	32.48
500	1.1124	2637.80	72.64	36.32

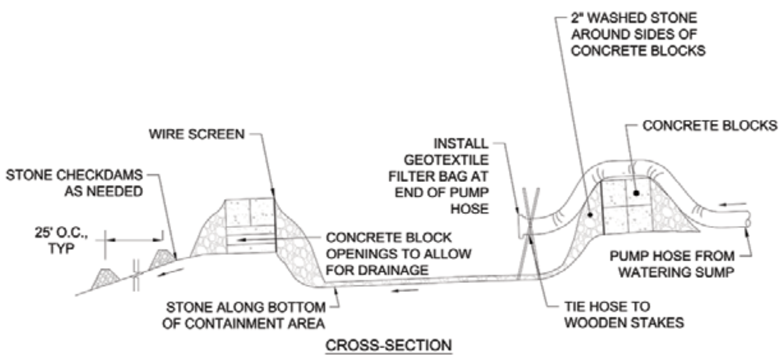


Figure 3.11. Example schematic showing a stone and block dewatering containment area (Horsley Witten Group).

Good use of a weir tank to force sediment to settle out between separate compartments.

Good use of containment area to surround dewatering bag and provide additional treatment. Note that this practice is in need of maintenance.

Maintenance Required

Inspect and monitor dewatering practices on an hourly basis while pumps are running. Make sure that discharges are not causing additional erosion and sedimentation.

Follow manufacturer's instructions for removing sediment in reusable bags, or for determine when a bags need to be replaced. Have a plan for proper disposal procedures.

Common Problems

- **Discharge still turbid.** Use the appropriate pump size and device dimensions. Add another filtering practice. Remove accumulated sediment.
- **Sump pit not filtering.** Consider wrapping perforated pipe in filter fabric. Be careful, this could clog.
- **Bag explosion.** Too much sediment accumulation. Increase bag size and maintenance frequency.

TEMPORARY STREAM DIVERSION AND ISOLATION

Definition

For culvert, bridge, or shoreline projects, isolating the construction area from surrounding waters may be necessary to create a dry work area and minimize contact of flowing water with exposed soils. Because these activities are in the water resource, proper permitting, design, and practice maintenance are critical.

Cofferdams or **impervious dikes** are used to isolate the work area from a surrounding waterbody. They can be made from welded metal sheet piling, inflatable bladders, sandbags, or other materials (Figure 3.12).

Piped diversions and **temporary channels** are used to convey streams around construction until the site has been stabilized. Channels should be stabilized with stone, liners, or erosion control blankets (Figure 3.13). Pumps or the natural current will move water through these diversions.

Design & Installation

- Specify the appropriate sized practice (and pumps, if needed) for length of site and anticipated flows.
- Size channels to convey at least the 2-yr storm with a maximum of 2:1 side slopes. Protect channel and top of bank from erosion (e.g., liners for channels; berms/silt fence for top of bank). Do not install in fill material.
- Use geotextile and/or stone below pipes.
- Be sure to anchor all pumps and pipes securely.
- Ensure a good seal with cofferdams by properly preparing the sub-grade.
- Minimize amount of disturbance at diversion points.
- Specify dewatering procedures.
- Try to work during the dry season.
- Do not use earthen dams.

Maintenance Required

Inspect and monitor daily to make sure dams are functioning properly. Where pumps are being used, inspect on an hourly basis. Make sure erosion is not occurring upstream or downstream of the diversions and that channel side-slopes are stable.

Figure 3.12. Examples of various materials used as cofferdams (Sources: NCDOT and Horsley Witten Group), and plan view schematic showing dewatering device (Horsley Witten Group).

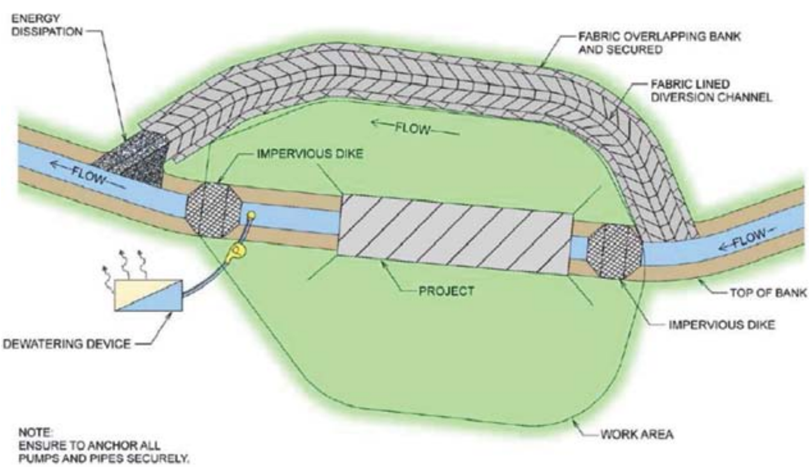
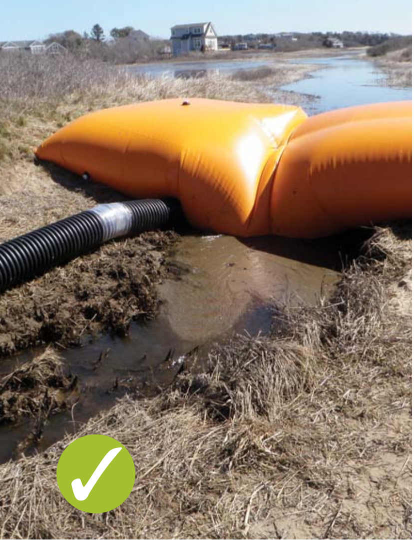


Figure 3.13. Examples of pipe and lined-channel diversions and a schematic illustrating a channel diversion with impervious dikes and dewatering device (Source: NC DOT, 2003).

Common Problems

- **Not sized appropriately.** Check your math.
- **Erosion of channel and at diversion points.** Install erosion control practices.



Piped diversion of stream using a bladder bag impervious barrier.

Earthen berm and silt fence do not provide adequate isolation of work area.

Working in the stream channel with no separation from stream flow.

Diversion of stream into a temporary rock channel while stabilizing existing channel during bridge reconstruction. Note use of silt fence at top of channel.

Stabilization with Vegetation, Mulch, or Topsoil

Surface Roughening

Pipe Slope Drains

Erosion Control Blankets

CHAPTER 4 STABILIZATION PRACTICES

Aggressive protection of slopes is critical since erosion can occur rapidly and contribute to extensive sediment transport and slope instability.

STABILIZATION WITH VEGETATION, MULCH, OR TOPSOIL

Definition

Covering an area of bare ground with vegetation, topsoil, mulch, or erosion control blankets for temporary or permanent erosion prevention is critical. Temporary stabilization is often needed because grading operations can last several months and extend into or through the rainy season. Final stabilization will be required for project close out.

Vegetative cover can be established through a combination of seeding techniques, topsoil amendments, and mulching to conserve moisture and control weeds.

Design & Installation

- Stabilize bare areas that will be untouched for more than 14 days, after final grading, at completion of construction, or when waiting for optimal planting time.
- Preserve existing topsoil in place where possible. Stockpile topsoil from excavated areas for later use.
- Complete rough and final grading. Remove large woody debris and other litter.
- Compact all fill material and roughen surface at least 12 inches deep in the area to be seeded.
- Amend soil and add fertilizer where necessary.
- Evenly apply seed mix per site plan specifications. Suitable plants include fast-growing and hardy species, such as grasses and legumes (Table 4.1).
- Apply mulch or chemical stabilizers at specified application rates after or in combination with seeding (hydroseeding). Tackifiers are useful on slopes to help anchor soils and seed mixes.
- As needed, install erosion control blankets to protect areas being stabilized.

Maintenance Required

Irrigate as necessary to establish plants. Reapply seed, mulch, or topsoil as needed to provide uniform stabilization. Maintain associated ESC practices to protect stabilization area until plants are fully established.

Table 4.1. Common Grasses Suitable for Stabilizing Waterways and Exposed Soils (Source: 2010 NRCS Pacific Islands Area Vegetative Guide[1])

Common Name	Scientific Name/ Cultivar	Elevation (ft.)	Rainfall (in.)	Planting Rate[5]
Bermuda Grass[2]	*Cynodon dactylon*	0 - 3,000	20 - 100 (-170)	35 lbs/PLS/ac
Carpet Grass[3,4]	*Axonopus affinis*	0 - 5,000	40 - 80 (-160)	40 lbs/PLS/ac
Centipede Grass[4]	*Eremochloa ophiuroides*	0 - 2,500	40+	20 lbs/PLS/ac
Digit Grass	*Digitaria eriantha*, 'Pangola', 'Transvala'	0 - 3,500	50 - 160	80 bu/ac
Paspalum	*Paspalum hieronymii*, 'Tropic Lalo'	0 - 3,000	50 - 150	80 bu/ac
St. Augustine Grass[4]	*Stenotaphrum secundatum*	0 - 3,000	40 - 80	80 bu/ac
Vetiver Grass	*Chrysopogon zizanioide 'Sunshine'*	0 - 3,000	35 - 200	Sprigs planted 3" apart
Zoysia Grass	*Zoysia japonica*, 'El Toro'	0 - 4,000	40 - 100	80 bu/ac

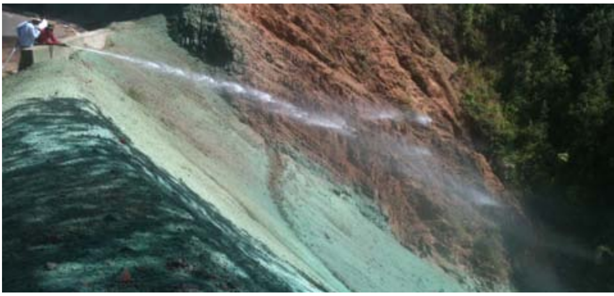
[1] List is not all-inclusive. Ideal species for seeding and stabilizing disturbed areas should be fast growing, non-invasive, tolerant of low fertility soils, and readily available. Seed availability is limited in Guam. Bermuda grass is most commonly available.

[2] Tolerant of soil salinity and wind-bourne salt.

[3] Tolerant of acid, low fertility soil

[4] May have potential to become invasive.

[5] Pure Live Seed (PLS). One bushel (bu) equals 1.25 cu. ft. ***May need to double these seeding rates when hydroseeding.***



Good use of hydroseed and coir fiber logs on an exposed slope to help quickly establish vegetative cover. Any areas of bare soil that will not be touched for more than 14 days should be temporarily stabilized. Permanent stabilization is required at the end of the construction period.

Formation of gullies and rills due to lack of stabilization. Presence of weeds indicates that soil has been exposed for a long period of time.

Topsoil may be required in poor soil conditions. Here topsoil was spread evenly across surface to be seeded. Grass has started to grow.

Even clearing of flat areas requires stabilization as demonstrated here with wood chips.

SURFACE ROUGHENING

Definition

Surface roughening is a simple method to slow runoff and minimize by creating horizontal grooves, depressions, or steps that run parallel to the contour of the land. Surface roughening should be done in conjunction with other stabilization activities. Roughening measures include:

Tracking: Driving a crawler tractor up and down a slope, leaving the cleat tracks parallel to the slope contour (Figure 4.1). This is the most convenient, but least effective of the roughening measures.

Stair-step grading: Benching or cutting stair-steps into slopes. Each step slopes towards the vertical wall (Figure 4.2). This works well with soils containing large amounts of small rock.

Grooving: Use discs, spring harrows, or teeth on the bucket of a front-end loader to create series of small ridges

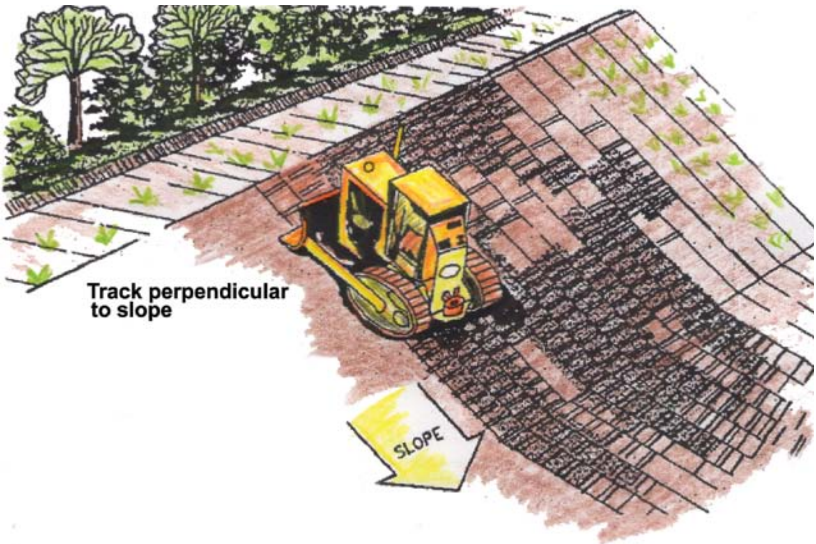


Figure 4.1. Tracking with bulldozer (Source: US Army Corps of Engineers,1997).

and depressions.

Design & Installation

- Perform surface roughening as soon as possible after the vegetation has been removed from the slope.
- Use with temporary seeding and temporary mulching to stabilize an area.
- Avoid excessive compacting of the soil surface when tracking, since soil compaction inhibits vegetation growth and causes higher runoff rates.
- When step-grading, ratio of vertical cut to horizontal distance should not be steeper than 1:1. Maximum step width/height is 4 feet.
- For slopes steeper than 3:1 but less than 2:1, grooving should be used. Install grooves a minimum of 3 inches deep and maximum 15 inches apart.

Maintenance Required

May need to reapply at the end of each day until other stabilization practices are installed. Inspect every 7 calendar days and within 24 hours after major rainfall event. If rills appear, re-grade and re-seed immediately.

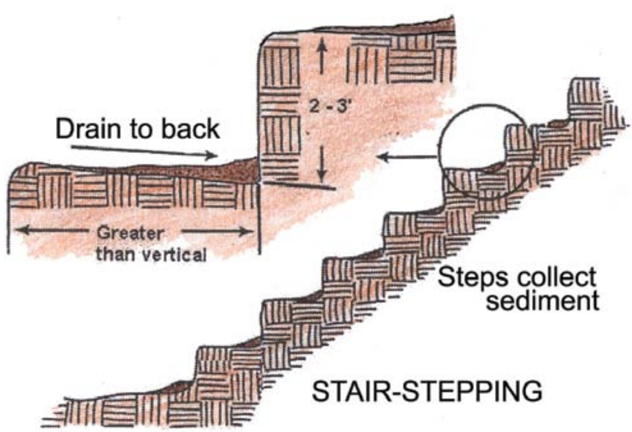


Figure 4.2. Stair-step grading to protect slopes.

PIPE SLOPE DRAIN

Definition

A pipe slope drain is a temporary pipe or flexible tubing with a stabilized entrance section, used where a concentrated flow of surface runoff must be conveyed down a slope without causing erosion.

Design & Installation

- The **maximum** allowable drainage area is 5 acres.
- Direct flows along top of slope to inlet using earth berms or other diversion practice (Figure 4.3).
- The inlet pipe leading to steep slope shall have a slope of 3% or steeper to prevent water pooling at top of slope.
- Cover inlet pipe at least a foot with hand compacted earth berm.
- Use corrugated metal pipe with watertight connecting bands or durable, flexible tubing of the same diameter as inlet pipe (Table 4.2).
- Securely anchor flexible tubing to the slope with stakes as needed.
- Discharge pipe slope drain to riprap apron and then into a stabilized area, watercourse, or sediment trap.

Pipe slope drains are used to convey concentrated flow down a slope.

Maintenance Required

Follow-up inspection and any needed maintenance should be performed after each storm.

Common Problems

- **Erosion at discharge.** Only discharge to stabilized area.
- **Pipe rolls or separates.** Stake in place. Replace connection bands.

Table 4.2. Optimal Pipe Diameter

Maximum Drainage Area (acres)	Pipe/Tubing Diameter (inches)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

Flexible pipe slope drain used to convey concentrated flow down slope. Note placement of large rocks to slow velocity at discharge point. Drain may need to be anchored with stakes to prevent movement.

Lined waterways (see Chapter 3) are also used as a permanent method to convey runoff down slopes, although designs that prevent concentrated flows down slopes are preferred.

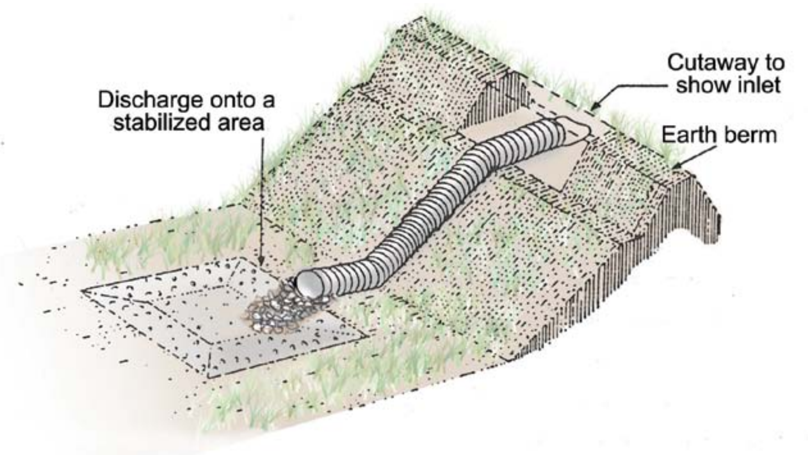


Figure 4.3. Pipe slope drain discharging to sediment trapping device.

EROSION CONTROL BLANKETS

Definition

Temporary erosion control blankets (also called matting) are used to hold seed and soil in place, particularly on steep slopes. There are many types of products available made of biodegradable or synthetic materials.

Design & Installation

- Grade and compact area prior to installation.
- Remove large rocks, soil clods, vegetation, and other sharp objects.
- Amend soil, add fertilizer, and seed prior to installation.
- Always install according to manufacturer's specifications.
- For slope installations:
  1. Dig anchor trench at top of slope (Figure 4.5).
  2. Extend end of blanket 6-12 inches beyond trench. Using staples/ stakes, fasten blanket into trench. Backfill with soil and compact. Cover backfill with remaining edge of blanket and fasten on downhill side of trench.
  3. Unroll matting down slope, ensuring direct contact with ground. Overlap edges a minimum of 3-6 inches.
  4. Fasten with stakes/ staples per manufacturer's specification. Do not stretch.

Maintenance Required

Regular inspections should be made to identify cracks or tears in fabric, which should be repaired or replaced immediately. Synthetics may degrade in sunlight.

Common Problems

- **Blanket slipping down slope.** Re-anchor at top of slope. Use manufacturer's staples/stakes and stapling pattern.
- **Erosion occurs underneath the material.** Make sure material is in contact with the ground.

Always install erosion control matting according to manufacturer's specifications.

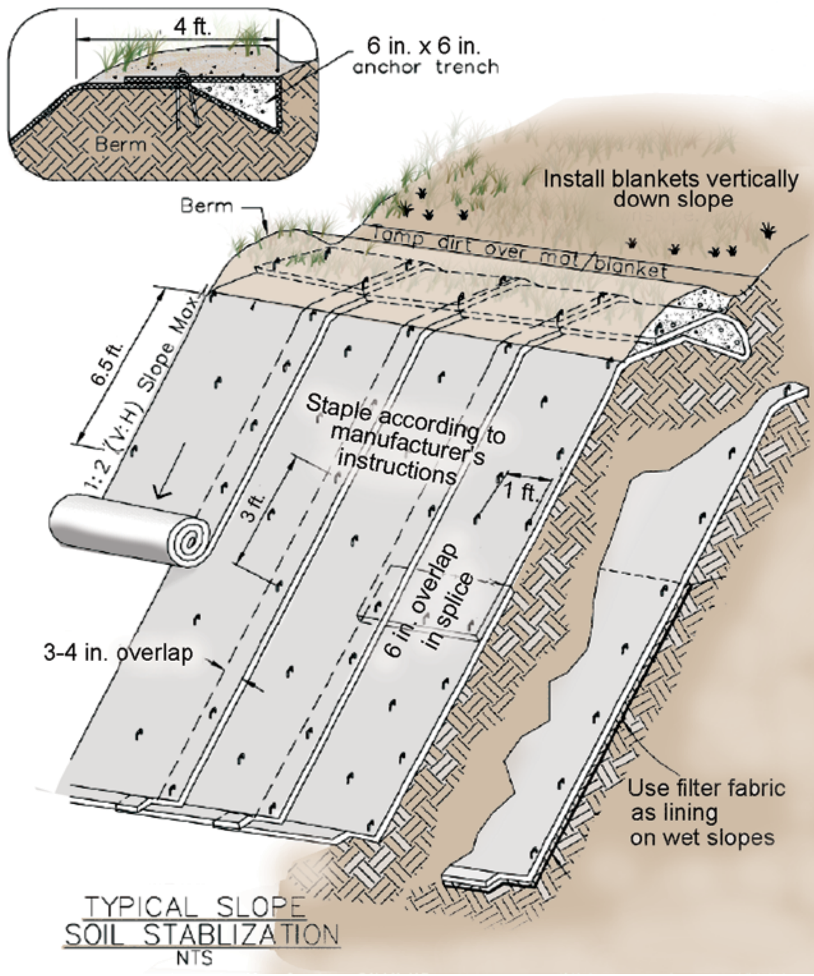


Figure 4.5. Erosion control blanket (Adapted from: State of California DOT Construction Site BMPs Manual, 2003).

Good coverage of slope with geotextile matting. Inspect routinely to make sure material is not torn, particularly if woody vegetation starts to grow up through material. Consider benefits of biodegradable vs synthetic materials.

Erosion control blanket was not installed vertically down slope and does not cover lower half of exposed bank. Disturbed areas above slope should also be stabilized. Good use of silt fence to protect top of slope.

Inlet protection practices prevent sediment from entering the drainage network until the site is stabilized and temporary ESC practices removed.

CHAPTER 5

INLET AND OUTLET PROTECTION

INLET PROTECTION

Definition

Various inlet protection devices can be used as temporary structures to keep silt, sediment, and construction debris from entering storm drains through open inlets. Practices should trap sediment while allowing water to slowly flow over or through materials.

Design & Installation

- Install protection device per specifications on site plan.
- Do not use in place of sediment traps, diversions, or other ESC practices.
- Limit drainage area to 1 acre or less per inlet device.
- The top elevations of these practices should provide storage and minimize bypass flow.
- Do not remove until drainage area is permanently stabilized.

Excavated Drop Inlet Protection

- Excavate side slopes less than 2:1.
- Depth should be between 1 to 2 feet as measured from top of inlet.
- Provide weep holes, protected by fabric and/or rock, to drain temporary pool (Figure 5.1).

Fabric Drop Inlet Protection

- Use approved filter fabric cut from continuous roll to avoid joints.
- The maximum height of the fabric above the inlet crest shall not exceed 1 ½ feet unless reinforced. Stake material using 2x4 inch wood or equivalent metal.
- Support stakes for fabric should be 3 feet long, spaced a maximum 3 feet apart.
- Drive stakes into ground a minimum of 18 inches as close to the inlet as possible.
- Trench fabric 1 foot and back fill. Fasten to stakes.

**Rock protection on outside of fabric can be added if available.*

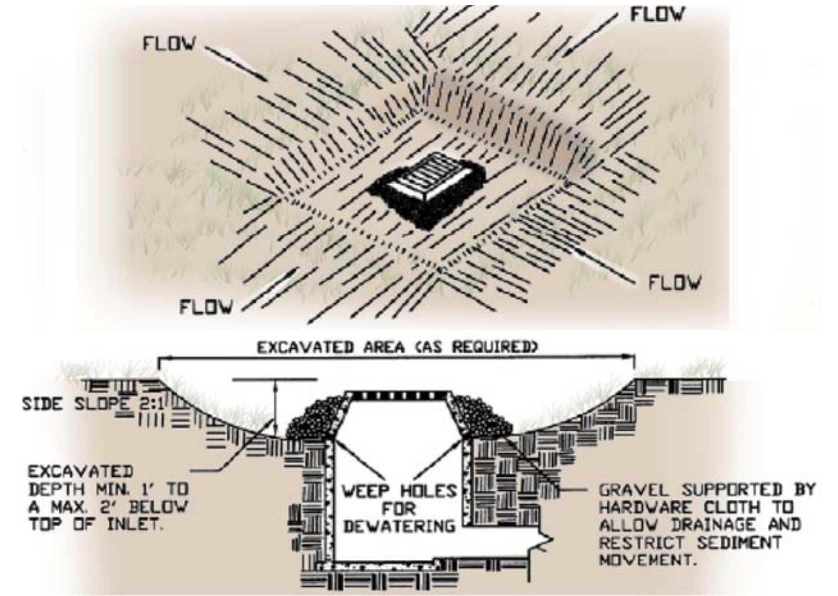


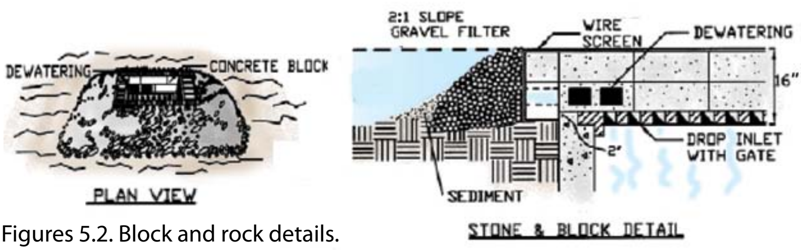
Figure 5.1. Excavated drop inlet protection with weep holes.

Block and Rock Drop Inlet Protection

- Double stack rows (1-2 feet above top of inlet) of concrete blocks around drop inlet. Do not use mortar. Recess the first row of blocks 2 inches below the top of inlet (Figure 5.2).
- Orient a few blocks on bottom row for dewatering. Cover openings with cloth or wire mesh to support rock.
- Use clean rock ½-¾ inch diameter placed 2 inches below top of block on 2:1 slope or flatter.

Curb Inlet Protection

- Install **pre-fabricated** products in front of curb inlet opening, extending 2 feet on either side. Allow for overflows at top into catch basin. Follow manufacturer's specifications.
- For **block and rock** curb inlet protection, place single row of concrete blocks across inlet opening with open ends facing outward. Place wire mesh over open ends of blocks to support rocks. Pile washed rock ($\leq$3 inch diameter) against mesh to top of blocks.
- For **fabric and rock** protection, install wooden frame with spacers



Figures 5.2. Block and rock details.

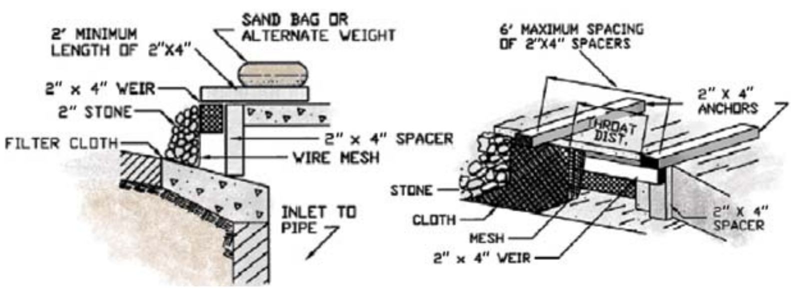


Figure 5.3. Fabric and rock curb inlet protection.

and overflow weir. Attach wire mesh and approved fabric to frame across inlet opening. Pile clean rock against mesh (2 inches minimum diameter). Structure should extend 2 feet on either side of inlet (Figure 5.3).

Maintenance Required

Inspect after each rain event and make repairs as needed. Check materials for proper anchorage and secure as necessary. Remove sediment when storage area is ½ full. Upon stabilization of the drainage area, remove all materials and sediment and dispose of properly. Seal weep holes. Bring adjacent areas to grade, smooth, compact, and stabilize.

Common Problems

- **Excessive sediment entering inlet.** Ensure protection devices installed properly. Ensure soil is stabilized and upstream practices are installed.
- **Rock filter material clogged.** Pull rocks away from inlet, clean, or replace with new/washed rock.
- **Sediment accumulating outside of practice.** Remove when ½ full.

Good example of a compost sock inlet protection. When it rains, runoff filters through the compost, removing sediment and preventing flooding.

This prefabricated product is not suited for this type of inlet structure. Good extension of device on either side of inlet; however, "dirty" flows enter drain directly through grated opening. Consider covering with wire mesh/fabric and/or rock.

Sediment and trash at this outlet is an indicator that inlet protection has either failed or was not provided at all at this construction site.

Impermeable sand bags can cause flooding when used around inlets, and filter fabric can clog and tear. At this site, sand bags and fabric were partially removed to alleviate flooding, allowing dirty water into the inlet.

ROCK OUTLET PROTECTION

Definition

Rock should be placed around and below an outlet to stabilize the outlet, reduce the depth and velocity of discharge waters, and prevent downstream erosion. Outlet protection applies to culverts, outfalls from basins, and other conduits.

Design & Installation

- Design depends on the location (not at top of cuts or on slopes >10%) and tailwater depth. Follow specifications from approved drawings.
- Prepare subgrade as specified. Compact fill to density similar to surrounding material.
- Outlet aprons should be straight and flat. The end of the apron should be at same elevation as receiving channel or ground (Figure 5.4).
- Use rock riprap composed of a well-graded mixture of rock size specified in ESC plan.
- Apply layer of approved filter material between riprap and underlying soil surface. Overlaps should be >1 foot.
- Place rock with equipment in one operation. Avoid displacement of, or damage to, underlying material. Follow with hand placement when necessary.
- Place rock around and above outlets with no headwalls (Figure 5.5).

Maintenance Required

Once a riprap outlet has been installed, the maintenance needs are very low. It should be inspected after high flows for evidence of scour beneath the riprap or for dislodged rocks. Repairs should be made immediately.

Common Problems

- **High flows cause scour.** Replace filter fabric and rearrange rock appropriately.
- **Riprap dislodged.** Replace by hand.
- **Ripped filter cloth.** Cover with another piece of cloth or replace.
- **Riprap filled with sediment.** Evaluate upstream ESC practices. Remove sediment by hand.

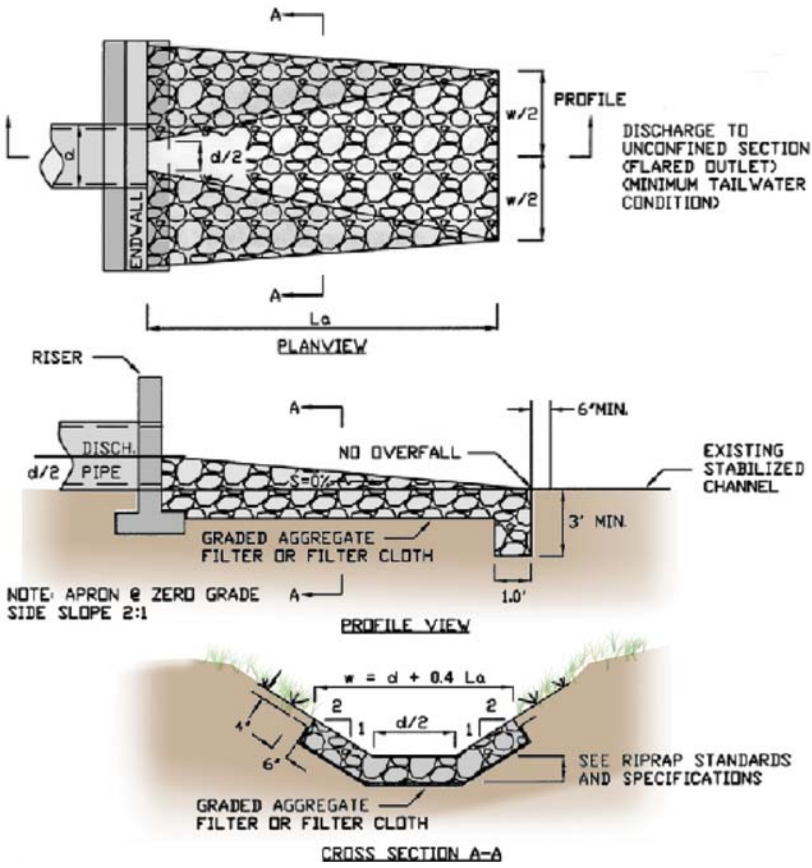


Figure 5.4. Riprap outlet protection for discharge to unconfined section.

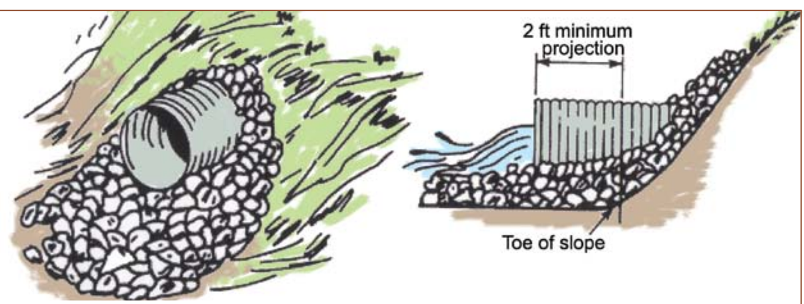


Figure 5.5. Protect outfalls without headwalls (Source: British Columbia, 2001).

Good protection for outfall without a headwall. Discharge is dissipated in rock-lined pool which will then discharge as sheet flow to adjacent wetland. Berm behind outlet pipe is well stabilized with vegetation.

This outlet is discharging to a non-stable area on a slope, which will result in erosion and undermining of pipe structure. This muddy discharge also indicates a general lack of compliance with ESC principles.

To help stabilize rock apron and reduce undermining, filter fabric should be placed below the layer of riprap, not on top as shown here.

This outlet and surrounding area is well stabilized with rock and grass. A little sediment is depositing in the apron.

LEVEL SPREADER

Definition

Level spreaders are temporary (or permanent) devices that take concentrated flow from a pipe, berm, or swale and release it evenly over a wider area to prevent erosion and promote infiltration. Particularly useful where sheet flow discharges through vegetated buffers are possible.

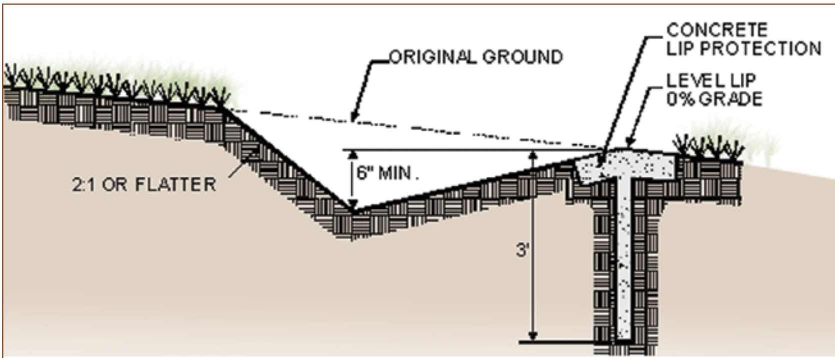
Design & Installation

- Install in an undisturbed or finished area. Do not install on fill, or above a slope steeper than 10%.
- Maximum drainage area to spreader is 2.5 acres.
- Minimum depression depth of 6 inches behind lip.
- **Spreader lip must be level** (uniform height and zero grade) and reinforced with erosion control matting, concrete, or gravel.
- Runoff entering spreader must not contain significant sediment. An upstream sediment removal practice, forebay, and/or energy dissipater at inlet may be required.
- A level spreader should disperse onto a vegetated slope of less than 10:1.
- The lip can be constructed of grass for low flows or timber/concrete for higher flows.
- The length of the level spreader lip is dependent on the volume of water that must be discharged, but the minimum length for the level spreader lip is 6 feet.
- Make sure area below level spreader is stabilized and uniform.

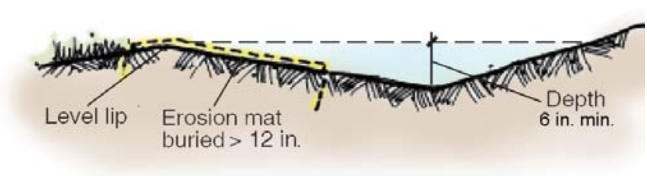
Maintenance Required

Relatively low maintenance if installed correctly. Inspect regularly for sediment removal in sump and erosion at inlet/outlet. Repair as needed.

Level spreaders convert concentrated flow into non-erosive sheet flow.



Concrete lip



Earthen lip

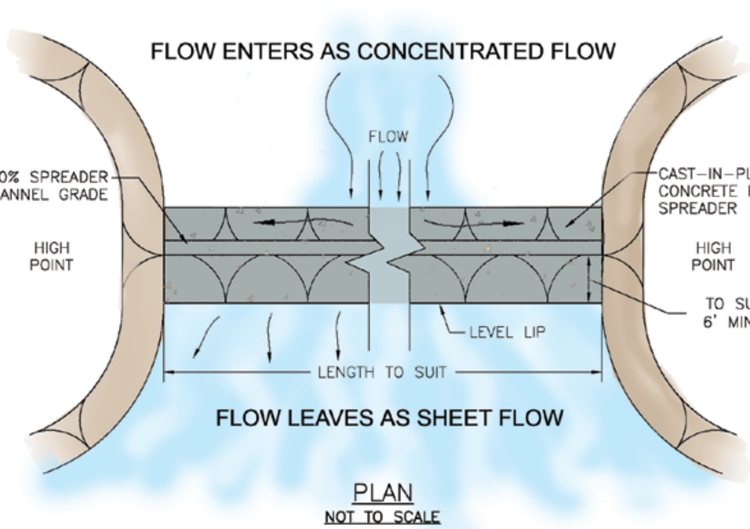
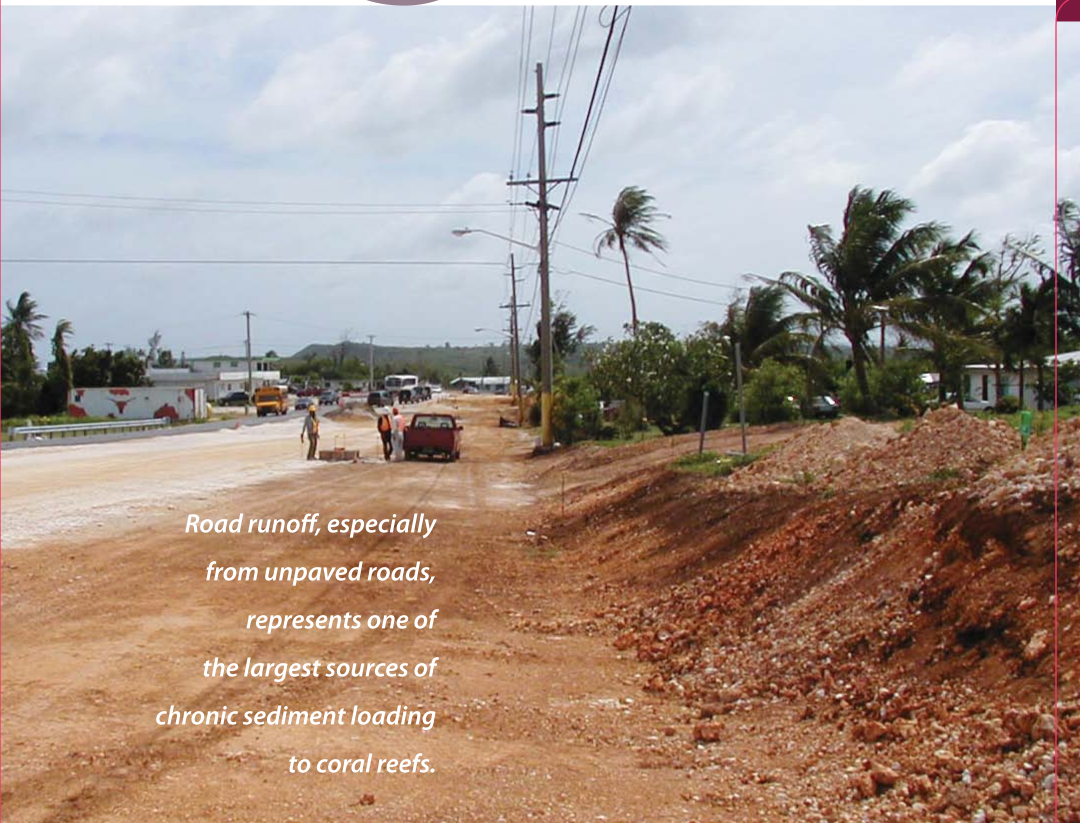


Figure 5.7. Concrete and earth lipped level spreaders (Adapted from: RI Stormwater Manual and NC State University).

Good application of level spreader at outfall from large ponding basin. Flows plunge into small pool, spread out evenly across level concrete lip, then sheet flow from lip across gravel into grass (Source: NC State University).

Concentrated flows are collected in small forebay and discharged into 6 inch deep "swale" before overflowing concrete lip as sheet flow (Source: NC State University).

CHAPTER 6 MANAGING ROAD CONSTRUCTION



Road runoff, especially from unpaved roads, represents one of the largest sources of chronic sediment loading to coral reefs.

ESC During Road Construction

Temporary exposure of erodible soils during road construction and maintenance activities can impact water quality, road stability, and public safety.

Good road design and construction can minimize soil erosion and reduce drainage problems.

The challenge of road projects is that they are **linear, space is limited,** and there is an added element of **traffic management**. Road projects are highly visible, so problems with ESC are noticeable to the public. Preventing erosion and controlling sediment requires use of ESC practices illustrated in Figure 6.1, including.

- Sediment barriers along perimeter
- Check dams in roadside ditches
- Slope stabilization
- Inlet protection
- Outlet protection
- Stockpile management
- Traffic safety

Unpaved Roads

Permanently unpaved roads can be chronic sources of sediment. To reduce sediment loads coming off of unpaved roads:

- Design roads for minimal disruption of drainage patterns.
- Use **outsloped** roads with drain dips when fill slopes are stable.
- Use **insloped roads** with ditches, water bars, and cross drains if steep enough (2-8%) to prevent sediment deposition and ditch erosion.
- Vary road grades to reduce concentrated flows. Space drainage structures based on grade (Table 6.1).
- Prevent sediment transport by using changes in road grade or recessed cut slopes.
- Do not discharge drainage structures onto erodible soils or fill slopes without outfall protection (rock piles, logs, etc.). Direct road drainage through vegetation or other sediment trapping devices.
- Surface with crushed rock, concrete, or pavement if road is highly erodible or heavily used.

Exposed soils were hydroseeded and temporary inlet protection applied on road construction project. Active roadway is clean of sediment.

No erosion control provided and sediment is directly entering stream through culvert. Sediment tracked onto active roadway. No protective barrier blocking sediment from adjacent natural areas.

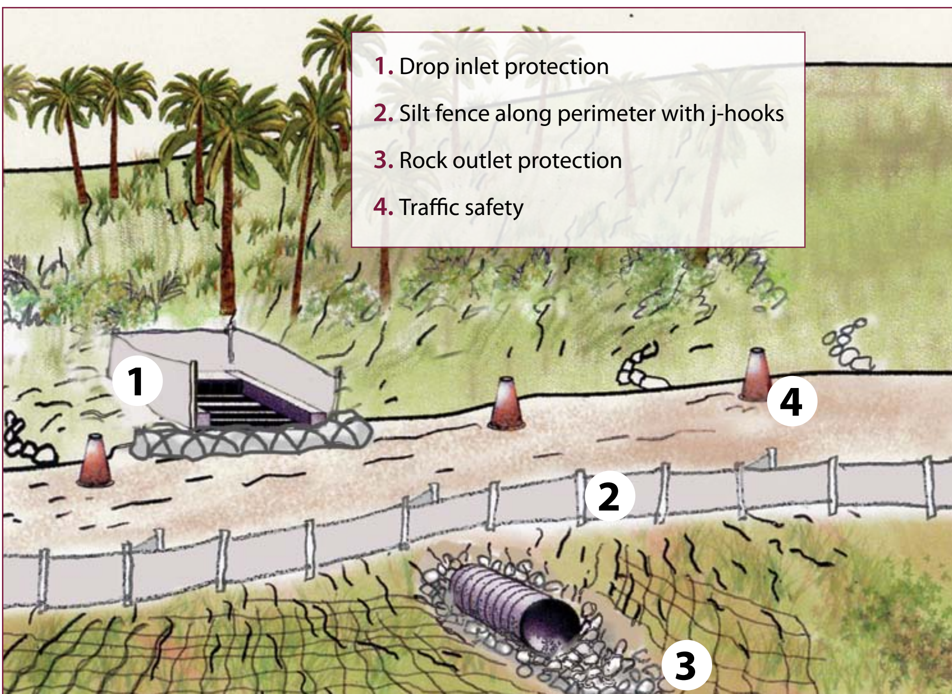
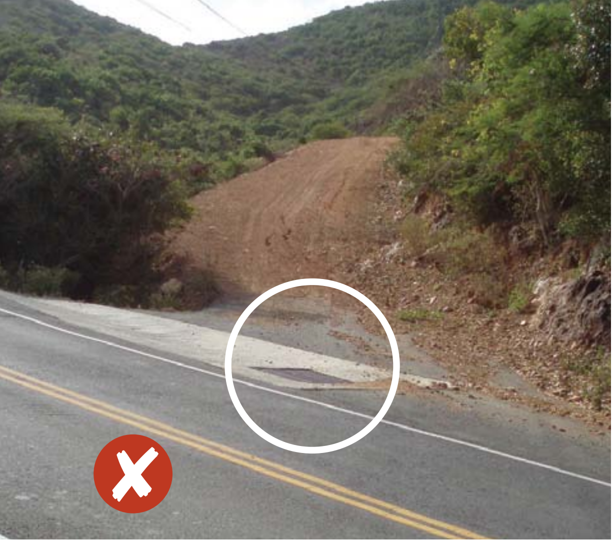
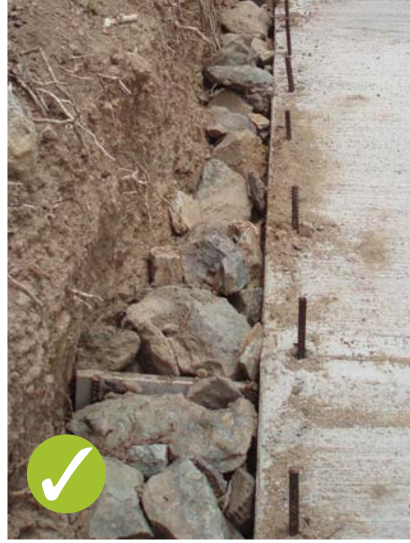


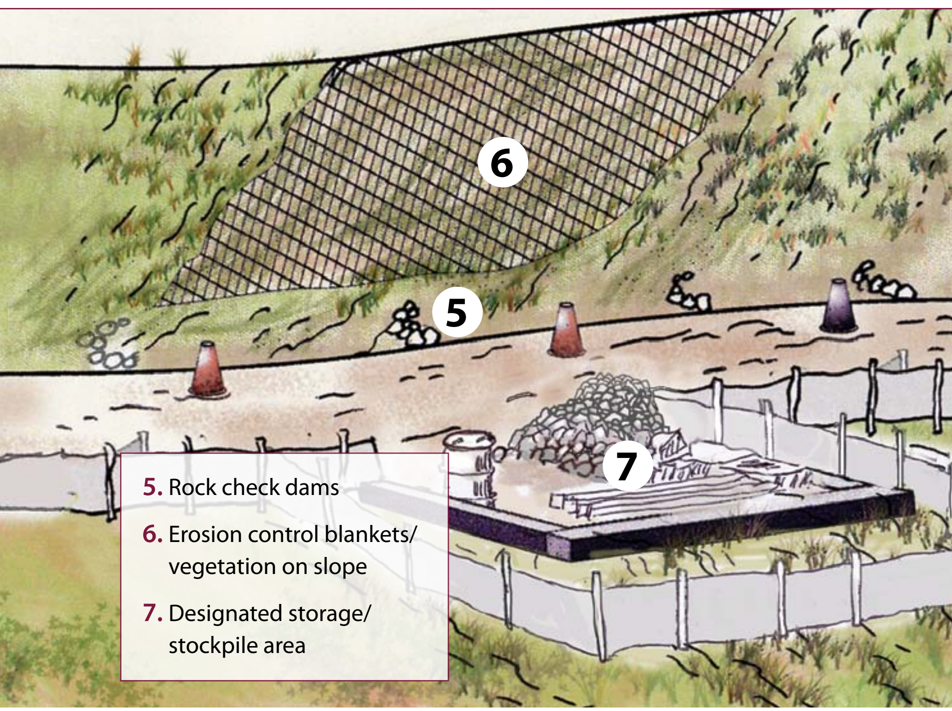
Figure 6.1. Illustration of ESC practices used during road construction.



Avoid situations where runoff from unpaved roads drains directly to drop inlets. This inlet will discharge sediment to waterways, and will quickly become clogged with debris and sediment causing road flooding.



Pave roads as soon as feasible. Good example of using wood check dams and rock fill to protect edge of pavement and slow down drainage.



5. Rock check dams

6. Erosion control blankets/ vegetation on slope

7. Designated storage/ stockpile area

Broad-based dips are wide (~20 feet) depressions used to convey **ditch drainage** across the road surface as sheet flow (Figure 6.2). Dips only work on roads with slopes <12%.

Water bars are narrow, earthen berms built across roads to divert **road surface runoff** into vegetated areas (Figure 6.3). To install:

1. Excavate a trench at a 30- to 45-degree angle across the road. Trench outlet should be at least 3 inches lower than the upper end.
2. Build a berm on the downhill side of the trench (12-inch distance between berm top and trench bottom).
3. Extend water bars slightly beyond both ends of the road. Direct diverted water into a stable, vegetated area, not into open water.

Table 6.1. Optimal Structure Spacing

Road Grade	Spacing (ft)		
	Water Bars	Dips	Cross Drains
2%	250	300	135
5%	135	180	100
10%	80	140	80
15%	60	Do not use	60
20%	45		45
25%	40		30
Source: HI DFW (2003) and VICES (2003); Coeur d'Alene RMP/EIS (2006)			

Cross drain and open-top culverts intercept ditch or road surface runoff and divert flows across the road in underground pipes or grated trenches. Piped culverts should be no less than 12 inches in diameter, angled at 30-45 degrees, have 2% slope, and covered with fill at a depth of ½ pipe diameter (Figure 6.4). The entry and outlet of pipe should be armored with rock or concrete.

Open-top culverts should be covered with a grate material that can handle vehicle loads.

Open-top culverts should be at least the width of a shovel for easy maintenance.

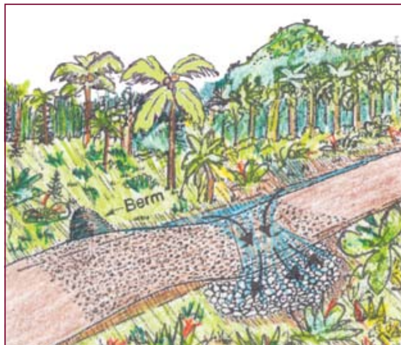


Figure 6.2. Wide dips allow ditch runoff to be directed by berms to flow across road to stable outlet. Not for use on grades greater than 12% (Adapted from: Wisconsin Department of Natural Resources).

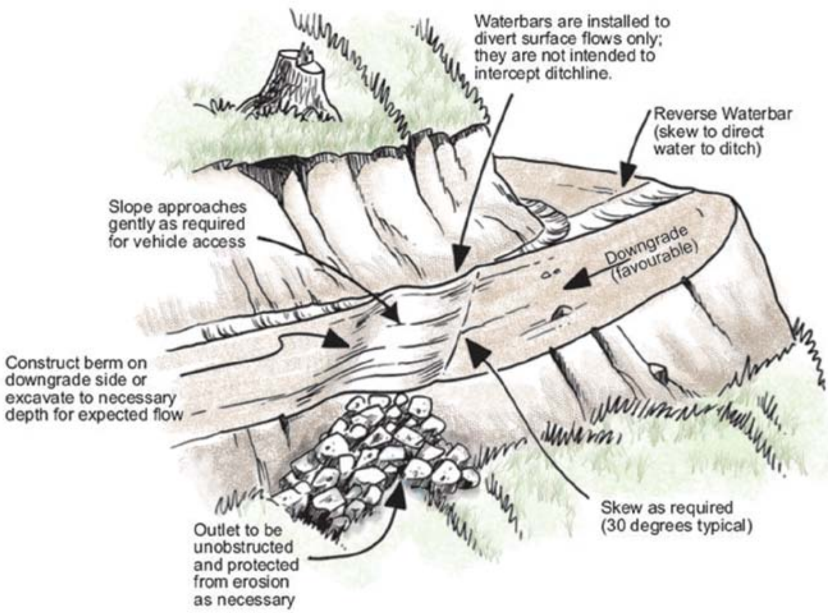
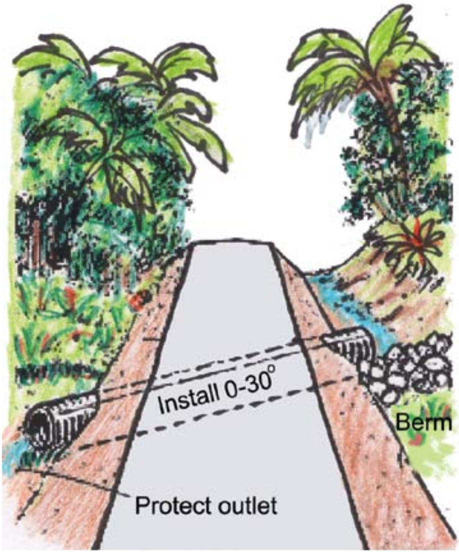


Figure 6.3. Water bars divert surface flows and are not intended to intercept roadside ditches (Source: British Columbia, 2001).

Figure 6.4. Cross drain and open-top culverts carry water under road surface to stable discharge points (Adapted from: University of MN Extension Service).



Road Maintenance

Timely maintenance can prevent road-related sediment from entering streams and waterbodies.

- Inspect the road system at regular intervals, especially after heavy rainfall, to detect problems and to schedule repairs.
- Road surface erosion from ditch overflow indicates a need for unplugging culverts, cleaning ditches, additional cross drains or dips, or other ditch stabilization.
- Remove debris from culverts, outlets, and catch basins particularly before rainy weather.
- Place the debris where it cannot be washed back into these structures or into open water.
- Stabilize fill slopes and maintain roadside vegetation.
- Keep traffic to a minimum during wet periods to reduce maintenance needs.
- Grading (shaping) as necessary to maintain proper surface drainage, remove potholes or ruts, or mix surface rock and fines.
- Grading should always push debris towards center of road for compacting or removal.
- Debris should never be pushed to side where it will form a berm and cause more erosion/maintenance problems.
- Avoid cutting the toe of cut slopes when grading roads or pulling ditches.
- If dust control agents are used, keep compounds from entering waterways.

Routine maintenance during construction and proper removal of temporary practices prior to final site stabilization will help ensure ESC compliance.

CHAPTER 7 MAINTAINING AND CLOSING OUT PROJECTS

Inspections and Maintenance

Managing Trash, Supplies, and Materials

Removing Temporary Practices

Permanent Stormwater Management

Inspections and Maintenance

Erosion and sediment control practices need to be inspected and maintained during all stages of the construction process to ensure proper function.

Routine maintenance by workers on site may include:

- Removing sediment tracked on to roads.
- Visual inspection and repair of silt fences and inlet protection devices.
- Replacing fencing and signage protecting trees and natural areas.
- Removal of accumulated sediment in traps, behind check dams, and on rock outlet aprons.
- Replacement of rock protection or filter fabric at outlets.
- Filling of rills and gullies.
- Irrigation for vegetative establishment.

Inspectors should:

- Conduct inspections at required frequency (every 14 days), after storm events, and during key times during construction (installation and closeout).
- Evaluate practice effectiveness.
- Evaluate locations where drainage leaves site, particularly along waterways, natural areas, and public roads.
- Use approved inspection forms and checklists if available (Table 7.1).

See maintenance requirements for individual ESC practices as described in Chapters 2–5.

Table 7.1. GEPA Erosion and Sediment Control Inspection Form

Project Name:	**Location:**				
Date:___________ Inspector:_________________	**Type of Inspection: ( ) Regular ( ) Pre-storm ( ) During storm ( ) Post storm**				
Weather conditions:					
LOCATION OF POTENTIAL EROSION, SEDIMENTATION, BLOCKAGE OR DAMAGE	Implemented		Maintenance Required		**DESCRIBE CONDITION AND CORRECTIVE ACTION NEEDED; NOTES**
	YES	**NO**	**YES**	**NO**	
A. ESC Plan Review					
Practices shown on ESC plan					
Practices installed as shown on ESC plan					
Sequence of construction followed					
Cut and fill conducted as described in ESC plan					
B. Sediment Barriers					
Silt fence, turbidity curtain, or other barrier installed/maintained correctly					
Construction entrance functions properly					
Amount of sediment tracked onto roads or deposited outside of barriers acceptable					
Are natural resource areas (i.e. streams or wetlands, sinkholes, seashore, trees) protected with barriers					
C. Diversions					
Berms stabilized and performing adequately					
Swales/waterways constructed and functioning					
Extent of erosion at outlets meets standards					
D. Traps and Basins					
Dams/overflows/risers constructed & functioning					
Slopes stabilized, particularly at inlets					
Good level of sediment accumulation					
E. Stabilization					
Exposed soils and slopes protected from erosion					
Good vegetative establishment					
Erosion control matting/Pipe slope drains, mulch, or other practice installed/functions properly					
F. Inlet and Outlet Protection					
Practices installed correctly around drop, yard, and curb inlets					
Rock outlet protections installed and maintained					
Sediment removal, erosion repairs, and other maintenance performed					
G. Other					
Good offsite conditions at key discharge locations					
Previously required repairs have been made					
Discharge outlets and receiving water free of any sediment deposit					
Nonstructural BMPs being practiced					

2012 ESC FIELD GUIDE FORM

Managing Trash, Supplies, and Materials

To keep debris and contaminants out of runoff during construction:

- Keep waste materials, stockpiles, and building supplies tied down or covered to protect from wind or stormwater.
- Manage designated areas for equipment washing, fueling, or servicing to prevent runoff.
- Store hazardous materials in a covered area to prevent contact with rain water. Concrete slabs and secondary containment berms are necessary to prevent spills from discharging into the environment.
- Recycle or reuse construction materials where possible to reduce waste going to landfill.
- Keep your site clean.
- Provide for proper sewage disposal.

Removing Temporary Practices

When construction is completed, all temporary ESC practices will need to be removed or converted to permanent structures. All construction waste will need to be disposed of properly and the site cleaned.

No site can be closed out or practices removed until vegetation is established on all bare soil areas and all ditches and slopes are stable.

When removing practices, be sure to:

- Remove accumulated sediment, regrade to new specifications, and replace/install water quality risers when converting temporary basins to permanent stormwater practices.
- Do not remove protection devices from inlets leading to basins until the basin has been stabilized.
- Fill in, grade, and seed traps/basins that have been removed. Double seeding rate where higher flows are expected.
- Remove all silt fencing. Disperse accumulated sediment on-site or dispose of properly.
- Replace dislodged rocks or soils at culverts and outlets. Stabilize with vegetation, and remove debris that could block outlets or clog inlets. Fill, grade, and stabilize eroded areas.
- Remove inlet protection devices once drainage area has been stabilized.
- Check ditches and channels to make sure banks and bottoms are stabilized. Bare areas should be re-seeded and/or repaired.
- Check areas where erosion control blankets were installed. Remove loose or excess materials. Re-seed bare areas.

Permanent Stormwater Management

To ensure proper drainage after construction, installation of permanent stormwater practices, drainage connections, and final site grading should be performed according to the stormwater plan. Special care should be given to make sure:

- All permanent stormwater facilities and drainage structures are **installed as designed**. If required, final "as-builts" should be submitted to the approval authority to ensure facilities were built according to approved plan.
- Final site grading directs stormwater to appropriate drainage structures.
- Paving of parking lots, roads, and other impervious areas **maintains proper drainage patterns**.
- Rooftop runoff drains to stabilized vegetated area or approved drainage structure.
- Permanent stormwater facilities and drainage structures are inspected before temporary practices are removed.
- Sediment or debris accumulated in stormwater practices is removed and disposed of properly.

Paving of parking area and use of trench drain (orange grating) occurred prior to installation of permanent stormwater controls downstream and final site stabilization. Drainage from parking lot discharges to exposed sediment rather than approved stormwater practice or drain pipe.

Final grading and paving at this site left inlet at a high point, causing surface runoff to bypass the stormdrain inlet.

Sediment will need to be removed from permanent practices such as permeable pavers left unprotected during construction.

Before this temporary sediment basin can be converted to a permanent stormwater practice, accumulated sediment will be removed, the basin regraded, and vegetation established.

Occupancy should not occur until vegetation has been permanently established.

Good example of designating an area for equipment washing. Before project closeout, these areas will need to be removed and trash, waste materials, and supplies cleaned up (Source: SoCal Sandbags).

Key Contact Information

For comments or questions regarding this guidance, please contact the GEPA Water Pollution Control Program at 671-475-1601. Additional information and electronic copies of this guide are available at the GEPA website at

www.epa.guam.gov.

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Ablemarle County, VA
Dr. Patrick L. Collin, Coral Reef Research Foundation
Mr. Jon Vogt
Virginia Erosion and Sediment Control Handbook, Third Edition

Designed by Kathryn M. Foltin. Unless otherwise noted, design schematics for ESC practices were adapted from NY State Soil and Water Conservation Committee (2005) as used in 2006 CNMI/Guam Stormwater Management Manual.

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Guam Coastal Management Program · Bureau of Statistics and Plans

Guam Environmental Protection Agency 1973

Todo y Nilala y Tano Man Uno
All living things of the earth are one

National Oceanic and Atmospheric Administration · NOAA · U.S. Department of Commerce

U.S. Department of the Interior · March 3, 1849

United States Environmental Protection Agency

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