EROSION PREVENTION AND SEDIMENT CONTROL MEASURES AND BEST MANAGEMENT PRACTICES

This chapter presents best management practices for erosion prevention and sediment control. Information such as advantages, disadvantages, design, inspection, and maintenance requirements for each BMP are also included and should help the designer choose the most appropriate measure or control. In order to maximize the overall benefits of any BMP selection and location, planners and designers must have a thorough understanding of the site characteristics. In addition, preconstruction meetings provide a means of opening lines of communications between all individuals affected by the construction, either directly or indirectly.

The details of installation can and should vary in the field depending on the site conditions. Field variations for each type of measure are encouraged. The substitution of other cost-effective products or methods that provide substantially equivalent or superior performance is allowed if approved by the City.

As implied by their name, BMPs are stabilization methods and structural erosion control measures that represent commonly accepted practices. Table 4-1 represents ratings for basic applications of commonly used erosion and sediment control measures. Tables 4-2 through 4-4 are matrices presenting recommended minimum erosion control measures for various site and construction types. Additional measures may be required based on specific site conditions. Table 4-2 is a matrix summarizing recommended erosion controls for single family residential and duplex construction activities on single lots of record. Table 4-3 summarizes recommended erosion control measures for larger construction sites including commercial, industrial, and subdivision development and construction. Table 4-4 is a matrix presenting recommended erosion controls for small, linear utilities construction and ditches/swales.

Erosion control measures are divided into two categories:

- Base measures which are required for construction sites at all times while there is disturbed or unstabilized ground surface on the site, and
- Supplementary wet weather measures which are required from October through April in addition to the base measures.

Base measures are indicated on Tables 4-2 through 4-4 with an “X” indicating primary recommended base measures and “A” indicating alternate measures. Wet weather measures are indicated on Tables 4-2 through 4-4 with an “*” for primary recommended measures and with an “O” for alternate measures. In the event of unusual weather patterns, the use of wet weather measures may be required at other times of the year. This is particularly true for the use of plastic sheet coverings.

Each erosion control measure presented in the matrices is presented in further detail with design, construction and maintenance criteria in the following sections of this chapter.

Table 4-1 Matrix of Temporary and Permanent Erosion Control Measures and Estimated Effectiveness Ratings: E = Excellent, M = Moderate, P = Poor

BMP APPLICATION	TEMPORARY VS PERMANENT	RATING	PAGE
4.1 EROSION PREVENTION			
4.1.1 Preserve Natural Vegetation	**P**	**E**	**4-6**
4.1.2 Buffer Zone	**P**	**E**	**4-7**
4.1.3 Seeding Temporary/Permanent	**T/P**	**E**	**4-8**
4.1.4 Ground Cover	**T**	**E**	**4-12**
4.1.5 Hydraulic Applications	**T/P**	**E**	**4-14**
4.1.6 Sod	**P**	**M**	**4-15**
4.1.7 Matting	**T**	**M**	**4-16**
4.1.8 Plastic Sheeting	**T**	**M**	**4-22**
4.1.9 Dust Control	**T**	**M**	**4-24**
4.2 RUNOFF CONTROL			
4.2.1 Construction Entrance	**T**	**E**	**4-26**
4.2.2 Tire Wash	**T**	**E**	**4-28**
4.2.3 Pipe Slope Drain	**T**	**E**	**4-31**
4.2.4 Outlet Protection	**T**	**E**	**4-34**
4.2.5 Surface Roughening	**P**	**E**	**4-37**
4.2.6 Check Dams	**T**	**M**	**4-41**
4.2.7 Diversion Dikes and Swales	**T**	**M**	**4-45**
4.2.8 Grass-lined Swale	**T**	**M**	**4-48**
4.3 SEDIMENT CONTROL			
4.3.1 Sediment Fence	**T**	**M**	**4-49**
4.3.2 Bio-filter Bags	**T**	**M**	**4-52**
4.3.3 Sand Bags	**T**	**M**	**4-54**
4.3.4 Filter Berm	**T**	**M**	**4-55**
4.3.5 Wattles	**T**	**M**	**4-57**
4.3.6 Sidewalk Subgrade Gravel Barrier	**T**	**M**	**4-58**
4.3.7 Inlet Protection	**T**	**M**	**4-60**
4.3.8 Dewatering	**T**	**E**	**4-67**
4.3.9 Sediment Trap	**T**	**E**	**4-68**
4.3.10 Sediment Basin	**P**	**E**	**4-71**

Table 4-2 Erosion Control Matrix
Single-Family, Duplex Residential, Manufactured Homes

		Construction Site		Stock Piles
Base Measures		Slope < 2%	Slope > 2%	
1.	Gravel construction entrance (BMP 4.2.1)	X	X	
2.	Sediment barrier at toe of disturbed area or stockpile (BMP 4.3.1 to 4.3.5)	X	X	X
3.	Sidewalk subgrade gravel barrier (site slopes to street at < 5%) (BMP 4.3.6)	A	A	
4.	Undisturbed buffer at toe of disturbed areas (site slopes < 10%) (BMP 4.1.2)	A	A	
5.	Storm drain inlet protection barrier (BMP 4.3.7)	X	X	X
Wet Weather Measures				
6.	6-mil plastic sheet cover (BMP 4.1.8)			*
7.	2”-minimum straw mulch cover (BMP 4.1.4)			O
Post Construction				
8.	Re-establish permanent ground cover or landscape prior to removing erosion measures (BMP 4.1.3)	X	X	

Key:

X Base measure
A Alternate to Base Measure 2
* Supplemental wet weather measures (October – April) (Seeding prior to September 1)
O Alternate supplemental wet weather measures, can be used as applicable

Table 4-3 Erosion Control Matrix
Commercial, Subdivision and Large Site Construction

	Site Slope							Stock Piles
	< 2%	< 10%	< 15%	< 20%	< 30%	< 50%	50%	
Base Measures								
Gravel construction entrance (BMP 4.2.1)	X	X	X	X	X	X	X	
1. Sediment barrier at toe of disturbed area (BMP 4.3.1 to 4.3.5)	X	X	X	X	X	X	X	X
2. Undisturbed buffer at toe of disturbed area (BMP 4.1.2)	A	A						
3. Sediment fence installed on contours (spacing) (BMP 4.3.1)		X(300')	X(150')	X(100')	X(50')	X(25')	X(25')	
Temporary interceptor dikes/swales around active work areas (BMP 4.2.7)	#	#	#	#	#	#	#	
Storm drain inlet protection barrier(BMP 4.3.7)	X	X	X	X	X	X	X	X
Wet Weather Measures								
4. Established grass (BMP 4.1.3)		*	*	*	*	*	*	
5. 2' minimum straw mulch cover (BMP 4.1.4)		O	O	O	O	O		O
6. Erosion blankets with anchors (BMP 4.1.7)		O	O	O	O	O	O	
7. 6-mil plastic sheet cover (BMP 4.1.8)		O	O	O	O	O	O	*
8. Sediment traps or ponds (BMP 4.3.9 and 4.3.10)		O	O	O	O	O		
Post Construction								
9. Reestablish permanent ground cover prior to removing erosion measures (BMP 4.1.3)	X	X	X	X	X	X	X	

Key:

X Base measure
A Alternate to Base Measure 2
Optional base measure, can use as applicable
* Supplemental wet weather measures (October – April) (Seeding prior to September 1)
O Alternate supplemental wet weather measures, can be used as applicable

Note: If different areas of the site have considerably different slopes, the site may be divided and erosion

measures selected for each area for the appropriate columns in the matrix.

Table 4-4 Erosion Control Matrix
Utilities Construction and Stock Piles / Ditches / Swales Protection

	Utilities Construction		Stock Piles	Ditches/ Swales
	Catch Basin drainage	Ditch Drainage		
Base Measures				
1. Sediment fence or barrier at toe (BMP 4.3.1)				X
2. Check dams (BMP 4.2.6)		X		X
Storm drain inlet protection barrier (BMP 4.2.7)	X		X	
Wet Weather Measures				
3. Established grass (BMP 4.1.3)				*
4. 6-mil plastic sheet cover (BMP 4.1.8)			*	
5. 2”-min. straw mulch cover (BMP 4.1.4)			O	O
6. Erosion blanket with anchors (BMP 4.1.7)				O
Post Construction				
7. Reestablish permanent ground cover or landscape prior to removing erosion measures (BMP 4.1.3)	X	X		X

Key:

X Base measure
* Supplemental wet weather measure (October – April) (Seeding prior to September 1)
O Alternate wet weather measure to *

4.1 Erosion Prevention

The designer should keep in mind when laying out an erosion control plan that the purpose of the plan is to maximize erosion prevention and minimize sediment transport from disturbed ground surfaces. Erosion prevention is the most effective and inexpensive method for reducing overall environmental impacts associated with construction activities. With this in mind, timing, staging, minimizing the amount of exposed soil, and directing surface water runoff away from exposed soil are all excellent ways to minimize erosion during construction. Erosion control practices primarily involve preserving natural vegetation when possible or stabilizing exposed soils with temporary covers or permanent vegetation. Reducing the erosion associated with construction vehicle traffic is also covered in this section. Many of these techniques can reduce erosion by 80 to 95 percent compared with exposed soils. Erosion prevention BMPs include:

1. Preserve Natural Vegetation
2. Buffer Zone
3. Temporary and Permanent Seeding
4. Hydraulic Applications
5. Ground Cover
6. Sod
7. Matting
8. Plastic Sheeting
9. Dust Control

4.1.1 Preserve Natural Vegetation

This BMP involves preserving natural vegetation to the greatest extent possible during the construction process, and after construction where appropriate. Maintaining natural vegetation is the most effective and inexpensive form of erosion prevention control. This method is particularly important in sensitive areas such as wetlands, stream corridors, lakes, and near steep slopes. The project manager, inspector, and contractor should address and discuss preserving natural vegetation during the Pre-construction meeting. Although this is a proven BMP, it is imperative all exposed soils are covered in a timely manner.

Advantages

- Helps reduce soil erosion and runoff while beautifying an area
- Saves landscaping costs, provides areas for wildlife, and provides visual screening
- Helps maintain water temperature. Temperature moderation is especially important when detention ponds drain to salmonid-bearing streams.
- Retains existing shade and cover habitat
- Conserves or increases property values

Disadvantages

- Retaining older, weak, or diseased trees could create a safety hazard
- May constrict area available for construction activities

Design Criteria

- Coordinate with the Landscape Architect and Environmental Professionals assigned to the project when determining what to save and how to save it
- Vegetation can be preserved in natural clumps or as individual trees, shrubs, and vines
- Clearly establish ground disturbance limits outside the dripline of preserved trees, using orange construction safety fence or flagging if approved
- Protect vegetation from:
    - Construction equipment injury above or below the ground level. Injury occurs from scarring, cutting roots, or compaction.
    - Grade changes, which affect the plants' ability to obtain air, water, or minerals
- Placing a layer of gravel and a tile system over the roots before a major fill allows air to circulate and protects the plant from the fill
- Terracing the area around the plant, or leaving the plants on an undisturbed mound can increase the plants' survival chances.
    - Root exposure can lead to drying, freeze damage, and potentially wind-throw
    - Raising the grade as little as six inches can retard the normal exchange of air and gases
    - Damage caused by excavations for tile, water, and sewer lines.

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Repair fencing and/or flagging
- Re-cover and/or seal exposed plant roots

4.1.2 Buffer Zone

A buffer zone consists of an undisturbed area or strip of natural vegetation or an established suitable planting adjacent to a disturbed area that reduces erosion and runoff. The rooted vegetation holds soils; acts as a wind break, and filters runoff that may leave the site.

Advantages

- Filters Sediment
- Promotes infiltration
- Provides habitat
- Reduces velocity and quantity of runoff, dissipates energy
- Provides visual screening
- Can be used to stabilize stream banks
- Low maintenance

Disadvantages

- Requires keeping all construction equipment, debris, and soils out of the natural areas
- Extensive buffers can cover large areas of land not available for project development
- Are not adequate in areas of concentrated flows

Design Criteria

- The vegetative buffer zone shall be located along the entire length of the down slope edge of the entire disturbed area.
- The vegetation shall consist of 3- to 12-inch high grassy vegetation that uniformly covers at least 90 percent of a representative one square yard plot. No more than 10 percent of the surface area shall be comprised of woody vegetation.
- Clearly establish buffer zone limits with orange construction safety fence and signs spaced 100 feet apart. Entry on the buffer zone shall be prohibited.
- Vegetative buffer zone widths shall be determined in accordance with the following:
    - Minimum width shall be 10 feet for slopes less than five percent
    - An additional five feet shall be added for each degree of slope above five percent but not exceeding 10 percent. A 10 percent slope would require a 35-foot buffer zone (10' + {5' × 5'})
    - An additional eight feet shall be added for each degree of slope above six percent but not exceeding 15 percent. A 15 percent slope would require a 75-foot buffer zone (35' + {5' × 8'})
    - An additional 10 feet shall be added for each degree of slope above 15 percent but not exceeding 20 percent. A 20 percent slope would require a 125-foot buffer zone (75' + {5' × 10'})
    - Vegetative buffer zones are not an adequate control measure for slopes above 20 percent.
- Vegetative buffer zones for streams, lakes, or other waterways shall be a minimum 100 feet wide. An incremental adjustment in accordance with the instructions above shall be added to the minimum. A 20 percent slope above a stream would require a 215-foot buffer zone.

Inspection and Maintenance

- Inspect flagging and fencing frequently and repair any rills and replace and/or add additional plants as needed.

4.1.3 Seeding (Temporary/Permanent)

A well-established vegetative cover is one of the most effective methods of reducing erosion. Vegetation should be established on construction sites as the slopes are finished, rather than waiting until all the grading is complete. Equally important and often overlooked is temporary or permanent irrigation. **Temporary or permanent seeding applications must be completed prior to September 1st of each year.**

Advantages

- Eliminates splash erosion
- Traps sediment
- Promotes infiltration
- Improves appearance of the site
- Reduces runoff velocities
- Provides excellent stabilization
- Relatively inexpensive erosion control measure
- Effective for dust control

Disadvantages

- Needs sufficient time for seed to establish

- Requires mulch or other cover until vegetation is established
- May require fertilizer and lime to establish on poor soils
- Requires irrigation
- Must be removed prior to applying fill material

Design Criteria

The following discussion presents general information regarding seeding, bed preparation, mulching, and fertilizing.

Selection Criteria

Standard grass and legume seed mixes for erosion control purposes are developed by local or regional distributors for site-specific applications. Often more than one plant species is selected so at least one species will do well given the extreme seasonal fluctuations that occur in nature. Specific plant characteristics are chosen when developing an erosion control seed mix. Grass species are normally used rather than other plant species because of their fibrous root systems and quick establishment.

Seedling vigor is an important plant characteristic to consider for erosion control seeding because the goal is to have rapid establishment and a dense fibrous root system. This holds the soil in place and provides a thick canopy over the soil to break the raindrop velocity. Some grasses do well early in the season and can act as nurse or cover crops until the slower growing species can establish. Seed mixes are developed for specific climatic zones around the state to match the optimum growing conditions for each species.

One grass seed characteristic considered is the season predominant growth will occur. Grass species are often characterized as being either warm- or cool-season grasses. A warm-season grass, such as bluegrass, will have its predominant growth during the warm months of the year. Conversely, cool-season grasses, like hard fescue, have their predominant growth in the cool weather and produce seeds in the early spring. To obtain optimum establishment, a cool or warm season grass, or both, may be used depending on whether the seed is planted in the spring or fall.

Another plant characteristic of importance in erosion control is the method by which the grass develops, grows, and spreads. Grasses can be either rhizomatous, where the grass plant will send out runners that will start new growth, a bunch grass; or a sod-forming grass. Rooting depth is important and grasses are characterized as being deep, moderate, and shallow rooting for erosion control purposes. The mixture of rooting depths provides optimum support for soils and best enables the removal of water by the roots at the various zones in the soil.

Seed Purity

All seed applied should be those specified in the project plan and should be measured by Pure Live Seed (PLS) weight. Pure live seed refers to the portion of a seed lot that is live seed of the desired kind. The purpose of measuring the application on a PLS basis is so trash and empty seeds do not confuse seeding rate calculations.

The seed lots should be tested and meet the minimum seed standards. Lots showing Oregon prohibited weeds are not approved. Seed must meet minimum viability standards. Oregon State University Extension Service keeps a listing of seed varieties certified in the OSU Extension Certified Seed Handbook.

The seed variety must be approved by the OSU Seed Certification Board to be eligible for certification or meet the standards for certification.

- Temporary grass cover measures must be fully established by October 1st or other ground cover measures will have to be implemented. In order to establish an 80 percent healthy stand of grass, all seeding applications must be completed prior to September 1st.
- Apply permanent seeding when no further disturbances are planned.
- Seed should be applied immediately after seedbed preparation while the soil is loose and moist.
- Apply seed before applying straw mulch or other ground cover applications.
- Hydromulch shall be applied with grass seed at a rate of 2,000 pounds per acre. On slopes steeper than 10 percent, hydroseed and mulch shall be applied with a bonding agent (tackifier). Application rate and methodology shall be in accordance with seed supplier recommendations.
- Dry, loose, weed-fee straw used as mulch shall be applied at double the hydromulch application requirement (4,000 pounds per acre). Anchor straw by working in by hand or with equipment (rollers, cleat tracks, etc).
- Permanent or temporary irrigation shall be supplied especially in abnormally hot or dry weather or on adverse sites. Water application rates should be controlled to provide adequate moisture without causing runoff.

Site Preparation

- Bring the seedbed area to final grade, remove all rocks and debris, and smooth surface undulations larger than two inches.
- Divert concentrated flows away from the seeded area.
- For optimum seeding conditions preserve topsoil and stockpile material until final grades are established. Spread topsoil over new grades or:
- Conduct soil test to determine pH and nutrient content.
- Roughen the soil by harrowing, tracking, grooving, or furrowing.
- Apply amendments as needed to adjust pH to 6.0-7.5. Incorporate these amendments into the soil.
- The seedbed should be firm but not compact. The top four to six inches of soil should be loose, moist, and free of large clods and stones.
- If the seedbed has been idle long enough for the soil to become compact, the topsoil should be harrowed with a disk, spring tooth drag, spike tooth drag, or other equipment designed to condition the soil for seeding.
- Harrowing, tracking, or furrowing should be done horizontally across the face of the slope, so ridges are along the slope contour.

Seeding

- Seed to soil contact is the key to good germination.
- Apply seed at the rates specified using calibrated seed spreaders, cyclone seeders, mechanical drills, or hydroseeder so the seed is applied uniformly on the site
- Broadcast seed should be incorporated into the soil by raking or chain dragging, and then lightly compacted to provide good seed-soil contact.
- Apply mulch and tackifier or matting, as specified, over the seeded areas.
- To prevent seed from being washed away, confirm installation of all required surface water control measures.
- Double the rate of seed application when mulch and seed is applied in a single application.
- Recommended erosion control grass seed mixes are as follows. Similar mixes designed to achieve erosion control may be substituted with approval

1. Dwarf Grass Mix (low height, low maintenance)
   Dwarf Perennial Ryegrass, 80 percent by weight
   Creeping Red Fescue, 20 percent by weight
   Application rate: 100 pounds minimum per acre
2. Standard Height Grass Mix
   Annual Ryegrass, 40 percent by weight
   Turf-type Fescue, 60 percent by weight
   Application rate: 100 pounds minimum per acre

Fertilizer

- Slow-release fertilizers are more efficient and have fewer environmental impacts.
- Areas being seeded for final landscaping may require soil tests to determine the exact type and quantity of fertilizer needed to prevent the over-application of fertilizer. Use non-phosphorus fertilizer on disturbed areas within 50 feet of water bodies and wetlands.
- The use of stockpiled topsoil or compost reduces the need for fertilizer and improves the overall soil quality.
- Provide project-specific application rates

Mulch

- Refer to Ground Cover and Matting sections of this chapter.
- Straw mulch in loose condition is preferred for seeding during the wet season on slopes 3:1 or flatter.
- Straw mulch may be required during the dry season if:
  - Grass growth is expected to be slow
  - The soils are highly erodible
  - There is a water body close to the disturbed area
  - Significant precipitation is anticipated before the grass will provide effective cover.
- The straw mulch shall not be moldy, caked, decayed, or of otherwise low quality.
- Can be applied on top of the seed or applied with the seed during hydroseeding.
- The application rate of seed per acre should be increased if seed and mulch are applied in a single application.

Hydroseed

- Refer to Hydraulic Application section (BMP 4.1.5) of this chapter
- Hydroseeding requires a mulch or green dye tracer as a visual aid during application.
- On slopes steeper than 2:1, hydroseeding requires an increased rate of tackifier to be applied.
- During the dry season, hydroseeding with wood fiber mulch is adequate.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Newly seeded areas need to be inspected frequently to ensure the grass is growing.
- If the seeded area is damaged due to runoff, additional BMPs may be needed. Re-seed and mulch damaged areas.

- Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.
- If spot seeding is ineffective, use an alternate method, such as sod or matting.
- Re-seed and protect with mulch any areas affected by erosion. If the erosion is caused by concentrated runoff, fix the runoff problem and then re-seed and mat the area.

4.1.4 Ground Cover

Ground Cover is a protective layer of straw or other suitable material applied to the soil surface. Straw mulch and/or hydromulch are also used in conjunction with seeding of critical areas for the establishment of temporary or permanent vegetation. Ground cover provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture; holding fertilizer, seed, and topsoil in place; and moderating soil temperatures.

Advantages

- Provides immediate protection
- Conserves moisture
- Acts as a thermal layer for seed
- If used in conjunction with seed, allows seed growth through the mulch
- Protects seeding from direct heat, moisture loss, and transport due to runoff
- Used for dust control

Disadvantages

- Thick mulches can delay germination.
- Can be blown or washed away if not adequately tackified
- Must be removed prior to applying fill material

Design Criteria

- Divert concentrated runoff from above mulched areas
- Refer to Table 4-5 outlines mulch type, quality, and application rate
- The following pages include specific material and application criteria
- Refer to Appendix D for *Mulch Application Rate Worksheet*

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Maintain specified thickness of the cover.
- Re-mulch and/or protect with a net or blanket any areas that experience erosion.
- If the erosion problem is drainage related, fix the drainage problem and re-mulch the eroded area.
- Hydraulically treated areas shall be inspected and monitored after installation and periodically thereafter.
- Hydraulic mulches and tackifiers shall provide the necessary erosion protection until permanent erosion-resistant cover is established. If sheet or rill erosion is evident, prompt re-application of treatments shall be necessary.

- If the hydraulic mulch or tackifiers were applied as stand-alone (without vegetation) treatments for erosion and dust control, the product longevity must match the length of time that the soil will remain bare or until revegetation occurs. Periodic inspections will assure the intended purposes will be met.
- Areas that fail to establish cover adequate to prevent erosion shall be re-mulched as soon as such areas are identified.
- If mulched areas are damaged by concentrated runoff, the prompt implementation of additional practices and BMPs may be necessary.

Table: 4-5 Ground Cover Application

Mulch Material	Quality Standards	Application Rate Per Acre	Depth of Material	Considerations
Straw	Air dried, free from unwanted seeds & coarse materials	2-2 ½ tons or 90-120 bales	2 inches minimum uniform spread	Use where the mulching effects is to be maintained < 3 months. When chopped straw is applied, use a tackifier
Yard Debris Compost	Well composted organic matter free of metals, plastics and other foreign matter	3-6 tons	4:1 slopes - use 1 inch; 3:1 slopes - use 2 inches; 2:1 slopes - use 3 inches	Excellent soil amendment. Compost size: ¾ × 0 on 3:1 slopes or less. 1½ × 0 on 2:1slopes.
Wood or Cellulose Fiber	Dyed green, should not contain growth inhibiting factors	2,000 pounds	N/A	Apply with hydromulcher. May need to double the rate depending on soil and slope. Use tackifier as recommended by manufacturer.
Wood Chips or Grindings	Green or air dried free of objectionable coarse materials	5-6 tons	1-3 inches depending on slope	Very durable. Apply with mulch blower, excavation equipment, or by hand. Not suitable for areas that require close mowing.
Gravel or Crushed Rock	Washed ¾-1.5inch	9 yards/1,000 feet [2]	3 inches	Excellent for short slopes and where subject to foot traffic. Larger pit-run can be used on steep slopes prone to sub-surface water (springs).

4.1.5 Hydraulic Application

Hydraulic application is a mechanical method of applying erosion control materials to bare soil in order to establish erosion-resistant vegetation on disturbed areas and critical slopes. By using hydraulic equipment soil amendments, mulch, tackifying agents, Bonded Fiber Matrix (BFM), and liquid co-polymers can be uniformly broadcast as homogenous slurry onto the soil. These erosion and dust control materials can often be applied in one operation.

Advantages

- Provides rapid installation with a one step process
- Generally requires less seedbed preparation. The surface soil may be left irregular with large clods, stones, or rock outcropping exposed.
- Uniformly distributes seed and mulch material
- Increases favorable conditions for quick germination and growth
- Can be used effectively on steep slopes and other areas where access is limited

Disadvantages

- Generally more expensive than broadcast or drilling seed applications
- Thick mulch applications can delay germination
- Can be blown or washed away if not adequately tackified
- Required application rates can vary significantly dependant on site preparation

Design Criteria

- Divert concentrated runoff from above treated areas.
- Seed, fertilizer, mulch, tackifier, soil amendments, Bonded Fiber Matrix, and chemical stabilization can be applied in a one step procedure.
- Wood fiber mulch or wood/paper mulch should be applied at a rate of 2,000 to 2,500 pounds per acre.
- Bonded Fiber Matrix (BFM) is considered a liquid blanket and can be applied on steep 1:1 slopes. Application rates between 3,000 and 4,000 lbs per acre, depending upon soil type and irregularities.
- Use hydraulic applications on slopes steeper than 4:1 that cannot receive adequate seedbed preparation and where mulch would be difficult to otherwise anchor.
- On sites where other soil stabilization, seeding, and mulching practices would result in unacceptable levels of ground disturbance.
- Use where site conditions, such as irregular soil surfaces, existing vegetation, and shallow soils preclude the installation of erosion mats.
- If used when seeding, maintain sufficient moisture level using permanent or temporary irrigation.
- On sites where straw mulch has been applied and the straw needs to be anchored using a liquid tacking agent.
- On sites where dust control is desired
- If the hydraulic mulch or tackifiers were applied as stand-alone (without vegetation) treatments for erosion and dust control, the product longevity must match the length of time the soil will remain bare or until re-vegetation occurs.
- Refer to Appendix D Hydraulic Application Tables for seed and mulch.

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Re-mulch and/or protect with an erosion control mating any areas that experience erosion. If the erosion problem is drainage related, fix the drainage problem then make necessary repairs.
- Hydraulic mulches and tackifiers shall provide the necessary erosion protection until permanent erosion-resistant cover is established. If sheet or rill erosion is evident then prompt re-application of treatments shall be necessary.
- Areas that fail to establish 80 percent healthy stand of grass cover to prevent erosion shall be properly covered using one of the selected application.

4.1.6 Sod

Establishes permanent turf for immediate erosion protection and stabilizes drainage ways.

Advantages

- Provides immediate, effective protection, and is aesthetically pleasing
- Provides high-density vegetation, which is superior to a recently seeded area
- Placement can occur any time soil moisture is adequate and the ground is not frozen

Disadvantages

- Expensive
- Availability is seasonal
- Irrigation may be required if installed in summer
- Difficult to mow if installed on slopes steeper than 3:1
- Installations in grassed waterways may roll up if not anchored or drained properly
- Time necessary for root establishment may be lengthy

Design Criteria

- Use sod as a short- or long-term cover
- Use around inlets located off roadways
- Use sod that is generally weed free, has uniform thickness (approximately 1 inch thick), and dense root mat for mechanical strength.
- Generally inappropriate for bioswales. Sod can be used for lining ditches or waterways carrying intermittent flows.
- The following steps are general recommendations for sod installation:
    1. Shape and smooth the surface to final grade in accordance with the approved grading plan.
    2. Fertilize as per supplier's recommendations. Non-phosphorous fertilizer is required near water bodies and wetlands.
    3. Work lime and fertilizer into soil one to two inches deep and smooth the surface.
    4. Lay sod strips perpendicular to the direction of water flow, beginning at the lowest area to be sodded. Wedge strips securely into place and square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple sod onto 3:1 and steeper slopes.

- Roll the sodded area and irrigate
- Not for use in high velocity channels/ditches

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Inspect sod area frequently for soil moisture content and root establishment.
- Re-tack, re-sod or re-seed as necessary.
- If it is impossible to establish a healthy ground cover due to frequent saturation, instability, or some other cause; remove the sod, seed the area with an appropriate mix, and protect with matting.

4.1.7 Matting

There are numerous erosion control products available that can be described in various ways, such as matting, blankets, fabric, and nets. We will call them all matting. A wide range of materials and combination of materials are used to produce matting including, but not limited to: straw, jute, wood fiber, coir (coconut fiber), plastic netting, and Bonded Fiber Matrix. The selection of matting materials for a site can make a significant difference in the effectiveness of the BMP.

When selecting matting consider these questions:

1. How long will the matting be required to provide protection?
2. How steep is the slope?
3. What is the soil type?
4. What is the shear stress on the channel bottom?

Advantages

- Immediate cushioning against splash erosion from raindrop impact
- Does not generate high-velocity runoff and, therefore, offers temporary slope protection, which is superior to plastic sheeting
- Captures a great deal of sediment due to its open, porous structure
- Usually easy to install
- Provides long-term protection, based on matting selection

Disadvantages

- Correct installation is critical to the effectiveness of these products. Good ground contact during installation prevents runoff concentrating under the blanket and causing significant erosion (tenting).
- Soil surface must be graded smooth with no surface irregularities
- Limited protection capabilities when used as flexible channel liner

Design Criteria

- Generally used on slopes 3:1 and steeper
- Surface must be graded smooth
- Remove all debris and undulations larger than two inches in any dimension
- Apply seed and fertilizer prior to matting
- Install so matting is in complete contact with soil surface

- See Table 4-6 for matting application and staple pattern
- Organic matting materials (excelsior, jute and coir) biodegrade and are useful for applications requiring stabilization for up to three months. Use organic blankets, which retain moisture and provide organic matter to the soil, for slope protection, and short-term waterway protection and to improve the speed and success of re-vegetation.
- Excelsior brand (aspen wood fiber), woven straw, and coir (coconut fiber) blankets may be installed without mulch because they provide complete surface protection.
- Synthetic mats are made from non-biodegradable material and will remain in place for years (some photodegradation does occur). Use purely synthetic blankets for long-term stabilization of waterways.
    - Turf Reinforcement Mats (TRM) are made from polymer netting or monofilaments formed into a Synthetic 3-D mat. TRMs protect seed and increase germination and also act as part of the root structure; giving the turf higher strength.
    - Erosion Control and Revegetation Mats (ECRM), composed of heat-fused monofilaments or monofilaments stitched between netting act as permanent mulch. ECRM allow growth through the mat.
- Channel or swale applications:
    - Lengthwise overlap: Minimum 12 inches
- Crosswise overlap: Minimum six inches
- Avoid joining material in center of ditch or swale
- Slope application:
    - Lengthwise overlap: Minimum 6 inches
    - Crosswise overlap: Minimum 6 inches
    - At top of slope, entrench material in a six-inch × six-inch trench and staple at 12-inch intervals
    - At bottom of slope, extend mat two feet beyond the toe of the slope, turn material under four inches, and staple at 12 inch intervals
    - On 4:1 slopes, rolls can be placed in horizontal strips
    - Mats must be stapled in place as they are installed down the slope face every four feet until the bottom is reached. This keeps the blanket in relaxed position, eliminating the potential for under-rilling.

<u>Inspection and Maintenance</u>

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Repair any damaged areas of the net or blanket and staple into the ground any areas not in close contact with the ground surface.
- If erosion occurs, repair and protect the eroded area.

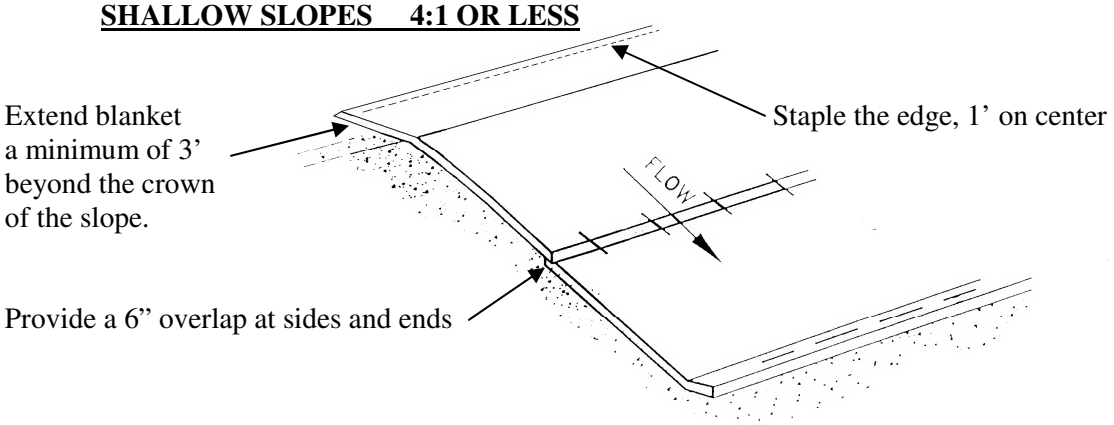
Table 4-6 Matting Specifications

Matting Type	Slope/ Channel Application	Netting Type
Straw	3:1 or less	Type 1 - Photo degradable polypropylene top/bottom Type 2 – 100 percent Bio degradable (used near sensitive habitat areas)
Straw/Coconut	2:1 or less	Type 1 – Photo degradable polypropylene top/bottom Type 2 – 100 percent Bio degradable (used near sensitive habitat areas)
Coconut	1:1 or less Low flow channels	Type 1 – Photo degradable polypropylene top/bottom Type 2 – 100 percent Bio degradable (used near sensitive habitat areas)
Jute	3:1 or less Short, 2:1 slopes	100 percent Bio degradable
Excelsior	2:1 or less Low flow channel	Photo degradable extruded plastic mesh top/bottom
Coir fabric	1:1 or less 8-10 fps channel	Type 1 – 1-inch grid 100 percent Bio degradable (4-10 year life) Type 2 – ½-inch grid 100 percent Bio degradable (4-10 year life) Type 3 – ¼-inch grid 100 percent Bio degradable (4-10 year life)
TRM	High flow Channels 8-20 fps	Three dimensional synthetic polyolefin fibers mechanically bonded between two nets.

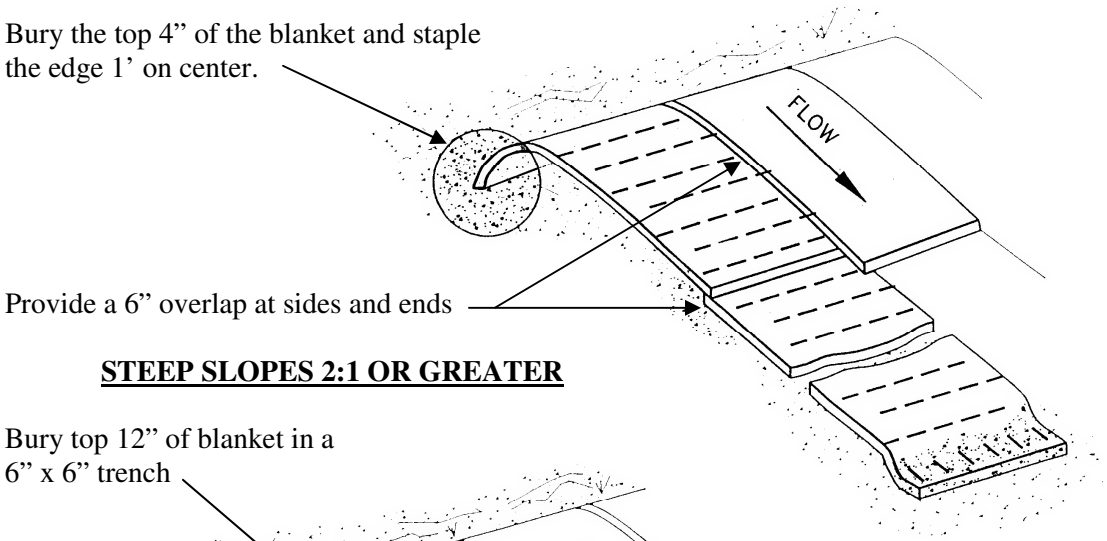
Diagram 4.1.7a

MATTING SLOPE INSTALLATION

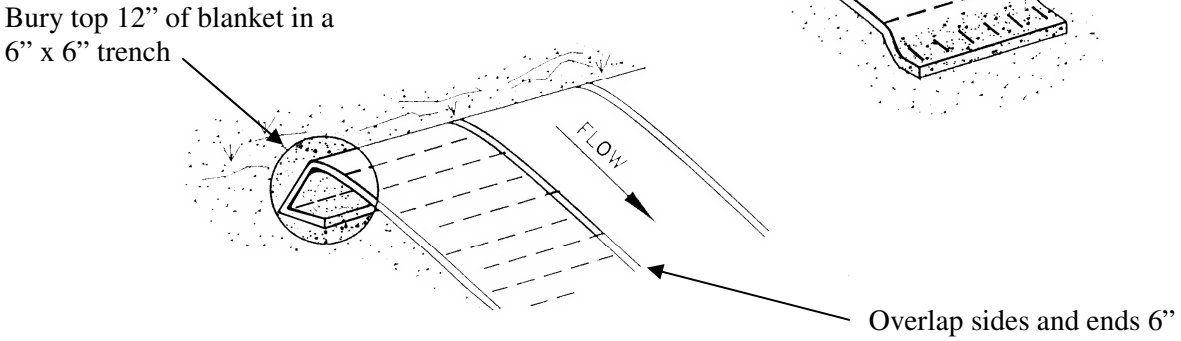
SHALLOW SLOPES 4:1 OR LESS



MODERATE SLOPES 3:1



STEEP SLOPES 2:1 OR GREATER

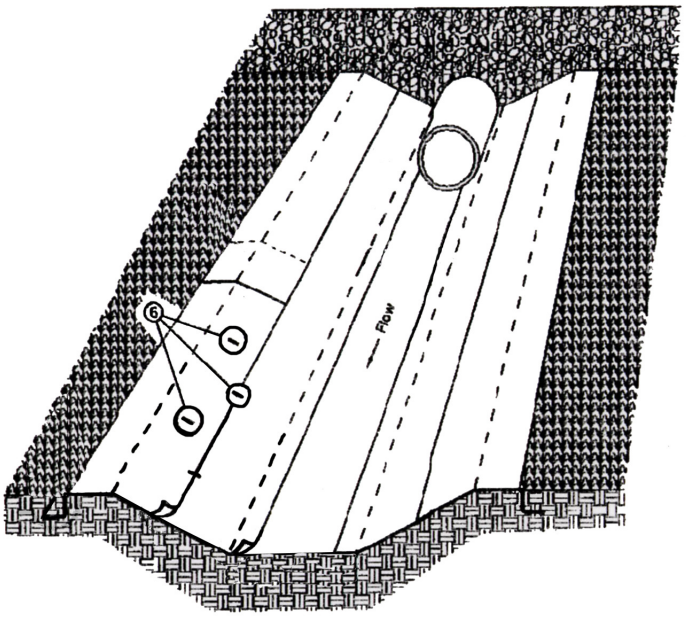


NOTES:

1. On shallow slopes, blankets may be applied across the slope.
2. All Blanket staples required as per table in Diagram 4.1.7c

Diagram 4.1.7b

MATTING CHANNEL INSTALLATION



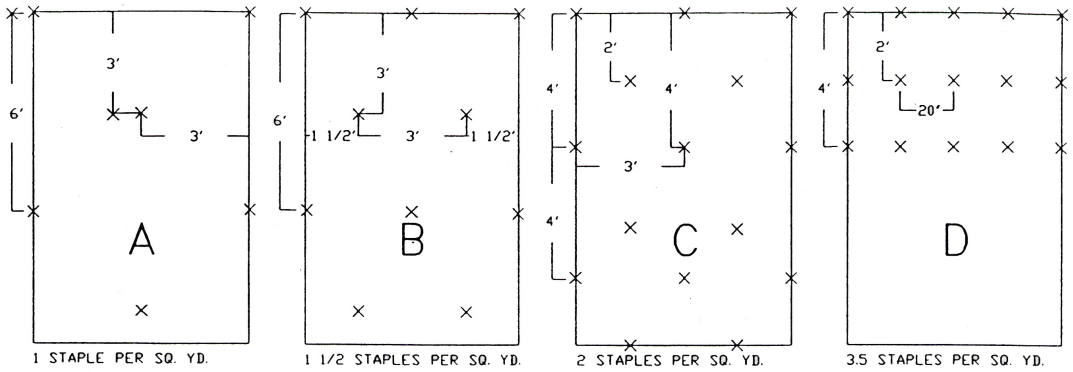
NOTES:

1. Information provided is the minimum protection required. Manufacturer's instructions shall be used where they are more stringent than those provided here.
2. Install mat parallel to flow, centered in channel. For culvert outfalls, place the mat under the culvert or rip rap the outlet over the mat.
3. Overlap sides and ends of blankets a minimum of 12 inches.
4. Refer to Diagram 4.1.7a for channel slope applications.
5. Refer to Diagram 4.1.7c for staple requirements.
6. The length of staples shall be determined by soil type. Cohesive soils shall use a minimum 6" staple. Non-cohesive soils shall use 8" – 12" staples.

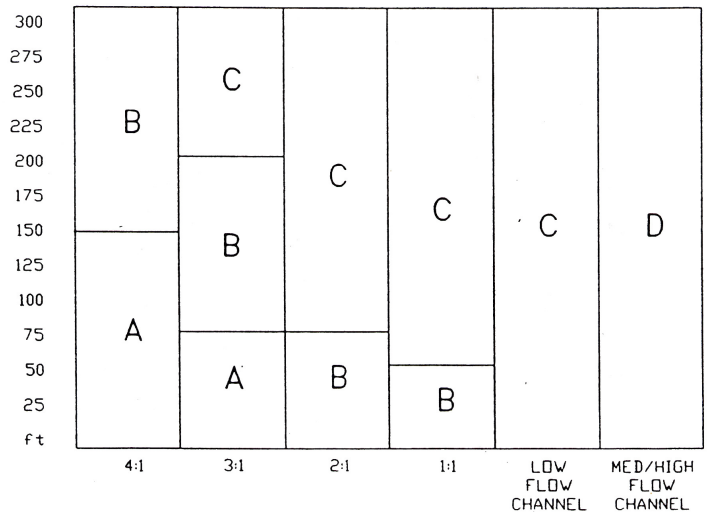
Diagram 4.1.7c

MATTING STAPLE REQUIREMENTS

STAPLE PATTERN



LENGTH AND SLOPE TABLE



*MINIMUM STAPLE PATTERN GUIDE AND RECOMMENDATION FOR SLOPE AND CHANNEL APPLICATION.

4.1.8 Plastic Sheeting

Provides immediate protection to slopes and stockpiles. Plastic sheeting has been known to transfer erosion problems because water will sheet flow off the plastic at high velocity. This is usually attributable to poor application, installation and maintenance. Use alternatives to plastic covering whenever possible.

Advantages

- Provides immediate, short-term erosion protection to slopes prone to erosion and to stockpiles.
- Fairly quick and easy to install.

Disadvantages

- Plastic sheeting may concentrate sunrays and burn the vegetation beneath it
- Material generates high velocity runoff
- Plastic breaks down quickly when exposed to ultraviolet radiation
- Plastic, when it is not completely removed, can clog drainage system inlets and outlets
- If not properly anchored, wind may transport plastic onto roadways and create traffic hazard
- Not effective for preventing illegal discharge

Design Criteria

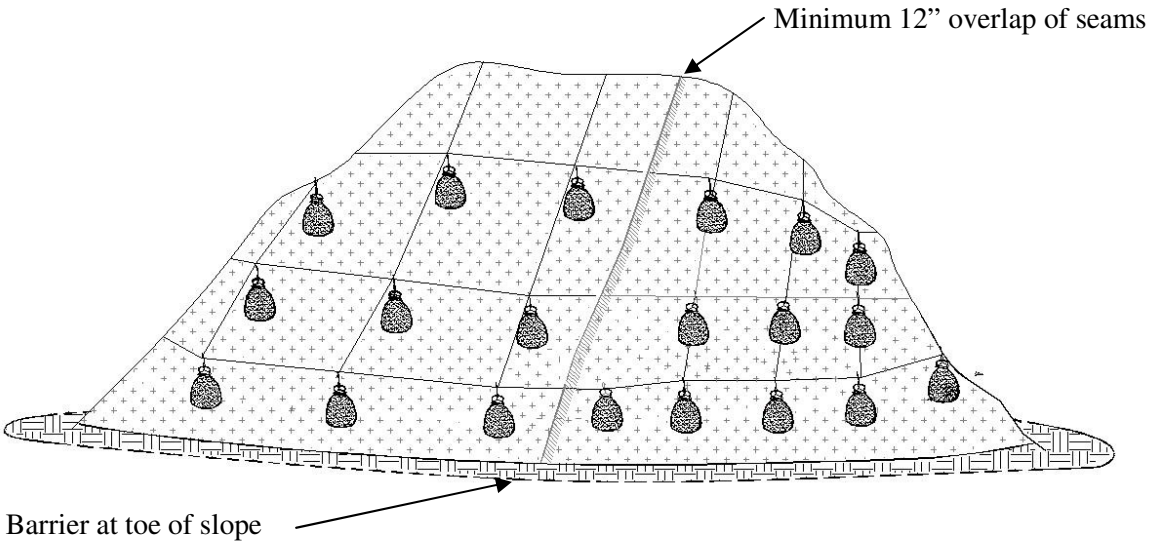
- Do not use plastic covering upslope of areas such as steep and/or unstable slopes that might be adversely affected by concentrated runoff.
- When possible, install an interceptor dike at the top of the plastic to divert flows away from the plastic.
- Toe-in the top of the sheeting in a 6 inch × 6 inch trench backfilled with compacted native material.
- Install a gravel berm, riprap, or other suitable protection at the toe of slope in order to dissipate runoff velocity.
- Anchor the plastic using sandbags or other suitable tethered anchoring system spaced on a 10-foot grid spacing.
- Overlap seams one to two feet, tape, roll, and stake the seams and then weigh down the entire length.

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Replace torn sheets and repair open seams
- Completely remove and replace plastic when it begins to deteriorate
- Completely remove all plastic once it is no longer needed
- Check anchoring system and repair or add anchors

Diagram 4.1.8

PLASTIC SHEETING INSTALLATION



NOTES:

1. Minimum 12” overlap of all seams is required
2. A barrier is required to be installed at the toe of the stock pile
3. Covering shall be maintained tightly in place by using sandbags or tires on ropes with a maximum ten foot grid spacing in all directions

4.1.9 Dust Control

Preventative measures to minimize the wind transport of soil, prevent traffic hazards and reduce sediment transported by wind and deposited in water resources.

Advantages

- Reduces movement of soil to offsite areas
- Increases visibility

Disadvantages

- Over watering may cause erosion
- Most methods require immediate reapplication if disturbed
- Too little watering fails to control dust

Design Criteria

- Installing construction entrances and stabilizing construction haul roads with crushed rock
- Designer can provide project-specific dust control specifications for the contractor to apply. Measures include:
  - Seeding
  - Mulching
  - Matting
  - Water
  - Tackifier
  - Chemical Soil Stabilizers
- Schedule construction operations so the least amount of project area is disturbed at one time.
- Install temporary or permanent surface stabilization measures immediately after completing land grading.

Inspection and Maintenance

- Maintain dust control measures through dry weather periods until all disturbed areas have been stabilized.
- Immediately re-stabilize areas disturbed by contractor's operations or other activities (wind, water, vandalism, etc.).

4.2 Runoff Control Practices

The greater the volume and velocity of surface water runoff on construction sites, the more sediment and other pollutants are transported to streams, wetlands, and lakes. Diverting runoff away from exposed soils can greatly reduce the amount of soil eroded from a site. Decreasing runoff velocities reduces erosion and the amount of pollutants carried off-site.

Runoff controls divert runoff from exposed areas and reduce runoff velocities. Runoff control BMPs that divert runoff from exposed areas include pipe slope drains and diversion swales. Runoff control BMPs include:

1. Construction Entrance
2. Tire Wash Facility
3. Pipe Slope Drain
4. Outlet Protection
5. Surface Roughening
6. Check Dam
7. Diversion Dike/Swale
8. Dewatering

4.2.1 Construction Entrance

A construction entrance consists of a stabilized rock pad placed at construction site ingress/egress locations that reduces the amount of sediment transported onto paved roads by vehicles or runoff. The Construction Entrance also includes a curb ramp designed out of wood.

Advantages

- Reduces traffic hazards caused by debris on public roadways
- Reduces sediment and other debris from entering roadways, which can then be washed into the storm

Disadvantages

- Only effective if erosion and sediment control employed elsewhere onsite
- Only works if installed at every location where significant construction traffic leaves the site
- Fills with sediment quickly and requires frequent maintenance and/or replacement of rock

Design Criteria

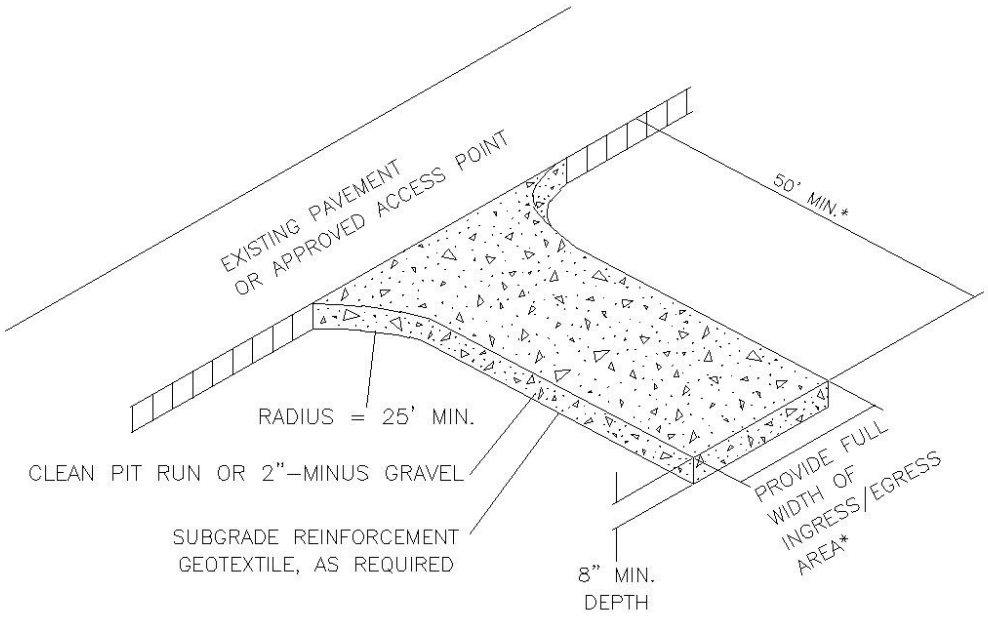
- Install construction entrance prior to any site work.
- Whenever possible, construct the pad on a firm, compacted subgrade.
- Install geotextile under rock when subgrade is not stable or is "pumping" up into the pad.
- **Minimum length:**
  - 20 feet - all single family sites.
  - 50 feet – all other development sites.
- **Minimum width:**
  - 20 feet – all construction sites.
- **Minimum Depth:**
  - 8 inches – all construction sites.
- **Rock Size:**
  - 1" minus – all single family sites
  - 3"-6" – all other construction sites
- Do not install rock on paved surfaces. (Use wood curb ramps.)
- Wood Curb ramps should be made out of 2 × 6 material, nailed together
- Include a tire wash facility if the entrance does not prove effective in retaining sediment onsite

Inspection and Maintenance

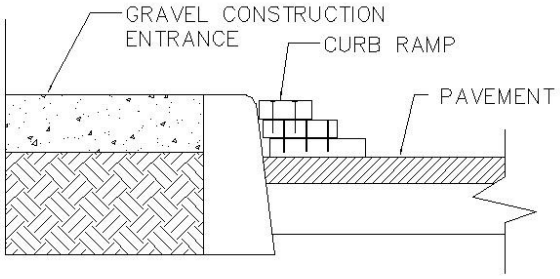
- Requires ongoing inspection
- Immediately sweep up and remove or stabilize onsite any sediment that is tracked onto pavement
- If the sediment poses a threat to public safety and street sweeping proves ineffective, consider washing the street and collecting the water in a sediment pond or sump before it leaves the site.
- Add or replace rock as needed to maintain the specified dimensions.
- Immediately remove any rock, which gets carried from the pad to the roadway.

Diagram 4.2.1

CONSTRUCTION ENTRANCE



*20' MIN. FOR SINGLE FAMILY AND DUPLEX RESIDENTIAL



NOTES:

DIMENSIONS

SINGLE FAMILY

20' LONG BY 20' WIDE

8" DEEP OF $\frac{3}{4}$" MINUS CLEAN ROCK.

COMMERCIAL

50' LONG BY 20' WIDE

3-6" CLEAN ROCK,

GOVERNING AUTHORITY MAY REQUIRE GEOTEXTILE FABRIC TO PREVENT SUB-SOIL PUMPING.

4.2.2 Tire Wash Facility

Two types of tire wash facilities are available depending on the severity of sediment tracking and the size and duration of project. Type 1 can be retro-fitted in the field, using geotextile fabric and rock. Like a stabilized construction entrance it is graded so collected wash water is conveyed to a sediment trap, basin, or other suitable treatment facility. Type 2 consists of a shallow concrete-lined basin partially filled with water, through which exiting vehicles drive.

Advantages

- Reduces traffic hazards caused by debris on public roadways
- Reduces sediment on roadways, which can wash into the storm sewer system
- Type 1 is easy to construct and is relatively inexpensive
- Type 2 is useful for high traffic volumes or large projects of long duration

Disadvantages

- Only works if installed at every location where construction traffic leaves the site
- Fills with sediment quickly and requires frequent maintenance
- Requires a source of wash water
- Requires a turnout or doublewide exit to avoid entering vehicles having to drive through wash area
- Type 2 is costly to construct
- Both facilities will generate large volumes of sediment-laden water, requiring treatment elsewhere on site

Design Criteria

Type 1 (temporary)
- Minimum length: 40 feet
- Minimum width: 10 feet
- Minimum rock depth: 8 inches
- Average tire wash sump: 18 inches
- Install subgrade geotextile fabric as a liner
- Use 4”-6” rock over geotextile fabric
- **Alternate:** 3” asphalt lift over a stable base coarse
- Grade the pad to drain to suitable collection and treatment facility.
- Install fencing as necessary to restrict exiting construction vehicle traffic to the tire wash.

Type 2 (permanent)
- Minimum length: 40 feet with sloping ingress and egress
- Minimum width: 10 feet
- Minimum rock depth: 8 inches
- Average tire wash sump: 18 inches
- Run out impervious area should be a minimum of 50 feet, graded back to facility
- Line bottom of basin with geotextile and 12 inches of rock base coarse
- Construct basin out of 12”. concrete with steel reinforcement
- Provide water supply

- Provide outlet for sediment-laden water discharge to treatment facility or provide pumps and tanks for water treatment

Inspection and Maintenance

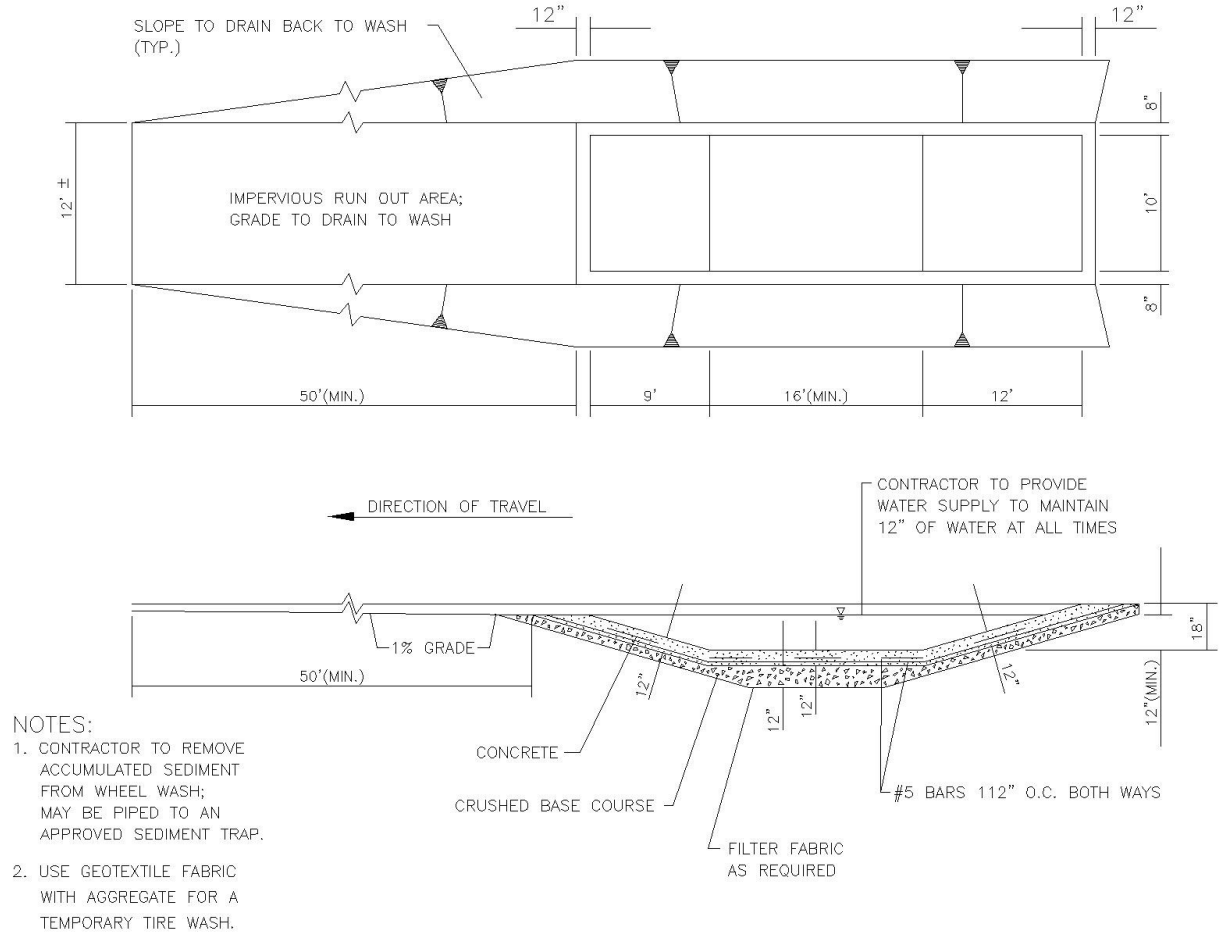
- Inspect weekly minimum, or more frequently depending upon use.

Type 1
- Clean or replace rock clogged with sediment
- Re-grade rock as needed
- Maintain tire wash sump depth
- Maintain a clean run-out pad
- Immediately remove any rock that gets carried from the pad to the roadway
- Ensure that wash water drainage, collection and treatment system is functioning

Type 2
- Remove/discharge wash water as needed
- Remove accumulated sediment from tire wash facility in order to maintain tire wash sump
- Ensure that wash water collection and treatment system is functioning

Diagram4.2.2

TIRE WASH FACILITY



NOTES:

1. CONTRACTOR TO REMOVE ACCUMULATED SEDIMENT FROM WHEEL WASH; MAY BE PIPED TO AN APPROVED SEDIMENT TRAP.
2. USE GEOTEXTILE FABRIC WITH AGGREGATE FOR A TEMPORARY TIRE WASH.

4.2.3 Pipe Slope Drain

A pipe slope drain is created by extending a pipe from the top to the bottom of a cut or fill and discharging into a stabilized watercourse, sediment trapping device, or onto a stabilized area. The pipe slope drain carries concentrated runoff down steep slopes without causing gullies, erosion, or saturation of slide-prone soils.

Advantages

- Effective method of conveying water down steep slopes
- Reduces or eliminates erosion
- Easy installation and little maintenance

Disadvantages

- Drain can be under-designed or incorrectly located
- Area cleared for drain installation requires stabilization to prevent erosion occurring under the pipe
- Outfall systems constructed of pipe segments, which are banded and/or gasketed together, could develop leaks causing erosion and failure of the system. Failures on erodible or steep slopes can cause downstream sedimentation or even mudflows.
- Adjustment of pipe lengths is necessary as cut and fill slopes are extended.

Design Criteria

- Capacity – Peak runoff from a 10-year storm. Inlet control is a critical factor when sizing pipes. Unless they are individually designed, size drains according to Table 4-7.
- On any slope where a large amount of flow must be collected and conveyed to avoid erosion
- Areas where clean water should be kept separate from sediment-laden water
- If a permanent measure is needed it should be designed as part of the roadway drainage facilities

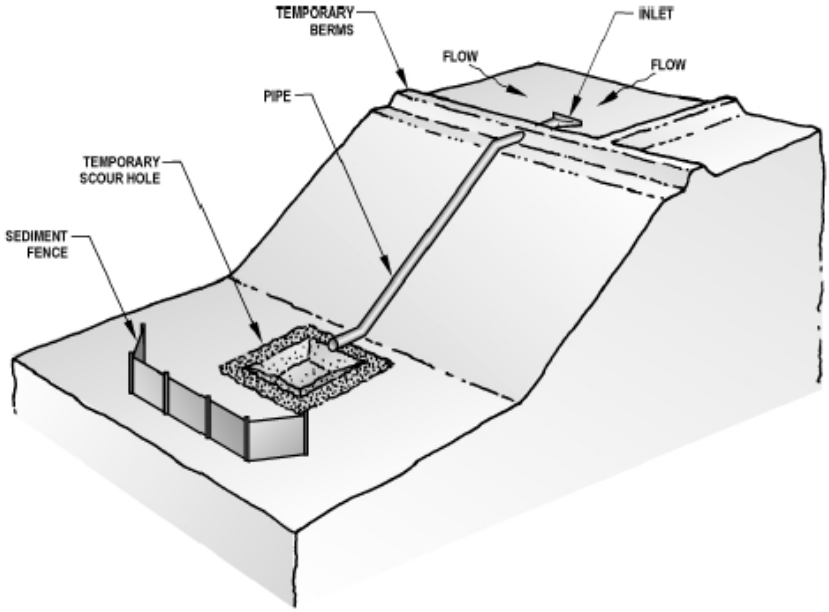


Table 4-7 Slope Drain Sizes

Contributing Drainage Area (Maximum)	Pipe Diameter
0.50 acre	12 inch
0.75 acre	15 inch
1.00 acre	18 inch

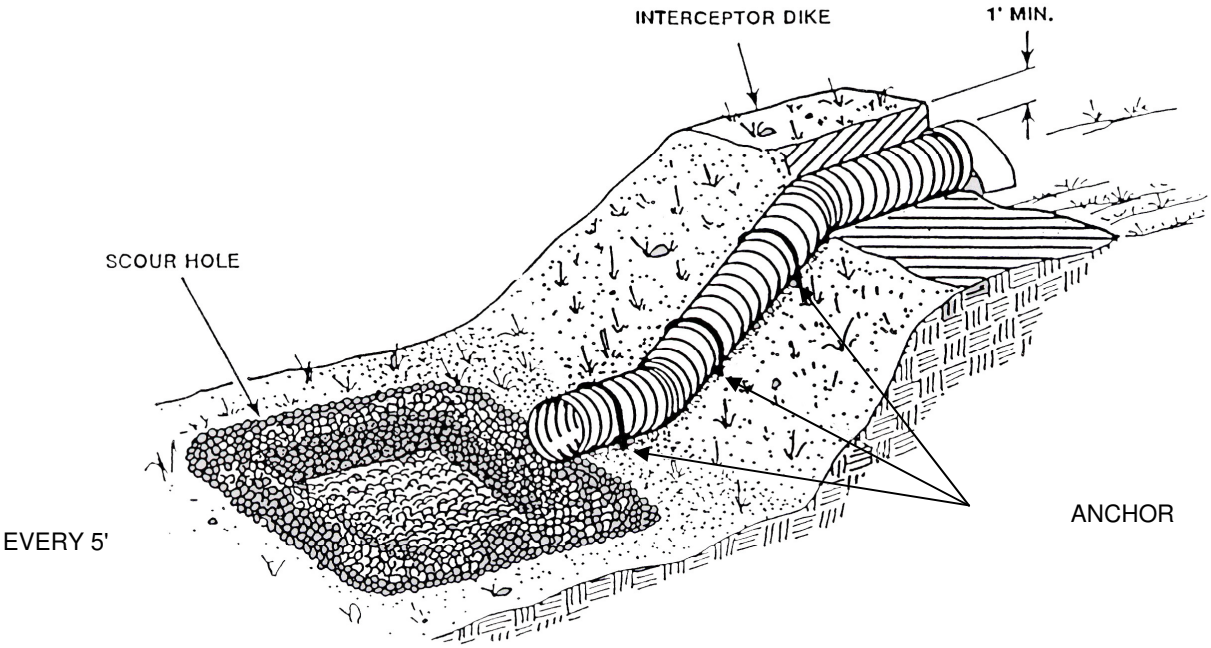
- Consider using continuously fused, welded, or flange-bolted mechanical joint systems with proper anchoring or HDPP (high-density polyethylene pipe) for outfalls on steep slopes.
- Show the entrance sloped toward the pipe inlet.
- At the inlet, show interceptor dikes that are at least 12 inches higher at all points than the top of the inlet pipe and placed to direct water into the pipe.
- If the pipe slope drain will convey sediment-laden runoff, direct the runoff to a sediment retention facility.
- If the runoff is not from a disturbed area or is conveyed from a sediment trap or pond, convey the runoff to a stabilized discharge point.
- Energy Dissipation – Scour holes or riprap-lined stilling basins prevent most scour problems at outfalls.
- Consider site conditions to determine if a more complex energy dissipater may be required.
- The special provisions and typical notes should include the following installation directions:
  - Minimize disturbance during installation. In some circumstances this requires HDPP installed by hand.
  - Slope anchor details.
  - Immediately stabilize any area disturbed during installation or maintenance.
  - Securely connect the standard flared end section at the entrance to the slope drain, using watertight connecting bands.
- Pipe should be staked securely to prevent movement.
  - Securely fasten together the slope drain sections with gasketed watertight fittings, and securely anchor the sections into the soil.
  - Stabilize the area below the outlet following the energy dissipater.

<u>Inspection & Maintenance</u>

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Adjust lengths of pipe when cut and fill slopes are extended.
- Regularly check the inlet and outlet points, especially following heavy rains. If there are signs of undercutting or water is going around the point of entry, reinforce the head wall with compacted earth or sand bags.
- Regularly check at connection points for signs of erosion. Tighten fittings and repair erosion as needed.
- Immediately repair and install appropriate protection if erosion occurs at the outlet.

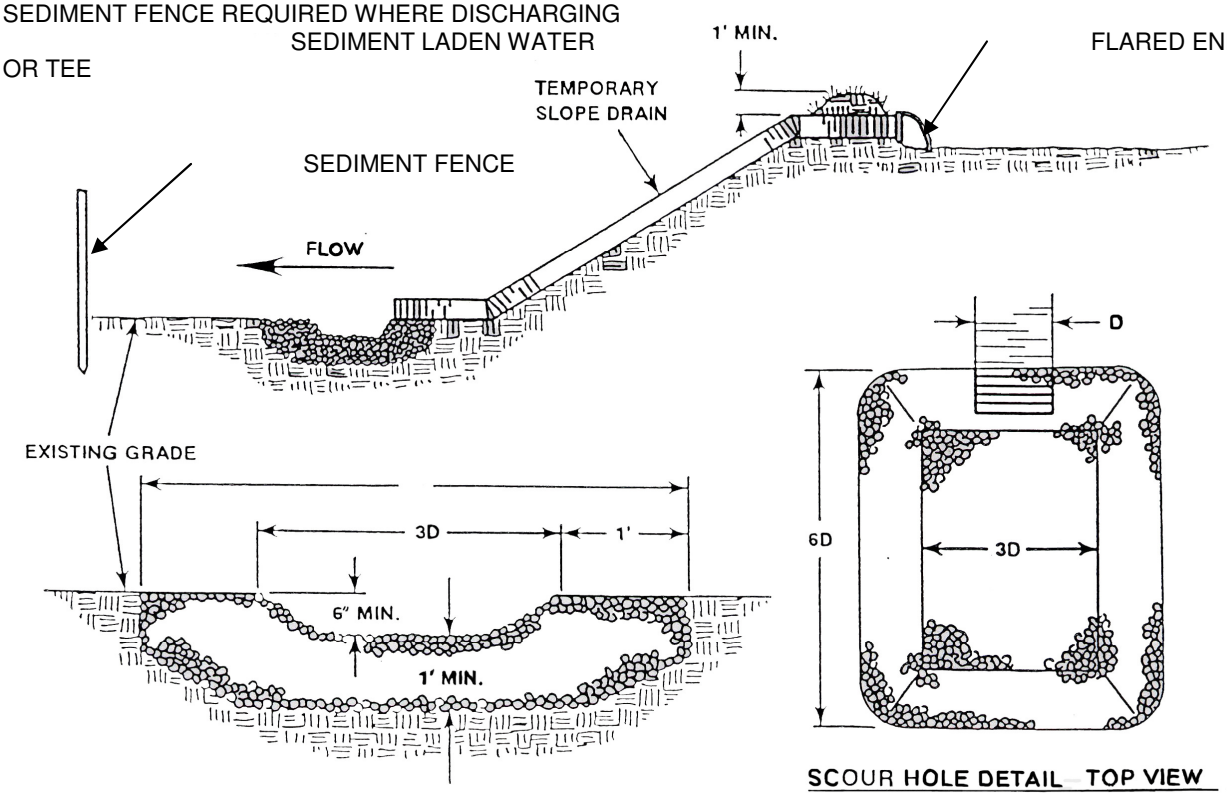
Diagram 4.2.3

PIPE SLOPE DRAIN



SEDIMENT FENCE REQUIRED WHERE DISCHARGING SEDIMENT LADEN WATER

OR TEE



4.2.4 Outlet Protection

Outlet protection reduces the speed of concentrated flow, thereby preventing scour at conveyance outlets. By dissipating energy, outlet protection lowers the potential for downstream erosion. Outlet protection includes rip-rap-lined basins, concrete aprons, and settling basins. Outlet protection prevents scour at storm water outlets and minimizes the potential for downstream erosion.

Advantages

- Many techniques are effective and relatively inexpensive and easy to install.
- Removes sediment and reduces velocity

Disadvantages

- Can be unsightly
- May be difficult to remove sediment without removing and replacing the structure itself
- Rock outlets with high velocity flows may require frequent maintenance.

Design Criteria

At a minimum, all outfalls shall be provided with a rock splash pad (see Figure 4.2.4), except as specified below and in Table 4-8:

1. For outfalls with a velocity at design flow greater than 10 fps, gabion dissipater or engineered energy dissipater shall be required. Note that a design engineered to specific site conditions is required.
2. Engineered energy dissipaters, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with velocity at design flow greater than 20 fps. These should be designed using published or commonly known techniques found in such references as *Hydraulic Design of Energy Dissipaters for Culverts and Channels*, published by the Federal Highway Administration of the United States Department of Transportation; *Open Channel Flow*, by V. T. Chow; *Hydraulic Design of Stilling Basins and Energy Dissipaters, EM 25*, Bureau of Reclamation (1978); and other publications, such as those prepared by the Soil Conservation Service (now Natural Resource Conservation Service). Alternate mechanisms, such as bubble-up structures (which will eventually drain) and structures fitted with reinforced concrete posts, may require an approved adjustment and must be designed using sound hydraulic principles and considering constructability and ease of maintenance.

Table 4–8 Rock Protection at Outfalls

Discharge Velocity at design Flow (fps)		REQUIRED PROTECTION				
Greater than	Less than or equal to	Minimum Dimensions				
		Type	Thickness	Width	Length	Height
0	5	Rock lining	1 foot	Diameter + 6 feet	Greater of: 8 feet or 4x diameter	Crown + 1 foot
5	10	Riprap(2)	2 feet	Greater of: Diameter + 6 feet or 3x diameter	Greater of: 12 feet or 4x diameter	Crown + 1 foot
10	20	Gabion Outfall	As required	As required	As required	Crown + 1 foot
20	N/A	Engineered energy dissipater required				

- Rock lining shall be quarry spalls with gradation as follows:

  Passing 8-inch square sieve: 100%
  Passing 3-inch square sieve: 40 to 60% maximum
  Passing 3/4-inch square sieve: 0 to 10% maximum

- Riprap shall be reasonably well graded with gradation as follows:

  Maximum stone size: 24 inches (nominal diameter)
  Median stone size: 16 inches
  Minimum stone size: 4 inches

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3: 1.

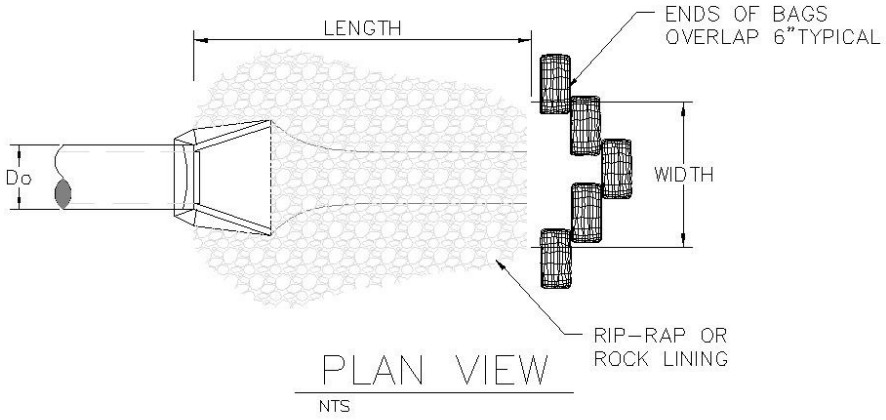
- **Other Recommended Outfall Features** – Mechanisms which reduce velocity prior to discharge from an outfall are encouraged. Some of these are drop manholes and rapid expansion into pipes of much larger size. New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall to the stream. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows.

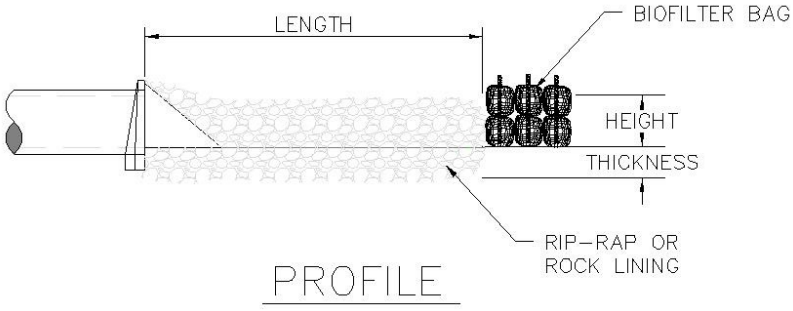
Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- If there is scour at the outlet, protect the eroded area by increasing the size of the energy dissipater facility
- Remove accumulated sediment frequently.

Diagram 4.2.4

OUTLET PROTECTION





NOTE:
1. BIO BAGS ONLY REQUIRED WHEN DISCHARGING SEDIMENT LADEN WATER.
2. STAKING OF BAGS REQUIRED WITH EITHER METHOD USING (2) 1"x 2" WOOD STAKES OR APPROVED EQUAL PER BAG.

4.2.5 Surface Roughening

Leaving the slopes in a roughened condition after clearing or creating a rough soil surface with horizontal depressions or grooves will trap seed and reduce runoff velocity. Roughening can be accomplished by "track walking" slopes with tracked equipment, by using a serrated wing blade attached to the side of a bulldozer, or by other agricultural equipment.

Advantages

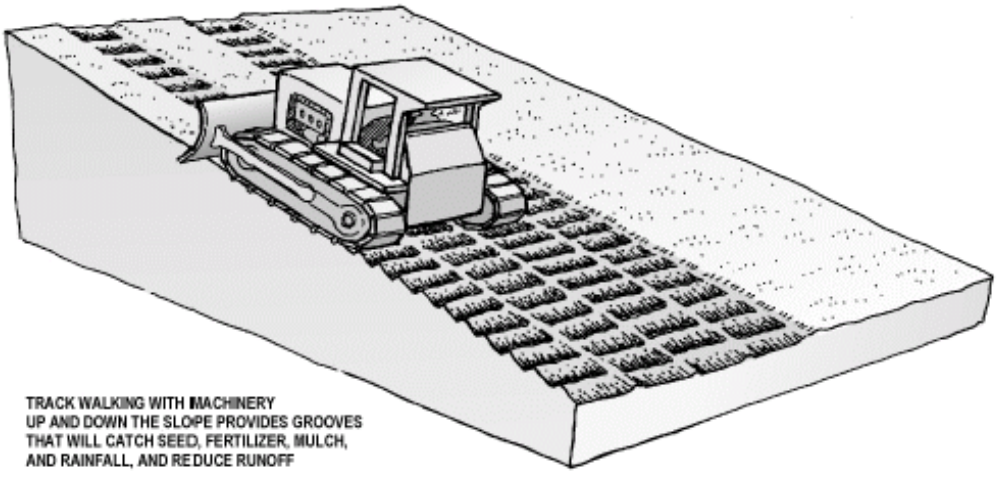
- Grooves trap seed
- Increased vegetation establishment
- Reduces runoff velocity, increases infiltration
- Provides some instant protection from sheet erosion
- Traps soil eroded from the slopes above

Disadvantages

- Tracking with a bulldozer/heavy equipment may compact the soil
- May increase time to finish slopes
- Should not be relied on as sole means of erosion control

Design Criteria

- All slopes to be seeded
- On slopes 3:1 or less, but can be used on steeper slopes in conjunction with the addition of staging sediment barriers.
- Immediately seed and mulch roughened areas to obtain optimum seed germination and growth
- Height of track grousers should be 1 ½ inches or greater
- Tracking should be accomplished by driving equipment up and down slope to create horizontal depressions/grooves



TRACK WALKING WITH MACHINERY UP AND DOWN THE SLOPE PROVIDES GROOVES THAT WILL CATCH SEED, FERTILIZER, MULCH, AND RAINFALL, AND REDUCE RUNOFF

Cut Slope Roughening

- Stair-step grade or groove cut slopes that are steeper than 3:1.
- Use stair-step grading on all erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with the same subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical wall.
- Do not make individual vertical cuts more than 2 feet high in soft materials or more than 3 feet in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run across the slope, on the contour.

Fill Slope Roughening

- Place fill slopes with a gradient steeper than 3:1 in lifts not to exceed ½ foot, and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill four to six inches deep.
- Use horizontal grooving along the contour or tracking to roughen the face of the slopes, if necessary.
- Apply seed, fertilizer and straw mulch, and then track or punch the mulch with a bulldozer.
- Do not blade or scrape the final slope face.

Cuts, Fills, and Graded Areas

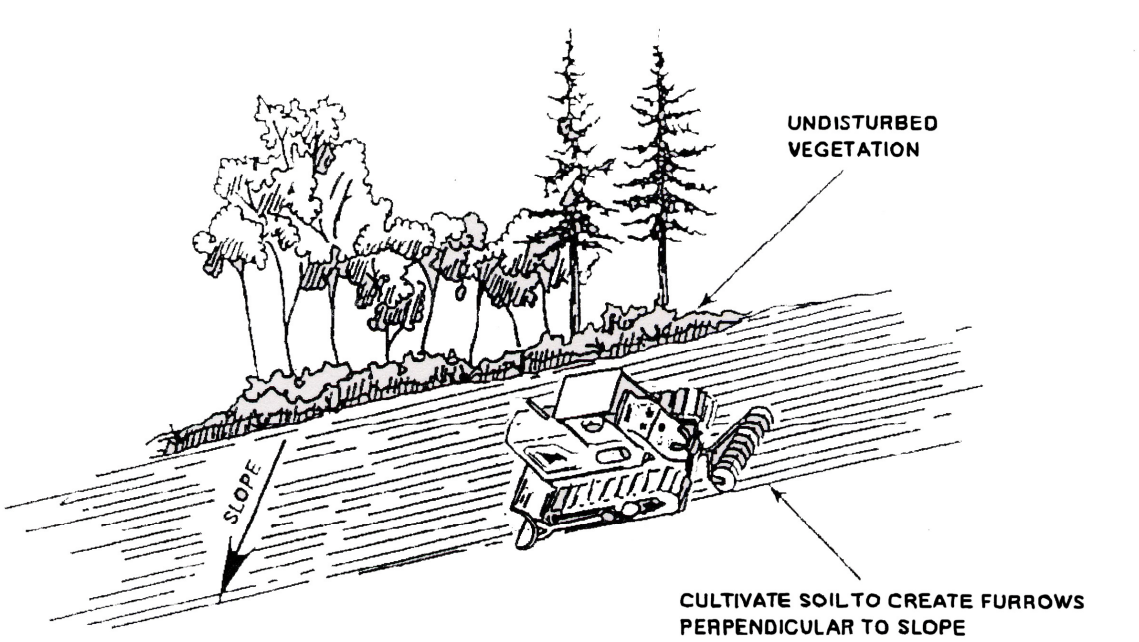
- Make mowed slopes no steeper than 3:1.
- Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use a cultipaker-seeder. Make the final pass of any such tillage on the contour.
- Excessive roughness is undesirable where mowing is planned.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Check the seeded slopes for rills and washes. Fill these areas slightly above the original grade, then re-seed, mulch, or mat as soon as possible.

Diagram 4.2.5a

SURFACE ROUGHENING – CAT TRACKING



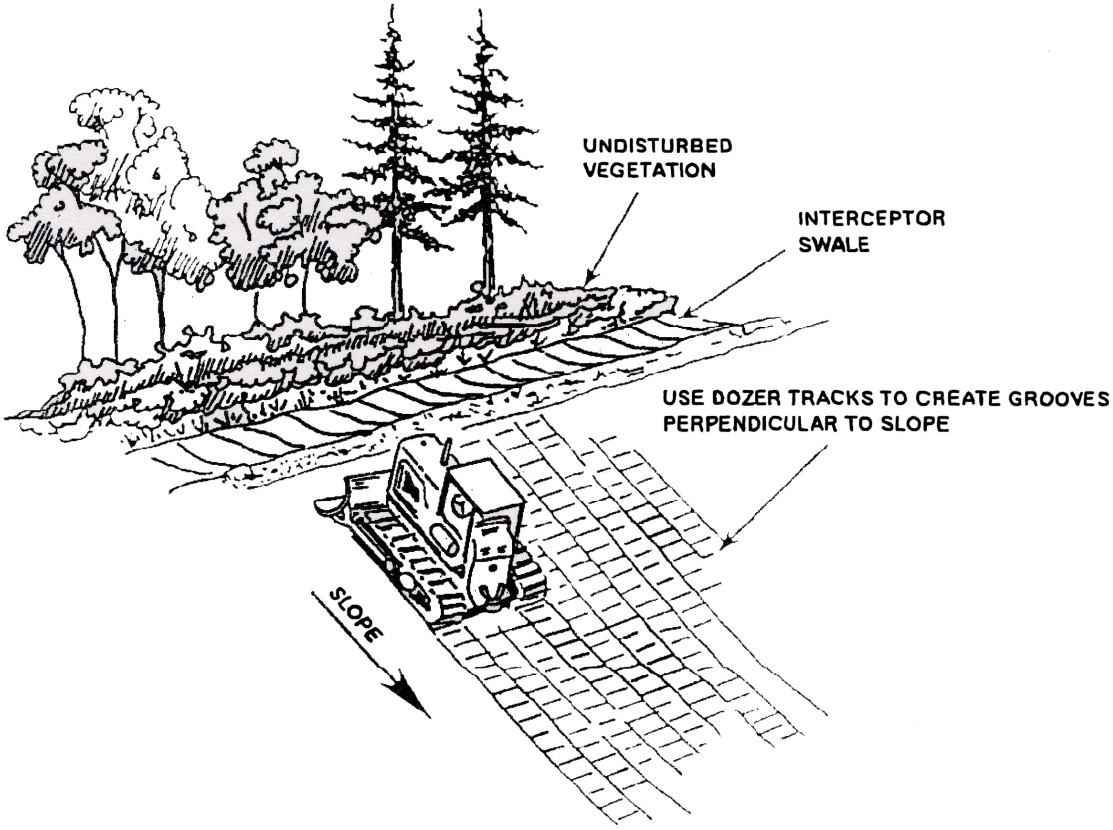
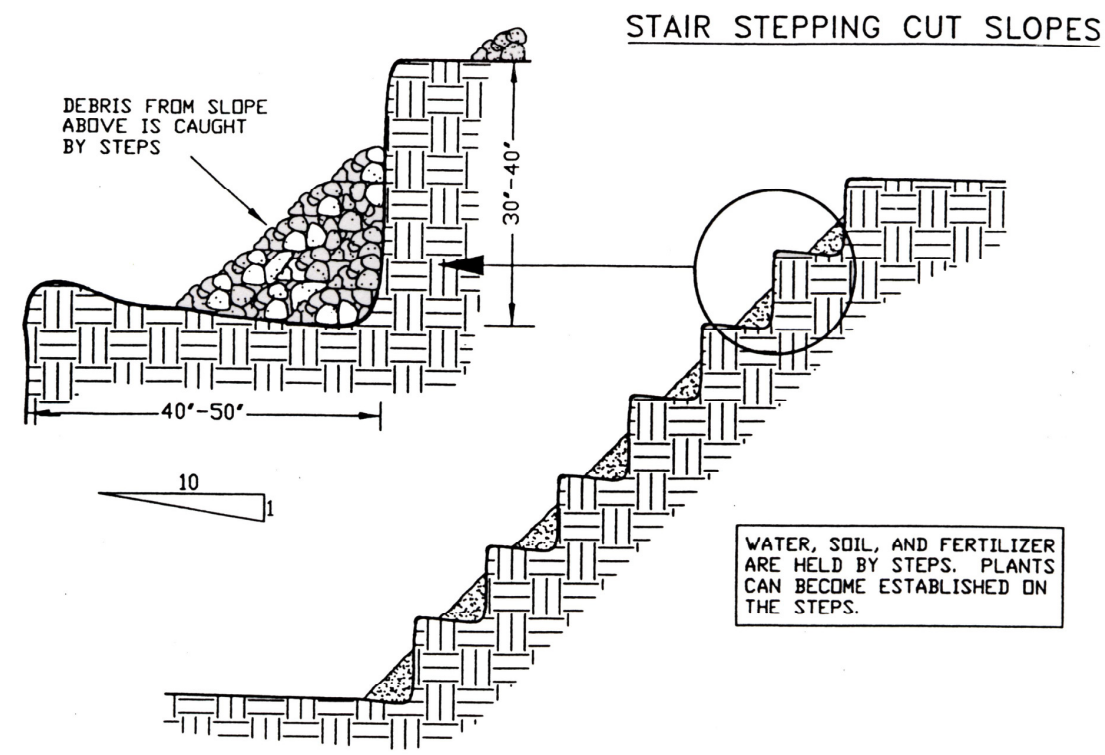
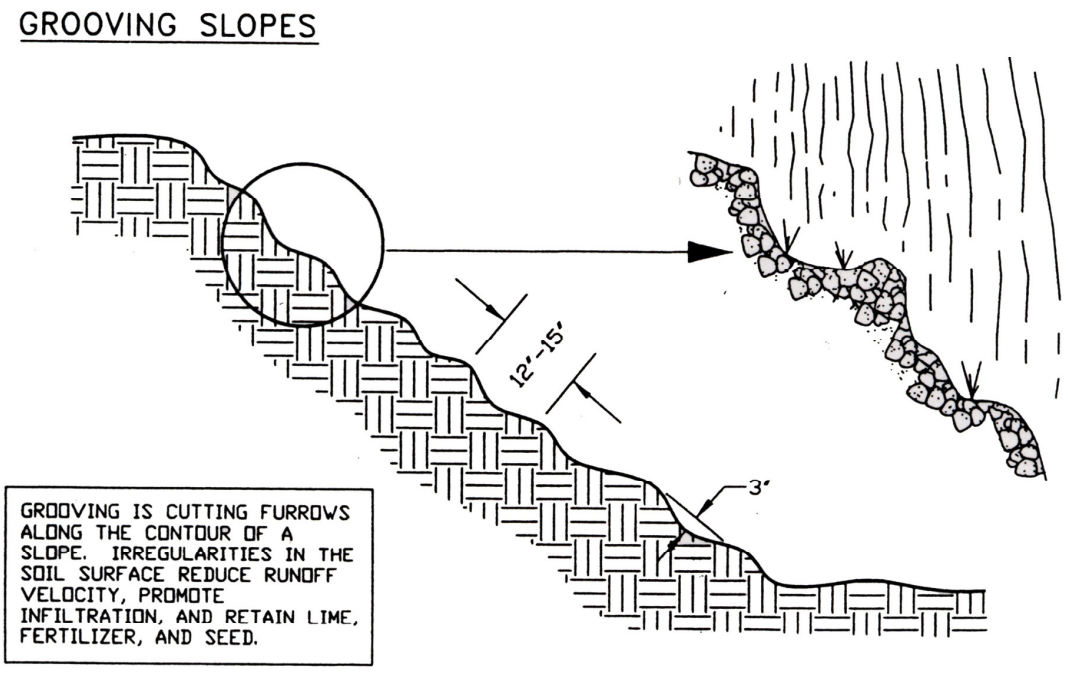


Diagram 4.2.5b

SURFACE ROUGHENING – STAIR STEPPING/GROOVING SLOPES





4.2.6 Check Dam

Small dams constructed across a swale or ditch to reduce velocities of concentrated flows, thereby reducing erosion in the swale or ditch. Check dams not only prevent gully erosion from occurring before vegetation is established, but also allow a significant amount of suspended sediment to settle out.

- Check Dams can be constructed from a variety of materials.
  - Rock: Rock material only
  - Bio-filter Bags: Bio-filter bags staked to the ground
  - Sand Bags
  - Pre-fabricated Check Dam System: A manufactured system specifically designed to slow water so that suspended particles settle out. Field fabricated systems are not allowed.

Advantages

- Prevent erosion and promote settling of sediment in runoff
- When carefully located and constructed, check dams may function as permanent installations.
- Reduces flow velocity
- Inexpensive and easy to install
- Rock can be spread into ditch and used as a channel lining when the check dam is no longer necessary.
- Some pre-fabricated check dams are reusable.

Disadvantages

- Removal may be costly for some types of check dams
- Suitable only for a limited drainage area
- May reduce hydraulic capacity of the channel
- May create turbulence downstream, causing erosion of the channel banks
- Ponded water may kill grass in grass-lined channels
- May be an obstruction to construction equipment

Design Criteria

- Space check dams according to the following table.

Table 4-9 Spacing for Check Dams

Ditch Grade	Minimum Weir Depth		
	6 inch	**12 inch**	**18 inch**
6%	**	16 feet O.C.	26 feet O.C.
5%	**	20 feet	30 feet
4%	**	26 feet	40 feet
3%	15 feet	33 feet	50 feet
2%	25 feet	50 feet	80 feet

** Not Allowed

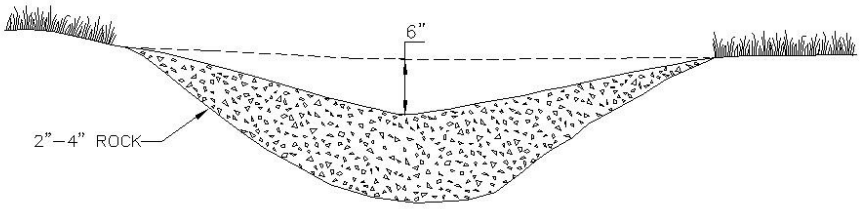
- In temporary or permanent channels not yet vegetated when installing channel lining is not feasible
- In small open channels that drain 10 acres or less
- Not for use in streams or rivers
- Construct rock check dams sized to stay in place given the expected design flow velocity. Typical rock size of three- six-inch. Place rock by hand or by mechanical means rather than dumping the rock.
- Bridge entire ditch or swale width and ensure the center of the dam is six inches lower than the outer ends.
- Remove check dams from grass-lined ditches and swales when the grass is established.
- Seed, mulch, or mat the area where the check dams were, immediately following removal.

Inspection and Maintenance

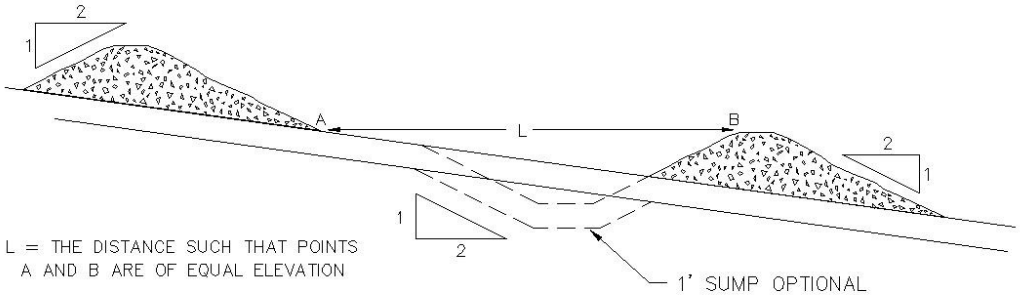
- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Remove sediment once it reaches one-third the depth of the rock weir.
- Replace rock weir when filtering capacity is reduced by one-half.

Diagram 4.2.6a

CHECK DAM - ROCK



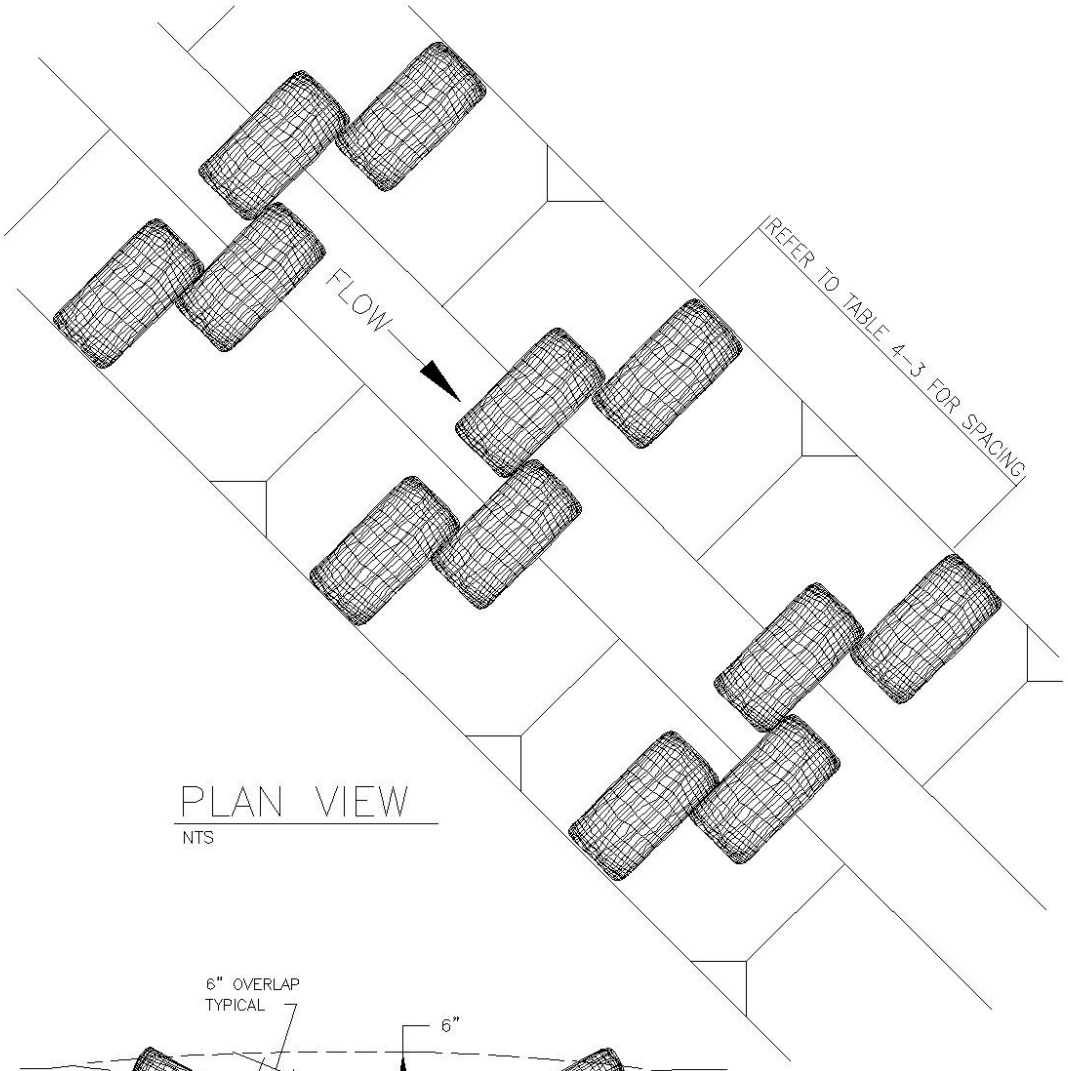
ROCK CHECK DAM



SPACING BETWEEN CHECK DAMS

Diagram 4.2.6b

CHECK DAM – BIO FILTER BAG



NOTES:

1. STAKING OF BAGS REQUIRED USING (2) 1"X2" WOOD STAKES OR APPROVED EQUAL PER BAG.
2. SURFACE MUST BE SMOOTH BEFORE APPLICATION.

4.2.7 Diversion Dike/ Swale

A ridge of compacted soil or a lined swale with vegetative lining located at the top, base, or somewhere along a sloping disturbed area. The dike or swale intercepts and conveys smaller flows along low-gradient drainage ways to larger conveyances such as ditches or pipe slope drains or to a stabilized outlet. Dikes and swales may be used singly or in combination with each other.

Advantages

- Provides a practical, inexpensive method to divert runoff
- Can handle flows from large drainage areas
- Use on-site material and equipment to construct

Disadvantages

- If improperly constructed, can contribute to erosion caused by concentrating the flow
- High flow velocity can damage vegetation
- Not effective for preventing illegal discharge

Design Criteria

- Refer to Table 4-10, "Dike Design Criteria" and Table 4-11, "Swale Design Criteria."
- Install the dike and/or swale horizontally at intervals across a disturbed slope. Space horizontal interceptor dikes and swales according to Tables 4-10 and 4-11.
- For slopes of erodible soils, steeper than 2:1 with more than 10 feet of vertical relief, construct benches or shorten distance between dikes or swales.
- If the dike or swale intercepts runoff from disturbed areas, discharge the runoff to a stable conveyance that routes the runoff to a sediment trap or basin.
- If the dike or swale intercepts runoff that originates from undisturbed areas, discharge the runoff to a stable conveyance that will route the runoff downslope of any disturbed areas and release the water at a stabilized outlet.
- May need matting to protect seed bed and channel from erosion.

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Immediately repair damage resulting from runoff or construction activity.
- If the dike or swale regularly overflows, increase the capacity and/or frequency of the dikes/swales.
- Inspect and repair as necessary after every major storm.
- Minimize construction traffic over temporary dikes and swales.
- Clean out clogged pipes (as part of the swale system) under roads.

Table 4-10 Diversion Dike Design Criteria

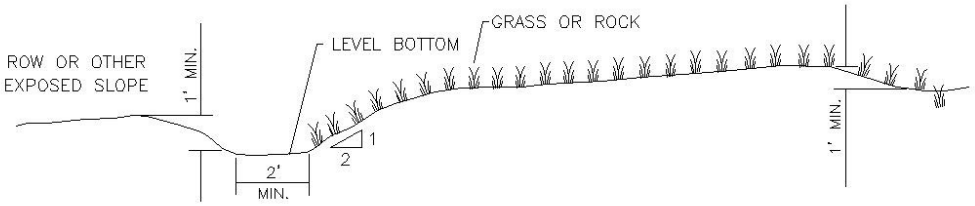
Top Width	24 inch minimum	
Height	20 inch minimum Measured from upslope toe and at a 90% standard proctor compaction ASTM D698.	
Side Slopes	2:1 or flatter	
Grade	Topography Dependent	
Dike grade	Between 0.5-1%	
Slope of Disturbed Area vs.Horizontal Spacing	< 5%	300 feet
	5-10%	200 feet
	10-25%	100 feet
	25-50%	50 feet
Slope Stabilization	<5% Seed and mulch within 5 days following dike construction	
	5-40% Stabilize immediately using either sod or riprap.	
Outlet	Upslope side of dike provides positive drainage to the outlet.Provide energy dissipation as necessary to prevent erosion. Release sediment-laden runoff to a sediment trapping facility.	

Table 4-11 Diversion Swale Design Criteria

Bottom Width	24 inch. The bottom should be level across the swale.	
Depth	12 inch	
Side Slopes	2:1 or flatter	
Grade	Maximum 5% with positive drainage to a suitable outlet.	
Slope of Disturbed Areavs. Horizontal Spacing	<5%	300 feet.
	5-10%	200 feet.
	10-25%	100 feet.
	25-50%	50 feet.
Slope Stabilization	Temporarily seed or line with riprap 12 inch thick and press into thebank approximately 3-4 inch	
Outlet	Level spreader or riprap to stabilized outlet/sedimentation pond.	

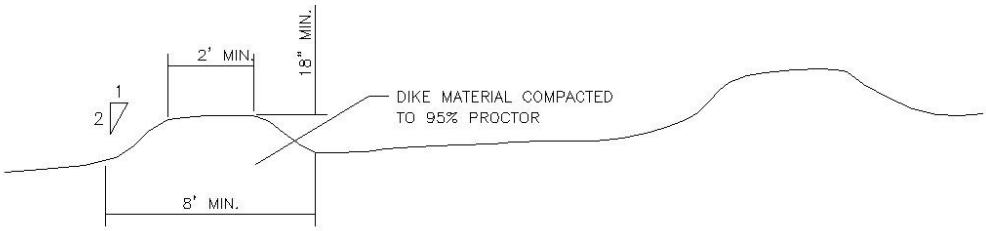
Diagram 4.2.7

DIVERSION DIKE / SWALE



BOTTOM WIDTH	2 FEET MINIMUM; THE BOTTOM WIDTH SHALL BE LEVEL
DEPTH	1 FOOT MINIMUM
SIDE SLOPE	2H:1V OR FLATTER
GRADE	MAXIMUM 5 PERCENT, WITH POSITIVE DRAINAGE TO A SUITABLE OUTLET (SUCH AS SEDIMENTATION POND)

DIVERSION SWALE



TEMPORARY DIVERSION DIKE

Slope	Spacing
<5%	300 feet
5–10%	200 feet
10–40%	100 feet

NOTE:
IMMEDIATELY UPON CONSTRUCTION, ESTABLISHED VEGETATION OR EROSION CONTROL BLANKETS ARE REQUIRED.

4.2.8 Grass-lined Swale

A channel with vegetative lining constructed to convey and dispose of concentrated surface runoff without damage from erosion, deposition, or flooding.

Advantages

- Does not generate high velocity runoff and offers temporary slope protection, which is superior to plastic sheeting
- Capture a great deal of sediment due to the filtering effect of vegetation
- Usually easy to install

Disadvantages

- Requires temporary irrigation to establish vegetation
- Cannot be used until vegetation is established

Design Criteria

- As a minimum, grass-lined channels should carry a peak runoff from a 10-year storm event without eroding. Where flood hazards exist, increase the capacity according to the potential damage. The allowable design velocity for grassed-lined channels is based on soil conditions, type of vegetation, and the method of establishment. The channel shape may be parabolic, trapezoidal, or v-shaped, depending on the need and site conditions. Small check dams or flow spreaders may be necessary to minimize channelization.

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- During the initial establishment, grass-lined channels should be repaired and grass re-established if necessary.
- After grass has become established, the channel should be checked periodically to determine if the channel is withstanding flow velocities without damage.
- Check the channel for debris, scour, or erosion and immediately make repairs. It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes and make repairs immediately.
- Remove all significant sediment accumulations to maintain the designed carrying capacity.
- Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.
- Permanent grassed waterways should be seasonally maintained by mowing and/or irrigating, depending on the type of vegetation selected.
- Newly seeded areas need to be inspected frequently to ensure the grass is growing.
- If the seeded area is damaged due to runoff, additional storm water measures such as check dams or matting may be needed.

4.3 Sediment Control Practices

Once soil erosion occurs, sediment trapping or removal techniques can reduce the amount of sediment and associated pollutants that leave the site, thus protecting nearby streams, wetlands, and lakes. Sediment controls are usually placed around the perimeter of a disturbed area and where concentrated water leaves the site. Sediment control BMPs should be in place before land clearing and grading begins. It is important to note that sediment controls, if poorly maintained, can become sources of sediment and other pollutants during larger storms. Sediment control BMPs include:

1. Sediment Fence
2. Bio-filter Bags
3. Sand Bags
4. Filter Berm
5. Wattles
6. Sidewalk Subgrade Gravel Barrier
7. Fabricated Barriers
8. Inlet Protection
9. Dewatering
10. Sediment Trap
11. Sediment Basin

4.3.1 Sediment Fence

Temporary sediment trap consisting of an entrenched geotextile stretched across and attached to supporting posts. Sediment fences are adequate to treat flow depths consistent with overland or sheet flow. Standard or heavy duty sediment fence fabric must meet specific ASTM requirements, outlined in Table 4-13.

Advantages

- Reduces runoff velocity
- Requires minimal ground disturbance to install
- Relatively inexpensive

Disadvantages

- Applicable to small drainage areas and overland flow; not applicable to concentrated flows
- Incorrect geotextile or installation decreases sediment fence performance
- Requires frequent maintenance and inspection

Design Criteria

- See Table 4-13 for Sediment Fence Fabric Specifications
- Show sediment fence installed along ground contours according to Table 4-12
- Sediment fence should only be used for sheet and rill erosion
- Standard or heavy-duty sediment fence filter fabric shall have manufactured stitched loops with 2” × 2” × 4’ posts. Stitched loops shall be installed on the uphill side of the sloped area.

- Sediment fences should be installed a minimum of 3 feet from toe of slope in order to maximize storage.
- A trench should be excavated 6 inches deep along the line of the posts.
- Trench should be backfilled and the soil compacted on both sides of the sediment fence.
- Posts should be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 12 inches.
- When sediment fence approaches it's termination point, turn fence uphill and extend one full panel (6 ft).
- When joining two or more sediment fences together, join the two end stakes by wrapping the two ends at least one and one half turns and driving the joined stakes into the ground together.
- Height of a sediment fence should not exceed 3 feet. Storage height and ponding height should never exceed 1.5 feet.

Table 4-12 Barrier Spacing for General Application

BARRIER SPACING FOR GENERAL APPLICATION

INSTALL PARALLEL ALONG CONTOURS AS FOLLOWS		
% Slope	Slope	Maximum Spacing on Slope
10 % Flatter	10:1 or Flatter	300 ft
10 > % < 15	10:1 > x < 7.5:1	150 ft
15 > % < 20	7.5:1 > x < 5:1	100 ft
20 > % < 30	5:1 > x < 3.5:1	50 ft
30 > % < 50	3.5:1 > x < 2:1	25 ft

Table 4-13 Sediment Fence Fabric Specifications

WOVEN POLYPROYLENE SEDIMENT FENCE FABRIC

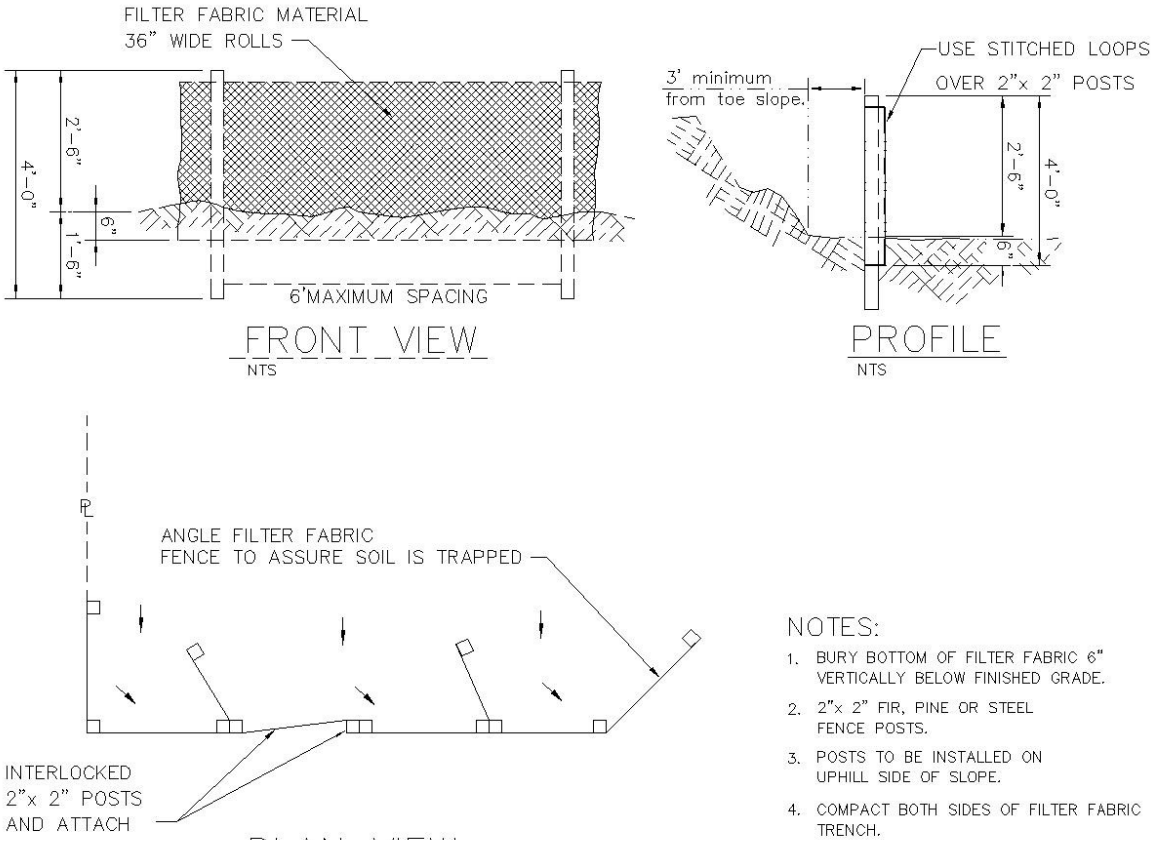
PROPERTY	TEST PROCEDURE	MINIMUM FABRIC VALUE
Grab Tensile Strength	ASTM D-4632	180 lbs.
Grab Elongation	ASTM D-4632	15%
Trapezoid Tear	ASTM D-4533	70 lbs.
Mullen Burst	ASTM D-3786	300 psi
Puncture	ASTM D-4833	80 lbs
Permitivity	ASTM D-4491	.07 sec -1
Permeability	ASTM D-4491	.005 cm/sec
Apparent Opening Size (AOS)	ASTM D-4751	50 U.S. Sieve
UV Resistance (500 hrs)	ASTM D-4355	90%

Inspection & Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5 inch rain event
- Immediately repair any damage.
- Remove accumulated sediment once it has reached ⅓ the height of the sediment fence or 1 ft maximum.
- Inspect for channel formation parallel to the fence, which indicates the geotextile is acting as a flow barrier.
- Replace deteriorated or clogged geotextile.
- Check for under cutting or piping under fence.

Diagram 4.3.1

SEDIMENT FENCE



PLAN VIEW

4.3.2 Biofilter Bags

Biofilter bags are manufactured from 100 percent recycled wood-product waste placed in plastic mesh bags.

Advantages

- Relatively low cost
- Can be used in place of sediment fences at toe of slope, without trenching in
- Wood-product can be recycled or used on site when no longer needed
- Installation is simple, can be done by hand
- Bags are easy to move, replace, and reuse on paved surfaces
- Are good short-term solution in situations where concentrated flows are causing erosion.

Disadvantages

- Generally effective for only a few months
- Can be easily damaged by construction equipment or by traffic in paved areas
- Can become clogged with sediment and cease to filter runoff
- If improperly installed can allow undercutting or end-flow
- Not effective where water velocities or volumes are high
- Light weight results in higher buoyancy if not properly installed
- Low sediment retention capacity may require frequent maintenance

Design Criteria

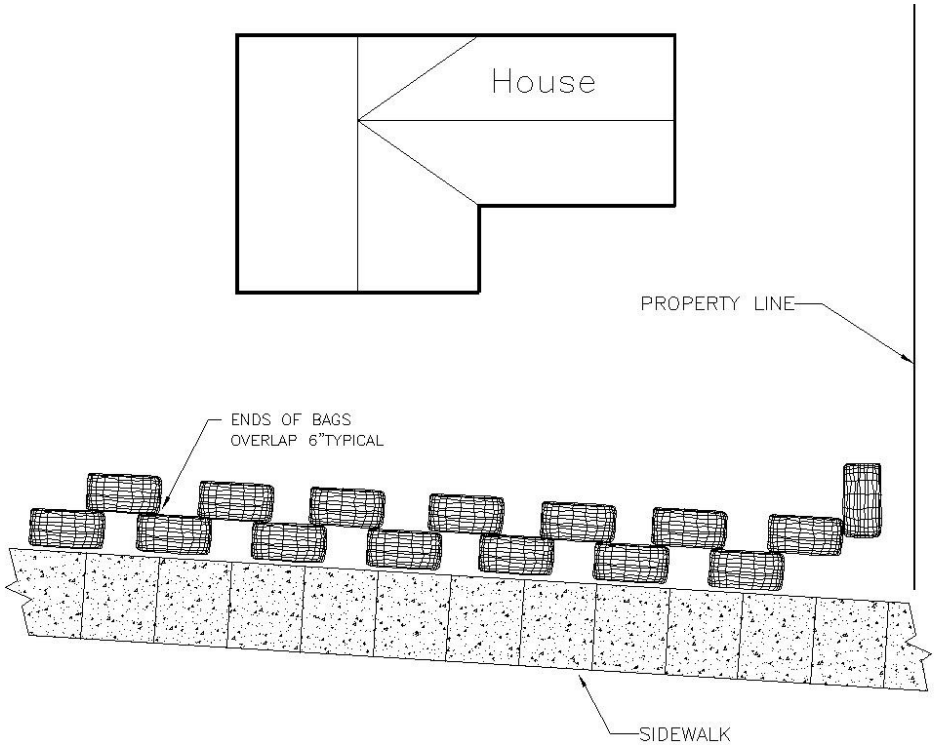
- Bio-filter bags should be clean 100 percent recycled wood product waste. Standard size 10 × 8 × 30 inches, weight approximately 45 pounds, with ½-inch plastic netting
- May be left in place or used as mulch once they have served their purpose
- Surface area should be smooth
- Use (2) 1 × 2 inch stakes per bag, driven 12 inches into ground.
- Ends of bags must be overlapped six inches to prevent piping between joints.

Inspection and Maintenance

- Requires routine inspection
- Check that stakes are secure and ends of bags are tightly overlapped. Check that undercutting or end-flow is not occurring.
- Inspect plastic mesh bags for tears
- Remove sediment when 1/3 height of bag has accumulated
- Replace damaged bags as needed.

Diagram 4.3.2

BIOFILTER BAGS



PLAN VIEW
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NOTE:

1. STAKING OF BAGS REQUIRED USING (2) 1"x 2" WOOD STAKES OR APPROVED EQUAL PER BAG.
2. BAGS ARE USED AS ALTERNATE FOR SEDIMENT FENCE FOLLOWING INSTALLATION OF SIDEWALK ON SINGLE FAMILY CONSTRUCTION ONLY.

4.3.3 Sand Bags

Sandbags are manufactured from durable, weather-resistant, tightly-woven, Geotextile fabric material sufficient to prohibit leakage of the filler material. The bags should measure 24 × 12 × 6 inches and be filled with firmly packed sand weighing at least 75 pounds.

Advantages

- Relatively low cost
- Installation is simple, can be done by hand
- Bags are easy to move, replace, and reuse on paved surfaces
- Are good short-term solution in situations where concentrated flows are causing erosion
- Can be used to divert and slow velocity of small flows
- Can be used in concrete lined ditches to capture sediment and reduce water velocity

Disadvantages

- Generally effective for only a few months
- Can be easily damaged by construction equipment or by traffic in paved areas
- Can contribute sediment to runoff if bags rupture
- Cannot be staked and are not appropriate on steep slope applications
- Not effective in steep swales, channels, or ditches
- If improperly installed can allow undercutting or end-flow
- Not effective where water velocities or volumes are high, can get washed away

Design Criteria

- Generally used in ditches and/or swales as a check dam
- Can be used on highway or road projects to divert run-off
- Ends of bags must be tightly abutted and overlapped to direct flow away from bag joints

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Check that ends of bags are tightly abutted. Check that undercutting or end-flow is not occurring.
- Remove sediment accumulated behind bags when sediment reaches one-third of the barrier height.
- Replace damaged bags as needed.

4.3.4 Filter Berm

Sediment is retained in gravel or crushed rock berm.

Advantages

- Very efficient method for sediment removal.
- Reduces runoff velocity.

Disadvantages

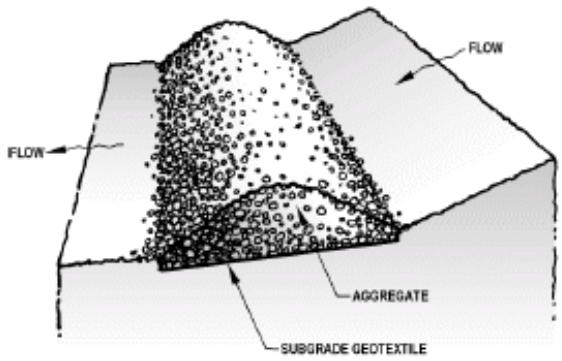
- More expensive than some other measures because requires clean gravel or crushed rock rather than materials found onsite.
- Clogging from mud and soil may make maintenance difficult.
- Has a limited life span.

Design Criteria

- Use two inches maximum washed and well-graded gravel or crushed rock with less than five percent fines.
- Berm Dimensions:
  - Height and side slopes: one foot high with 3:1 side slopes
  - Length: Eight feet per one cubic foot per second flow, based on the peak flow for the 10-year storm.
  - If used as slope application, use Table 4-12 for spacing.
  - Used primarily as a base measure (toe of slope)

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Remove and replace rock when filtering capacity is reduced by half to maintain performance.
- Removed sediment accumulation when it reaches one-third of the barrier height.



4.3.5 Wattles

Wattles are manufactured from straw, coconut, or other material wrapped in tubular plastic netting. They are approximately eight to nine inches diameter by seven to 25 feet long. Wattles are placed in shallow trenches and staked along the contour of newly constructed or disturbed slopes.

Advantages

- They can often replace sediment fences on steep slopes
- Wattles store moisture for vegetation planted immediately upslope
- May be left in place to biodegrade and/or photodegrade, adding organic material to the soil
- Reduces runoff velocity
- Light weight and easy to install

Disadvantages

- Wattles only function for one or two seasons.
- If not installed properly with sufficient trench, wattles may fail during the first rain event
- Wattles may require maintenance to ensure the stakes are holding and the wattles are still in contact with the soil. This is especially true on steep slopes in sandy soil.
- Low sediment retaining capacity may require frequent maintenance.

Design Criteria

- Wattles can be made from straw, coconut, or other approved material.
- Slope requires minor preparation prior to installation.
- Rills and shallow gullies should be smoothed as work progresses.
- Wattles should be installed on contours. Trench should be deep enough to accommodate half the thickness of the wattle.
- Wattles should be installed from the bottom of the slope up.
- Wattle must be tight against the soil with no gaps between the soil and the wattle in the trench.
- If live willow stakes are installed, use a straight bar to drive holes through wattles.
- Stakes must be driven a minimum of 12 inches into undisturbed material.
- Install stakes every four feet. Additional stakes may be needed on highly erosive or very steep slopes.

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Make sure the wattles are in contact with the soil.

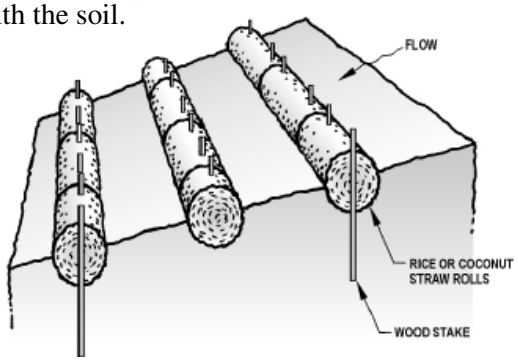
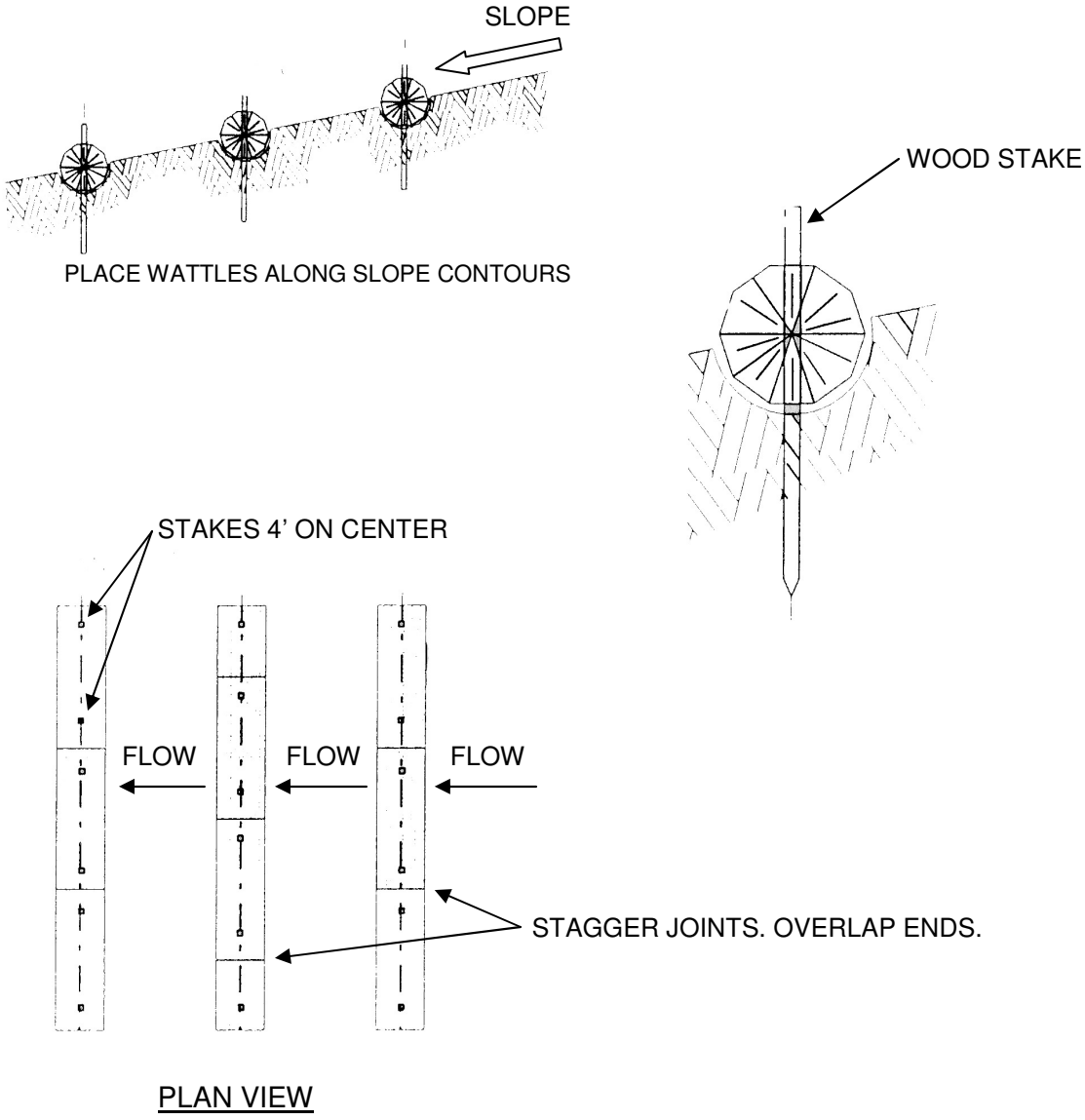


Diagram 4.3.3

WATTLES



4.3.6 Sidewalk Sub-grade Gravel Barrier

A sidewalk sub-grade gravel barrier is an application that provides storage and filtration from run-off on sites with mild slopes. It can be used on all types of projects but generally on single family dwellings. Normal installation occurs when excavating for footing and foundation.

Advantages

- Easy to install
- Very economical
- Can retain suspended soils

Disadvantages

- May require additional measure depending upon soil type
- May need periodic maintenance for removal of suspended materials
- May not be an adequate sediment barrier for steep lots or concentrated flows

Design Criteria

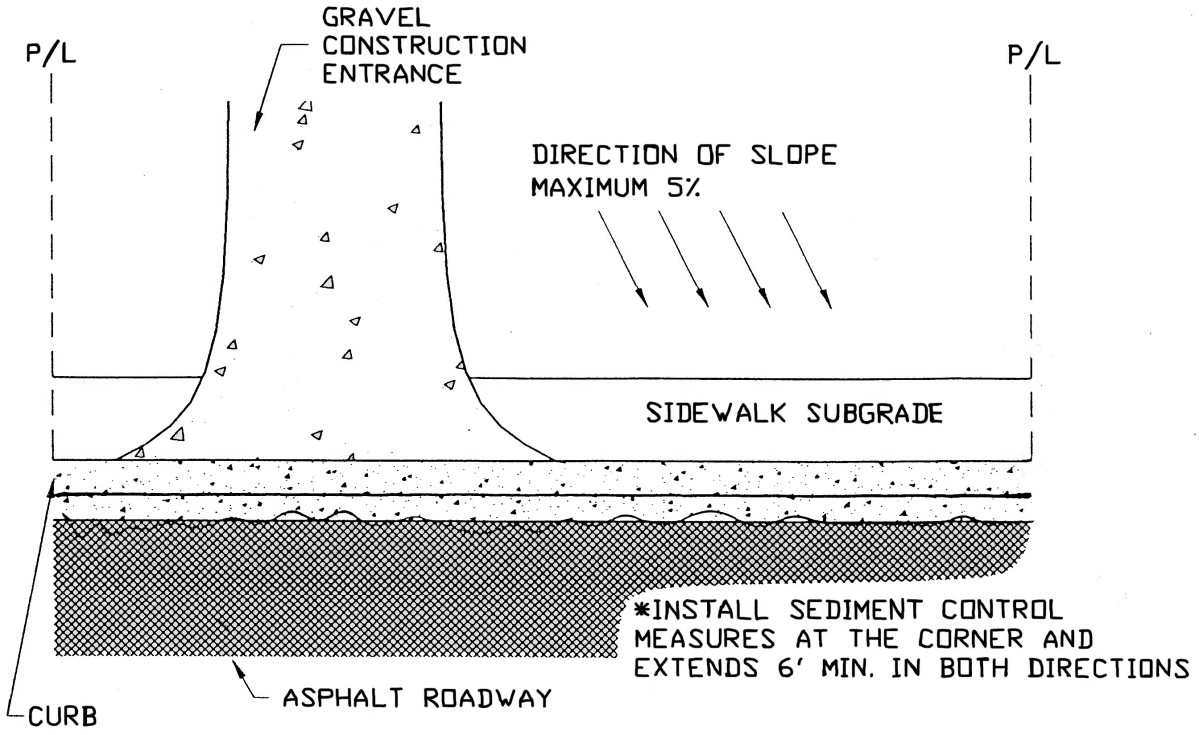
- Install where the site slopes to a street with curbs and slopes are five percent or less
- Plug all weep holes in curb
- Sidewalk sub-grade must have a minimum four-inch depth and a four-foot width.
- A two inch layer of approved sub-base material must be installed
- A gravel filter berm may be installed along the inside edge, or toe of slope to increase filtration
- Install sediment barrier on the downhill corner of property to intercept run-off
- On development sites, install sidewalk sub-grade as part of post construction
- On single family sites, install as part of the footing/foundation excavation
- If sidewalk concrete is to be poured prior to establishment of permanent site cover, approved sediment barriers must be installed prior to pouring sidewalk
- Sidewalk construction is required to conform to the City of Albany *Standard Construction Specifications*, in addition to measures undertaken in this section.

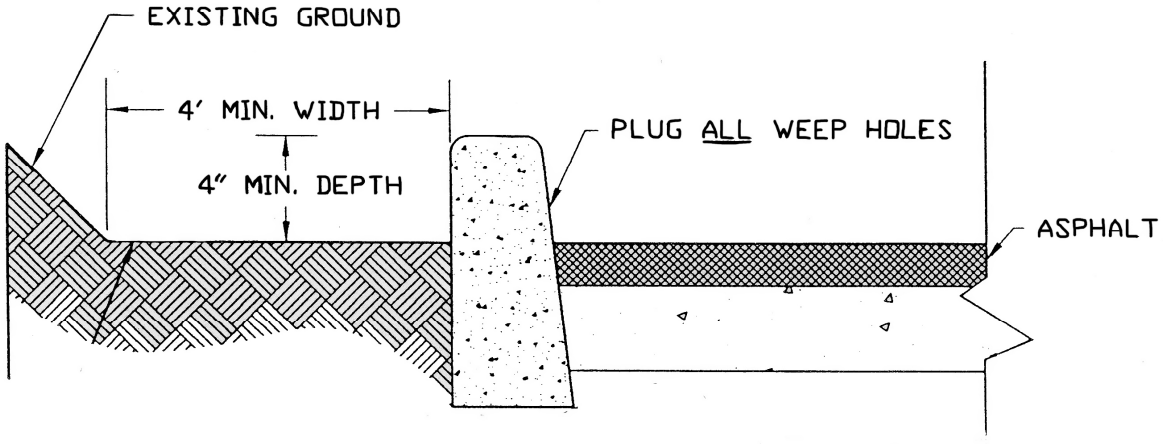
Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Remove and replace gravel when filtering capacity is reduced by half, to maintain performance

Diagram 4.3.6

SIDEWALK SUBGRADE GRAVEL BARRIER





4.3.7 Inlet Protection

This BMP prevents coarse sediment from entering the storm drainage system by filtering runoff and retaining sediment before it reaches a drainage inlet or the storm sewer system. There are many options and variations of inlet protection available.

Advantages

- Prevents sediment from entering the storm drain system
- Reduces amount of sediment leaving the site

Disadvantages

- May result in ponding of water above the catch basin
- Sediment removal may be difficult under high-flow conditions
- May result in a traffic hazard
- Short-circuiting of flow may occur if not properly installed
- Useful only for low flows having low sediment loading
- Improper installation, maintenance, or removal may introduce sediment into the storm drain system

Design Criteria

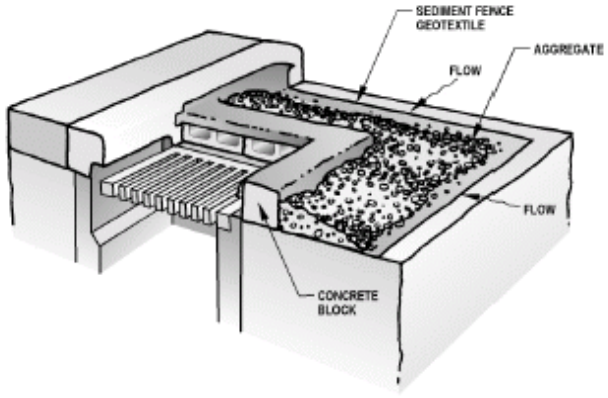
- Place inlet protection in areas where water can pond, and where ponding will not have adverse impacts.
- Inlet protection must allow for overflow in a severe storm event.
- Addition measures must be considered depending upon soil type.
- Inlet protection types include:
- Type 1 – Rock and wire mesh
- Type 2 – Masonry and rock
- Type 3 – Sediment fence
- Type 4 – Biofilter bags
- Type 5 – Catch basin insert

Inspection and Maintenance

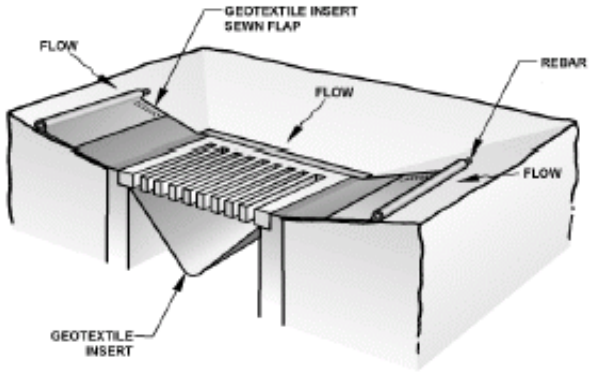
- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Clean inlet protection during and after each significant storm and remove sediment from behind structure after every storm.
- If the rock becomes clogged with sediment, it must be carefully removed from the inlet and either cleaned or replaced.
- Assess the impacts of allowing water to pond at the inlet and provide an overflow weir or some other type of relief as needed.
- Consider the effect of placing obstructions at inlets on grade may have on their efficiency.
- Use mechanical means to remove sediment deposits (shovel, broom, sweeper/vactor unit.
- Remove sediment accumulated on or around the protection as needed to maintain intended functions.
- Repair or replace materials as needed to ensure proper functioning.

4.3.7 (cont'd.) Inlet Protection

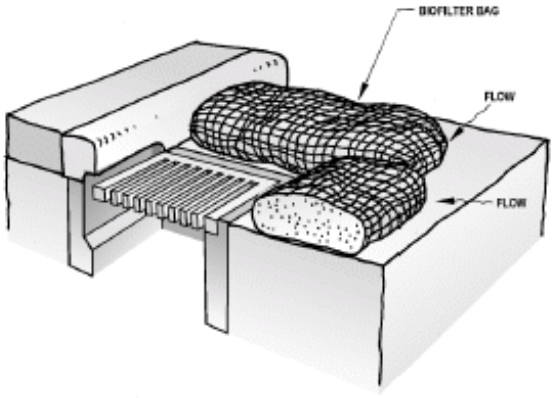
Masonry / Aggregate
Type 2



Prefabricated Filter Insert
Type 5



Biofilter Bags Around Catch Basin
Type 4



Biofilter Bags Around Area Drain
Type 4

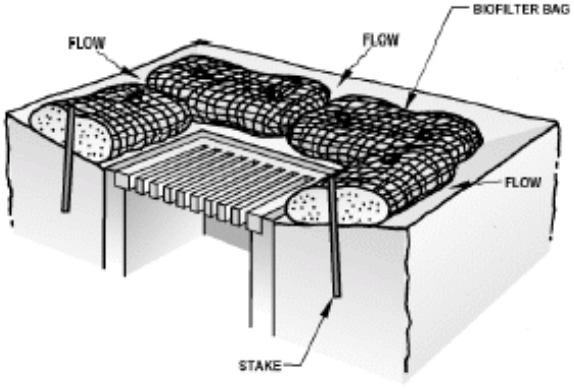
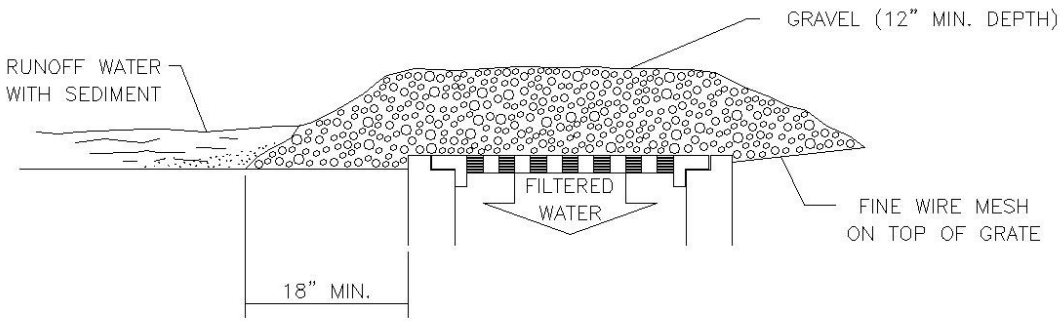


Diagram 4.3.7a

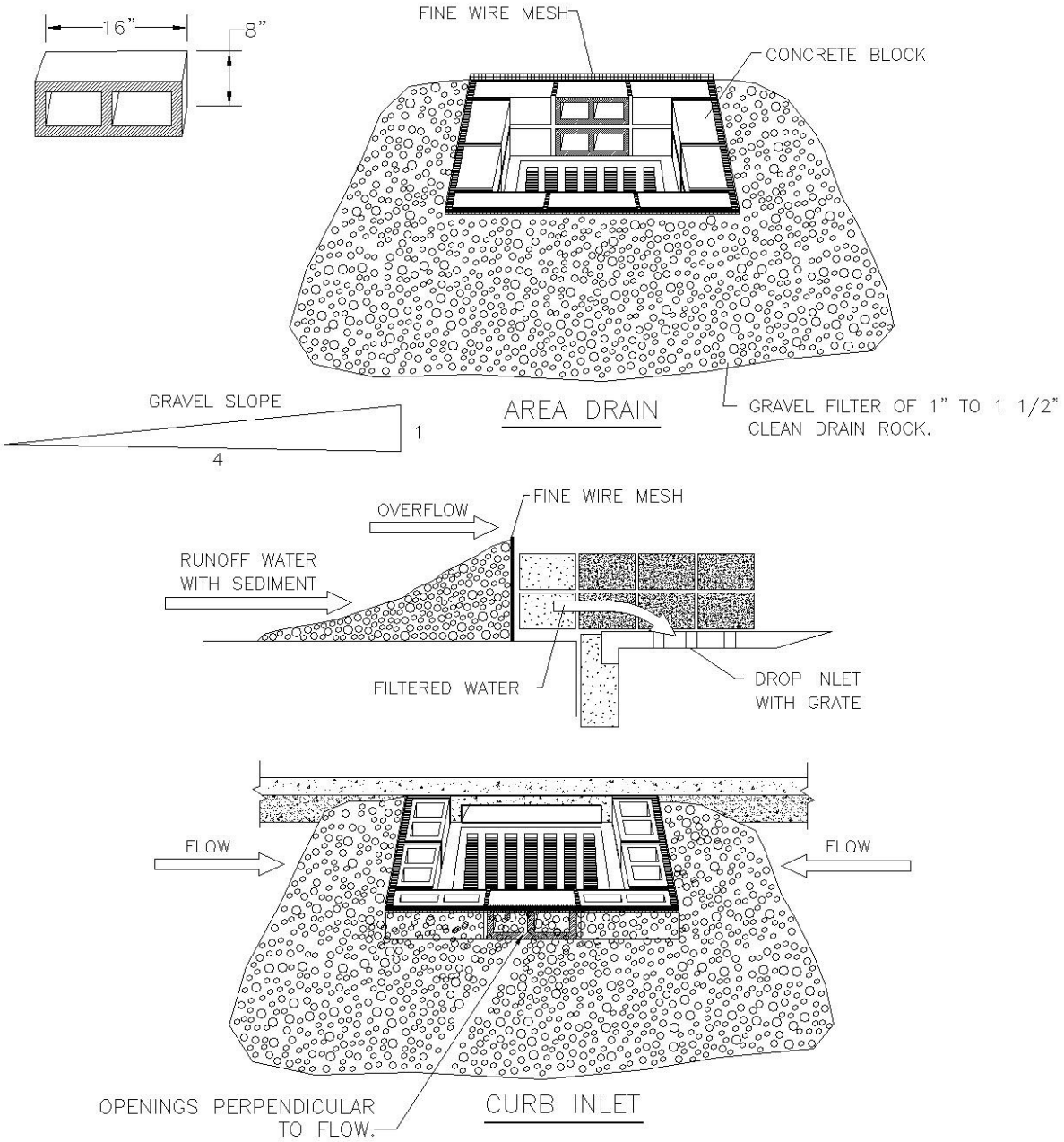
INLET PROTECTION TYPE 1



GRAVEL & WIRE MESH

Diagram 4.3.7b

INLET PROTECTION TYPE 2



BLOCK AND GRAVEL INLET BARRIERS

NOTE:

1. BLOCKS SHALL BE STACKED WITH THE OPENINGS ON THE TOP AND BOTTOM EXCEPT FOR THE CENTER BLOCKS. CENTER BLOCKS WILL HAVE OPENINGS PERPENDICULAR TO FLOW.

Diagram 4.3.7c

INLET PROTECTION TYPE 3

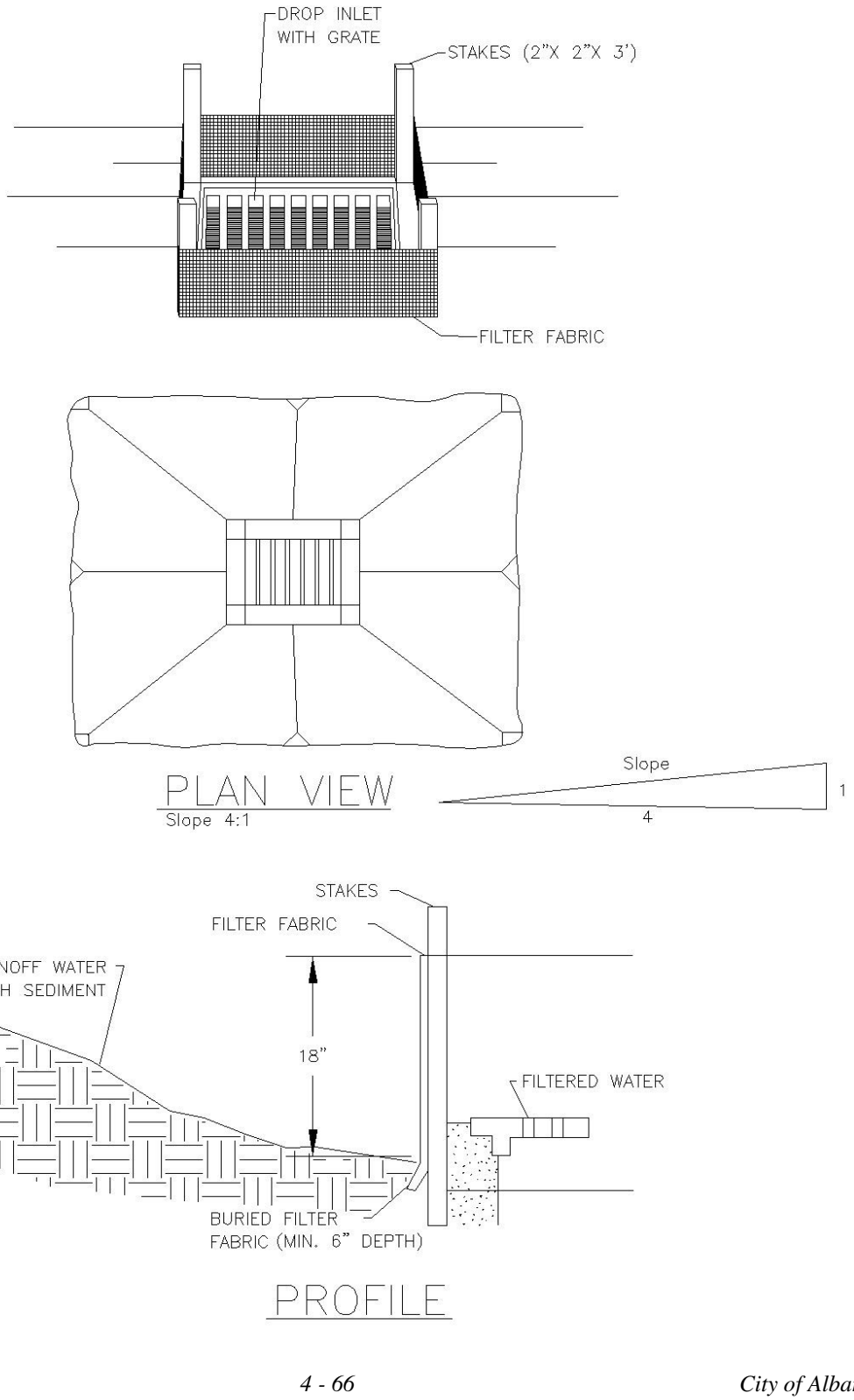
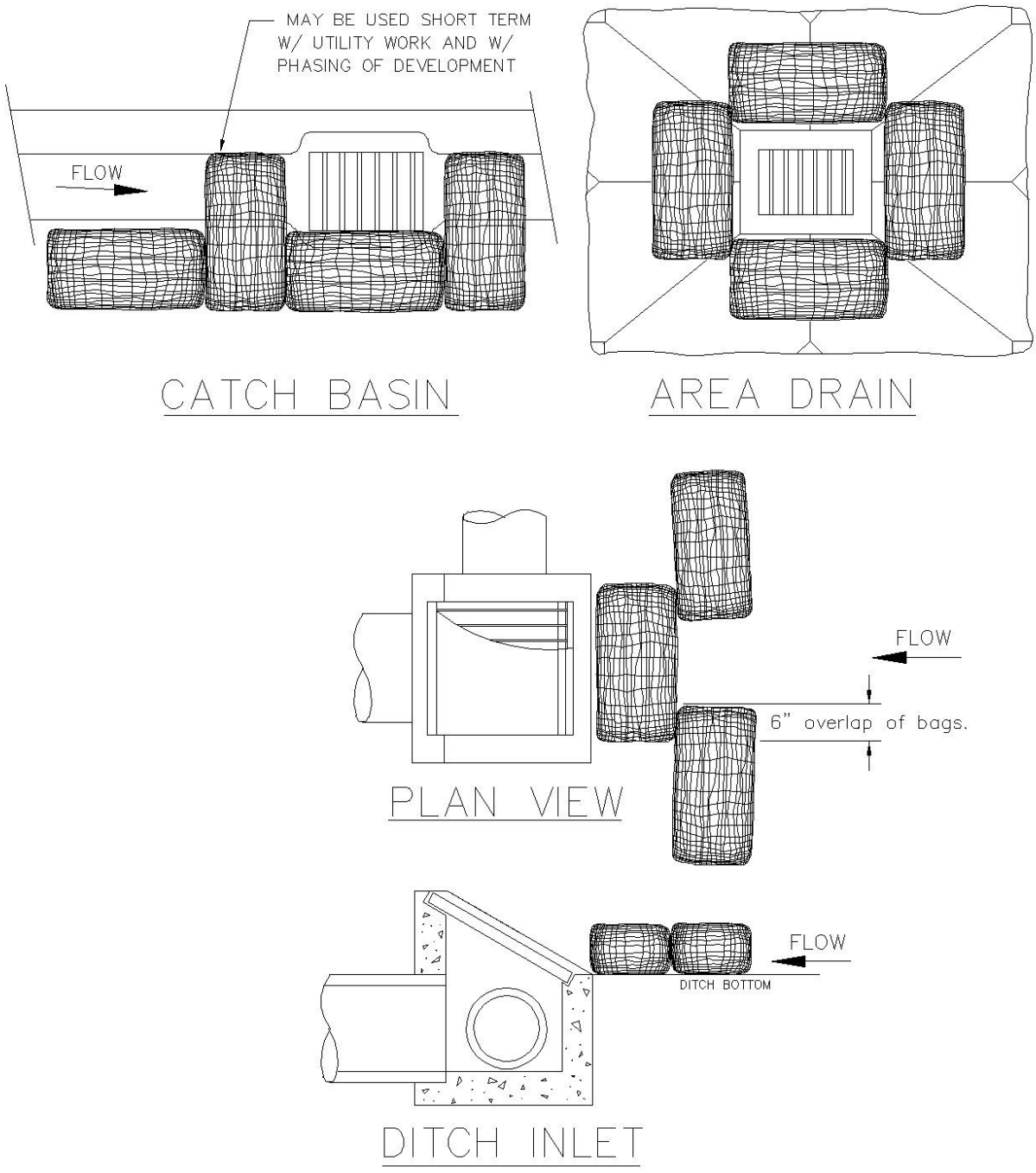


Diagram 4.3.7d

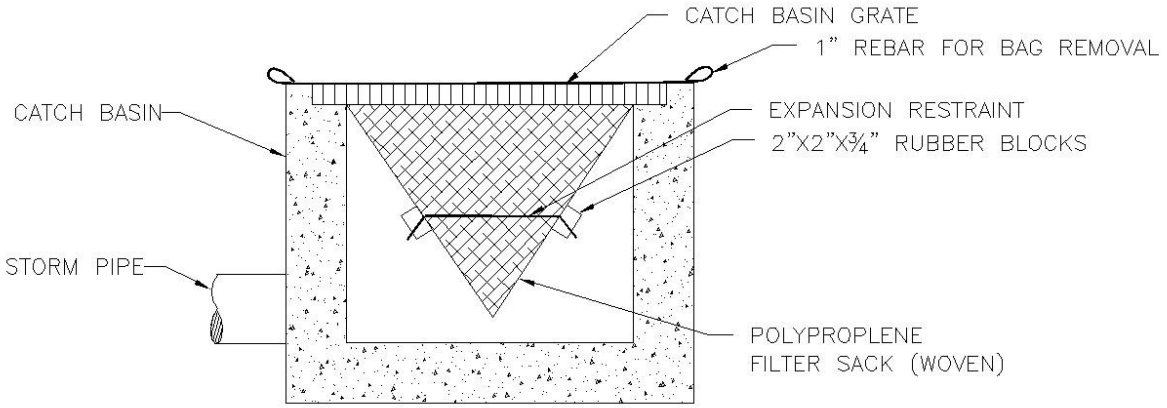
INLET PROTECTION TYPE 4



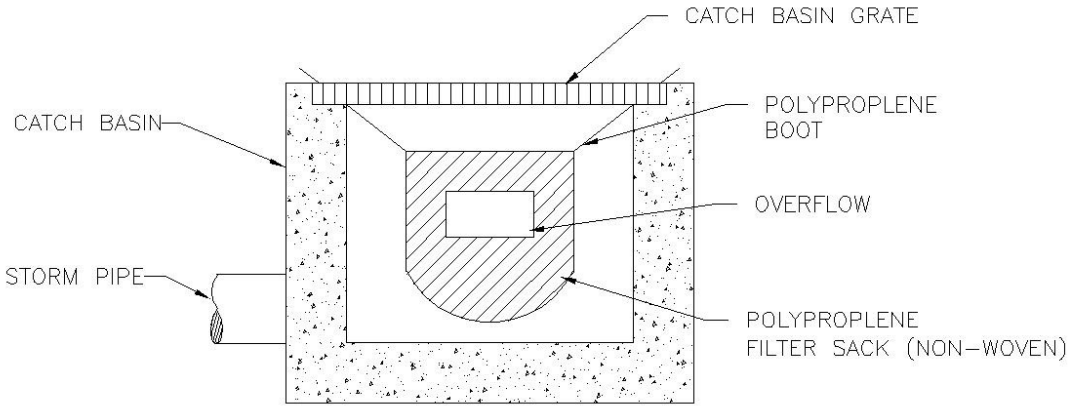
NOTES:
1. ADDITIONAL MEASURES MUST BE CONSIDERED DEPENDING ON SOIL TYPES.
2. BIOFILTER BAGS SHOULD BE STAKED WHERE APPLICABLE USING (2) 1"x2" WOODEN STAKES OR APPROVED EQUAL PER BAG.

Diagram 4.3.7e

INLET PROTECTION TYPE 5



WOVEN POLYPROPLENE SACK



NON-WOVEN POLYPROPLENE SACK

NOTE:
1. RECESSED CURB INLET CATCH BASINS MUST BE BLOCKED WHEN USING FILTER FABRIC INLET SACKS. SIZE OF FILTER FABRIC INLET SACKS TO BE DETERMINED BY MANUFACTURER.

4.3.8 Dewatering

Temporary settling and/or filtering devices for water which is discharged from dewatering operations. Filtration is the separation of sediment from a fluid by passing the fluid through a permeable medium that will trap a high percentage of the particles. This is not a new concept; it has been employed in all types of industries, for various type of liquids, including water. The equipment necessary for filtration applications associated with water containing sediment would be weir tanks, gravity boxes, non-contained sediment bags, sand media filtration, and bag/cartridge chambers. There are two types of filtration systems, gravity and pressure.

Advantages

- Excellent for utility work such as repairs, replacements, or new installations
- Depending upon the choice of filtration systems, can remove small particles of silt and clays
- Can be used as an alternate to sediment trap/basin on smaller sites
- Can hold large amounts of sediment which reduces overall maintenance
- Can be used in conjunction with other types of filters as a pre-filter
- Can be easily mobilized from site to site

Disadvantage

- Limited storage capacity depending upon the site
- Have limitations in removing silts and clays, depending upon selection
- May require heavy equipment to load and unload system
- May be cost inhibitive

Design Criteria

- Determine soil type prior to selecting type of Dewatering system.
- Select an appropriate location that will reduce overall impacts.
- Weir tanks, Filter Boxes are effective for removal of large particles such as sand.
- Sand Media Filters are effective for removal of smaller particles such as sand and silt.
- Filter bags can remove large particles until fabric pores start to fill in or cake over, then filter capacity increases to smaller sand and silt.
- Filter bags should be placed in a heavily vegetated area to increase their efficiency.
- Cartridge Filter Units will remove smaller particles such as silt and clay.
- Rock Berms, Bio-filter Bags, or Sediment Fence shaped in a half circle and stages in a series of three can be installed as an alternate, or in conjunction with other systems.

Inspection and Maintenance

- Ongoing inspection is necessary in order to detect any malfunctions or operation of equipment.
- Periodic inspection of discharge areas.
- Remove sediment when it reaches 1/3 capacity of a sediment barrier.
- Material must be placed in an approved location on site or exported from site.

4.3.9 Sediment Trap

A sediment trap consists of a small, temporary ponding area, with a rock weir or perforated riser pipe at the outlet, formed by excavation or by constructing a weir. The sediment trap serves drainage areas five acres and smaller. They are a retention structure designed to remove sediment from runoff by holding a volume of water for a length of time, allowing particles 0.02 mm and large to settle out. Sediment retention should be used as a last line of defense when included in a ESCP and never used by itself.

Combining with Permanent Drainage Facilities

- If a project includes a permanent storm water retention/detention pond, the rough-graded or final-graded facility could function as a trap during construction. Design features of the permanent structure, such as surface area, retention time, and outlet control, should meet the design requirements of the temporary facility. Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.
- If a project includes an infiltration facility, the roughly excavated facility could be used as a trap or basin providing the facility provides the surface area and retention time required by the trap or basin. Excavate the sides and bottom of the facility to a minimum of three feet above final grade with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface.
- Additionally, any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

Advantages

- Protects downstream riparian properties from sediment deposits
- Prevents reduced downstream capacity due to sediment deposition in a stream channel
- Prevents clogging of downstream facilities
- Removes particles up to medium silt size (0.02 mm)
- Surface water conveyances can be connected to the facility as site development proceeds. The designer may want to route surface water collected from disturbed areas of the site through a sediment trap prior to release from the site.

Disadvantages

- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Maintenance and sediment removal is essential for adequate performance
- Serves limited areas
- Does not reduce turbidity resulting from fine silts and clays in runoff. Traps are more effective when used in conjunction with other measures such as seeding and mulching.

Design Criteria

- Construct prior to any upslope clearing and grading
- Locate in a low area where the trap will intercept all or most of the runoff from the disturbed area before it enters a waterway, considering safety in case structure fails.
- Locate the trap so that it is readily accessible for maintenance
- Provide for diversion dikes and ditches, as needed, to collect and divert water toward the trap. Sediment storage volume can be calculated using the USLE assuming a minimum one year

sediment accumulation period for design purposes. To convert tons of sediment as calculated to cubic feet, multiply 0.05 tons per cubic foot.

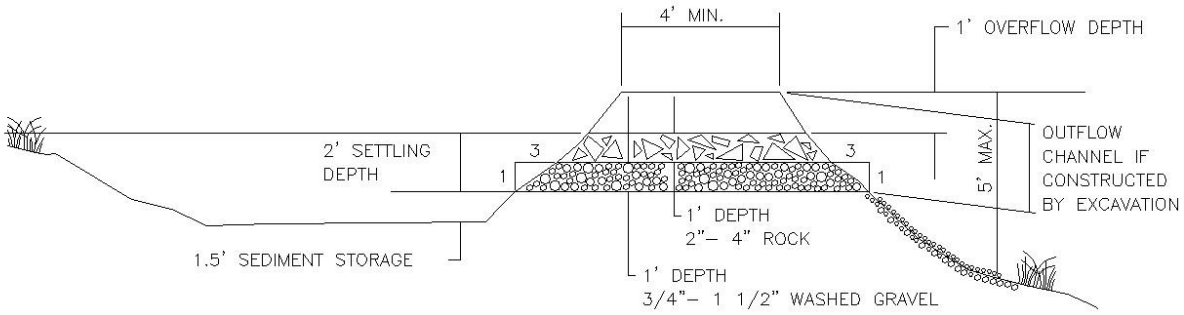
- Determine the bottom surface area of the sediment trap using the calculated sediment volume and the maximum 1½ depth.
- Determine the total trap dimensions by adding an additional two feet of depth for settling volume (before overtopping of spillway) above the sediment storage volume, while not exceeding 3:1 side slopes.
- Design the trap with a level bottom, 3:1 or flatter side slopes and a L:W ratio of 3.
- Construct the trap as the first step in the clearing and grading of the site.
- Form the trap by excavation or by construction of compacted embankment. If the trap is formed by embankment, the designer should note that dam safety regulation may apply to heights exceeding five feet. The embankment should be stabilized using a cover method such as seeding, mulching, or erosion control matting.
- Water temperature in the trap may be too high for direct release. Always moderate the water temperature before it drains into a lake, stream, wetland, or waterway. Whenever possible, release the trap discharge onsite onto a relatively level, densely grassed area at least 50 feet from a waterway or wetland.
- Evaluate the release areas on a site-by-site basis to determine appropriate locations for and methods of releasing runoff. Do not use vegetated wetlands for this purpose.

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- Constant maintenance is essential for proper functioning.
- Remove sediment from the trap when it reaches one-third the storage capacity.
- Repair any damage to the trap, the embankments or the slopes.

Diagram 4.3.9

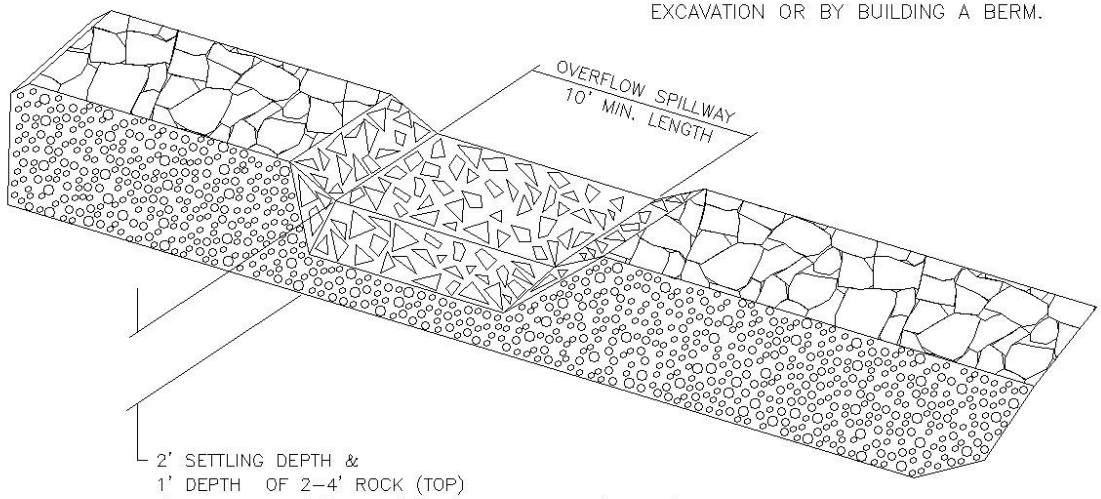
SEDIMENT TRAP



CROSS SECTION

NTS

NOTE: MAY BE CONSTRUCTED BY EXCAVATION OR BY BUILDING A BERM.



SEDIMENT TRAP OUTLET

NTS

NOTE:
A FILTER FABRIC FENCE OR SIMILAR FILTER MUST BE CONSTRUCTED TO FILTER RUNOFF FROM THE SEDIMENT TRAP PRIOR TO DISCHARGE FROM THE CONSTRUCTION SITE.

4.3.10 Sediment Basin

A temporary sediment basin has one or more inflow points and baffles to spread the flow, wet and dry storage, a securely anchored riser pipe, a dewatering device, and an emergency overflow spillway. The sediment basin serves drainage areas less than 10 acres and has a design life of approximately one year.

Basins are large facilities that treat runoff from large drainage areas. Because of this, basins have limited application on linear construction projects. The applications, advantages, and disadvantages of basins are included here for the designer's edification.

Combining with Permanent Drainage Facilities

- If a project includes a permanent storm water retention/detention pond, the rough-graded or final-graded facility could function as a basin during construction. Design features of the permanent structure, such as surface area, retention time, and outlet control, should meet the design requirements of the temporary facility. Completion of the permanent facility should occur only when all upstream control structures are in place and stabilization of contributing drainage areas is complete.
- If a project includes an infiltration facility, the roughly excavated facility could be used as a basin, providing the facility provides the surface area and retention time required by the basin. Excavate the sides and bottom of the facility to a minimum of two feet above final grade with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface.
- Any required pretreatment facilities should be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavations are intended to prevent the clogging of soil with fines.

Advantages

- Protect downstream riparian properties from sediment deposits
- Prevent reduced downstream capacity due to sediment deposition in a stream channel
- Prevents clogging of downstream facilities
- Remove particles up to medium silt size 0.02 mm
- Surface water conveyances can be connected to the facility as site development proceeds

Disadvantages

- May become an attractive nuisance. Care must be taken to adhere to all safety practices.
- Failure of a basin which is not properly located could result in loss of life, damage to homes or buildings or interruption of services such as transportation or power.
- Maintenance and sediment removal is essential for adequate performance.
- Does not reduce turbidity resulting from fine silts and clays in runoff. Basins are more effective when used in conjunction with other measures such as seeding and mulching.

Design Criteria

- Water temperature in the basin may be too high for direct release. Always moderate the water temperature before it drains into a lake, stream or waterway. Whenever possible, release the trap discharge onsite onto a relatively level, densely grassed area at least 50 feet from a waterway or wetland.
- Require installation of a staff gauge to aid in determining sediment depth.

- The designer may want to route surface water collected from disturbed areas to a sediment basin prior to release from the site.
- A qualified engineer should design temporary sediment basins.

Inspection and Maintenance

- Inspect once per week on active sites, once every two weeks on in-active sites, and within 24 hours following a 0.5-inch rain event
- All damages caused by soil erosion or construction equipment shall be repaired before the end of each working day.
- Remove sediment when the sediment storage zone is half full. This sediment shall be placed in such a manner that it will not erode from the site. The sediment shall not be deposited downstream from the embankment or adjacent to a stream or floodplain.
- When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankments and resulting sediment deposit shall be leveled or otherwise disposed of in accordance with the approved erosion and sediment control plan.

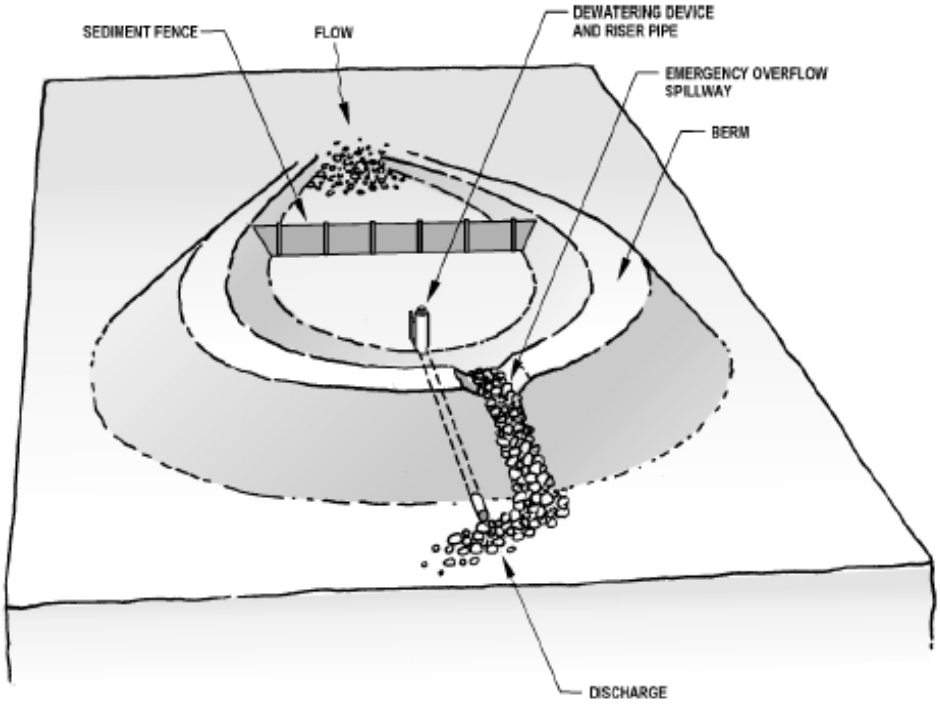
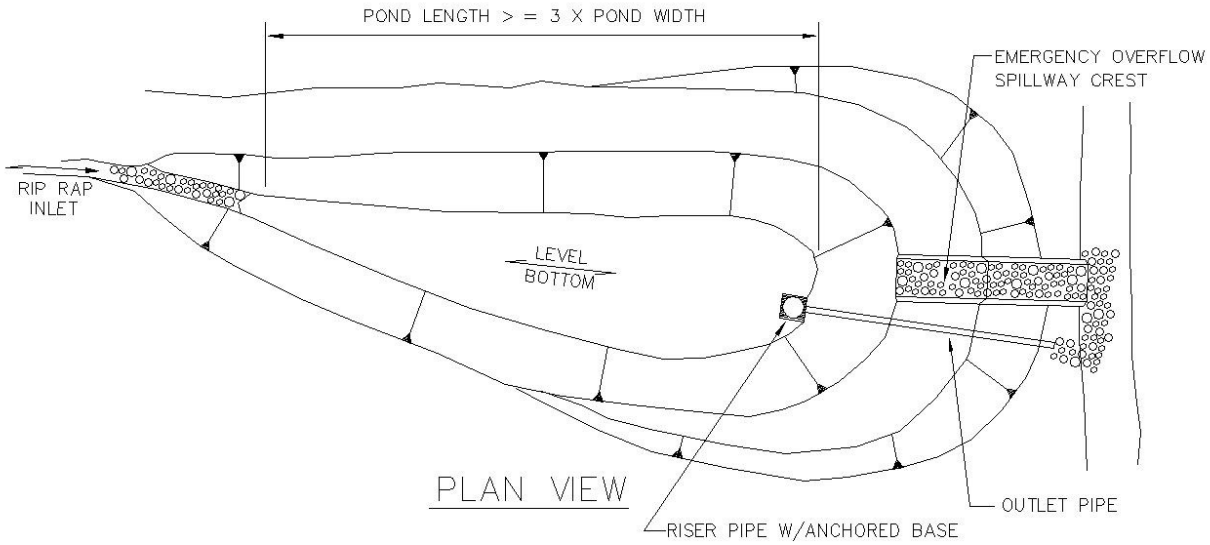
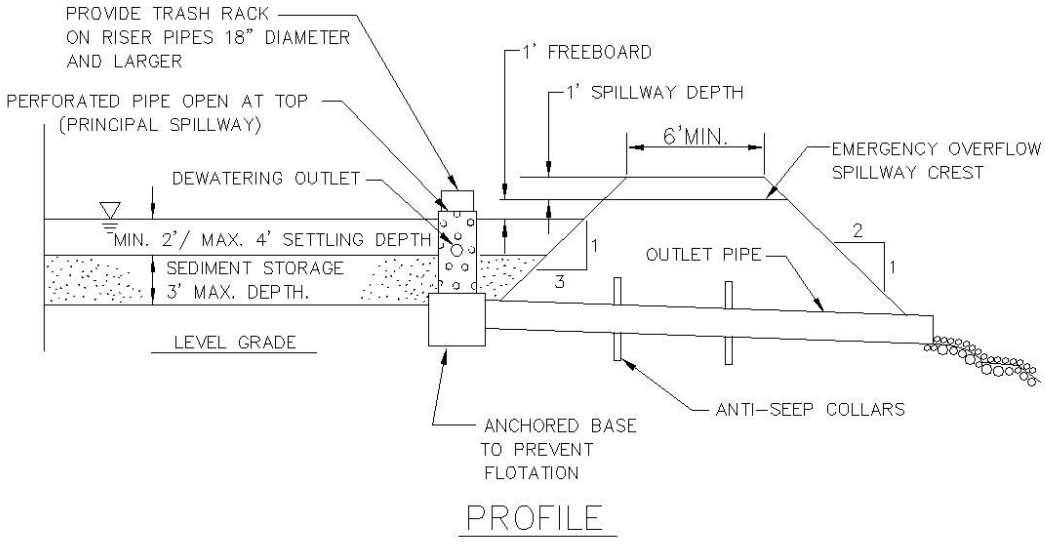


Diagram 4.3.10

SEDIMENT BASIN





NOTE:

1. 50' MINIMUM OF HIGHLY VEGETATED AREA AND OR SEDIMENT FENCE IS REQUIRED PRIOR TO DISCHARGING TO STREAM OR WETLAND.