4.0 Erosion Control BMPs

Storm Water Pollution Prevention Plans must include descriptions of both temporary and permanent stabilization/erosion control practices. Temporary erosion controls should be considered the first line of defense for prevention of water pollution during construction activities. It is much simpler to maintain the soil cover than to trap the sediment once it has been mobilized. In addition, effective erosion prevention can result in cost savings, since repair of erosion damage can be minimized. The primary goal of erosion control is to divert runoff away from unstable areas or to provide a stable surface that will resist the effects of rain and runoff.

Figure 4.1 – Note extent of vegetation left in place.

Preserving existing vegetation or revegetating disturbed soil as soon as possible during construction is one of the most important and cost effective erosion control measures. A vegetative cover reduces the erosion potential by shielding the soil surface from the direct impact of rainfall, improves the soil water storage capacity, slows the runoff allowing sediment to settle out of suspension, and tends to hold the soil in place. Vegetative covers may consist of grass, trees, mulch, straw, or retention blankets. The following measures always should be considered for site stabilization:

- Existing vegetation should be preserved as much as practicable. Areas not to be disturbed should be indicated on plans.

- Disturbed areas should be minimized to the extent practicable by staging construction operations.

- As required by the Construction General Permit, disturbed areas on which construction activity has ceased (temporarily or permanently) and that will be

exposed for more than 21 days shall be stabilized within 14 days. Areas receiving less than 20 inches of annual rainfall should be stabilized as soon as practicable.

The most common Best Management Practices (BMPs) for erosion control are:

- Temporary vegetation
- Mulch
- Blankets and matting
- Permanent seeding and sodding
- Interceptor and perimeter swales
- Diversion, interceptor, and perimeter dikes
- Stone outlet structures
- Pipe slope drain

Refer to "A Practical Guide to the Establishment of Vegetative Cover on Highway Rights-of-way" (July 1993) prepared by the Division of Maintenance and Operations – Landscape Section for additional information on stabilization practices.

Table 4.1 - Erosion Control BMPs: Advantages and Disadvantages

Measure	Characteristics	Advantages	Disadvantages
Temporary Seeding	Establish temporary vegetative cover	• Inexpensive and easy to perform • Reduces the number of other controls required and maintenance costs	• Depends heavily on location, season and rainfall • Requires protection from construction activities once seeded
Mulching	Used to increase infiltration, decrease runoff and protect soil surface from raindrops. Application rate very important. Can be used in conjunction	• Provides immediate and effective protection to soils • Retains moisture which can reduce need for watering • Inexpensive and easy to perform • Requires no removal because of natural deterioration	• May delay germination of some seeds because of the cover • More costly than seeding

	with soil tackifiers or binders.		
Blankets	Retains soil until vegetation becomes established	• Provides quick and effective protection until vegetation is established • Design methods available for channel liners • Good protection to final graded slopes > 3:1	• If not properly selected, designed and installed, effectiveness is reduced • Can be costly on some applications – e.g. temporary installations
Vegetative Buffers	Strip of dense vegetation used to prevent erosion and promote sedimentation of eroded material	• Can be inexpensive, especially if created from existing vegetation • Water quality, aesthetic, and habitat benefits	• Not feasible if land is not available • Requires plant growth before it is effective
Preserving Natural Vegetation	Provides natural buffer zones and limits disturbed area	• Can handle higher quantities of runoff than seeded areas • Increases filtering capacity due to denser root structure • Water quality, aesthetic, and habitat benefits • Natural areas do not warrant pollution control devices thereby reducing the cost of control measures	• Requires substantial planning to protect areas

4.1 Temporary Vegetation

Description: Vegetation can be used as a temporary or permanent stabilization technique for areas disturbed by construction. Vegetation effectively reduces erosion in swales, stockpiles, berms, mild to medium slopes, and along roadways. Other techniques such as matting, mulches, and grading may be required to assist in the establishment of vegetation.

Materials:

- The type of temporary vegetation used on a site is a function of the season and the availability of water for irrigation.

- Temporary vegetation should be selected appropriately for the area.

- County agricultural extension agents are a good source for suggestions for temporary vegetation.
- All seed should be high quality, U.S. Dept. of Agriculture certified seed.

Installation:

- Grading must be completed prior to seeding.
- Slopes should be minimized.
- Erosion control structures should be installed.
- Seedbeds should be well pulverized, loose, and uniform.
- Fertilizers should be applied at appropriate rates.
- Seeding rates should be applied as recommended by the county agricultural extension agent.
- The seed should be applied uniformly.
- Steep slopes should covered with appropriate soil stabilization matting.

Figure 4.2 – Rye grass used to temporarily stabilize a slope.

Considerations: Planting should take place when conditions are most favorable for growth (as long as the planting does not interfere with the schedule of other activities

and/or regulatory requirements). Before seeding, install other erosion control devices such as dikes, basins, and surface runoff control measures (e.g. gradient terraces, interceptor dikes/swales, and level spreaders). Temporary seeding may not be an effective practice in arid and semi-arid regions where the climate prevents fast plant establishment. In those areas, mulching may be a more appropriate temporary erosion control measure.

Proper seedbed preparation and the use of high quality seed are needed to grow plants for effective erosion control. Soil that has been compacted by heavy traffic or machinery may need to be loosened. All temporary seeding should be in accordance with applicable portions of the Standard Specifications.

In cold weather regions, if seeds are planted in the fall or winter, the areas should be covered with mulch to provide protection from the weather. On slopes of 3:1 or more, or where adverse soil conditions such as in the presence of excessively hot or dry weather, seeding should be followed by spreading mulch (see section 4.2). Frequent inspections are necessary to ensure that conditions for growth are good. If the plants do not grow quickly or thick enough to prevent erosion, the area should be reseeded as soon as possible. Seeded areas should be kept adequately moist. If normal rainfall will not be sufficient, mulching, matting and controlled watering should be performed. Care should be taken to avoid over-irrigation of seeded areas.

Seeds appropriate for the season and location should be selected. The following tables describe the cool and warm season grass mixtures recommended for differing areas of the state.

Table 4.2 - Cool Season Grass Mixtures for Temporary Erosion Control (in pounds of live seed per acre)

Districts	Dates	Common Name	Rate
1, 2, 3, 4, 5, 8, 18, 23, 25	August 15-November 30	Tall Fescue Western Wheatgrass Wheat (Red, Winter)	4.0 5.0 30.0
6, 7, 24	August 15-November 30	Western Wheatgrass Wheat (Red, Winter)	7.5 45.0
9, 10, 11, 14, 15, 17, 19	September 1-November 30	Tall Fescue Oats* Wheat (Red, Winter)	4.0 21.0 30.0
12, 13, 16, 20, 21	September 1-November 30	Oats*	64.0

* Note: Barley may be substituted for oats. Sow at 72 pounds of live seed per acre divided by the number of species in the mix.

Table 4.3 - Warm Season Grass Mixture for Temporary Erosion Control (in pounds of live seed per acre)

Districts	Dates	Common Name	Rate
2, 3, 7, 15, 16, 18, 21, 24	May 1– August 31	Foxtail Millet	30.0
1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 17, 19, 20, 23, 25	May 15- August 31	Foxtail Millet	30.0

The plans and specifications should reflect temporary seeding locations, quantities, and pay items. Consideration also should be given to placement of the permanent vegetation in areas that received temporary seeding.

4.2 Mulch

Description: Mulching is the process of applying a material to the exposed soil surface to protect it from erosive forces and to conserve soil moisture until plants can become established. When seeding critical sites, sites with adverse soil conditions or seeding on other than optimum seeding dates, mulch material should be applied immediately after seeding. Seeding during optimum seeding dates and with favorable soils and site conditions will not need to be mulched.

Materials:

- Mulch may be small grain straw that should be applied uniformly.
- On slopes 15 percent or greater, a binding chemical must be applied to the surface.
- Wood-fiber or paper-fiber mulch may be applied by hydroseeding.
- Mulch nettings may be used.
- Wood chips may be used where appropriate.

Installation: Mulch anchoring should be accomplished immediately after mulch placement. This may be done by one of the following methods: peg and twine, mulch netting, mulch anchoring tool, or liquid mulch binders.

Considerations: Mulches are applied to the ground surface to conserve soil properties and promote vegetative growth. A surface mulch is one of the most effective means of controlling erosion on disturbed areas. On steep slopes and critical areas such as waterways, mulch matting is used with netting or anchoring to hold it in place.

Mulching operations shall conform to the applicable portions of Standard Specification No. 164, “Seeding for Erosion Control.” See Table 4.4 for details regarding mulch types.

Final grading is necessary before mulching. The area should be inspected often to identify loosened or missing mulch cover. Such areas should be reseeded (if necessary) and the mulch cover replaced immediately. Binders may consist of organic soil tackifiers, cutback asphalt, emulsified asphalt, or synthetic liquid binders. The use of asphalt as a tackifying agent is not prohibited by law; however, if runoff from these areas exhibit excess levels of pollutants such as hydrocarbons, oils, etc., the stream standards may be violated.

Table 4.4 - Mulch Types

Mulches	Rates	Notes
Straw	1.5 – 2.0 tons/acre	Free from weeds and coarse matter. Anchored with tracking, netting or liquid tackifiers.
Hay	1.5 – 2.0 tons/acre	
Cellulose Fiber	1.0 – 1.5 tons/acres	Apply as slurry – effective in quick vegetative cover
Chemical Binders	Manufacturer Specifications	Asphalt, emulsions, synthetic binders (e.g. vinyl and acrylic)
Organic Tackifiers	Manufacturer Specifications	

4.3 Blankets and Matting

Description: Blankets and matting material can be used as an aid to control erosion on critical sites during the establishment period of protective vegetation. The most common uses are in channels, interceptor swales, diversion dikes, short, steep slopes, and on tidal or stream banks.

Materials: New types of blankets and matting materials are continuously being developed. TxDOT has defined the critical performance factors for these types of products and has established minimum performance standards which must be met for any product seeking to be approved for use within any of TxDOT's construction or maintenance activities. The products that have been approved by TxDOT are also appropriate for general construction site stabilization. TxDOT maintains a web site at:

http://www.dot.state.tx.us/insdtdot/orgchart/cmd/erosion/contents.httm

The site is updated as new products are evaluated.

Installation:

- Install in accordance with the manufacturer's recommendations.

- Ensure proper anchoring of the material (see Figures 4.3 and 4.4).
- Prepare a friable seedbed relatively free from clods, rocks, and any foreign material.
- Fertilize and seed in accordance with seeding guidelines or other type of planting plan.
- Erosion stops should extend beyond the channel liner to full design cross-section of the channel.
- A uniform trench perpendicular to line of flow may be dug with a spade or a mechanical trencher.
- Erosion stops should be deep enough to penetrate solid material or below level of ruling in sandy soils.
- Erosion stop mats should be wide enough to allow turnover at bottom of trench for stapling, while maintaining the top edge flush with channel surface.

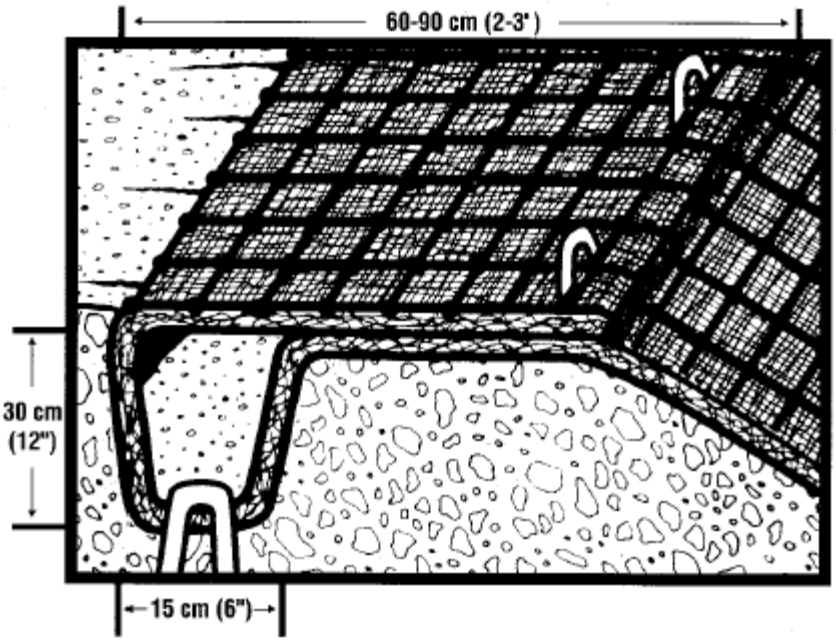

Figure 4.3 - Initial Anchor Trench for Blankets/Matting

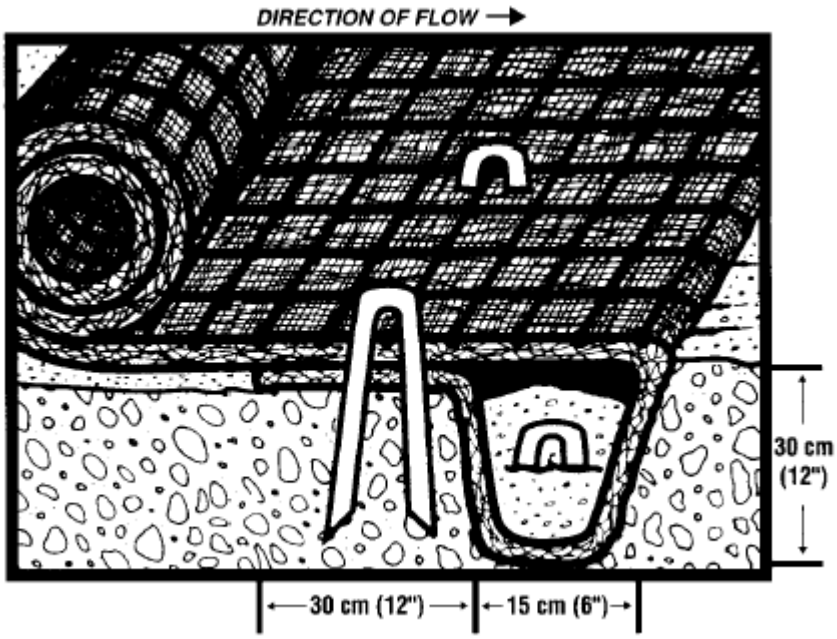

Figure 4.4 - Terminal Anchor Trench for Blankets/Matting

Considerations: The selection and use of soil retention blankets should be appropriate for the amount of runoff, steepness of the slope, and type of substrate (see Figure 4.5). The two main applications for soil retention blankets are for slope protection and as flexible channel liner protection. For slope protection applications, the blankets are useful in preventing the loss of topsoil, thereby reducing surface erosion and promoting the establishment of grass cover.

Figure 4.5 – Soil retention blankets used, in conjunction with silt fence, to stabilize a slope.

The use of blankets should be in accordance with applicable Standard Specifications.

Based on testing at the Texas Transportation Institute (TTI), the following criteria have been established for the use of soil retention blankets for slope protection:

Table 4.5 – Soil Retention Blanket Types (Slope Protection)

Type	Slope Class	Soil Type
Type A	3:1 or flatter	Clay
Type B	3:1 or flatter	Sandy
Type C	Steeper than 3:1	Clay
Type D	Steeper than 3:1	Sandy

Soil retention blankets may be used to stabilize drainage ditches as a flexible channel when more severe measures such as concrete rip rap or rock revet mattresses are not appropriate. The purpose of the blankets in this application is to protect the integrity of the ditches while the vegetative cover is established.

The selection of erosion control blankets for flexible channel liners depends greatly on the hydraulic characteristics of the area. The average shear stress resulting from flow in the channel or ditch must be estimated to ensure the proper selection:

$$t_d = \mu \ x \ d \ x \ S$$

where:

t_d = shear stress in lbs/sq. ft
μ = weight of water (62.4 lb/ cu. ft)
d = depth of water (feet)
S = average slope of the channel bottom (ft/ft)

Based on this value, Table 4.6 indicates the type of soil retention blankets to specify:

Table 4.6 – Soil Retention Blanket Types (Channel Liner)

Type	Shear Stress
Type E	< 1.0
Type F	1.0 – 2.0
Type G	2.0 – 5.0
Type H	> 5.0

4.4 Permanent Seeding and Sodding

Description: Sod is appropriate for disturbed areas that require immediate vegetative covers, or where sodding is preferred to other means of grass establishment. Locations particularly suited to stabilization with sod are waterways carrying intermittent flow areas around drop inlets or in grassed swales, and residential or commercial lawns where rapid establishment and aesthetics are factors. Sod is composed of living plants and those plants must receive adequate care in order to provide vegetative stabilization on a disturbed area.

Materials:

- Sod should be machine cut at a uniform soil thickness.
- Pieces of sod should be cut to the supplier's standard width and length.
- Torn or uneven pads are not acceptable.
- Sections of sod should be strong enough to support their own weight and retain their size and shape when suspended from a firm grasp.
- Sod should be harvested, delivered, and installed within a period of 36 hours.

Installation:

- Areas to be sodded should be brought to final grade.
- The surface should be cleared of all trash and debris.
- Fertilize according to soil tests.
- Fertilizer should be worked into the soil.
- Sod should not be cut or laid in excessively wet or dry weather.
- Sod should not be laid on soil surfaces that are frozen.
- During periods of high temperature, the soil should be lightly irrigated.
- The first row of sod should be laid in a straight line with subsequent rows placed parallel to and butting tightly against each other.
- Lateral joints should be staggered to promote more uniform growth and strength.
- Wherever erosion may be a problem, sod should be laid with staggered joints and secured.

- Sod should be installed with the length perpendicular to the slope (on the contour).
- Sod should be rolled or tamped.
- Sod should be irrigated to a sufficient depth.
- Watering should be performed as often as necessary to maintain soil moisture.
- The first mowing should not be attempted until the sod is firmly rooted.
- Not more than one third of the grass leaf should be removed at any one cutting.

Considerations: Vegetation cannot be expected to prevent soil erosion on a soil that is not stable due to its texture, structure, runoff patterns, or excessively steep slopes. Permanent seeding can be accomplished by broadcast seeding, mulch seeding, cellulose fiber mulch seeding, or as part of the installation of soil retention blankets.

A problem with permanent seeding is the control of erosion during the establishment period and the seasonal fluctuation and maintenance requirements. The quicker the final grade can be treated with the permanent vegetation, the sooner the final stabilization can be achieved. The use of mulches and blankets assists the establishment time by trapping soil particles, retaining soil moisture, and protecting seeds from the erosive forces of raindrops.

The establishment of permanent vegetation requires careful consideration of seasonal and geographic conditions and the irrigation, fertilizer, and maintenance requirements of the selected materials.

4.6 Interceptor and Perimeter Swales

Description: Interceptor and perimeter swales are excavated drainageways located across disturbed areas or right-of-ways or along the perimeter of a construction site. Their purpose is to protect exposed slopes by intercepting runoff. Perimeter swales prevent offsite runoff from entering the disturbed areas or prevent sediment-laden runoff from leaving the construction site or disturbed area (see Figures 4.6 and 4.7). The outflow of sediment-laden runoff from a swale must be directed to a stabilized outlet or sediment trapping device.

Considerations:

- The drainage area should be less than 5 acres.
- The bottom width should be 4 feet minimum and the bottom should be level.
- The depth should be a minimum of 1 foot.

- Side slopes should be 2:1 or flatter. Swales within the safety zone should have side slopes of 6:1 or flatter.

- The grade should be sufficient to have positive drainage to an adequate outlet.

- Channel stabilization should be provided when erosive velocities are expected.

- All points where vehicles will cross swales must be stabilized. If a stone lining is used, it should be at least 6 inches in thickness for the full width of the traffic crossing.

- Spacing table:

Table 4.7 - Swale Spacing

Slope of right-of-way of disturbed area	> 10%	5% - 10%	< 5%
Minimum Distance	100 feet	200 feet	300 feet

- Runoff diverted from a protected or stabilized upland area should outfall directly onto an undisturbed or stabilized area.

- Runoff diverted from a disturbed or exposed upland area should be conveyed to a sediment trapping device such as a rock berm, stone outlet structure, sediment trap or sediment basin or to an area protected by any of these practices.

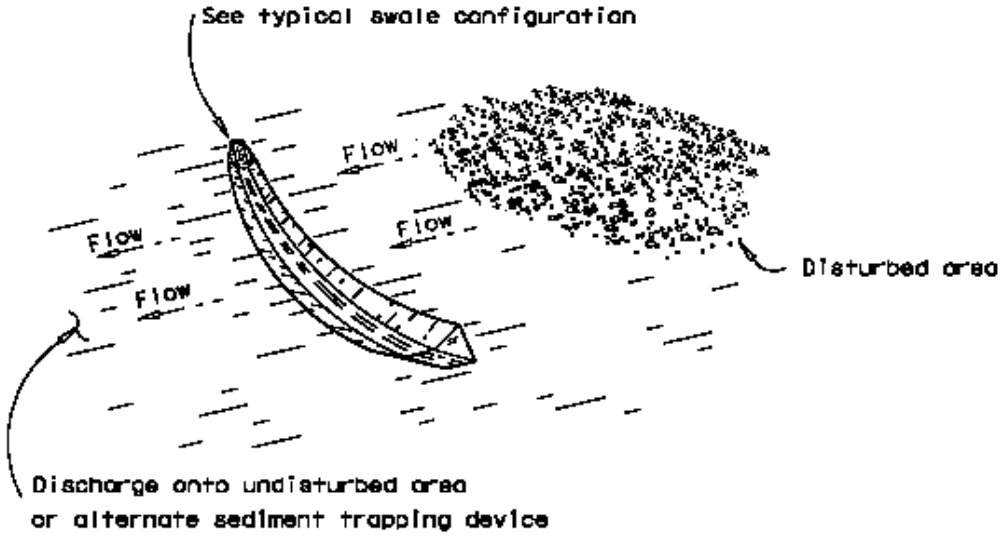

Figure 4.6 - Interceptor Swale
(see Appendix G for TxDOT Standard EC (5)-93)

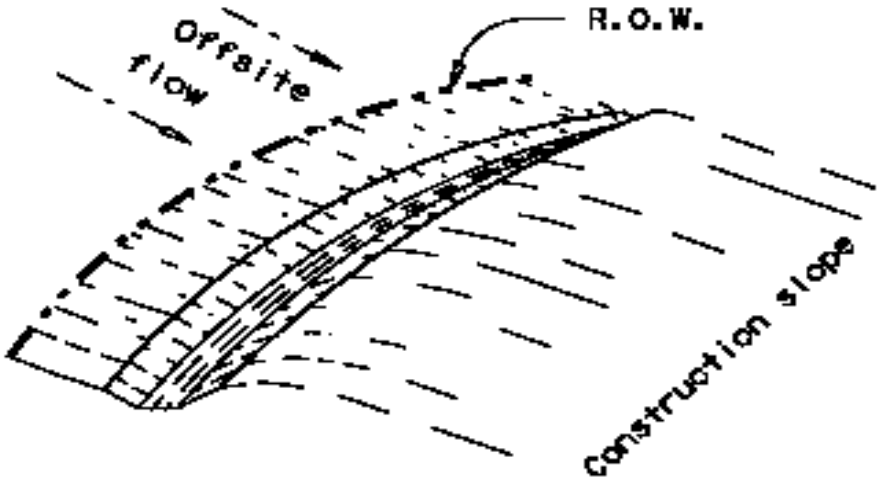

Figure 4.7 - Perimeter Swale
(see Appendix G for TxDOT Standard EC (5)-93)

4.6 Diversion, Interceptor, and Perimeter Dikes

Description: A temporary diversion dike is a temporary ridge of compacted soil located either (1) immediately above cut or fill slopes, (2) across disturbed areas or rights-of-way, or (3) along the perimeter of the site or disturbed areas. A diversion dike intercepts runoff from small upland areas and diverts it away from exposed slopes to stabilized areas to prevent flow through disturbed areas. An interceptor dike protects exposed slopes by intercepting runoff and diverting it to a stabilized outlet away from the exposed area. A perimeter dike prevents offsite runoff from entering the disturbed area and prevents sediment-laden runoff from leaving the construction site or disturbed area. A diversion or interceptor dike can be utilized to divert sediment-laden runoff to a stabilized outlet and minimize the need for other costly perimeter devices (e.g. silt fences).

Generally, dikes are used during the construction period to intercept and re-route runoff from disturbed areas to prevent excessive erosion until permanent drainage features are installed and/or slopes are stabilized (see Figures 4.7, 4.8 and 4.9). These devices can often result merely from the excavation and embankment construction activities. Therefore, consideration to the earthwork requirements of a project may indicate the location for these devices.

Design Guidelines:

- The drainage area should be less than 5 acres.

- The top width should be a minimum of 2 feet.

- The height (compacted fill) should be 18 inches minimum measured from the top of the existing ground at the top of the dike.

- Side slopes should be 2:1 or flatter. Dikes within the safety zone should have side slopes of 6:1 or flatter.

- Channel stabilization should be provided when erosive velocities are expected. The dikes themselves should be stabilized.

- Drainage diversions should not be directed to adjacent property.

- Runoff diverted from a protected or stabilized area should outfall directly to an undisturbed or stabilized area.

- Runoff diverted from a disturbed or exposed upland area should be conveyed to a sediment trapping device such as a rock berm, stone outlet structure, sediment trap, sediment basin, or to an area protected by any of these practices.

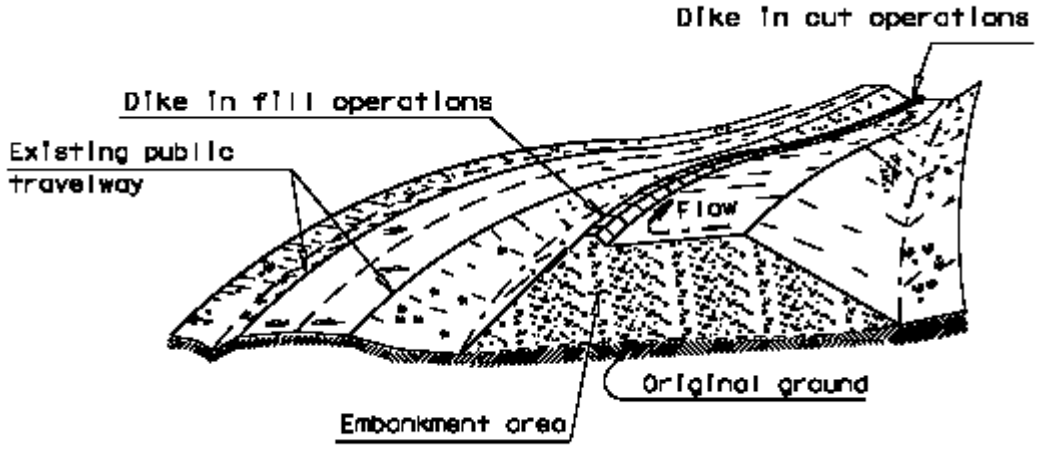

Figure 4.7-Diversion Dike
(see Appendix G for TxDOT Standard EC (4)-93)

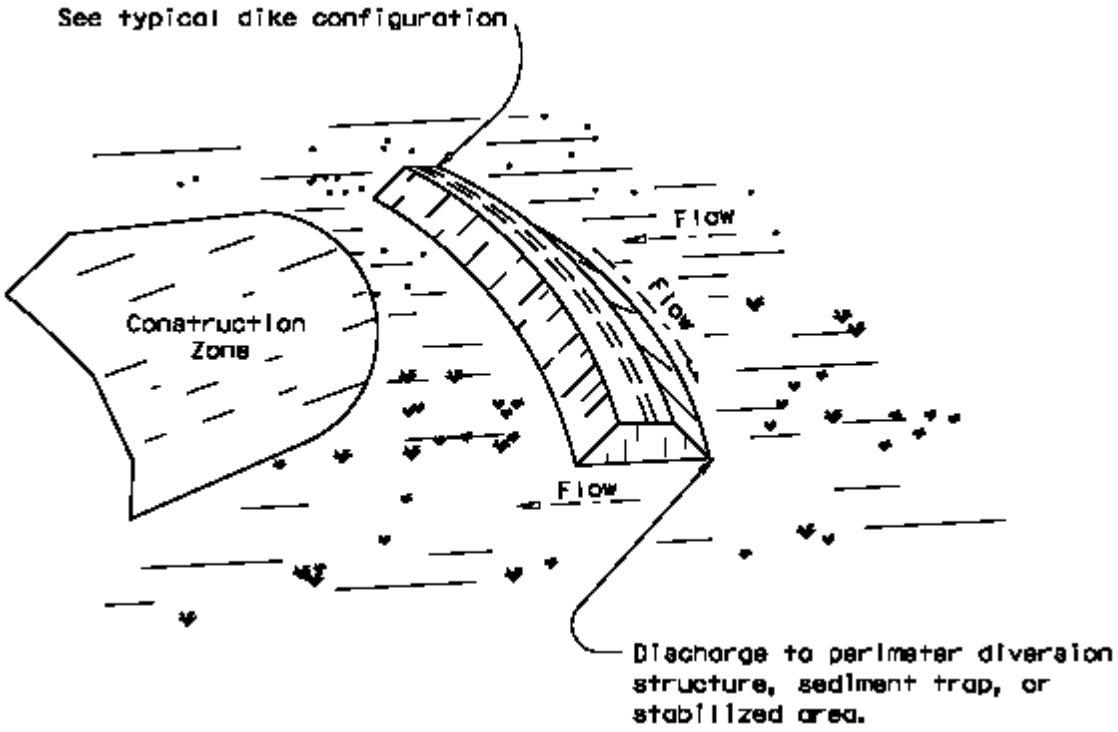

Figure 4.8 - Interceptor Dike
(see Appendix G for TxDOT Standard EC (4)-93)

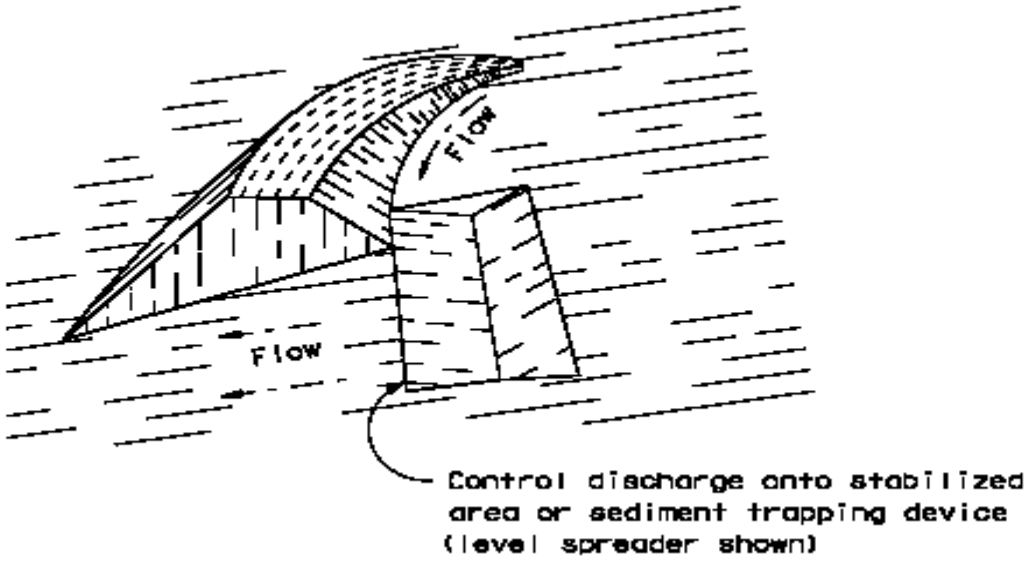

Figure 4.9 - Perimeter Dike
(see Appendix G for TxDOT Standard EC (4)-93)

4.8 Stone Outlet Structures

Description: A stone outlet structure is a temporary crushed stone filter dam installed in conjunction with and as part of a diversion dike, interceptor dike, perimeter dike, pipe slope drain, or sediment trap or basin (see Figure 4.10). The purpose of the stone outlet structure is to provide a protected outlet for any measure that requires velocity dissipation and diffusion of concentrated flow. Stone outlet structures apply to any point of discharge where there is need to dispose of runoff at a protected outlet or to diffuse concentrated flow for the duration of the construction period.

Design Guidelines: The drainage area above the structure is recommended to be less than 5 acres. The minimum length, in feet, of the crest of the stone outlet structure should be equal to 6 times the number of acres of contributing drainage area. Maximum allowable flow through rate is 60 gallons per minute per square foot. The crest of the stone dike should be at least 6 inches lower than the lowest elevation of the top of the earth dike and should be level. The stone should be crushed stone. Unless otherwise specified, all aggregate used in a stone outlet structure should be 3 to 5 inches open graded rock. A fabric core consisting of filter fabric may be incorporated into the structure provided maintenance of the core is made possible. If a fabric core is used, the maximum flow through rate is 40 gallons per minute per square foot. The stone outlet structure should be located so as to discharge onto an already stabilized area or into a stable watercourse. Stabilization shall consist of a complete vegetative cover, paving, etc. sufficiently established to be erosion resistant.

Maintenance: The area upstream from the stone outlet structure should be maintained in a condition that will allow sediment to be removed following the runoff of a rainfall event. Periodic inspections (after each rainfall) should be made by the Contractor and when the silt reaches a depth equal to 1/3 the height of the structure or 1 foot, whichever is less; accumulated silt should be removed and disposed of at an approved site in a manner that will not contribute to additional siltation. The structure should be reshaped as needed during inspection. The structure should be left in place until all upstream areas are stabilized and accumulated silt is removed.

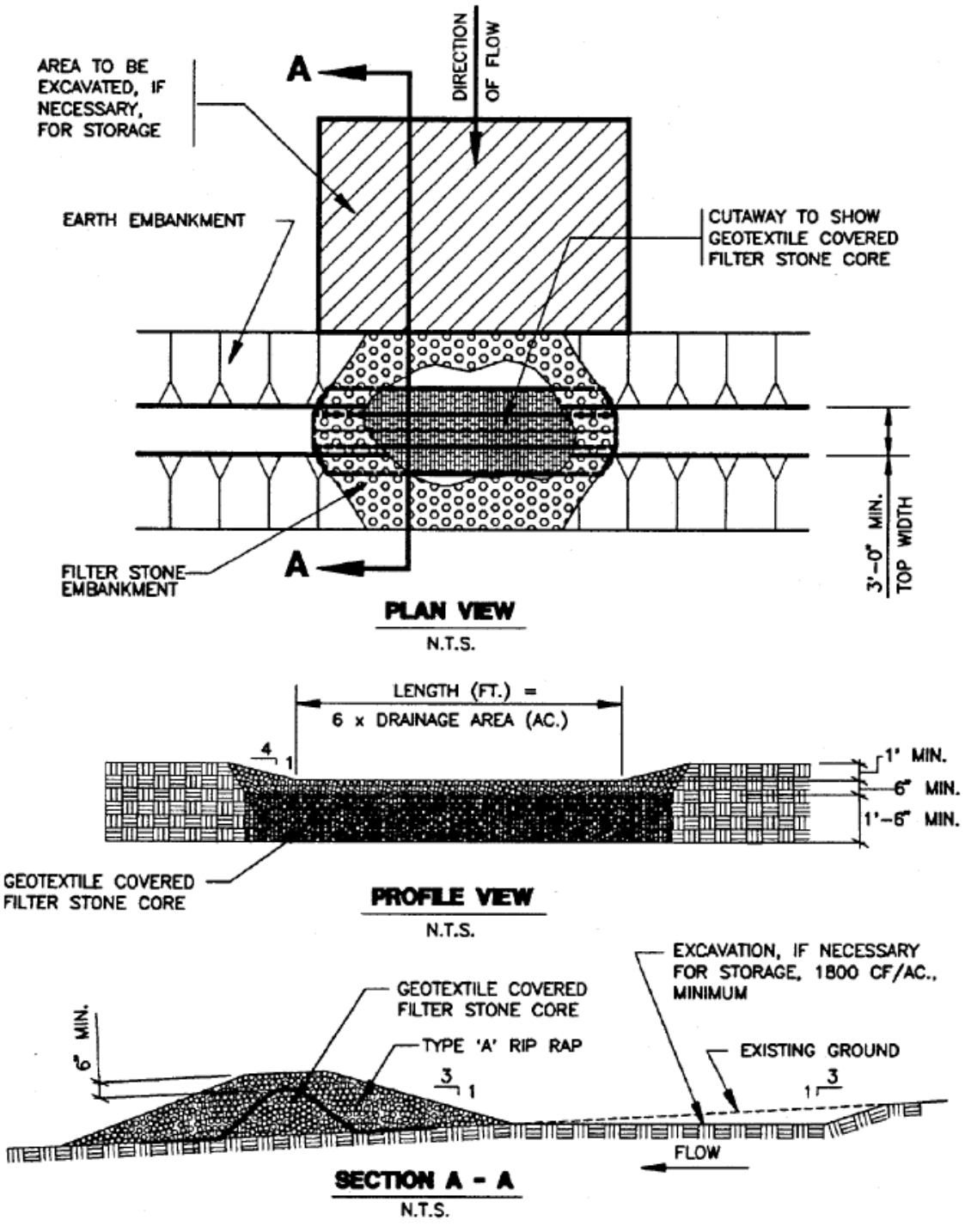

Figure 4.10 - Stone Outlet Structure Installed in Conjunction with a Sediment Trap

4.9 Pipe Slope Drain

Description: A pipe slope drain is a flexible tubing and/or rigid pipe with prefabricated entrance section temporarily placed to extend from the top of a slope to the bottom of the slope (see Figure 4.11). The purpose of the pipe slope drain is to convey surface runoff safely down slopes without causing erosion. Pipe slopes drains are used where concentrated runoff must be conveyed down a slope in order to prevent erosion.

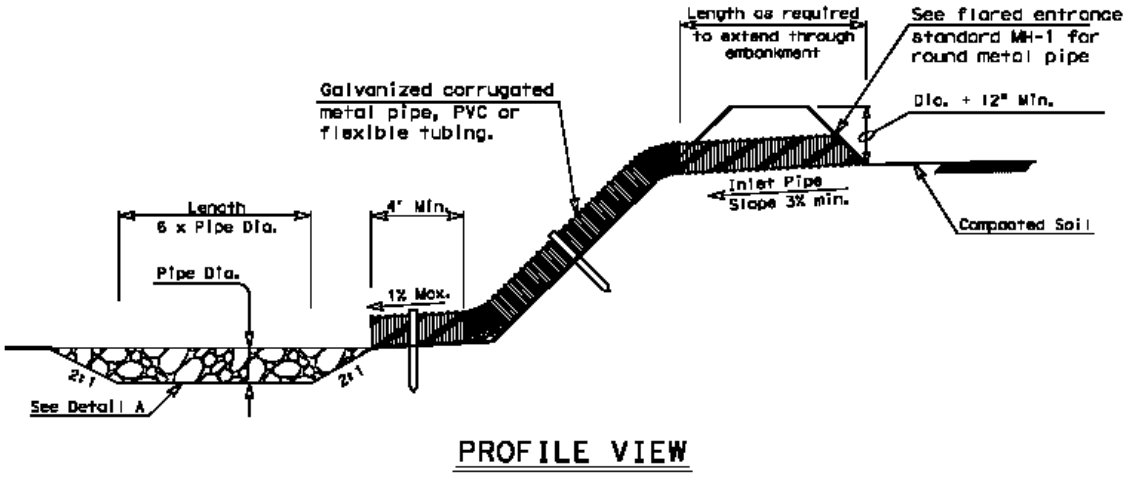

Figure 4.11 - Pipe Slope Drain with Energy Dissipater (see Appendix G for TxDOT Standard EC (7)-93)

Considerations:

- The recommended maximum drainage area is 5 acres.
- Unless otherwise specified, pipe slope drains may be sized as follows:

Table 4.8 - Pipe Slope Drain Sizes

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

- The height of the earth dike at the entrance to the pipe slope drain should be equal to or greater than the diameter of the pipe (D), plus 12 inches and should be adequate to prohibit overtopping by the 25-year storm.

- The pipe slope drain should outlet onto a stabilized area or stable watercourse. A sediment trapping device shall be used to trap sediment from any sediment-laden storm water runoff conveyed by the pipe slope drain unless the runoff is directed to a sediment basin.