BMP: VEGETATIVE STREAMBANK STABILIZATION

Definition

The use of vegetation in stabilizing streambanks.

Purpose

To protect streambanks form the erosive forces of flowing water.

Conditions Where Practice Applies

Along banks in creeks, streams and rivers subject to erosion from excess runoff. This practice is generally applicable where bankfull flow velocity does not exceed 1.5 meters per second (5 ft./sec) and soils are erosion resistant. Above 1.5 meters per second, structural measures are generally required. This practice does not apply where tidal conditions exist.

Planning Considerations

A primary cause of stream channel erosion is the increased frequency of bank-full flows which often result from upstream development. Most natural stream channels are formed with a bank-full capacity to pass the runoff from a storm with a 11/2 to 2-year recurrence interval. However, in a typical urbanizing watershed, stream channels are subject to a 3 to 5-fold increase in the frequency of bank-full flows. As a result, stream channels that were once parabolic in shape and covered with vegetation are often transformed into wide rectangular channels with barren banks.

In recent years, a number of structural measures have evolved to strengthen and protect the banks of rivers and streams. These methods, if employed correctly, immediately insure a satisfactory protection of the banks. However, many such structures are expensive to build and to maintain and frequently cause downstream velocity problems. Without constant upkeep, they are exposed to progressive deterioration by natural agents. The materials used often prevent the re-establishment of native plants and animals, especially when the design is executed according to standard cross-sections which ignore natural variations of the stream system. Very often these structural measures destroy the appearance of the site.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. The degree of protection, which may be low to start with, increases as the plants grow and spread. The repair and maintenance of structures is unnecessary where self-maintaining streambank plants are established. The protection provided by natural vegetation is more reliable and effective where the cover consists of natural plant communities which are native to the site. Planting vegetation is less damaging to the environment than installing structures. Vegetation also provides habitat for fish and wildlife and is aesthetically pleasing. Plants provide erosion protection to streambanks by reducing stream velocity, binding soil in place with a root mat and covering the soil surface when high flows tend to flatten vegetation against the banks. For these reasons, vegetation should always be considered first.

One disadvantage of vegetation is that it lowers the carrying capacity of the channel, which may promote flooding. Therefore, maintenance needs and the consequences of flooding should be considered. The erosion potential for the stream needs to be evaluated to determine the' best solutions. The following items should be considered in the evaluation:

1. The frequency of bankfull flow based on anticipated watershed development.

2. The channel slope and flow velocity, by design reaches.

3. The antecedent soil conditions.

4. Present and anticipated channel roughness ("n") values.

5. The location of channel bends along with bank conditions.

6. The location of unstable areas and trouble spots. Steep channel reaches, high erosive banks and sharp bends may require structural stabilization measures such as riprap, while the remainder of the streambank may require only vegetation.

Where streambank stabilization is required and velocities appear too high for the use of vegetation, one should consider structural measures (see BMP-23, STRUCTURAL STREAMBANK STABILIZATION) or the use of permanent erosion control matting (see BMP-36, SOIL STABILIZATION MATTING). Notably, <u>any applicable approval or permits from other state or federal agencies must be obtained prior to working in such areas</u>.

Vegetation Zones Along Watercourses-

At the edge of all natural watercourses, plant communities exist in a characteristic succession of vegetative zones, the boundaries of which are dependent upon site conditions such as the steepness and shape of the bank and the seasonal and local variations in water depth and flow rate. Streambanks commonly exhibit the following zonation:

1. Aquatic Plant Zone - This zone is normally permanently submerged. In Mid-Atlantic states, this zone is inhabited by plants such as pondweeds and water lilies, which reduce the water's flow rate by friction. The roots of these plants help to bind the soil, and they further protect the channel from erosion because the water flow tends to flatten them against the banks and bed of the stream.

2. Reed-Bank Zone - The lower part of this zone is normally submerged for only about half the year. In Mid-Atlantic states, this zone is inhabited by rushes, reed grasses, cattails, and other plants which bind the soil with their roots, rhizomes and shoots and slow the water's flow rate by friction.

3. Shrub Zone - This zone is flooded only during periods of average high water. In Mid-Atlantic states, the shrub zone is inhabited by trees and shrubs--such as willow, alder, dogwood and viburnum--with a high regenerative capacity. These plants hold the soil with their root systems and slow water speed by friction. They also protect tree trunks from damage caused by breaking ice and help to prevent the formation of strong eddies around large trees during flood flows. Shrub zone vegetation is particularly beneficial along the impact bank of a stream meander, where maximum scouring tends to occur. Infringement of shrub vegetation into the channel tends to reduce the channel width, increasing probability of floods. However, brief flooding of riverside woods and undeveloped bottomlands does no significant damage, and the silt deposits in these wooded areas are less of a problem than failed banks.

4. Tree Zone - This zone is flooded only during periods of very high water (i.e., the 2 year bank-full flow or greater flows). Typical plants in the Mid-Atlantic states are trees in the ashelm, alder-ash, and oak-hornbeam associations. These trees hold soil in place with their root systems.

Design Criteria

Table 22-1 provides general guidelines for maximum allowable velocities in streams to be protected by vegetation.

1. Ensure that channel bottoms are stable before stabilizing channel banks.

2. Keep velocities at bankfull flow non-erosive for the site conditions.

3. Provide mechanical protection such as rip-rap on the outside of channel bends if bankfull stream velocities approach the maximum allowable for site conditions.

4. Be sure that requirements of other state or federal agencies are met in the design in the case that other approvals or permits are necessary.

TABLE 22-1
CONDITIONS WHERE VEGETATIVE
STREAMBANK STABILIZATION IS ACCEPTABLE

Frequency of Bankfull Flow	Max. Allowable Velocity in meters per second (m/sec) for Highly Erodible Soil	Max. allowable Velocity in meters per second (m/sec) for Erosion Resistant Soil
> 4 times/yr.	1.2 m/sec (4 ft/sec)	1.5 m/sec (5 ft/sec)
1 to 4 times/yr.	1.5 m/sec (5 ft/sec)	1.8 m/sec (6 ft/sec)
< 1 time/yr.	1.8 m/sec (6 ft/sec)	1.8 m/sec (6 ft/sec)

Planting Guidelines

Guidelines will be presented only for the reed-bank and shrub zones. The aquatic plant zone is difficult to implant and establish naturally when reed-bank vegetation is present. There are presently many experts in this field at the federal, state, and private sector levels who can be consulted concerning successful establishment of plants in the aquatic zone. The tree zone is least significant in terms of protecting banks from more frequent erosion-force flows, since this zone is seldom flooded. Also, shade from trees in this zone can prevent adequate establishment of vegetation in other zones.

1. Establishing Reed-Bank Vegetation

There are various ways of planting reed-bank vegetation. The following plants are considerable suitable:

Common Reed	(Phragmites communis)
Reed Canary Grass	(Phalaris arundinacae)
Great Bulrush	(Scirpus lacustris)
Common Cattail	(Typha latifolia)

The greatest protection seems to be provided by the Common Reed. It is a very robust plant whose stems become woody in the autumn, resulting in continued protection during the winter. Because the shoots and rhizomes are deeply and strongly rooted and densely intertwined, they bind the soil more firmly than any other reed. The stems and roots have dormant buds at the nodes and are capable of sprouting when planted. However, the Common Reed does grow high and thick, and periodic maintenance may be needed in order to achieve a neat appearance.

a. Planting in Clumps: The oldest and most common method of planting reeds is planting in clumps. The stems of the reed colony are scathed. Then square clumps are cut out of the ground and placed in pits prepared in advance on the chosen site. The clumps are planted at a depth where they will be submerged to a maximum of two-thirds of their height.

b. Planting Rhizomes and Shoots: Less material is needed for the planting of rhizomes and shoots, a procedure which can be used to establish the Common Reed, Reed Grass, Bulrush, Cattail and other plants. Slips are taken from existing beds during the dormant season, after the stems have been cut. Rhizomes and shoots are carefully removed from the earth without bruising the buds or the tips of the sprouts. They are placed in holes or narrow trenches, along the line of the average summer water level, so that only the stem sprouts are showing above the soil.

c. Planting Stem Slips: It is possible to plant stem slips of the Common Reed along slow-moving streams. Usually, three slips are set in a pit 0.3 to 0.5 meters (1 to 0.8 feet) deep. If the soil is packed or strong, the holes must be made with a dibble bar or some other metal planting tool. The pits should be located approximately 0.3 meters (1 foot) apart.

d. Reed Rolls: In many cases, the previously described methods do not consolidate the banks sufficiently during the period immediately after planting. Combined structures have therefore been designed, in which protection of the bank is at first insured by structural materials. Along slow to fairly fast streams, the most effective method of establishing reed-bank vegetation has been found to be the use of Reed Rolls. A trench 0.5 meters (1.5 feet) wide and deep is dug behind a row of stakes. Wire netting, such as 13 millimeter (0.5 inch) hardware cloth, is then stretched from both sides of the trench between upright planks. Onto this netting is dumped fill material such as coarse gravel, sod, or soil and other organic material. This material is then covered by reed clumps until the two edges of the wire netting can just be held together with wire. The upper edge of the roll should be no more than 50 millimeters (2 inches) above the level of the water. Finally, the planks are taken out, and any gaps along the sides of the roll are filled in with earth. This method provides greater protection from the possibility of a heavy flow washing away the vegetative materials before they have a chance to become established.

e. Seeding: Reed Canary Grass can be sown 13 millimeters (0.5 inches) deep on very damp bank soil, provided that the seeded surface is not covered by water for six months after sowing. Seed at a rate of 2.2 - 2.8 kg/ha (12-15 lbs/acre). Reed Canary Grass is a cool season grass and should not be seeded in the summer.

f. Vegetation and Stone Facing: Reed-bank and other types of vegetation can be planted in conjunction with rip-rap or other stone facing by planting clumps, rhizomes or shoots in the crevices and gaps along the line of the average summer water level.

2. Establishing Shrub Zone Vegetation: Stands of full-grown trees are of little use for protecting streambanks apart from the binding of soil with their roots. Shrubwood provides much better protection; and in fact, riverside stands of willow trees are often replaced naturally by colonies of shrub-like willows. Plants should be used which can easily adapt to the stream and site conditions.

a. Seeding and Sodding: Frequently, if the stream is small and a good seedbed can be prepared, grasses can be used alone to stabilize the streambanks. To seed the shrub zone, first grade eroded or steep streambanks to a maximum slope of 2:1 (3:1 preferred). Existing trees greater than 100 millimeters (4 inches) in diameter should be retained whenever possible. Topsoil should be conserved for reuse. Seeding mixtures should be selected and operations performed according to

BMP-32, PERMANENT SEEDING. Some type of erosion control blanket, such as jute netting, excelsior blankets, or equivalent should be installed according to BMP-36, SOIL STABILIZATION BLANKETS & MATING. Sod can also be placed in areas where grass is suitable. Sod should be selected and installed according to BMP-33, SODDING. Turf should only be used where the grass will provide adequate protection, necessary maintenance can be provided, and establishment of other streambank vegetation is not practical or possible.

b. Planting Cuttings and Seedlings: Shrub willows, shrub dogwoods and alders can be put into the soil as cuttings, slips or stems. In dense shade, shrubs such as the Blue Arctic Willow (Salix purpurea nana) and the Silky Dogwood (Cornus amomum) or evergreen ground covers such as Lily Turf (Liriope Muscari) or Hall's Honeysuckle (Linicera hallsiana) are appropriate. The Silky Dogwood also works well in sunny areas. On larger streams, "Streamco" Purpleosier Willow (Salix purpurea "Streamco") and Bankers' Dwarf Willow (Salix x Cotteti) have been widely used with success. Two native river alders (Alnus serrulata and Alnus rugosa), which occur throughout the northeast, also show great promise for streambank stabilization, although they have not been fully tested. Again, the first step in the planting process is to grade eroded or steep slopes to a maximum slope of 2:1 (3:1 preferred), removing overhanging bank edges.

Willows can be planted as 1-year old, nursery-grown, rooted cuttings or as fresh hardwood cuttings gathered from local mother-stock plantings. Silky Dogwood and the alders should be nursery-grown seedlings 1 or 2 years old. Fresh cuttings should be 10 to 13 millimeters (3/8- to 1/2-inch) thick and 300 to 450 millimeters (12 to 18 inches) long. They should be kept moist. If not used at once, they should be stored in cool moist sand.

Streambanks are often difficult to plant, even when they are well-sloped. This is especially true in gravelly or strong banks. Where mattocks or shovels are unsatisfactory tools, a stiff steel bar, such as a crowbar, is better. The best tool for this purpose is a dibble bar, a heavy metal tool with a blade and a foot pedal. It is thrust into the ground to make a hole for the plant.

Rooted cuttings should be planted vertically in the bank with 25 or 50 millimeters (1 or 2 inches) of wood protruding above the ground surface. They should be stuck in a hole large enough to accommodate the root system when well spread. The plant roots must be maneuvered into the bottom of the hole so they will grow down instead

of up. The roots should not be twisted, nor should they be exposed above the ground surface. After the plant is placed, the dibble bar can be installed a few inches away from the plant to close the hole. Slow-release fertilizer should be applied on the surface, not in the hole. The soil should be tamped adequately to provide complete contact between the soil and the cutting. Cuttings should be planted 0.3 meters (1 foot) on center in at least 3 rows located at the top, middle and bottom of the shrub zone.

Plant seedings of the river alders vertically in the bank to the depth they were growing in the nursery. Use the same procedure described previously. Plant one row of alders at 0.6 meter (2-foot) intervals at the base of the shrub zone, not more than 0.5 to 1 meters (1.5 to 3 feet) from the average summer water level or from the reeds. A greater distance is of no use unless a belt of tall perennial herb colonies is established between the reeds and the alders. Plant the next row 0.3 meters (2 feet) up the slope, with a third row 1.2 meters (4 feet) up the slope. Plant at least 3 rows. Locate the plants in a diamond pattern.

Since these plants are generally not effective for the first two years, grasses can be seeded immediately following their planting to provide initial streambank protection.

The seedbed should be roughened with rakes and fertilized with 90 to 180 kg/hectare (500 to 1000 pounds per acre) of 10-10-10, adjusted to meet the needs of the site. Special care should be used when fertilizing next to water sources to avoid any unnecessary introduction of nitrogen/phosphorus into the water. Seed should be broadcast, covered lightly and mulched with 735 kg of straw per hectare (4,000 lbs per acre) approximately 2-3 bales per 100 square meters or a minimum of 275 kilograms of wood fiber mulch per hectare (1500 pounds per acre), although it is prefrred to use 370 kilograms per hecatare (2000 pounds per acre). If straw is used, it should be properly anchored with netting or an effective tackifier. Erosion control blankets/mats are often very effective aids in the establishment of grasses or plant material along streambanks (see BMP-36, SOIL STABILIZATION BLANKETS & MATTING).

Willows and other softwoods can also be bound together in various ways in order to insure immediate protection of the streambank.

c. Fascine Rolls: Fascine rolls are bundles of brushwood and sticks, without branches if possible, that are filled with coarse gravel and rubble and wired tightly around the outside. They are 4 to 18 meters (12 to 60 feet) long and 100 to 400 millimeters (4 to 16 inches) in diameter. They are set against the bank so that the parts which are to take root touch the ground above the water level and are able to get sufficient moisture. Covering with earth improves the contact with the ground and retards the loss of moisture from the wood.

d. Willow Mattresses: The degree of streambank protection can be increased by using willow mattresses or packed fascine work. Willow mattresses consist of 100 to 200 millimeter (4 to 8 inch) thick layers of growing branches set perpendicular to the direction of the current or sloping downstream. With the broad ends of the branches oriented downwards. The branches are held together with interweaving wire or other branches at intervals of 0.6 to 0.8 meters (2 to 2.7 feet), set parallel to the direction of the current or at an angle of 30 degrees. If several layers of mattress are necessary, the tops of the lower layers should cover the bases of the upper layers. The bottom layer is fixed at the base in a trench previously dug at the base of the softwood zone. The whole mattress structure should be covered with 50 to 255 millimeters (2 to 10 inches) of earth or fine gravel.

e. Packed Fascine-Work: Packed fascine-work consists essentially of layers of branches laid one across the other to a depth of 200 to 300 millimeters (8 to 12 inches) and covered with fascine rolls. The spaces between the fascine rolls are filled with gravel, stones and soil so that no gaps remain; and a layer of soil and gravel 200 to 300 millimeters thick is added on top. Packed fascine-work is particularly suitable for repairing large breaches in the banks of streams with high water levels.

f. Combination with Stone Facing: In many places, the bank is not adequately protected by vegetation until the roots are fully developed, and temporary protection must be provided by inanimate materials. There is a wide choice of methods, including the planting of woody plants in the crevices of stone facing. For structural protection measures, see BMP-23, STRUCTURAL STREAMBANK PROTECTION.

Maintenance

Streambanks are always vulnerable to new damage. Repairs are needed periodically. Banks should be checked after every high-water event is over. Gaps in the vegetative cover should be fixed at once with new plants, and mulched if necessary. Fresh cuttings from other plants on the bank can be used, or they can be taken from mother-stock plantings if they are available. Trees that become established on the bank should be removed at once.