Chapter 11. STREAM PROTECTION AND RESTORATION

11.1. Structural Streambank Stabilization

Streambank stabilization is used to prevent streambank erosion from high velocities and quantities of stormwater runoff. Typical methods include the following:

- Riprap - Large angular stones placed along the streambank or lake.
- Gabion - Rock filled wire cages that are used to create a new streambank.
- Reinforced Concrete - Concrete bulkheads and retaining walls that replace natural streambanks and create a non-erosive surface.
- Grid Pavers – Pre-Cast or poured-in-place concrete units that are placed along streambanks to stabilize the streambank and create open spaces where vegetation can be established.
- Cribb Walls- Logs with vegetation used to create new streambanks.

11.1.1 Applications

Structural streambank stabilization is used where vegetative stabilization practices are not practical and where the streambanks are subject to heavy erosion from increased flows or disturbance during construction. Stabilization should occur before any land development in the watershed area. Stabilization can also be retrofitted when erosion of a streambank occurs. All applicable Federal Army Corps of Engineers and SCDHEC Regulations, including Section 404 of the Clean Water Act that regulates the placement of fill-in wetlands, must be met while working in the stream.

An important design feature of structural streambank stabilization methods is the foundation of the structure; the potential for the stream to erode the sides and bottom of the channel should be considered to make sure the stabilization measures will be supported properly. Structures can be designed to protect and improve natural wildlife habitats; for example grid pavers can be designed to keep vegetation. Permanent structures should be designed to handle expected flood conditions. A well-designed layer of stone can be used in many ways and in many locations to control erosion and sedimentation. Riprap protects soil from erosion and is often used on steep slopes built with fill materials that are subject to harsh weather or seepage. Riprap can also be used for flow channel liners, inlet and outlet protection at culverts, streambank protection, and protection of shorelines subject to wave action. It is used where water is turbulent and fast flowing and where soil may erode under the design flow conditions. It is used to expose the water to air as well as to reduce water energy. Riprap and gabion (wire mesh cages filled with rock) are usually placed over a filter blanket (i.e., a gravel layer or filter cloth). Riprap is either a uniform size or graded (different sizes) and is usually applied in an even layer throughout the stream. Reinforced concrete structures may require positive drainage behind the bulkhead or retaining wall to prevent erosion around the structure. Gabion and grid pavers should be installed according to manufacturers' recommendations.

Streambank stabilization structures should be inspected regularly and after each large storm event. Structures should be maintained as installed. Structural damage should be repaired as soon as possible to prevent further damage or erosion to the streambank.

11.1.2 Design Criteria

Since each reach of channel requiring protection is unique, measures for streambank protection should be installed according to a unique plan and adapted to the specific site. Design should be developed according to the following principles:

- Bottom scour should be controlled, by either natural or structural means, before any permanent type of bank protection can be considered feasible.
- Specific attention should be given to maintaining and improving habitat for fish and wildlife.
- Structural measures must be effective for the design flow and be capable of withstanding greater flow without serious damage.

Refer to Section 8.4.2 for the design of riprap lined channels.

11.1.3 Maintenance

- Inspections should be made regularly and after each large storm event. Repairs should be made as quickly as possible after the problem occurs.
- All temporary and permanent erosion and sediment control practices should be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair should be conducted in accordance with an approved manual.

11.2. Bioengineering Streambank Stabilization

Bioengineering systems are installed to establish vegetation on bank slopes, provide soil protection, control erosion and reinforce the outer layers of the bank slope. In general terms, eroded streambank slopes are reshaped to a workable shape and live cuttings of woody native plants are installed into the slope during the dormant season. The cuttings develop root systems and flourish to provide a dense vegetation growth. All applicable federal U.S. Army Corps of Engineers and SCDHEC Regulations, including Section 404 of the Clean Water Act that regulates the placement of fill in wetlands, must be met while working in the stream.

11.2.1 Applications

Vegetative streambank stabilization is used on sections of streambanks subject to erosion from excess runoff. This practice is generally applicable where bank flow velocities do not exceed 6 ft/sec and soils are erosion resistant. When velocities are above 6 ft/sec, geotextiles, or structural measures are generally required.

Structural streambank measures are expensive to build and to maintain. Without constant upkeep, natural agents expose them to progressive deterioration. The materials used often prevent the reestablishment of native plants and animals. Very often these structural measures destroy the aesthetics of the stream.

In contrast, the utilization of living plants instead of or in conjunction with structures has many advantages. Vegetated measures provide a habitat for fish and wildlife and are aesthetically pleasing. The degree of protection, which may be low to start with, increases as the plants grow and spread. Repair and maintenance is unnecessary where self-maintaining streambank plants are established. In addition, planting vegetation is less damaging to the environment than installing structures, therefore vegetation should always be considered first.

11.2.2 Plant Zones

At the edge of all natural watercourses, plant communities exist in a characteristic succession of vegetative zones. The following zones are a guide for locating plant groups for successful establishment;

- Aquatic plant zone,
- Reed bank zone,
- Shrub zone, and
- Tree zone.

A typical annual curve of the water levels correlated with these typical vegetated zones is shown in **Figure 11-1**.

11.2.2.1 Aquatic Plant Zone

The aquatic plant zone is normally submerged and is inhabited by plants such as pond weeds and water lilies. 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 the bed of the stream.

11.2.2.2 Bank Zone

The lower part of the reed bank zone is generally submerged for about half the time and is inhabited by rushes, reeds, grasses, cattails, and other water plants which bind the soil with their roots rhizomes and shoots and slow the water's flow rate by friction.

11.2.2.3 Shrub Zone

The shrub zone is flooded only when flow exceeds the average high water level. The shrub zone is inhabited by trees and shrubs with high regenerative capacities such as willow, alder, dogwood, and viburnum. These plants hold the soil with their root systems and slow water speed by friction. Shrub zone vegetation is recommended for the impact bank of stream meander where maximum scouring occurs.

11.2.2.4 Tree Zone

The tree zone is flooded only during periods of very high water.

11.2.3 Two-Stage Channels

Two-staged channels are constructed water courses consisting of a smaller channel within a larger channel. A two-staged channel is designed to meet conveyance requirements while minimizing environmental impacts and taking advantage of naturally stable geometry. Two-staged channels shall be used where:

- Channel relocation is unavoidable and a new stream channel must be constructed.
- The conveyance efficiency of an existing channel must be increased to alleviate flooding.
- The depth of an existing channel must be increased to accommodate increasing flow rates and volumes from upstream development.
- Stream restoration would benefit a previously modified or heavily impacted channel.

Typical specifications for two-staged channels are shown in **Figure 11-2**. Two-staged channels are designed to have a low-flow channel section and an overflow channel section.

11.2.3.1 Low-Flow Channel

Low flow-channels shall be designed using the following criteria:

- The capacity shall be able to carry 50 percent (1/2) of the 2-year 24-hour storm event.
- Stream stability, water quality, and habitat enhancement features shall be added in the design such as meanders, eddy rocks, pools, and riffles.
- The base of the channel shall consist of natural soil, sand, and rocks.

11.2.3.2 Overflow Channel

Flood channels shall be designed using the following criteria:

- The capacity of the overflow channel shall be designed to carry the 10-year, 24-hour storm event.
- The minimum bottom width of the overflow channel shall be at least three times the top width of the low-flow channel.
- Proper vegetation shall be incorporated into the overflow channel to benefit water quality, bank stability, and wildlife.

11.2.4 Bioengineering Streambank Stabilization Design Criteria

Bioengineering streambank stabilization applications usually employ plant materials in the form of live woody cuttings or poles of readily sprouting species, which are inserted deep into the bank or anchored in various other ways. This serves the dual purposes of resisting washout of plants during the early establishment period, while providing some immediate erosion protection due to the physical resistance of the stems. Plant materials alone are sufficient on some streams or some bank zones, but as erosive forces increase, they can be combined with other materials such as rocks, logs or brush, and geotextile matting. The evaluation of the erosion potential of streambanks should be made considering;

- Frequency of bank-full flow based on anticipated watershed development;
- Channel slope and flow velocity, by design reaches;
- Soil conditions;
- Present and anticipated channel Manning's "n" values;
- Channel bend and bank conditions; and
- Identification of stable area and troubled spots.

Preliminary site investigations and engineering analysis must be completed to determine the mode of bank failure and the feasibility of using vegetation as a component of streambank stabilization work. In addition to the technical analysis of flows and soils, preliminary investigations must include consideration of access, maintenance, urgency, and availability of materials.

Cuttings, pole/post plantings, and live stakes taken from local species that sprout readily (e.g., willows) are more resistant to erosion and can be used lower on the bank. In addition, cuttings and pole plantings can provide moderation of velocities when planted in high densities. Often, they can be planted deep enough to maintain contact with adequate soil moisture levels and eliminate the need for irrigation. The reliable sprouting properties, rapid growth, and availability of cuttings of willows and other pioneer species makes them appropriate for streambank stabilization. There are different planting methods to consider when designing bioengineering systems.

11.2.4.1 Pole/Post Plantings

Pole /posts typically are typically 3- to 5-inches in diameter and 5- to 7-feet long, but may be 12-feet long or more if required for a particular situation. Large dormant posts offer the most initial bank structure stability. They are useful on steep overhanging banks that are expected to continue to erode. Posts should be large enough to remain in place without breaking or being buried if some additional erosion takes place. On potentially dry streambanks where water availability may be a problem, longer posts can be planted deep enough to intercept water.

Large posts offer resistance and dissipate high flow energies within the stream. The resistance of large posts may not be desirable where high conveyance efficiencies are required.

Heavy equipment may be required to install very large posts. A backhoe fitted with a ramrod is an effective tool for creating the holes required for planting the posts. Post ranging from 5- to 7-feet in length may be driven into streambanks using a hand-held fence-post driver.

11.2.4.2 Live Stakes

Live stakes are typically 1- to 3-inches in diameter and 1.5- to 3-feet long. Live stakes are adequate for stable streambanks that may experience minor erosion, but will not solely rely on the live stakes for stability and erosion protection.

Live staking involves the installation of single plant cuttings large and long enough to be pushed into the ground in the form of stakes. A sledgehammer is typically sufficient for driving live stakings into streambanks. In some instances, pilot will be required to initiate the driving of the stakes.

11.2.4.3 Seedlings

Seedlings shall not be planted on actively eroding streambanks and do not offer any initial bank stability. Seedlings are typically planted with shovels and is labor intensive but easily accomplished by a crew of several workers.

11.2.4.4 Planting Combinations

Several techniques are available that employ large numbers of cuttings arranged in layers or bundles that can be secured to streambanks and be partially buried. Depending on the arrangement of these systems, they can provide direct protection from erosive flows, prevent erosion from upslope water sources, promote trapping of sediments, and quickly develop dense roots and sprouts.

- Joint planting makes use of live stakes installed between previously placed natural rocks within the channel and along the bank slopes.

- Brush mattresses and woven mats are typically used on the face of a bank and consist of cuttings laid side by side and interwoven or pinned down with jute cord or wire held in place by stakes.

- Brush layers are cuttings laid on terraces dug into the bank, then buried so that the branches extend from the bank.

- Live fascines, revetments, wattles and root wads are bundles of cuttings tied together, placed in shallow trenches arranged horizontally on the bank face, partially buried, and staked in place. The dormant plantings may be installed alone or with dead woody cuttings to provide protection for the live plants.

- These structures decrease erosion and promote silt and sand to be deposited along the bank and within the structure. The deposited materials form a good environment for new cuttings and a good seedbed for natural species to grow. These structure provide excellent fish and wildlife cover.

- Reed Rolls consist of burlap rolls filled with soil, root material and rooted shoots that are partially buried and staked to establish herbaceous species in appropriate habitats.

- Natural fibers are used in “fiber bio-logs” which are sold specifically for streambank applications. These are cylindrical fiber bundles that can be staked to a bank with cuttings or rooted plants inserted through or into the material.

- Geotextiles can be used for erosion control in combination with seeding, or with plants placed through slits in the fabric. The typical streambank use for these materials is in the construction of vegetated geogrids where the fill soils between layers of cuttings are encased in fabric, allowing the bank to be constructed of successive “lifts” of soil.

- The addition of vegetation to structural applications is also effective. This involves the placement of stakes and poles between riprap and stones of existing stabilization. Timber cribwalls may also be constructed with cuttings or rooted plants extending through the timbers from the backfill soils.

In most cases, streambank stabilization projects use combinations of the techniques described above in an integrated approach. Toe protection often requires the use of riprap, but the amounts can be reduced if vegetative practices are used along the bank. Likewise, stone blankets on the bank face can be replaced with geotextiles and geogrids supplemented with plantings and cuttings. Most upper bank areas can usually be stabilized with vegetation alone although anchoring systems may be required. Refer to **Figure 11-3** and **Figure 11-4** for typical soil bioengineering streambank stabilization methods.

11.2.4.5 Maintenance

Vegetated streambanks are always vulnerable to new damage, and repairs may be needed periodically. Check banks after every high water event and fix gaps in the vegetative cover with geotextiles or new plants mulched. Fresh cuttings from other plants on the bank may be used, or they can be taken from mother-stock plantings. Apply a complete fertilizer annually until the desired density of vegetation is reached. Protect new plantings from grazing livestock or wildlife where this is a problem.