PDHonline Course C187 (3 PDH)

Guidelines for Streambank Protection

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2020

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PROTECTING WATER QUALITY

A field guide to erosion, sediment and stormwater best management practices for development sites in Missouri and Kansas.

REVISED
JANUARY 2011

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Streanlbank Setback

Figure 6.6: Homes too Close to Streambank   Source: K. Grimes, SWCD, St. Charles County.

Practice Description

A streambank setback limits how close structures can be placed to the stream, and it restricts vegetation removal and grading of the riparian area along flowing waters. This practice is intended to protect the banks of natural streams from damage due to development, lessen the risk of flooding in developed areas and provide a buffer between the developed area and the stream. A properly maintained streambank setback will help maintain channel capacity and stability, reduce the sediment load in the channel and reduce the movement of pollutants into the stream. Setbacks help preserve natural channel meander and protect homes and other buildings from damage due to bank erosion and flooding.

The following recommended minimum requirements may not be adequate to protect water quality. Many communities have stream setback requirements up to 300 feet, depending on the quality of the stream to be protected. As a good example of a stream buffer ordinance, see the ordinance for the City of Kansas City or the City of Lenexa, Kansas at www.ci.lenexa.ks.us/LenexaCode/codetext.asp?section=004.001.015.

Streambank setbacks can also apply to areas adjacent to excavated open channels used for site drainage, drainage ways and watercourses that route runoff to streams. Consult your local government for ordinance requirements.

Recommended Minimum Requirements

Prior to the start of construction, the 100-year floodplain established by the Federal Emergency Management Agency and the streambank setback area should be shown on the design plan prepared by a registered design professional. Plans should be referred to by the site superintendent, job foreman and field personnel throughout the construction process. The streambank setback should be established according to the planned alignment and grade. Vegetation should be inventoried and flagged for retention.

Channel

Ensure that the channel is stable before determining the width of streambank setback.

Streambank Setback in Developed Areas

The greater of the following is recommended:

- A minimum of 50 feet from the top of the streambanks (larger setbacks will be needed where channels are downcutting, hydrology is shifting and in large drainage areas - if sufficient land is available, a 100-foot setback is encouraged to protect the stream from degradation and to protect property) beyond the 100-year floodplain.

Vegetation

If possible, preserve desirable natural vegetation within the setback area, especially on steep slopes. Establish vegetation on all areas without sufficient cover (see Vegetative Protection in the Streambank Protection section). Overall fish and wildlife habitat requirements and landscape character should be considered in determining the scope of streambank setback.

Street Setback

Streets in new developments should be constructed so that they remain usable during runoff from the design storm or according to local requirements.

Water Surface Elevation

A minimum of 1 foot below the ground floor of private dwellings and commercial buildings in a new development during the 100-year frequency, 24-hour duration storm.

Permits

Contact the Corps of Engineers and local authorities for permit requirements; permits may be needed if placing fill in wetlands or streams.

Construction

Site Preparation

- Follow all federal, state and local regulations for channel improvements required to increase stream capacity (due to development).
- Open channel cross sections should not be reduced in order to increase streambank setback. The use of levees within small watersheds is discouraged.
- Locate all underground utilities.

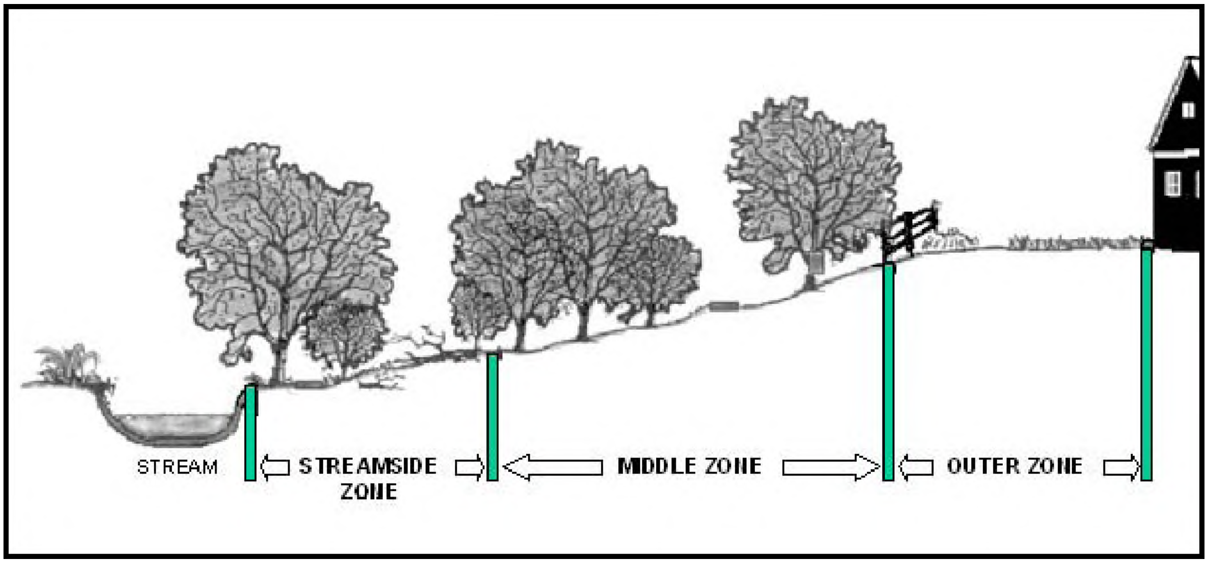

Figure 6.7 Three-Zone Stream Buffer System *Minnesota Stormwater Manual*. November 2005.
Source: Adapted from Schueler, 1995.

Natural Channels

- Natural channel side slopes should not be disturbed. When disturbance is necessary to develop a site, reestablish vegetation on channel side slopes as soon as possible after excavation or improvement.
- Consider the natural zones of a streambank community when placing vegetation. Use native plant materials for establishment and long term success. Lists of suitable species may be obtained from the Missouri Department of Conservation or NRCS. (See Streambank Protection.)
- Existing woody vegetation adjacent to the stream should not be disturbed.
- Leave any right-of-ways in the best condition feasible, consistent with the project purposes and adjacent land uses. A permit will be required to work in the right-of-way from the governing authority.
- Preserve or plant adapted trees to provide shade to prevent thermal pollution in the stream, help stabilize banks and provide wildlife habitat in those areas of perennial flow or where woody cover exists.

Erosion Control

- Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete.
- Establish vegetation on all disturbed areas immediately after construction.
- The streambank setback area should not be used as a buffer strip during construction. This is important – if it is used as a sediment buffer, it could become contaminated with sediment and kill all the natural vegetation.
- Use temporary diversions to prevent lateral surface water from running onto the streambank setback area.
- After construction, if overland flow is required to go through the streambank setback area, velocities should be low (5 feet per second or less).

Safety

- At the completion of each day's work, move all construction equipment away from the streambank setback area in anticipation of flooding.
- Temporary stream crossings should be used by construction equipment to prevent destruction of the streambank setback areas.
- Construction materials and waste material should not be stored in the stream channel or streambank setback area.
- Provide temporary fencing and post warning signs until vegetation is established in areas that are disturbed.
- Provide site drainage.

Construction Verification

The alignment and width of the setback should be maintained during all construction activities. The final grades and elevations of the setback area should be checked to insure compliance with plans and specifications.

Maintenance, Inspection and Removal

- Check the streambank setback area after every storm event during the period of construction. In the setback area immediately adjacent to the stream (a minimum 10 foot width), reseed bare areas of soil greater than one square foot upon discovery and protect from soil erosion.
- Protect new plantings in the streambank setback area from livestock or wildlife.
- Mulch, spray (with an herbicide approved for aquatic use) or chop out undesirable vegetation periodically to prevent its growth.
- Keep inlets to side drainage structures open.
- Keep subsurface drain outlet pipes open and protected.
- Prohibit certain activities in the stream setback area, such as clearing and grading, drainage ditching, filling or dumping; and storage of motorized vehicles.
- Streambank setback vegetation maintenance after construction is the responsibility of the land owner. Make sure the landowner knows and understands their responsibility and the state and local requirements in their area.

Common Problems and Solutions

Problem	Solution
Variations in topography on site indicate setback or channel is inadequate or will not function as intended.	Changes in the plans may be needed.
Design specifications for seed variety, trees, mulch and fertilizer cannot be met.	Substitution may be required. Unapproved substitutions could result in additional flooding and erosion of the streambank.
Erosion of streambank setback; caused by disturbed land in setback area, inadequate vegetation or concentrated flow	Establish adequate vegetation in all areas or install measures to reduce flow concentrations.
Slumping failure or slides in streambank; caused by steep slopes.	Repair by excavating failed material and replacing with properly compacted fill. Consider reducing slope or installing streambank protection measures.
Reduction in stream capacity; caused by overgrowth of vegetation on the streambank.	Selectively cut overgrown vegetation.

Soil Bioengineering for Slope Protection

Figure 6.37 Willows and other live stakes will root and sprout rapidly to protect slopes. The roots form an interlocking mat to hold soil in place, while the foliage protects the soil surface. These willows, planted along Hinkson Creek in Columbia, were 3- to 5-feet tall within six months. Source: Doug Wallace. NRCS. Boone Co.

Practice Description

Soil bioengineering consists of the use of live woody and mixed plant material to provide erosion control, slope and streambank stabilization, landscape restoration and wildlife habitat. These techniques are used alone or in conjunction with conventional engineering techniques. Soil bioengineering has the benefits of establishing permanent vegetation for decreased erosion, reduced off-site sedimentation lower runoff velocity and increased infiltration. Also, as the vegetation grows, the roots mechanically reinforce the soil and provide greater protection than just grass or a mechanical practice alone.

There are two approaches that can be used:

- Woody vegetation systems.
- Woody vegetation systems combined with reinforcing structures.

The structural part of the system helps establish vegetation on steep slopes or in areas subject to extreme erosion. Both systems provide immediate protection and grow stronger with time as the vegetation becomes established.

Soil bioengineering is advantageous where there is minimal access for equipment and workers, and in environmentally sensitive areas where minimal site disturbance is required. It is particularly suited for small, highly sensitive or steep sites. Most techniques can also be used for stream channel or bank protection. Once established, woody vegetation becomes self-repairing and needs little maintenance.

One of the best resources for soil bioengineering and slope protection is the U.S. Department of Agriculture's Natural Resources Conservation Service *Part 650: Engineering Field Handbook*. The handbook is broken into and published as many individual chapters. Chapter 16 is titled *Streambank and Shoreline Protection* and was published December 1996. Chapter 18 is titled *Soil Bioengineering for Upland Slope Protection and Erosion Reduction* and was published October 1992 with a reprinting December 1995. The *Engineering Handbook* provides standards and specifications, drawings and details of the different practices mentioned in this section. More information about bioengineering practices is available from your local National Resources Conservation Service/Soil and Water Conservation District and the Missouri Department of Conservation.

Recommended Minimum Requirements

Prior to start of construction, bioengineering practices should be designed by a registered design professional or an interdisciplinary team with knowledge of mechanical, biological and ecological concepts. The site superintendant and field personnel should refer to plans and specifications throughout the construction process.

Plant Species

Native species that root easily, such as willow. Use plants suitable for the intended use and adaptation to site conditions. While willow is one of the most common groups of plants used in bioengineering, there are several other native plants that offer function and aesthetics. Plants are usually harvested from a nearby local area. Contact your local conservation office for more information.

Cutting Size

Normally 1/2- to 2-inches in diameter and from 2- to 6-feet long (length will depend on project requirements).

Harvesting

Cut plant materials at a blunt angle, 8- to 10- inches from the ground, leaving enough trunk so that cut plants will regrow.

Transportation and Handling

Bundle cuttings together on harvest site, removing side branches. Keep material moist. Handle carefully during loading and unloading to prevent damage. Cover to protect cuttings from drying out.

Installation Timing

Deliver to construction site within 8 hours of harvest and install immediately, especially when temperatures are above 50 ^{0}F. Store up to two days if cuttings are "heeled in" moist soil, shaded and protected from wind.

Season

Install during plants' dormant season, generally late October to March.

Soil

Must be able to support plant growth with good topsoil (see Topsoiling and Stockpiling). Compact to fill voids and maintain good branch cutting-to-soil contact.

Velocities

Up to 6 feet per second for woody vegetation alone. Include simple structures with woody vegetation for velocities more than 6 feet per second. Use the velocity associated with the peak discharge of the design storm (see Streambank Protection section for structural protection alternatives).

Erosion Control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete. Seed and mulch bare areas on 3:1 or flatter slopes. Use netting, tackifiers or blankets with seeding on slopes steeper than 3:1.

Construction

Site Preparation

- Observe applicable government regulations especially the U.S. Army Corps of Engineers permits for work in and around waterways.
- Prior to excavation activities of any type, call 1-800-DIG-RITE (344-7483) to obtain utility locations.
- Locate source of live rooted plants or cuttings as specified in design plan. Local sources of native plants are ideal to use. Purchase of materials from commercial sources may be necessary to comply with local regulations. Specifically, if a bioengineering project is taking place within the riparian corridor, requirements may be required under a Section 404 permit administered by the Army Corps of Engineers. In addition, local governments may also have a stream buffer ordinance requirement.
- Prepare the site by clearing, grading and shaping according to the design plan. Stockpile topsoil to be used as backfill. Stabilize the soil and slope base before any structural or streambank work is done.

Installation

- If required by the design, prepare trenches or benches in cut and fill slopes and construct structural components such as cribwalls, walls or riprap according to the plan (See Structural Protection in this section).
- Install live cuttings, checking angle of placement. Secure cuttings with stakes or as specified in plan. Schedule the work so that plants are in a dormant state to enhance the success of establishment.
- Fertilize and lime according to soil test results as specified in the design plan.
- Install filter fabric if specified in the design plan. Backfill over the vegetative cuttings, compacting the soil to achieve good live branch cutting-to-soil contact. Fill any voids around the plant materials.
- Check to see adequate soil moisture is present to encourage rooting and growth. Water, if necessary.

Woody Vegetative Protection Installation

Live staking, live fascines, brushlayers, branchpacking and live gully repair are soil bioengineering practices that use the stems or branches of living plants as a soil reinforcing and stabilizing material. Eventually the vegetation becomes a major structural component of the bioengineered system.

Live Stake

Live staking is the use of live, rootable vegetative cuttings, inserted and tamped into the ground. As the stakes grow, they create a living root mat that stabilizes the soil. Use live stakes to peg down surface erosion control materials. Most native willow species root rapidly and can be used to repair small earth slips and slumps in wet areas.

Installation

- To prepare live material, cleanly remove side branches, leaving the bark intact. Use cuttings 1/2- to 11/2-inches in diameter and 2- to 3-feet long. Cut bottom ends at an angle to insert into soil. Cut the top of the stake square.
- Tamp the live stake into the ground at right angles to the slope, starting at any point on the slope face. Buds should point up. Install stakes 2- to 3-feet apart using triangular spacing with from two to four stakes per square yard.
- Use an iron bar to make a pilot hole in firm soil. Drive the stake into the ground with a dead blow hammer (hammer head filled with shot or sand).
- Four-fifths of the live stake should be underground with soil packed firmly around it after installation. Replace stakes that split during installation.

Live Fascine

Live fascines are long bundles of branch cuttings bound together into sausage-like structures. Place them in shallow contour trenches on dry slopes and at an angle on wet slopes to reduce erosion and shallow face sliding. This practice is suited to steep, rocky slopes, where digging is difficult.

Installation

- To prepare live materials, make cuttings from species such as young willows or shrub dogwoods that root easily and have long, straight branches.
- Make stakes 21/2 feet long for cut slopes and 3 feet long for fill slopes.
- Make bundles of varying lengths from 5- to 30-feet or longer, depending on site conditions and limitations in handling. Use untreated twine for bundling.
- Completed bundles should be 6- to 8-inches in diameter. Place growing tips in the same direction. Stagger cuttings so root ends are evenly distributed throughout the length of the bundle.
- Install live fascine bundles the same day they are prepared.
- Prepare dead stakes such as 21/2-foot long, untreated 2- by 4-inch lumber, cut diagonally lengthwise to make two stakes. Live stakes will also work.
- Beginning at the base of the slope, dig a trench on the contour large enough to contain the live fascine. Vary width of trench from 12- to 18-inches, depending on angle of the slope.
- Trench depth will be 6- to 8-inches, depending on size of the bundle.
- Place the live fascine into the trench.
- Drive the dead stakes directly through the bundle every 2- to 3-feet. Use extra stakes at connections or bundle overlap. Leave the top of the stakes flush with the bundle.
- Install live stakes on the down slope side of the bundle between the dead stakes.

Brushlayer

Brushlayering is similar to live fascine systems. Both involve placing live branch cuttings on slopes. However, in brushlayering, the cuttings are placed at right angles to the slope contour. Use on slopes up to 2:1 in steepness and not over 15 feet in vertical height.

Installation

- Starting at the toe of the slope, excavate benches horizontally, on the contour, or angled slightly down the slope to aid drainage. Construct benches 2- to 3-feet wide. Slope each bench so that the outside edge is higher than the inside.
- Crisscross or overlap live branch cuttings on each bench. Place growing tips toward the outside of the bench.
- Place backfill on top of the root ends and compact to eliminate air spaces. Growing tips should extend slightly beyond the fill to filter sediment. Soil for backfill can be obtained from excavating the bench above.
- Space brushlayer rows 3- to 5-feet apart, depending upon the slope angle and stability.

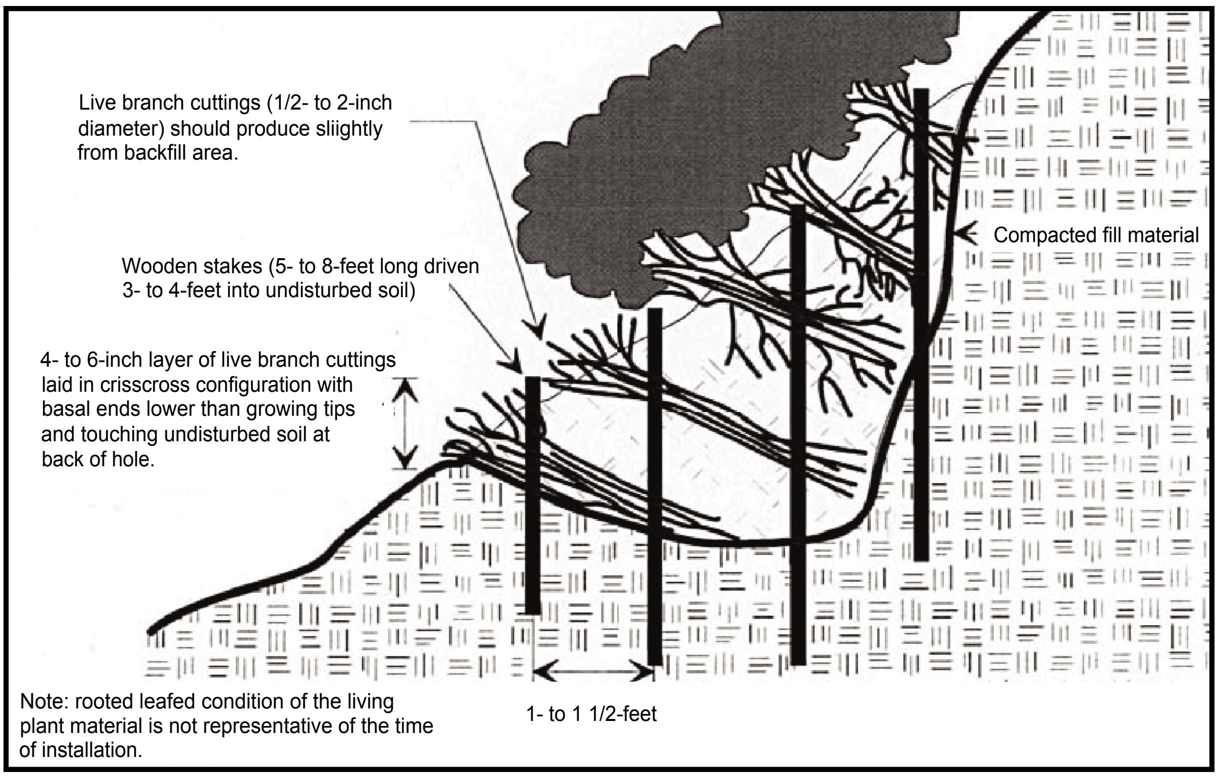

Figure 6.38 Typical branchpacking cross section. Source: *NRCS Engineering Field Handbook*, 1992.

Branchpacking

Branchpacking (see figure 6.38) consists of alternating layers of live branch cuttings and compacted backfill to repair small localized slumps and holes in slopes (no greater than 4 feet deep or 5 feet wide). Use for earth reinforcement and mass stability of small earthen fill sites.

Installation

- Make live branch cuttings from 1/2- to 2-inches in diameter and long enough to reach from soil at the back of the trench to extend slightly from the front of the rebuilt slope face.
- Make wooden stakes 5- to 8-feet long from 2 by 4 inch lumber or 3- to 4-inch diameter poles.
- Start at the lowest point and drive wooden stakes vertically 3- to 4-feet into the ground. Set them 1- to 11/2-feet apart.

- Place a layer of living branches 4- to 6-inches thick in the bottom of the hole, between the vertical stakes, and at right angles to the slope face. Place live branches in a crisscross arrangement with the growing tips oriented toward the slope face. Some of the root ends of the branches should touch the back of the hole.
- Follow each layer of branches with a layer of compacted soil to ensure soil contact with the branch cuttings.
- The final installation should match the existing slope. Branches should protrude only slightly from the rebuilt slope face.
- Ensure that the soil is moist or moistened to ensure live branches do not dry out.

Live Gully Repair

Live gully repair uses alternating layers of live branch cuttings and compacted soil to repair small rills and gullies. This practice is limited to rills or gullies less than 2 feet wide, 1 foot deep and 15 feet long.

Installation

- Make live branch cuttings 1/2- to 2-inches in diameter and long enough to reach from the soil at the back of the gully and extend slightly from the front of the rebuilt slope face.
- Starting at the lowest point of the slope, place a 3- to 4-inch layer of branches at the lowest end of the rill or gully and at right angles to the slope. Cover with a 6- to 8-inch layer of fill soil.
- Install the live branches in a crisscross fashion. Place the growing tips toward the slope face with root ends lower than the growing tips.
- Follow each layer of branches with a layer of compacted soil to ensure soil contact with the live branch cuttings and root ends.

Structural Protection Installation

Live cribwalls, vegetated rock gabions, vegetated rock walls and joint plantings are soil bioengineering practices that combine a porous structure with vegetative cuttings. The structures provide immediate erosion, sliding and washout protection. As the vegetation becomes established, the structural elements become less important.

Live Cribwall

A live cribwall consists of a hollow, box-like interlocking arrangement of untreated logs or timber. Use at the base of a slope where a low wall may be required to stabilize the toe of the slope and reduce its steepness or where space is limited and a more vertical structure is required. It should be tilted back if the system is built on a smooth, evenly sloped surface.

Installation

- Make live branch cuttings 1/2- to 2-inches in diameter and long enough to reach the back of the wooden crib structure.
- Build constructed crib of logs or timbers from 4- to 6-inches in diameter or width. The length will vary with the size of the crib structure.
- Starting at the lowest point of the slope, excavate loose material 2- to 3-feet below the ground elevation until a stable foundation is reached.
- Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability.
- Place the first course of logs or timbers at the front and back of the excavated foundation, approximately 4- to 5-feet apart and parallel to the slope contour. Place the next set of logs or timbers at right angles to the slope on top of the previous set.

- Place each set of timbers in the same manner and nail to the preceding set.
- Place live branch cuttings on each set to the top of the cribwall structure with growing tips oriented toward the slope face.
- Backfill crib, compacting soil for good root-to-soil contact, seed and mulch.

Vegetated Rock Gabions

Vegetated gabions combine layers of live branches and gabions (rectangular wire baskets filled with rock). This practice is appropriate at the base of a slope where a low wall is required to stabilize the toe of the slope and reduce its steepness. It is not designed to resist large, lateral earth stresses. Use where space is limited and a more vertical structure is required. Overall height, including the footing, should be less than 5 feet.

Installation

- Make live branch cuttings from 1/2- to 1-inch in diameter and long enough to reach beyond the rock basket structure into the backfill.
- Starting at the lowest point of the slope, excavate loose material 2- to 3-feet below the ground elevation until a stable foundation is reached. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability and ensure rooting.
- Place the gabions in the bottom of the excavation and fill with rock. Backfill between and behind the gabions.
- Place live branch cuttings on the gabions at right angles to the slope with the growing tips placed away from the slope and extending slightly beyond the gabions. Root ends must extend beyond the backs of the gabions into the fill material. Put soil over the cuttings and compact it.
- Repeat the construction sequence until the structure reaches the required height.

Vegetated Rock Wall

A vegetated rock wall is a combination of rock and live branch cuttings used to stabilize and protect the toe of steep slopes. This system is appropriate at the base of a slope where a low wall may be required to stabilize the toe of the slope and reduce its steepness. It is useful where space is limited and natural rock is available. Height of the rock wall, including the footing, should be less than 5 feet.

Installation

- Make live branch cuttings from 1/2- to 1-inch in diameter and long enough to reach the soil behind the rock structure.
- Rock should range from 8- to 24-inches in diameter. Use larger boulders for the base.
- Starting at the lowest point of the slope, remove loose soil until a stable base is reached, usually 2- to 3-feet below ground elevation. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability.
- Seat rocks firmly on the foundation material. Place rocks so that their center of gravity is as low as possible, with their long axis slanting inward toward the slope, if possible. Also attempt to imbricate the rock as much as possible for streambank application.
- Provide for drainage when a rock wall is constructed adjacent to an impervious surface or in locations subject to deep frost penetration.
- A sloping bench behind the wall can provide a base on which to place live branch cuttings during construction. Tamp or place live branch cuttings into the openings of the rock wall during construction. The root ends should extend into the soil behind the wall. Place cuttings at right angles to the slope contour with growing tips protruding from the wall face.

Joint Planting

Joint planting (see Figure 6.39) or vegetated riprap involves tamping live cuttings into soil between the joints or open spaces in rocks previously placed on a slope. Use this technique where rock riprap is required. Joint planting is used to remove soil moisture, to prevent soil from washing out below the rock and to increase slope stability over riprap alone.

Installation

- Make live branch cuttings from 1/2- to 11/2-inches in diameter and long enough to extend into soil below the rock surface. Remove side branches from cuttings leaving the bark intact.
- Tamp live branch cuttings into the openings of the rock during construction. The root ends should extend into the soil behind the riprap. Mechanical probes may be needed to create pilot holes for the live cuttings.
- Place cuttings at right angles to the slope with growing tips protruding from the finished face of the rock.

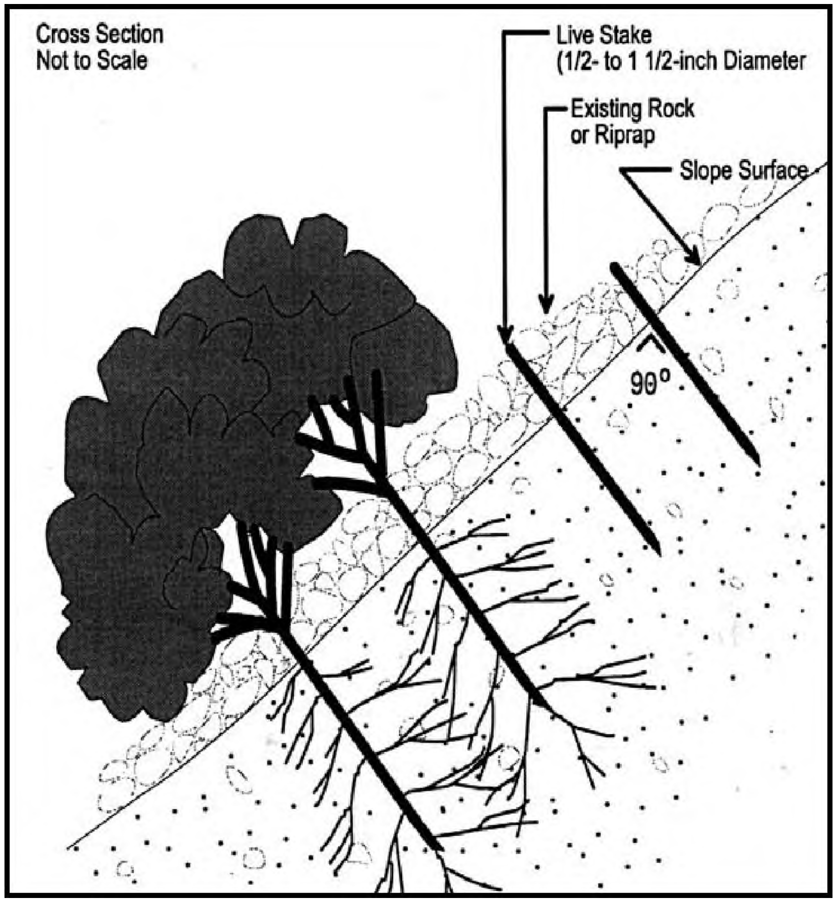

Figure 6.39 Typical Joint Planting Cross Section Source: *NRCS Engineering Field Handbook*, 1992.

Note: A detailed description, applications, effectiveness and construction guidelines for all types of bioengineering practices are discussed in Chapter 18, *Soil Bioengineering for Upland Slope Protection and Erosion Protection* , in the USDA NRCS *Part 650: Engineering Field Handbook*.

Erosion Control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete. Seed and mulch bare areas on 3:1 or flatter slopes. Use netting, tackifiers or blankets with seeding on slopes steeper than 3:1 (see Temporary or Permanent Seeding, Mulching and Erosion Control Blankets).

Construction Verification

For woody vegetative protection alone, check that live stakes were installed according to the design specifications. For structural protection, check that cross section of the improvements, thickness of protection and live stake installation meet with the design specifications.

Maintenance and Inspection

- For the first two months, check the treated area weekly for insects, soil moisture and other conditions that could cause failure. Water or treat with insecticide, if needed. Follow applicable federal, state and local guidelines for using insecticides next to a waterbody.
- From four to six months, check monthly and note areas where the vegetation is not growing acceptably.
- Every six months for the first two years, replace dead plants with the same species and sizes as originally specified. Install during the dormant season.
- Check the treated area after heavy rains or during drought. Fix gaps in the vegetative cover with structural materials or new plants. Make needed repairs to structural systems with similar material.
- Protect new plantings from grazing livestock or wildlife, if needed.
- After two year establishment period, maintenance requirements should be minimal. Heavy pruning may be required to reduce competition for light or stimulate new growth. Remove undesirable vegetation every 3 to 7 years.

Common Problems and Solutions

Problem	Solution
Variations in topography on-site indicate protection will not function as intended.	Changes in plan may be needed.
Design specifications for vegetative or structural protection cannot be met.	Substitution may be required. Unapproved substitutions could result in erosion damage to the disturbed area.
There is any indication of undermining of structural elements at their sides or base.	Consult with registered design professional.
Pressure behind the structure due to slope instability is causing any deformation to the structural elements.	Consult with registered design professional.
Erosion of treated areas; caused by inadequate vegetation or improper structural protection.	Repair erosion, replace vegetation or structural protection and consider methods to reduce or divert surface runoff from the slope, including but not limited to slope drains.
Slumping failure or slides in slope; caused by steep slopes.	Repair slide by excavating failed material, replacing vegetation and properly compacting fill. Consider flattening slope.
Sinkholes in riprap; caused by failure of the filter beneath the riprap.	Remove riprap, repair filter and reinstall riprap.
Death of vegetation; caused by drought, insect damage, cuttings damaged during installation, or poor cutting/soil contact.	Repair and replace vegetation during dormant season, maintain biweekly or monthly inspection schedule and water or treat with insecticide as needed. Follow applicable federal, state and local guidelines for using insecticides next to a waterbody.

Streambank Protection: Preservation, Enhancement and Restoration

Figure 6.140: Streambank Erosion. Source: Shockey Consulting LLC, Burr Oak Woods, Jackson County, MO

Practice Description

Restoration of the streambanks becomes necessary when permanent stormwater control measures have been insufficient or nonexistent to control runoff from the disturbed areas. Streams that receive increased flow volume and velocity will likely suffer bank erosion if not protected. Streambank protection can be vegetative, structural or a combined method where live plant material is incorporated into a structure (bioengineering). Vegetative protection is frequently the least costly and the most compatible with natural stream characteristics. Because each reach of channel is unique, a professional team should be consulted to ensure the specific site characteristics and sensitivities are considered in the design and installation of protective or restorative measures. The professional team will need to focus on streambank and channel stability, upstream contributions to increased flow and volume, and specific stream characteristics that will determine stabilization design (e.g. stream grade and soil type).

Streambanks tend to erode in watersheds where surface runoff rates have increased, causing higher peak flows in the stream. As a result, the stream reforms to carry its new load. Negative impacts to the stream result from changes in the watershed, such as removal of vegetation along a streambank, removal of open space, pavement of large-scale surfaces, removal of healthy vegetation upland and installation of piped stormwater systems.

Considerations in determining which type of streambank protection to use include:

- Current and future watershed conditions.
- Discharge velocity.
- Sediment load.
- Channel slope.
- Dynamics of bottom scour.
- Soil conditions.
- Present and anticipated channel roughness.
- Compatibility with other improvements.
- Changes in channel alignment.
- Fish and wildlife habitat.

Bioengineered Streambank and channel Protection

Bioengineering involves the use of living vegetation in combination with soil reinforcing agents such as reinforcing mats to provide bank stabilization by increasing soil shear resistance, dewatering saturated soils, and by reducing local shear stresses through increased hydraulic roughness.

Bioengineering is advantageous where there is minimal access for equipment and workers and in environmentally sensitive areas where minimal site disturbance is required. Most techniques can also be used for stream channel or bank protection. Once established, woody vegetation becomes self-repairing and needs little maintenance.

Combinations of vegetative and structural protection provide some of the advantages of both. The structures provide immediate erosion, sliding and washout protection. Vegetation provides greater infiltration than some structural methods, increases channel roughness, and filters and slows surface runoff entering the stream. Vegetation also helps maintain fish and wildlife habitat, and a natural appearance along the stream. It is important that the designer target the cause, not the symptom, of the problem in order to design an effective repair.

Combined methods can be used in areas where velocities exceed 6 feet per second, along bends, in highly erodible soils and on steep channel slopes. Common materials include cellular matrix confinement systems, grid pavers and bioengineering techniques. The upstream and downstream ends of the protection should begin and end along stable reaches of the stream. This practice should be designed for capacity at mature and self-sustaining growth and for stability at low or dormant growth.

See Appendix C and Appendix D for design manual references and other resources. More information about bioengineering practices is available from your local Natural Resources Conservation Service/Soil and Water Conservation District, the Missouri Department of Conservation, University Extension or local design professionals. See Soil Bioengineering for Slope Protection and Erosion Control Transition Mats

Vegetative Streambank Protection

Effective vegetative protection depends on locating plants where their natural characteristics provide the greatest benefit and their growth is assured. General planting information is listed below; however vegetation should be planted in accordance to the design plan with consideration to the vegetative zones. As above, vegetative protection should be designed for capacity at mature and self-sustaining growth and for stability at low or dormant growth. The location of each zone depends on the elevations of the mean high water level, the mean water level and the mean low water level as shown in Figure 6.141.

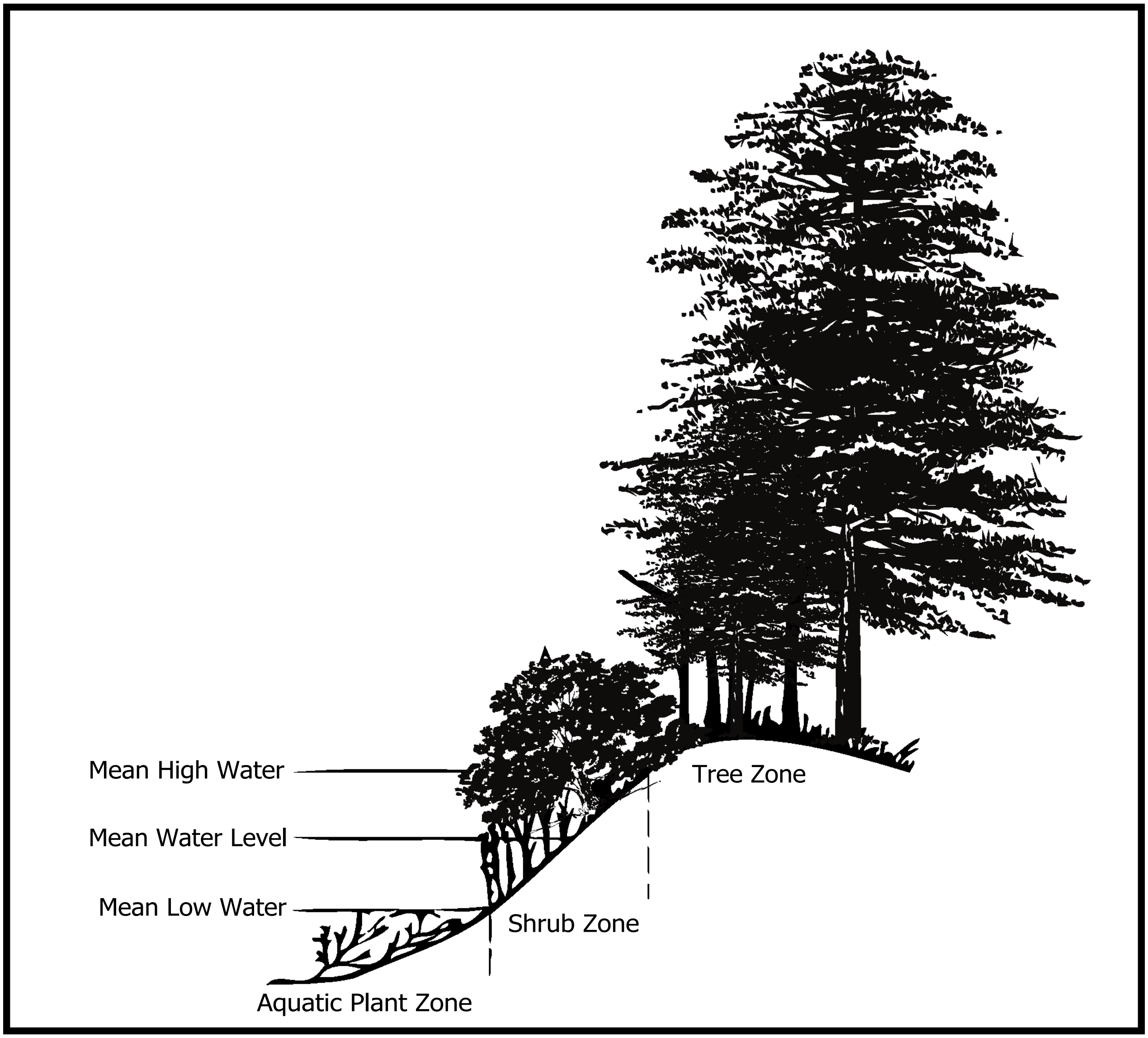

Figure 6.141: Vegetative Zones for Streambank Protection. Source: Missouri Department of Natural Resources

Aquatic Plant Zone

The aquatic plant zone includes the stream bed and is normally submerged at all times. Most often this area is not planted, yet sometimes aquatic plants are added here to achieve greater diversification in the restored stream bank community.

Shrub Zone

The shrub zone lies on the bank slopes just below the mean high water level and is normally dry, except during floods. Willows, silver maple, poplar and dog wood trees can be planted (staked) from top-of-bank to mean water line. They are preferred because they have high root densities and root depth, root shear and tensile strength is higher than that of most grasses or forbs, and they can transpire water at high rates.

- Upland trees should not be planted in the shrub zone. Refer to Appendix C and Appendix D for plant resource information, including the Grow Native! website for photos and narratives about Missouri native plants or consult the Missouri Department of Conservation, Kansas Wildlife and Parks or a professional forester for appropriate wetland shrub and tree species. Some grasses, sedges and bushes should be planted in the shrub zone if shear is not too high and plants are not submersed frequently or for long periods of time.
- Plant grasses in the spring or the fall. To seed grasses, roughen the seedbed, lime and fertilize according to soil test results. Check with the local Natural Resources Conservation Service, Missouri Department of Conservation, University Extension office or a local design professional for an appropriate seed mixture.

Tree Zone

Plant upland trees along the banks of the stream and not on the slopes. If trees provide shade to the streambank, grasses should be planted that will thrive in shady conditions.

Structural protection with engineered structures alone or bioengineered with plants should be provided in locations where velocities exceed 6-feet per second, along bends, in highly erodible soils and in steep channel slopes. Common materials include rock and revetments. Grouted riprap is not recommended, because grouted rock does not move with freeze/thaw and wetting/drying cycles. This lifting action results in voids quickly forming under grouted rock, allowing erosive forces to penetrate the structure and create potential failure of the grout and rock movement. The upstream and downstream ends of the structural protection should begin and end along stable reaches of the stream.

Streambank restoration efforts that involve structural practices or combination methods should be considered temporary if overall watershed factors are not considered in the design. Contributing erosion factors need to be corrected, because erosion will otherwise render the structural practice ineffective.

Structural Streambank Protection

Grid Pavers

Grid pavers are modular concrete units with interspaced void areas that can be used to armor a streambank while also establishing vegetation. Grid pavers are typically tied together with cables and come in a variety of shapes and sizes.

Figure 6.142: Interlocking concrete blocks along Two Mile Creek, St. Louis County.
Source: K. Grimes, SWCD, St. Louis County

Cellular Confinement Matrices

Cellular confinement matrices are commercial products usually made of heavy-duty polyethylene formed into a honeycomb-type matrix. The cellular confinement matrices are flexible to conform to surface irregularities. The combs may be filled with soil, sand, gravel or cement. If soil is used to fill the combs, vegetation must also be established.

Gabions

Gabions are rock-filled wire baskets stacked to form a wall against the streambank. Gabions are not the preferred alternative for streambank protection when bioengineering practices are available to provide adequate protection. Efforts should be made to identify the sources of erosion and streambank destabilization such as upstream devegetation, increased imperviousness, extensive curb and guttering. Efforts should be made to restore upland vegetation, slow the flow of stormwater entering the stream system and reroute to alternative practices. It is better to correct the problems, otherwise gabions and similar practices such as filter fabric revetments are only temporary fixes.

Gabions are typically designed to slow the flow of stormwater. They are sometimes used on steep slopes for temporary stabilization where there is not enough room to accommodate a “softer”, vegetated solution. Gabions are very labor intensive to construct, but are semi-flexible, permeable and can be used to line channel bottoms and streambanks. They can be placed (and vegetated when possible) in a manner to provide good drainage.

Additional Considerations

Gabions are more expensive than either vegetated slopes or riprap.

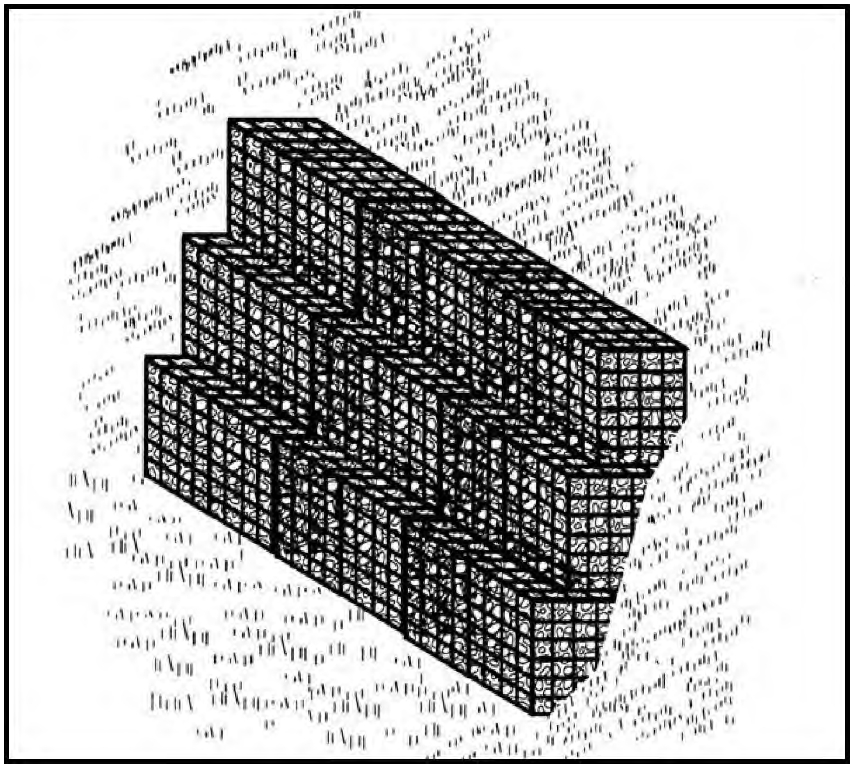

Figure 6.143 Typical gabion installation. Source: Shockey Consulting Services

The wire baskets used for gabions may be subject to heavy wear and tear due to wire abrasion by bedload movement in streams with high velocity flow. Gabions are difficult to install, requiring large equipment. Gabions are not the preferred alternative for streambank protection when bioengineering practices are available to provide adequate protection. Gabions are considered temporary. Permanent stabilization is dependant upon locating and correcting the problems contributing to erosion and destabilization. When gabions break down, the stream should already be in the process of stabilizing if erosive factors have been addressed upstream.

Recommended Minimum Requirements

Streambank protection projects should be designed by a registered Professional Engineer as part of the overall site design for long-term water quality, with significant attention given to upstream and downstream hydrologic factors and overall watershed health. Streambank and wetland work within jurisdictional waters require federal, state and possibly local permits. See Chapter 1 for regulation information.

Figure 6.144 Example of stable and unstable streambank. Source: MDC

Streambank protection should be considered in the initial design phases of any development project. An interdisciplinary team may provide the needed variety of expertise. Protection methods should focus on preserving, enhancing or restoring the stream hydraulics such that streambanks no longer erode.

Protection measures should begin and end at stable locations along the bank. Stable locations are typically where the streambed is armored with stable rocks occurring naturally at riffles, or man-made armored sections such as culvert crossings. By working between these stable locations, the impacts of the streambank protection are limited to the channel between stable locations so the erosive forces are not transferred to another location.

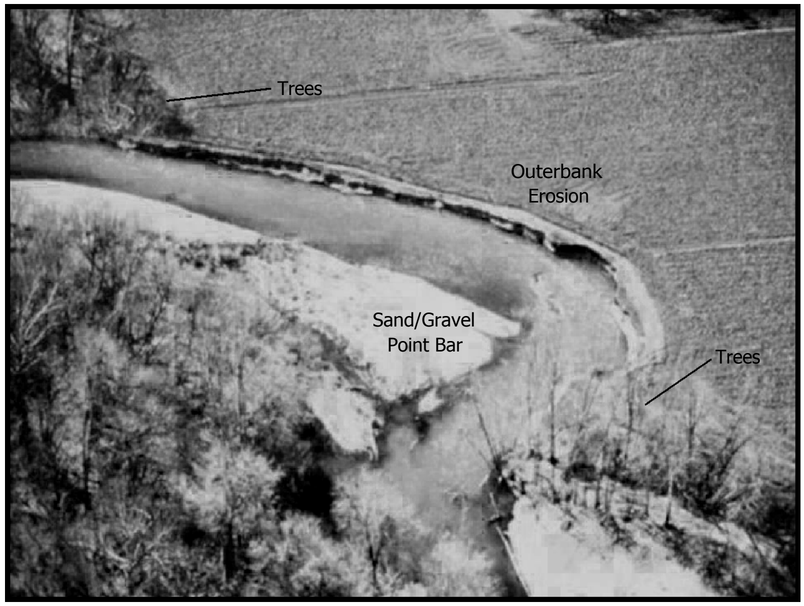

Figure 6.145 Example of stable and unstable streambank. Source: MDC

Before work is done within the channel, it should be determined if a Section 404 permit is required from the Corps of Engineers, as well as a Section 401 permit from the Department of Natural Resources. A local floodplain study may also be required. The site superintendent, job foreman and field personnel should refer to the plans and specifications throughout the construction process. The site superintendent should discuss any potential need for such permits with the site owner.

Several important considerations when designing streambank or channel protection include:

- **Velocities:** Vegetation alone may provide effective protection when stream velocities are 6-feet per second or less. Consider structural protection for velocities greater than 6-feet per second. Use the highest velocity expected, which is determined by evaluating the velocities through the full range of storms from the very frequent small events through large storm events. Allowable velocities vary depending on the soil and plant types. Refer to applicable design standards and manuals for more details.

- **Channel Bottom:** Downcutting must be stabilized before installing bank protection. An engineered grade control may be needed where downcutting is severe.

- **Streambank Plantings:** Consider the natural growth needs, patterns and preferences of selected planting stock when reestablishing the streambank community.

- **Plant Selection:** Use native or adaptive plant materials for establishment and long term success, because adapted plants are easier to establish and require less maintenance. See Appendix C and Appendix D for references about guiding plant selections.

- **Structural Methods:** Constructed “hard surfaced” features may be needed in especially challenging spots such as bends in the channel or changes in channel slope or where changes in hydrology, sediment load and channel alignment are occurring.

- **Combined Methods:** Many bioengineering practices (i.e. use of “living” structures) are useful to protect streambanks and channels. See Bioengineered Streambank and Channel Protection above.

- **Permits Requirements:** See Chapter 1 for regulation and permit requirements.

construction

Initial Site considerations

- Before starting construction, ensure all plans follow local, state and federal government regulations for any stream modification within jurisdictional waters. See Chapter 1 for regulation and permit requirements.
- Prior to excavation activities of any type, call 800-DIG-RITE (344-7483) to obtain utility locations.
- Examine the channel bottom before streambank protection measures are installed. Determine the need for grade control.
- Locate stable points along the channel to serve as anchor points for stream protection structures.

Follow design specifications for clearing, grubbing and grading. Grid pavers, cellular confinement matrices, gabions or other proprietary products should be designed and constructed into the project in accordance with manufacturer's guidelines and as specified in the design plan.

When filling products with rock, only durable crushed limestone, dolomite or granitic rock should be used. Shale, siltstone and weathered limestone should not be used because of their solubility or tendency to crumble. Depending on soil type, a filter fabric or a granular filter may need to be placed between streambank material and gabions. Use attractive facing stone toward the front of the wall.

Establish desirable vegetation where possible in between rocks and materials within the pavers, matrices or gabions. Otherwise, invasive and poorly rooting plants will take over the practice, reducing its effectiveness. Desirable vegetation will also increase habitat value.

Erosion control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete. Use temporary diversions to prevent surface water from running onto the streambank protection area. Route overland flow so it maintains the least possible velocity and exits the project site at a protected location. This information should be outlined in the community's stormwater pollution prevention plan associated with state, local or federal permits. See Chapter 1 for regulation and permit information.

Plant vegetation immediately after construction to promptly stabilize all disturbed areas.

Safety

Store all construction materials well away from the stream to avoid transport of polluted runoff or materials to the stream.

Clear, grub and grade the streambank surface to prepare for installing the matrices. Install systems according to engineered design plans and manufacturer's recommendations.

At the completion of each workday, move all construction equipment to a safe storage area out of and away from the stream to prevent damage from flooding. While working in streams, whether flowing or not, the following precautions should be taken:

- Avoid working above steep slopes on the streambank where cave-ins are possible.
- Fence area and post warning signs if trespassing is likely.
- Provide a means for draining the construction site if it becomes flooded.

construction Verification

For vegetative protection, check to see planting and seeding was done in compliance with the design specifications. For structural protection, check cross section of the channel, thickness of protection and confirm the presence of filter cloth between the protection and the streambank.

Maintenance and Inspection

Bank stability and vegetation should be assessed during routine inspections and after each storm event during the initial 2 years following construction. If any minor bank instabilities are documented, the repair should include back-filling with soil, installing erosion control blanket or bonded fiber matrix, planting seed blends and vegetative cover recommended in the plans.

Significant bank instabilities should be addressed by a professional design engineer. The extent of the project areas should be monitored with great frequency at project completion and less often as the project establishes, as presented below.

Table 6.18: Monitoring Frequency Following Plant Establishment

Growing Seasons	Frequency of Monitoring
1 - 2 years	Bi - Weekly
3 - 5 years	Bi-Monthly
Project Life	Two Inspections Annually

Maintenance activities should be in response to any new bank instabilities or vegetation issues detected. Maintenance activities may consist of weed control, bank stabilization and replanting vegetation that has died or eroded. It is important to identify what caused any issues so their reoccurrence can be prevented.

Bare areas of soil greater than 1 ft^2 shall be reseeded immediately upon discovery and protected from soil erosion. For any new plantings, adequate soil moisture is critical to plant establishment, and adequate soil moisture must be maintained immediately after each plant is sowed or set.

The project should require the contractor or property owner to maintain the plants throughout the first full growing season until they become established. Plants are more susceptible to mortality during the first two weeks of their growth and often require supplemental watering.

It is also important that other environmental and man-made stresses be monitored and timely adjustments be made to take these stresses into account. Some anticipated stresses include:

- Herbivory or Grazing (insects, deer, livestock).
- Vandalism.
- Wildlife Damage (rabbits, deer, beaver, muskrat).
- Insect infestations (grasshoppers, army cutworm, spider mites).
- Disease (not a frequent problem with non-horticultural varieties).
- Water stress (drought early on, typically the design is flood tolerant).
- Weather Damage (wind, hail).
- Weed Infestation.

Streambank maintenance after construction is the responsibility of the land owner, municipality or sewer district. The landowner needs to understand their responsibility and the state and local requirements in their area. Larger issues can be addressed through cooperative watershed planning and partnerships with regional planning groups.

Common Problems and Solutions

Problem	Solution
Variations in topography on-site indicate protection will not function as intended.	Consult with a registered Professional Engineer, changes in plan may be needed.
Design specifications for vegetative or structural protection cannot be met.	Consult with registered Professional Engineer, substitution may be required. Unapproved substitutions could result in erosion damage to the streambank and cause project failure.
Erosion of streambank; caused by inadequate vegetation, improper structural protection or an increase in stream velocity due to upstream development.	Repair erosion, establish adequate vegetation or structural protection and reduce stream velocities.
Slumping failure or slides in streambank; caused by steep slopes.	Repair a slide by excavating failed material and replacing with properly compacted fill. Consider flattening the slope and consult the Professional Engineer.

Rock Lined Channels

Highway drainage designers are ultimately left with the task of capturing runoff that does not infiltrate and then routing it via storm sewer to an outlet at some location. In the distant past, it was common to let this runoff discharge directly to a receiving water body, often resulting in an actively erosive area. Later, it became common to line the channel area with various sized rocks (riprap) in order to solve the problem.

Riprap is still used, however it is not always the most structurally sound nor is it the most aesthetic approach. Natural and synthetic geotextile reinforcements may be a suitable alternative and are available to fit a variety of needs. Choosing between these options depends a great extent on the nature of the problem. Product specifications for strength and applications should be examined to choose the proper material. Another option is compost-grouted riprap, in which compost is sprayed into voids and serves as a root medium for native plants.

As with grade controls, these reinforcement methods can be part of an initial installation or easily retrofit if a problem is identified and in need of a solution. However, erosive factors need to be addressed elsewhere in the watershed to avoid further failure.

- Rock lined channels require properly sized, graded, bedded and placed rock that rises and settles with soil movement.
- Stream banks should be sloped at 2:1 or flatter.
- In some cases, it might by beneficial to place filter fabric or a granular filter between the rock and the natural soil.
- Construct the riprap layer with sound, durable rock. Refer to plan for gradation and layering.
- Large and small rocks are required to lock in pieces and should not be flat or elongated.
- Place the toe of the rock at least 2-foot below the stream channel bottom or below the anticipated scour depth. Install toe walls as specified in plan.
- Extend the top of the riprap layer at least up to the two year water surface elevation. Vegetate the interface and remainder of bank.