Streambank and Shoreline Protection Manual

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Lake County Stormwater Management Commission

Lake County Planning, Building and Development Department

U.S.D.A. - Natural Resources Conservation Service

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Additional Copies

The "Streambank and Shoreline Stabilization Manual" is available to download on SMC's website at: www.co.lake.il.us\stormwater

REFERENCE

The Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois,
USDA Natural Resources Conservation Service, Chicago Metro Urban and Community and Assistance Office
December 1997.

Front Cover Photos:

TOP PHOTO: Village of Northbrook's riffles and pools project using rock rip rap, and deep-rooted native vegetation.

BOTTOM PHOTO: Deerfield High School's streambank stabilization using natural vegetation and coconut fiber rolls.

Streambank and Shoreline Protection Manual

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Disclaimer

Information contained in this manual was reproduced from the United States Department of Agriculture, Natural Resources Conservation Service “Engineering Field Handbook, Chapter 16, Streambank and Shoreline Protection,” December 1996.

This manual is designed to give the reader an overview of effective soil bioengineering and structural practices to stabilize streambank and shorelines. This information provided is based on careful research and input from experienced professionals.

The reader must assume responsibility for adapting this information to fit his or her conditions. This guide is not intended to replace the advice and guidance of an experienced professional. Permits are still required prior to any construction. For more information, you may call the agencies listed on the previous page.

STREAMBANK AND SHORELINE PROTECTION

Streambank and shoreline protection consists of restoring and protecting banks of streams, lakes, estuaries, and excavated channels against scour and erosion by using vegetative plantings, soil bioengineering, and structural systems. These systems can be used alone or in combination.

Categories of Protection:

The two basic categories of protection measures are those that work by reducing the force of water against a streambank or shoreline and those that increase their resistance to erosive forces. These measures can be combined into a system.

Revetment designs do not reduce the energy of the flow significantly, so using revetments for spot protection may move erosion problems downstream or across the stream channel.

Selecting streambank and shoreline protection measures:

After deciding rehabilitation is needed, a variety of remedies are available to minimize the susceptibility of streambanks or shorelines to disturbance-caused erosive process. They range from vegetation-oriented remedies, such as soil bioengineering, to engineered grade stabilization structures. In the recent past, many organizations involved in water resource management have given preference to engineered structures. Structures may still be viable options; however, in a growing effort to restore sustainability and ensure diversity, preference should be given to those methods that restore the ecological functions and values of stream or shoreline systems.

As a first priority consider those measures that:

- Are self sustaining or reduce requirements for future human support;
- Use native, living materials for restoration;
- Restore the physical, biological, and chemical functions and values of streams or shorelines;
- Improve water quality through reduction of temperature and chronic sedimentation problems;
- Provide opportunities to connect fragmented riparian areas;
- And retain or enhance the stream corridor or shoreline system.

You can use the summary table on page 23 to assist you in selecting an appropriate streambank or shoreline protection measure.

Planning and selecting streambank protection measures
(Data commonly needed for planning purposes):

- Watershed Data
- Causes and extent of erosion
- Hydrologic / Hydraulic data
- Stream reach characteristics
- Stream classifications
- Soils
- Climatic and vegetative conditions
- Habitat characteristics and desired habitat changes
- Environmental Data
- Social and Economic Factors

Design & Protection

Design considerations for streambank protection:

- Accessibility of site
- Channel grade
- Discharge frequency
- Discharge velocities
- Future maintenance
- Alignment
- Stream type and hydraulic geometry
- Sediment load and bed material
- Protection against failure
- Undermining
- Ends of revetment
- Debris removal
- Vegetative systems

Protective measures for streambanks:

<u>Vegetative Plantings</u>
Conventional plantings of vegetation may be used alone for bank protection on small streams and on locations having only marginal erosion, or it may be used in combination with structural measures in other situations. Considerations in using vegetation alone for protection include:

- Conventional plantings require establishment time, and bank protection is not immediate.
- Maintenance may be needed to replace dead plants, control disease, or otherwise ensure that materials become established and self-sustaining.
- Establishing plants to prevent undercutting and bank sloughing in a section of bank below baseflow is often difficult.
- Establishing plants in coarse gravely material may be difficult.
- Protection and maintenance requirements are often high during plant establishment.

Many deep-rooted species of plants are suitable for streambank protection. Use locally collected native seed or plugs as a first priority, after removing or thinning non-native and undesirable tree and shrub species to decrease shade canopy. The list on page 6 summarizes examples of species which are considered to have high stabilization potential.

Soil Bioengineering Systems:

Properly designed and constructed soil bioengineering systems have been used successfully to stabilize streambanks. Soil bioengineering is a system of living plant materials used as structural components. Adapted types of woody vegetation (shrubs and trees) are initially installed in specified configurations that offer immediate soil protection and reinforcement. In addition, soil bioengineering systems create resistance to sliding or shear displacement in a streambank as they develop roots or fibrous inclusions. Environmental benefits derived from woody vegetation include diverse and productive riparian habitats, shade, organic additions to the stream, cover for fish, and improvements in aesthetic value and water quality.

The <u>Native Plant Guide</u> describes native plant materials, general design concepts, application and maintenance. Pages 7-15 of this manual briefly describe different types of bio-engineering designs and effectiveness.

Structural Systems:

Structural measures include tree revetments; log, rootwad and boulder revetments; dormant post plantings; rock riprap; stream barbs and gabions.

Pages 16-23 briefly describe different types of structural designs and effectiveness.

Common name	Botanic name	Plugging rate (on center)	Seeding rate, Pure Live Seed (PLS)
1. Banks and slopes (stabilizing matrix):			
Big Bluestem	Andropogon gerardii	18-24"	5 lb/ac
Brown Fox Sedge	Carex vulpinoidia	"	0.25 lb/ac
Canada wild rye	Elymus Canadensis	"	5 lb/ac
Streambank rye	Elymus riparius	"	1 lb/ac
Silky Wild Rye	Elymus villosus	"	1 lb/ac
Virginia Wild Rye	Elymus virginicus	"	3 lb/ac
Torrey's Rush	Juncus torreyi	"	0.01 lb/ac
Evening Primrose	Oenothera biennis	"	0.25 lb/ac
Switch grass	Panicum virgatum	"	8 lb/ac
Blue Vervain	Verbena hastate	"	1 lb/ac
2. Toe of slope (lower banks):			
Sweet Flag	Acorus calamus	"	N/A
Water Plantain	Alisma subcordatum	"	N/A
Bluejoint grass	Calamagrostis canadensis	"	N/A
Creeping Spike Rush	Eleocharis acicularis	"	N/A
Blue Flag Iris	Iris virginica	"	N/A
Torrey's rush	Juncus Torreyi	"	N/A
Switch Grass	Panicum virgatum	"	N/A
Arrowhead	Saggittaria latifolia	"	N/A
Hardstem Bulrush	Scirpus acutus	"	N/A
Chairmaker's rush	Scirpus americanus	"	N/A
Dark Green Rush	Scirpus atrovirens	"	N/A
River Bulrush	Scirpus fluviatilis	"	N/A
Prairie Cord Grass	Spartina pectinada	"	N/A
Blue vervain	Verbena hastate	"	N/A
3. Cover crops:			
Annual ryegrass	Lolium multiflorum	N/A	60 lb/ac
Perennial ryegrass	Lolium perenne	N/A	25 lb/ac
Wheat		N/A	60 lb/ac
Oats		N/A	60 lb/ac

4. Brush for live stakes, brushmattresses, live fascines, live cribwalls, branchpacking, and vegetated geogrids: (Plant lightly on south bank to prevent overshading to north bank)

Buttonbush	Cephalanthus occidentalis
Silky dogwood	Cornus amonum
Red-osier dogwood	Cornus stolonifera
White willow	Salix alba
Peach-leaved willow	Salix amygdaloides
Pussy Willow	Salix discolor
Sandbar willow	Salix interior
Elderberry	Sambucus Canadensis

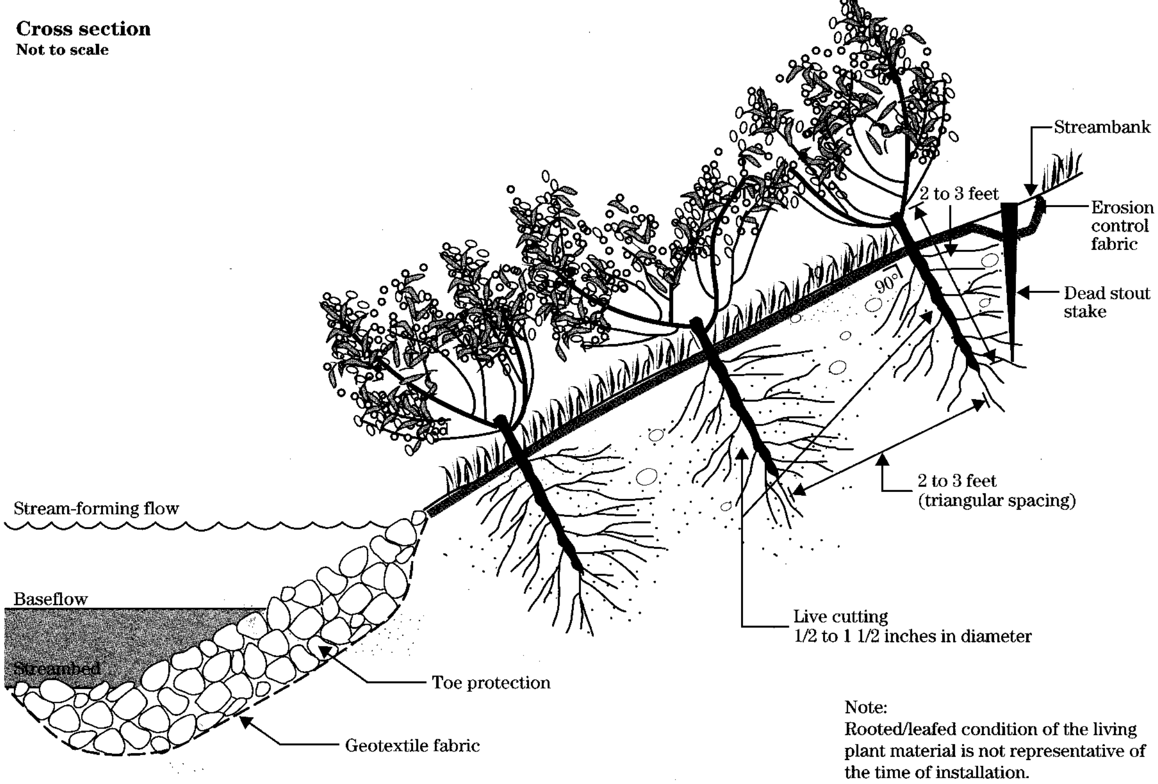
Live Stakes - Live staking involves the insertion and tampering of live, rootable vegetative cuttings into the ground (fig 1). If correctly prepared, handled and placed, the live stake will root and grow.

A system of stakes creates a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. Most willow species root rapidly and begin to dry out a bank soon after installation.

Applications and effectiveness

- Effective streambank protection technique where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed.
- Appropriate technique for repair of small earth slips and slumps that frequently are wet.
- Can be used to peg down and enhance the performance of surface erosion control materials.
- Enhance conditions for natural colonization of vegetation from the surrounding plant community.
- Stabilize intervening areas between other soil bioengineering techniques, such as live fascines.
- Produce streamside habitat.
- Recommended slope $\leq$ 3:1. Practice is not applicable for slopes $\geq$ 2:1.

Fig. 1



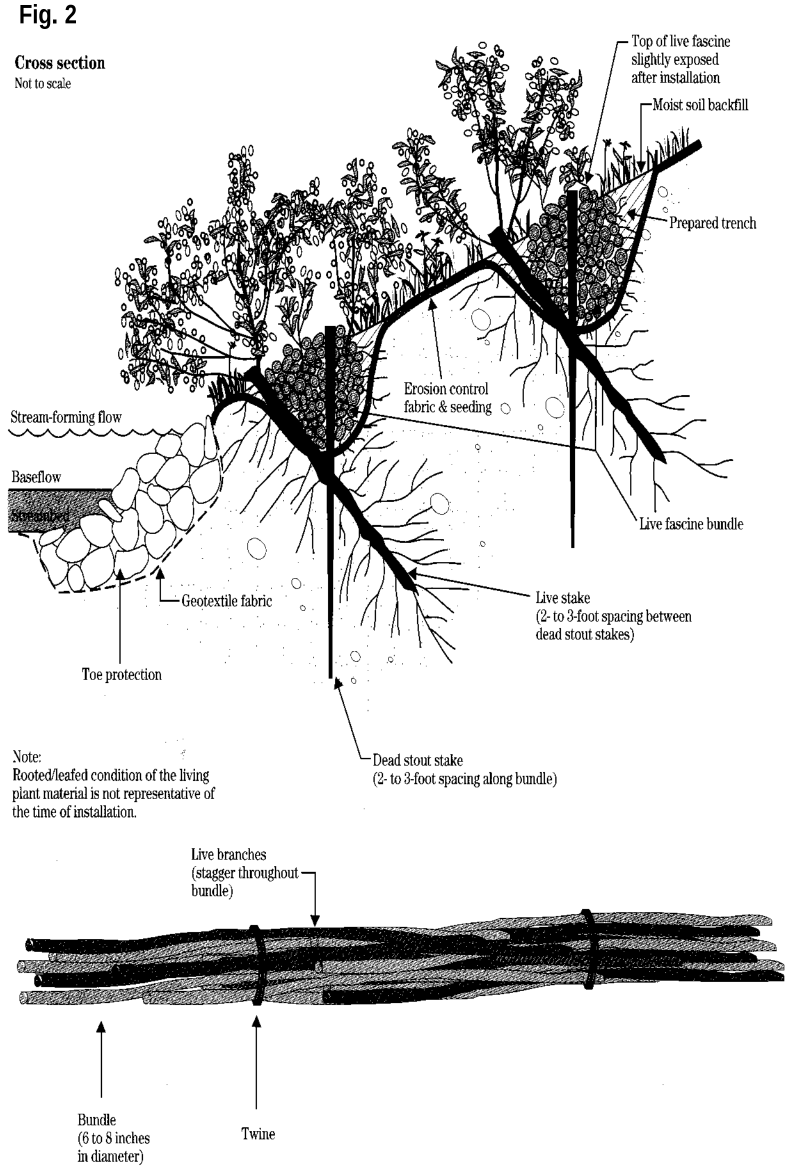
(210-vi-EFH, December 1996)

Live Fascines - Live fascines are long bundles of branch cuttings bound together in cylindrical structures (fig. 2). They should be placed in shallow contour trenches on dry slopes and at an angle on wet slopes to reduce erosion and shallow sliding.

Applications and effectiveness

- Apply typically above bankfull discharge (stream-forming flow) except on very small drainage area sites (generally less than 2,000 acres).
- Effective stabilization technique for streambanks. When properly installed, this system does not cause much site disturbance.
- Protect slopes from shallow slides (1 to 2 foot depth).
- Offer immediate protection from surface erosion.
- Capable of trapping and holding soil on streambank by creating small dam-like structures, thus reducing the slope length into a series of shorter slopes.
- Serve to facilitate drainage where installed at an angle on the slope.
- Enhance conditions for colonization of native vegetation by creating surface stabilization and a microclimate conducive to plant growth.

Fig. 2

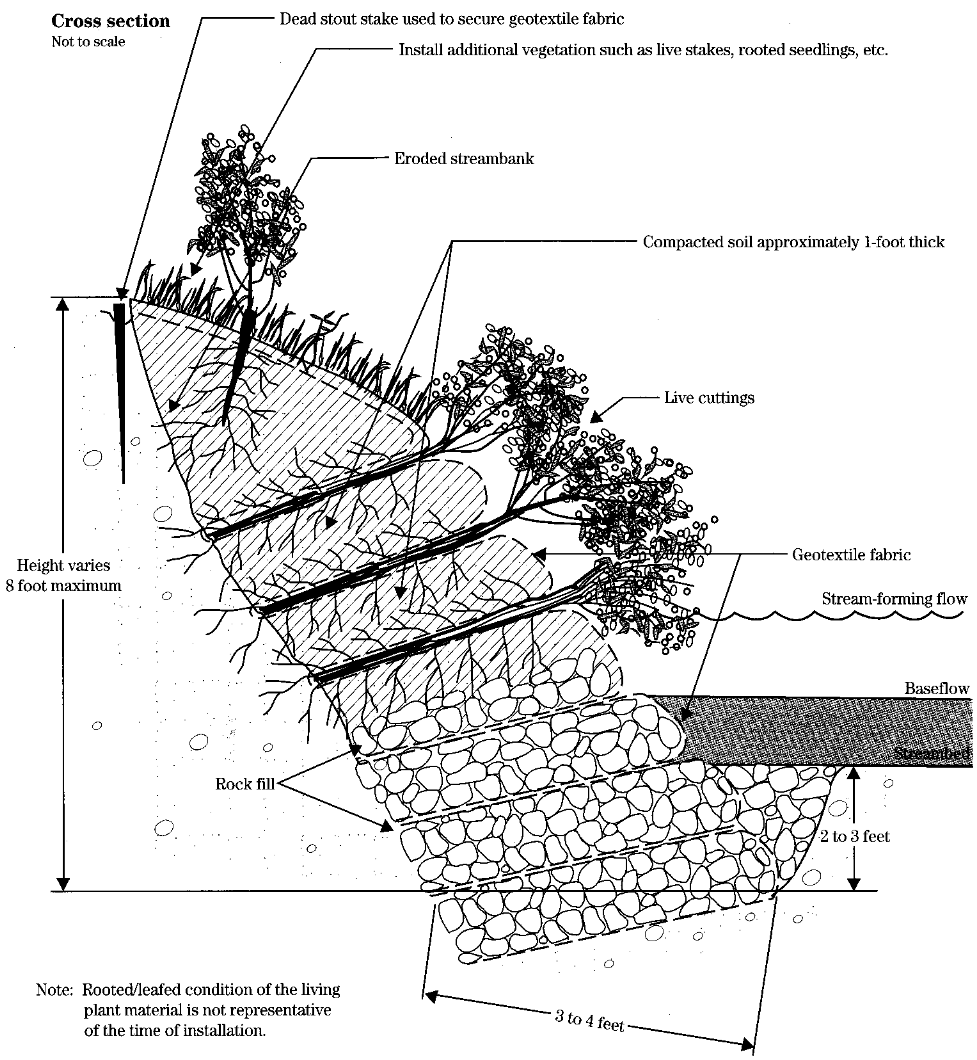


Vegetated Geogrids - Vegetated geogrids are similar to branchpacking except that natural or synthetic geotextile materials are wrapped around each soil lift between the layers of live branch cuttings (fig. 3).

Applications and effectiveness

- Used above and below stream-forming flow conditions.
- Drainage areas should be relatively small (generally less than 2,000 acres) with stable streambeds.
- The system must be built during low flow conditions.
- Produce a newly constructed, well-reinforced streambank.
- Useful in restoring outside bends where erosion is a problem.
- Capture sediment, which rapidly rebuilds to further stabilize the toe of the streambank.
- Function immediately after high water to rebuild the bank.
- Produce rapid vegetative growth.
- Enhance conditions for colonization of native vegetation.
- Benefits are similar to those of branchpacking, but a vegetated geogrid can be placed on a 1:1 or steeper slope.

Fig. 3



Live Cribwall or Lunker - A live cribwall or lunker consists of a box-like interlocking arrangement of untreated log or timber members. Once the live cuttings root and become established, the subsequent vegetation gradually takes over the structural functions of the wood members (fig. 4a and b).

Applications and effectiveness

- Effective on outside bends of stream where strong currents are present.
- 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.
- Appropriate above and below water level where stable streambeds exist.
- Useful where space is limited and a more vertical structure is required.
- Effective in locations where an eroding bank may eventually form a split channel.
- Maintains a natural streambank appearance.
- Provides excellent habitat.
- Provides immediate protection from erosion, while established vegetation provides long-term stability.
- Supplies effective bank erosion control on fast flowing streams.
- Should be tilted back or battered if the system is built on a smooth, evenly sloped surface.
- Can be complex and expensive.

Fig. 4a Live Cribwall

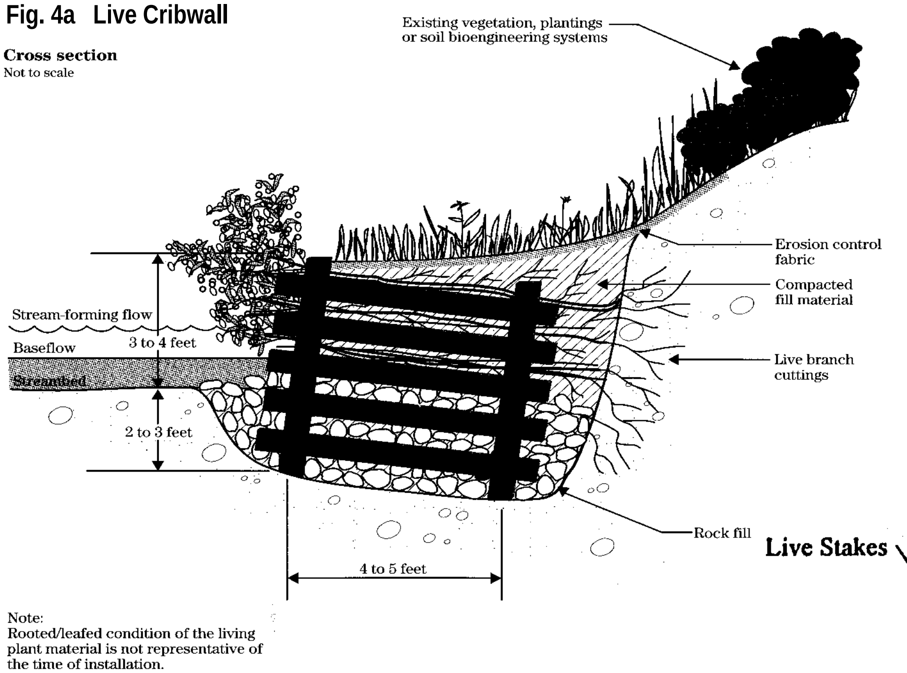
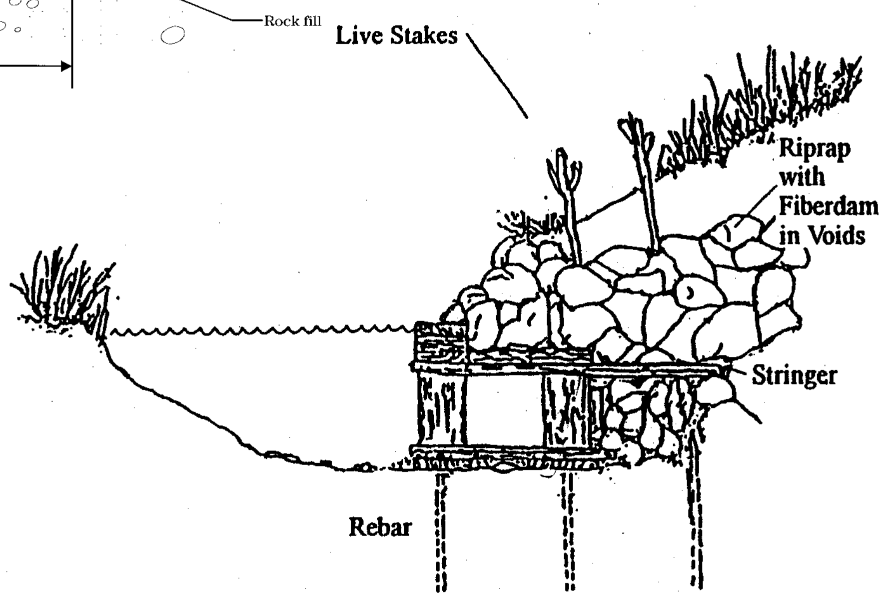


Fig. 4 b Lunker

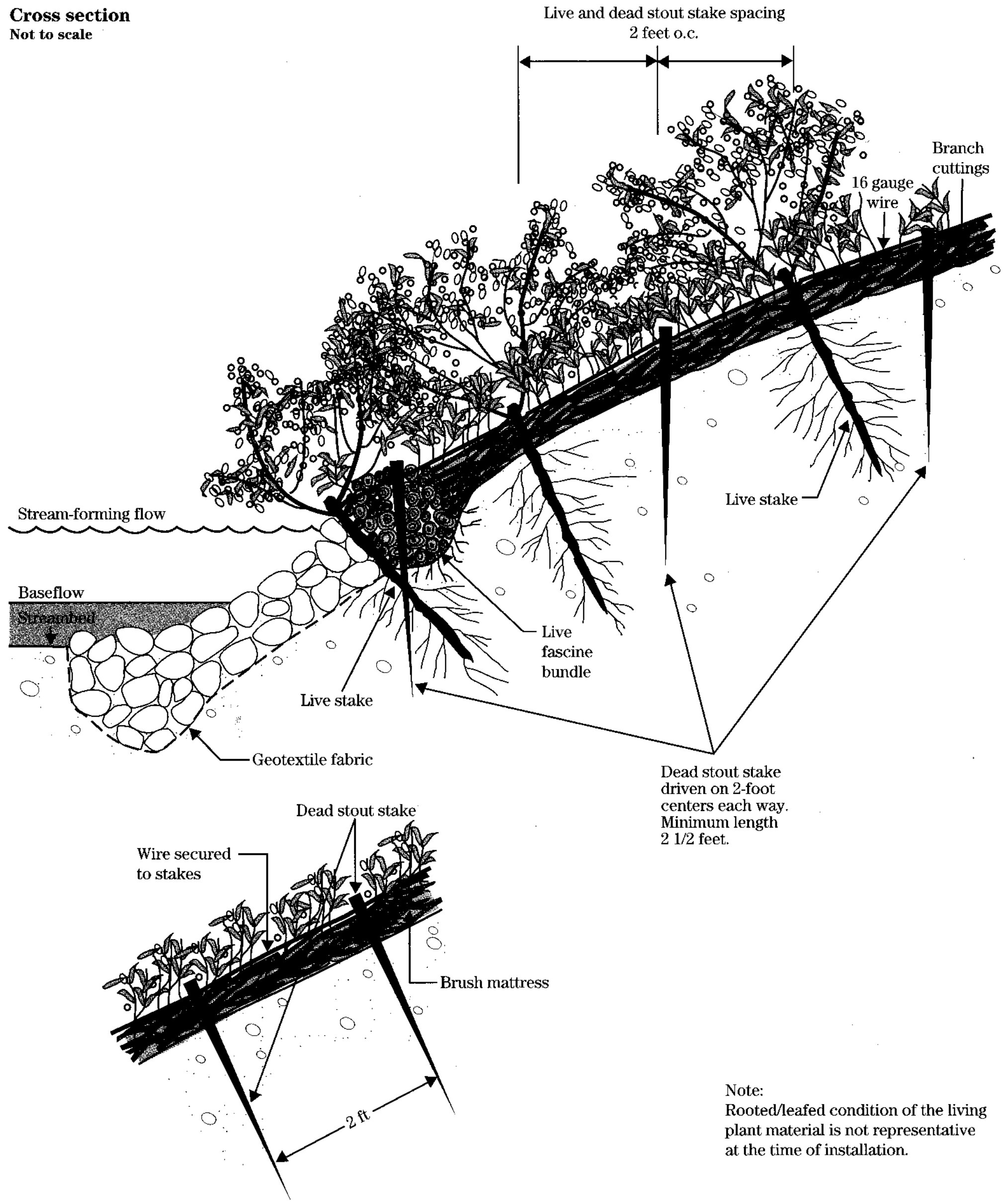


Brushmattress - A brushmattress is a combination of live stakes, live fascines, and branch cuttings installed to cover and stabilize streambanks (fig. 6). Application typically starts above stream-forming flow conditions and moves up the slope.

Applications and effectiveness

- Forms an immediate, protective cover over the streambank.
- Useful on steep, fast-flowing streams.
- Captures sediment during flood conditions.
- Rapidly restores riparian vegetation and streamside habitat.
- Enhances conditions for colonization of native vegetation.

Fig. 6



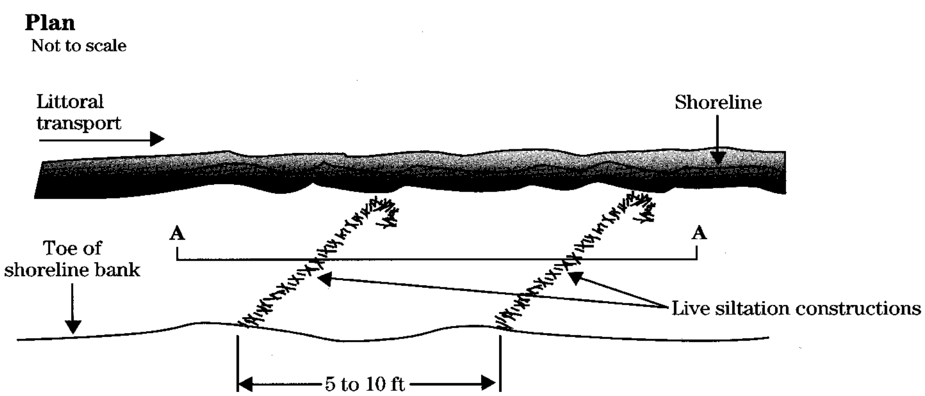
Live Siltation Construction - Live siltation construction is similar to brushlayering except that the orientation of the branches are more vertical. Ideally live siltation systems are approximately perpendicular to the prevailing winds. The branch tips should slope upwards at 45 to 60 degrees. Installation is similar to brush layering.

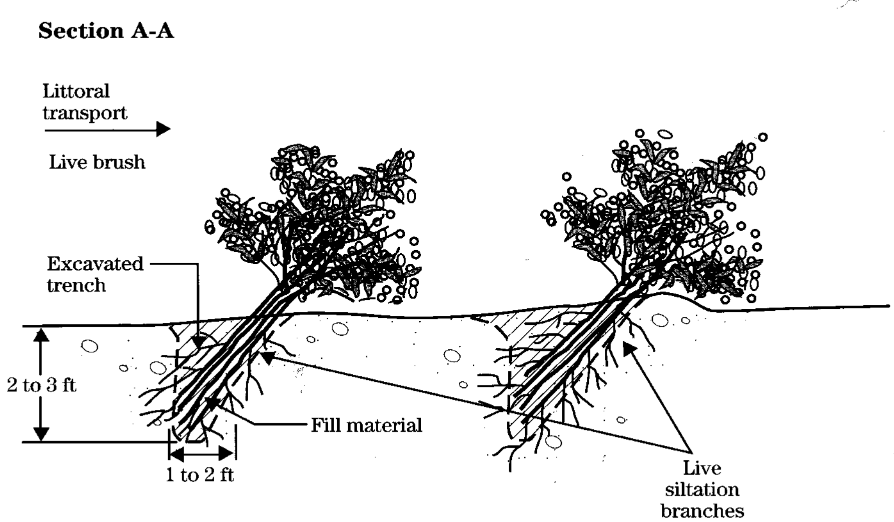
Live siltation branches that have been installed in the trenches serve as tensile inclusions or reinforcing units. The part of the brush that protrudes from the ground assists in retarding runoff and surface erosion from wave action and wind (fig. 7).

Applications and effectiveness
Live siltation systems provide immediate erosion control and earth reinforcement functions, including:

- Providing surface stability for the planting or establishment of vegetation.
- Trapping debris, seed, and vegetation at the shoreline.
- Reducing wind erosion and surface particle movement.
- Drying excessively wet sites through transpiration.
- Promoting seed germination for natural colonization.
- Reinforcing the soil with unrooted branch cuttings.
- Reinforcing the soil as deep, strong roots develop and adding resistance to sliding and shear displacement.

Fig. 7





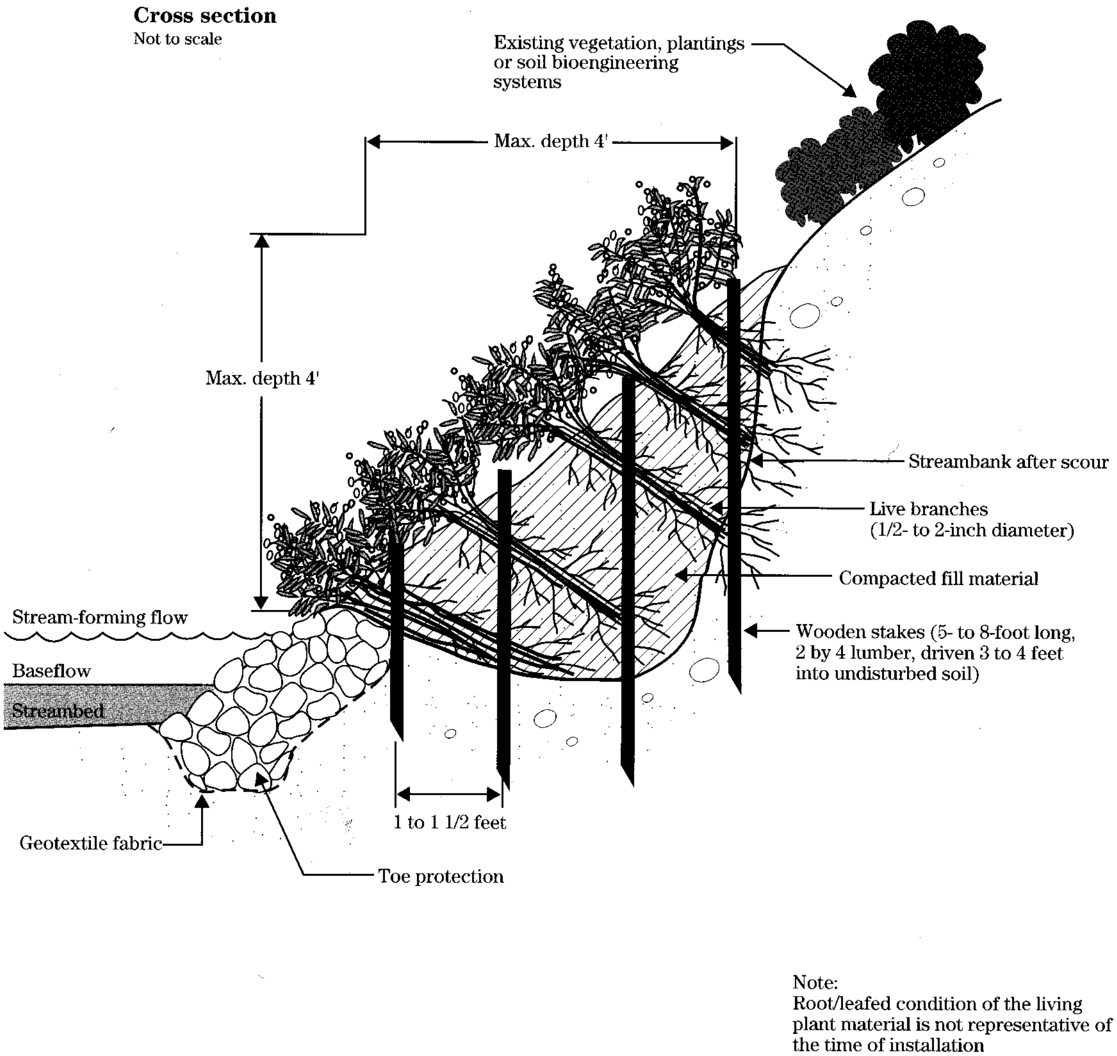
Note: Rooted/leafed condition of the living plant material is not rrespresentative of the time of installation.

Branchpacking - Branchpacking consists of alternating layers of live branches and compacted backfill to repair small localized slumps and holes in streambanks (fig. 8).

Applications and effectiveness

- Effective and inexpensive method to repair holes in streambanks that range from 2 to 4 feet in height and depth.
- Produces a filter barrier that prevents erosion and scouring from streambank or overbank flow.
- Rapidly establishes a vegetated streambank.
- Enhances conditions for colonization of native vegetation.
- Provides immediate soil reinforcement.
- Live branches serve as tensile inclusions for reinforcement once installed. As plant tops begin to grow, the branchpacking system becomes increasingly effective in retarding runoff and reducing surface erosion. Trapped sediment refills the localized slumps or hole, while roots spread throughout the backfill and surrounding earth to form a unified mass.
- Typically branchpacking is not effective in slump areas greater than 4 feet deep or 4 feet wide.

Fig. 8

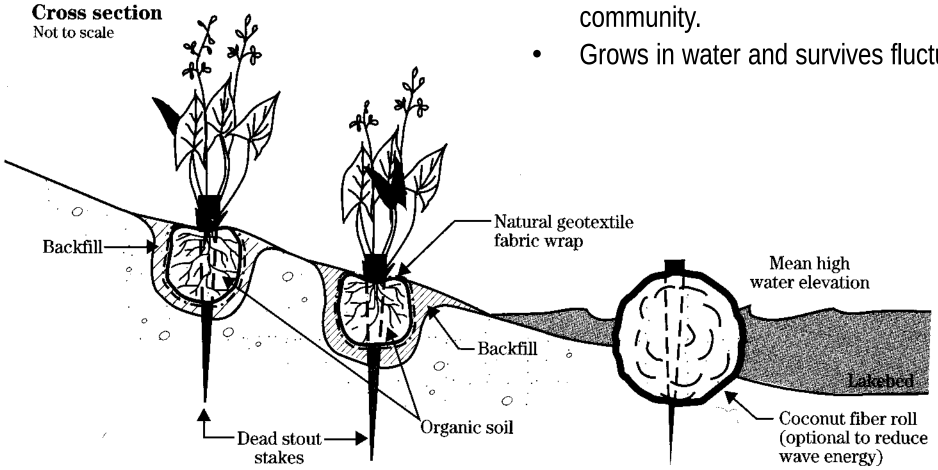


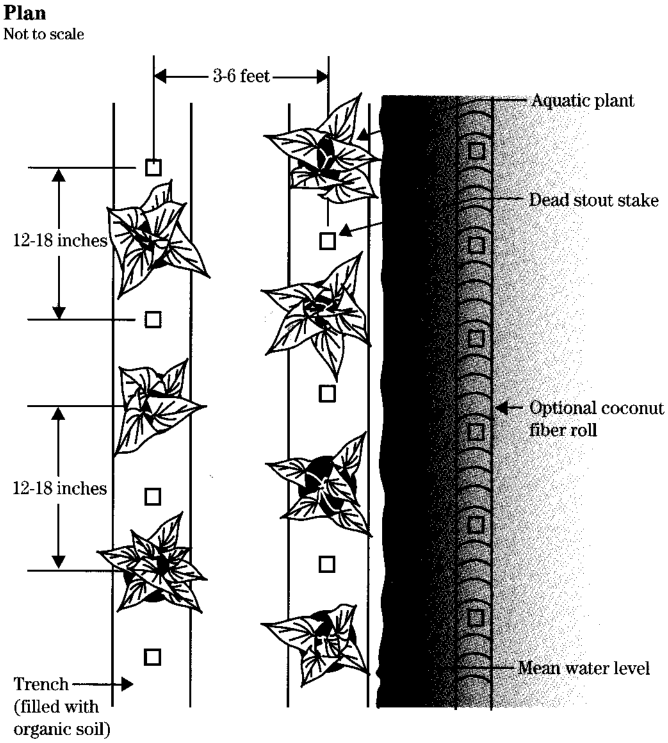
Reed Clump - Reed clump installations consist of root divisions wrapped in natural geotextile fabric, placed in trenches, and staked down. The resulting root mat reinforces soil particles and extracts excess moisture through transpiration. Reed clump systems are typically installed at the water's edge or on shelves in the littoral zone (fig. 9).

Applications and effectiveness

- Reduces toe erosion and creates a dense energy-dissipating reed bank area.
- Offers relatively inexpensive and immediate protection from erosion.
- Useful on shore sites where rapid repair of spot damage is required.
- Retains soil and transported sediment at the shoreline.
- Reduces a long beach wash into a series of shorter sections capable of retaining surface soils.
- Enhances conditions for natural colonization and establishment of vegetation from surrounding plant community.
- Grows in water and survives fluctuating water levels.

Fig. 9





Coconut Fiber Rolls - Coconut fiber rolls are cylindrical structures composed of coconut husk fibers bound together with twine woven from coconut (fig. 10). This material is most commonly manufactured in 12-inch diameters and lengths of 20 feet. It is staked in place at the toe of the slope, generally at the stream-forming flow stage.

The fiber rolls function as breakwaters along the shores of lakes and embayments. In addition to reducing wave energy, this product can help contain substrate and encourage development of wetland communities.

Applications and effectiveness

- Protect slopes from shallow slides or undermining while trapping sediment that encourages plant growth within the fiber roll.
- Effective in lake areas where the water level fluctuates because it is able to protect the shoreline and encourage new vegetation.
- Flexible, product can mold to existing curvature of streambank.
- Produce a well-reinforced streambank without much site disturbance.
- Prefabricated materials can be expensive.
- Manufacturers estimate the product has an effective life of 6 to 10 years.

Fig. 10

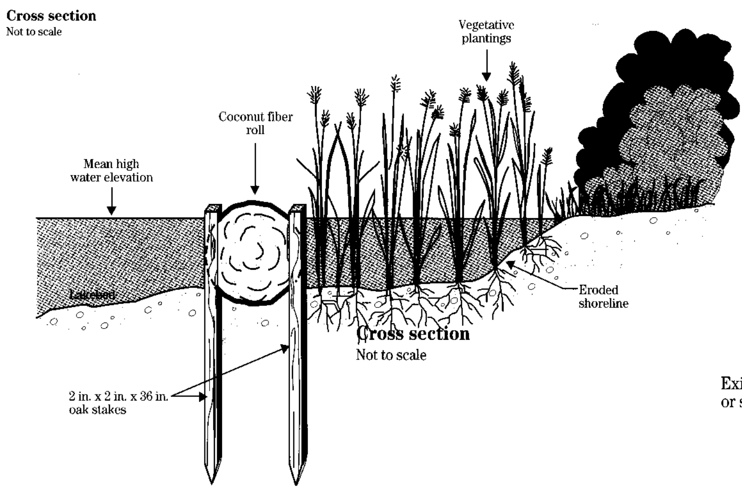
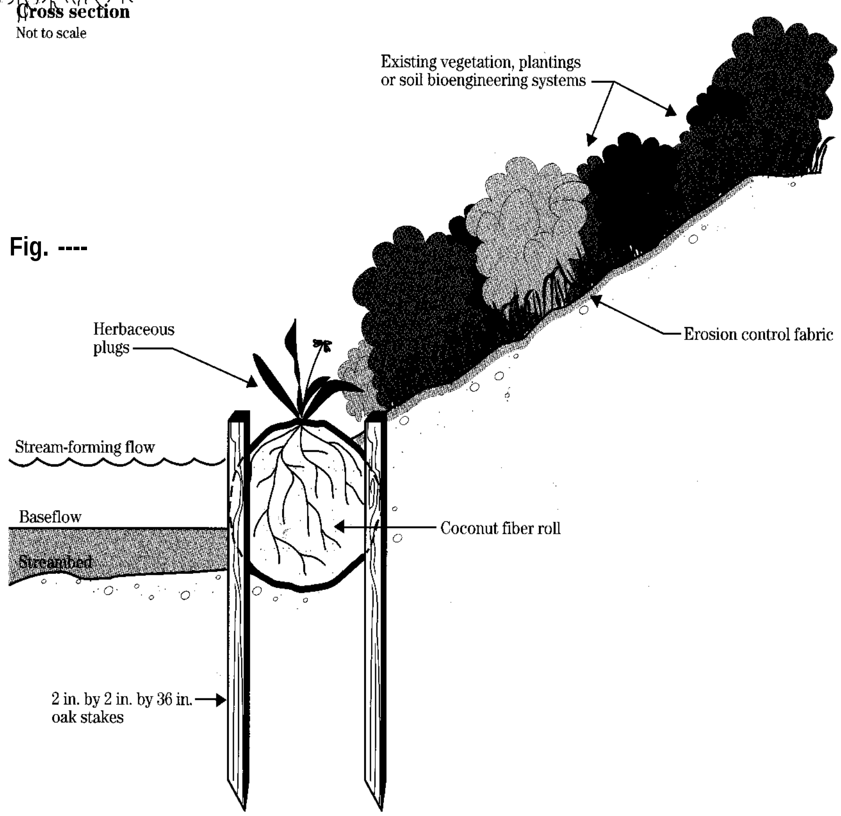


Fig. ----



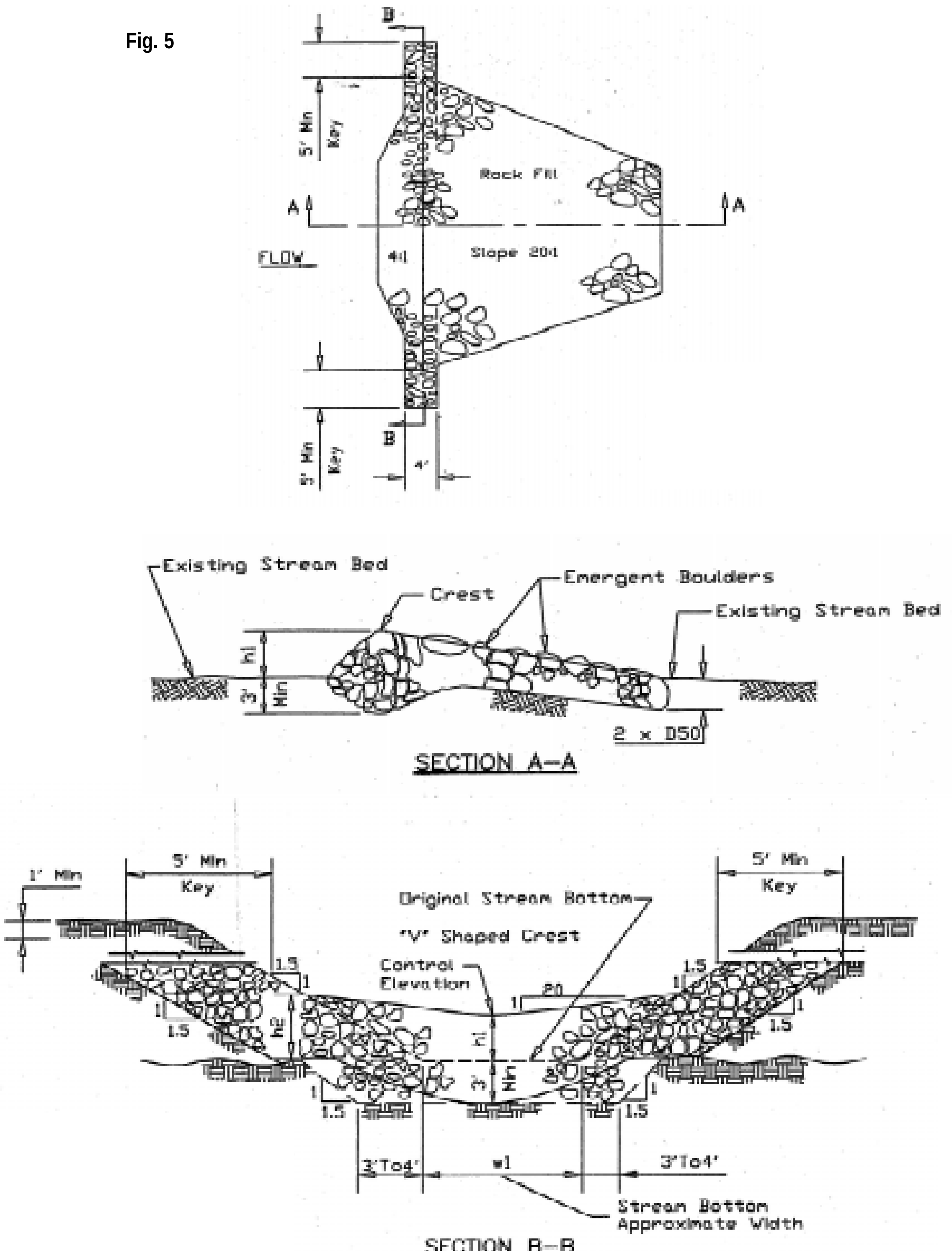
(210-vi-EFH, December 1996)

Rock Riffle - Also commonly referred to as pool riffle because it mimics a natural pool upstream of the installed riffle. The slope/velocities are reduced upstream of the riffle. At the point the velocity increases (across and through) the channel is stablized by the riffle.

Applications and effectiveness

- Limited to sites where grade is the main cause of soil erosion.
- Improves fish habitat by increased oxygen levels.
- Can be complex and expensive due to need for heavy equipment.

Fig. 5

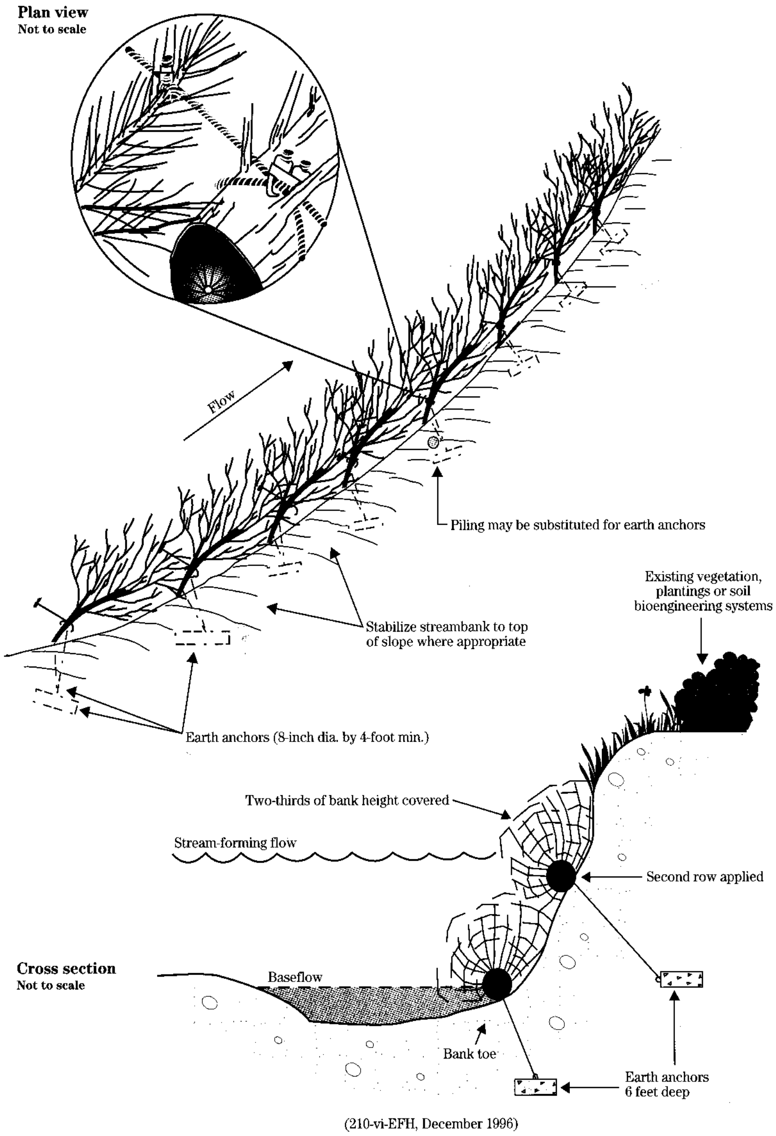


Tree Revetment - A tree revetment is constructed from whole trees (except rootwads) that are usually cable together and anchored by earth anchors, which are buried in the bank (fig. 11).

Applications and effectiveness

- Uses inexpensive, readily available materials to form semi-permanent protection.
- Captures sediment and enhances conditions for colonization of native species.
- Has self-repairing abilities following damage after flood events if used in combination with soil bioengineering techniques.
- Not appropriate near bridges or other structures where there is high potential for downstream damage if the revetment dislodges during flood events.
- Has a limited life and needs to be replaced periodically, depending on climate and duration of tree species used.
- May be damaged in streams where heavy ice flows occur.
- Requires periodic maintenance to replace damaged or deteriorating trees.

Fig. 11

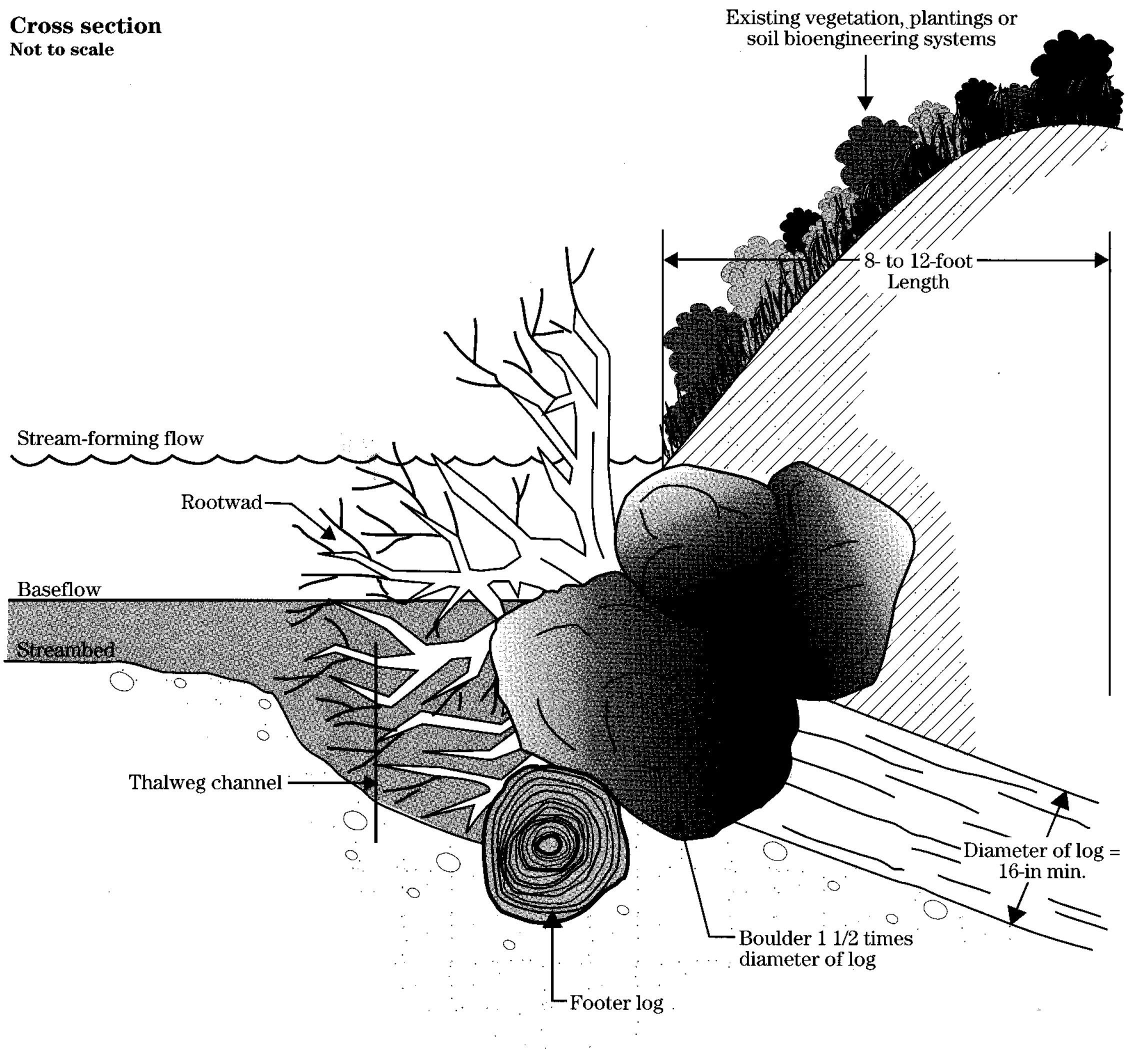


Log, Rootwad and Boulder Revetment - These revetments are systems composed of logs, rootwads, and boulders selectively placed in and on streambanks (fig. 12). These revetments can provide excellent overhead cover, resting areas, shelters for insects and other fish food organisms, substrate for aquatic organisms, and increased stream velocity that results in sediment flushing and deeper scour pools. Several of these combinations are described in Floyd Reynolds (1991), Rosgen (1992) and Berger (1991).

Applications and effectiveness

- Used for stabilization and to create instream structures for improved fish rearing and spawning habitat.
- Effective on meandering streams with out-of-bank flow conditions.
- Will tolerate high boundary shear stress if logs and rootwads are well anchored.
- Suited to streams where fish habitat deficiencies exist.
- Should be used in combination with soil bioengineering system or vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Enhance diversity of riparian corridor when used combination with soil bio-engineering systems.
- Have limited life depending on climate and tree species used.

Fig. 12

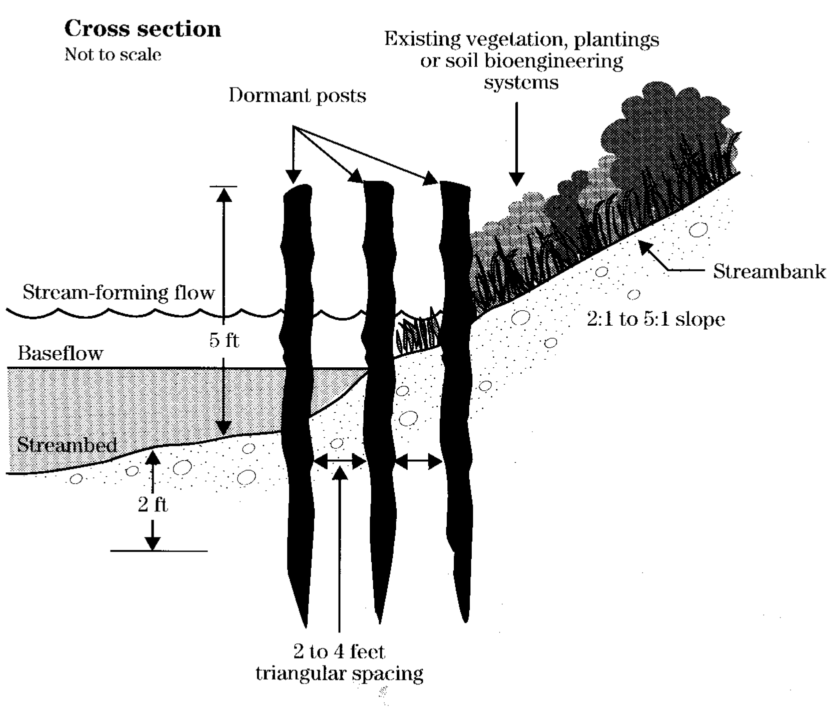


Dormant Post Plantings - Dormant post plantings form a permeable revetment that is constructed from rootable vegetative material placed along streambanks in a square or triangular pattern (fig. 13).

Applications and effectiveness

- Well suited to smaller, non-gravely streams where ice damage is not a problem.
- Quickly re-establish riparian vegetation.
- Reduce stream velocities and causes sediment deposition in the treated area.
- Enhance conditions for colonization of native species.
- Are self-repairing. For example, posts damaged by beaver often develop multiple stems.
- Can be used in combination with soil bioengineering systems.
- Can be installed by a variety of methods including water jetting or mechanized stingers to form planting holes or driving the posts directly with machine mounted rams.
- Unsuccessfully rooted posts at spacing of about 4 feet can provide some benefits by deflecting higher streamflows and trapping sediment.
- Suited towards smaller stream systems.

Fig. 13

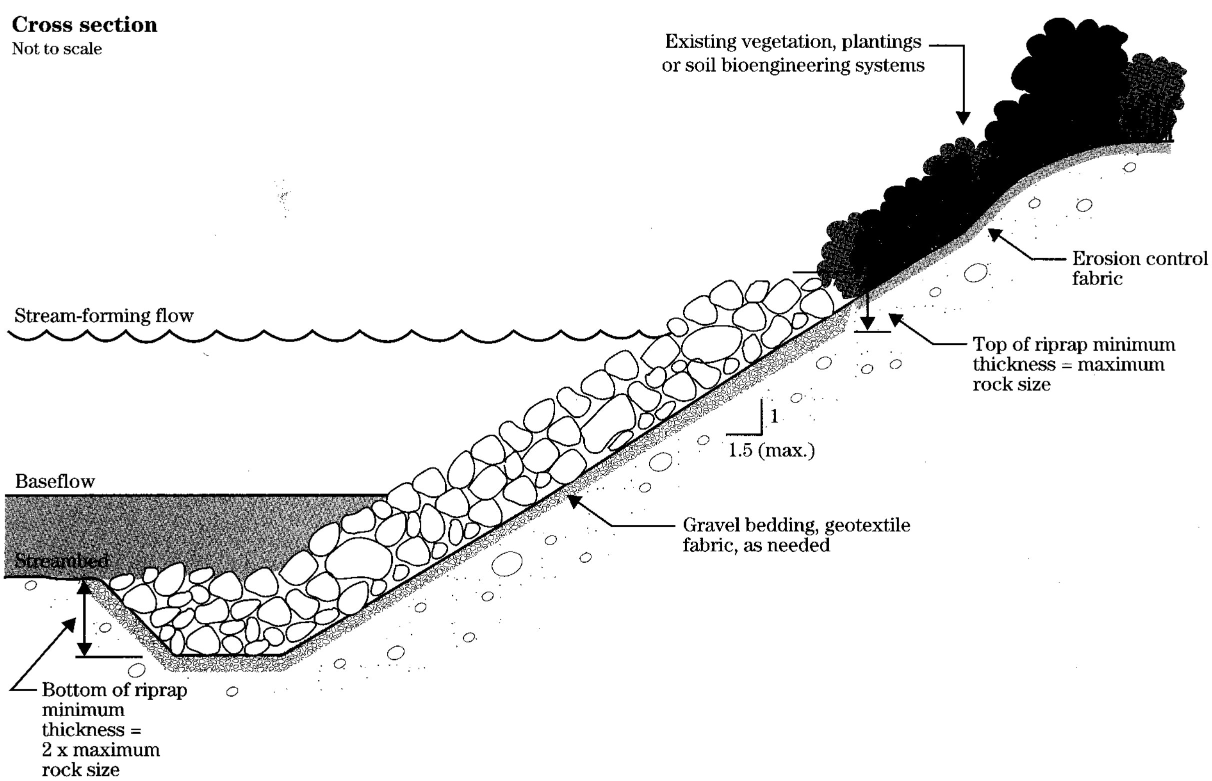


Rock Riprap - Rock riprap, properly designed and placed, is an effective method of streambank protection (fig. 14). The cost of quarrying, transporting, and placing stone and the large quantity of stone that may be needed must be considered. Gabion baskets, concrete cellular blocks, or similar systems can be an alternative to rock riprap under many circumstances.

Applications and effectiveness

- Provides long-term stability.
- Has structural flexibility. It can be designed to self-adjust to eroding foundations.
- Has a long life and seldom needs replacement, low maintenance.
- Is inert so does not depend on specific environmental or climatic conditions for success.
- May be designed for high velocity flow conditions.
- Typically only recommended for toe protection (up to baseflow line).
- Shade tolerant design.

Fig. 14



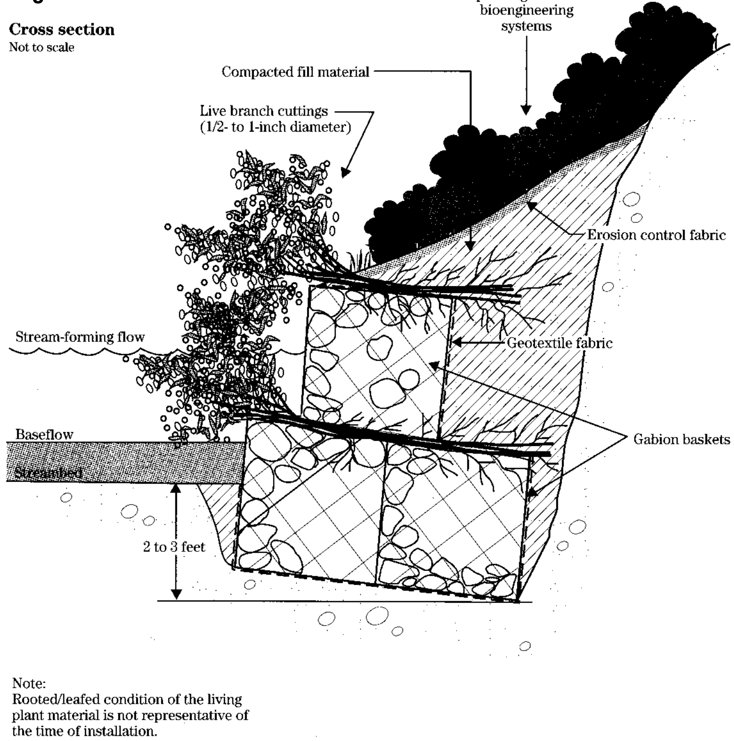
Rock Gabions - Rock gabions begin as rectangular containers fabricated from a triple twisted, hexagonal mesh of heavily galvanized steel wire. Empty gabions are placed in position, wired to adjoining gabions, filled with stones, and then folded shut and wired at the ends and sides. NRCS Construction Specification 64, Wire Gabions, provides detailed information on their installation.

Vegetation can be incorporated into rock gabions, if desired, by placing live branches on each consecutive layer between the rock-filled baskets (fig. 15). These gabions take root inside the gabion baskets and in the soil behind the structures. In time the roots consolidate the structure and bind it to the slope.

Applications and effectiveness

- Useful when rock riprap design requires a rock size greater than what is locally available.
- Effective where the bank slope is steep (typically greater than 1:5:1 and requires structural support). Useful where space is limited.
- 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.
- Can be fabricated on top of the bank and then placed as a unit, below water if necessary.
- Lower initial cost than a concrete structure.
- Tolerate limited foundation movement.
- Have a short service life where installed in streams that have a high bed load. Avoid use where streambed material might abrade and cause rapid failure of gabion wire mesh.
- Not designed for or intended to resist large, lateral earth stresses. Should be constructed to a maximum of 5 feet in overall height, including the excavation required for a stable foundation.
- Construction technique must ensure no water can flow behind practice.
- Where gabions are designed as a structural unit, the effects of uplift, overturning, and sliding must be analyzed in a manner similar to that for gravity type structures.
- Can be placed as a continuous mattress for slope protection. Slopes steeper than 2:1 should be analyzed for slope stability.
- Gabions used as mattresses should be a minimum of 9 inches thick for stream velocities of up to 9 feet per second. Increase the thickness to a minimum of 1.5 feet for velocities of 10 to 14 feet per second.

Fig. 15

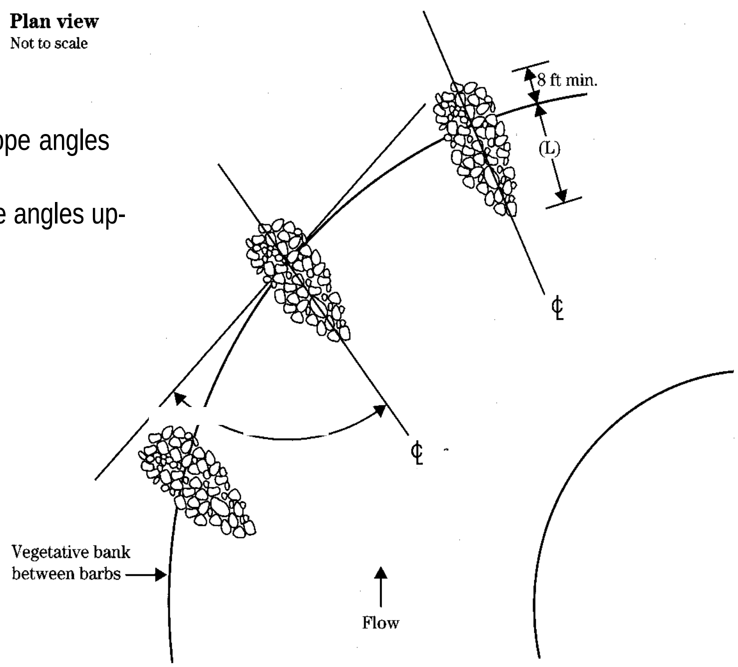


Stream Barb/Bendway Weir - Stream barbs/bendway weirs are low rock sills projecting out from a streambank and across the stream's thalweg to redirect streamflow away from an eroding bank (fig. 16). Flow passing over the barb/weir is redirected so that the flow leaving is perpendicular to the center line.

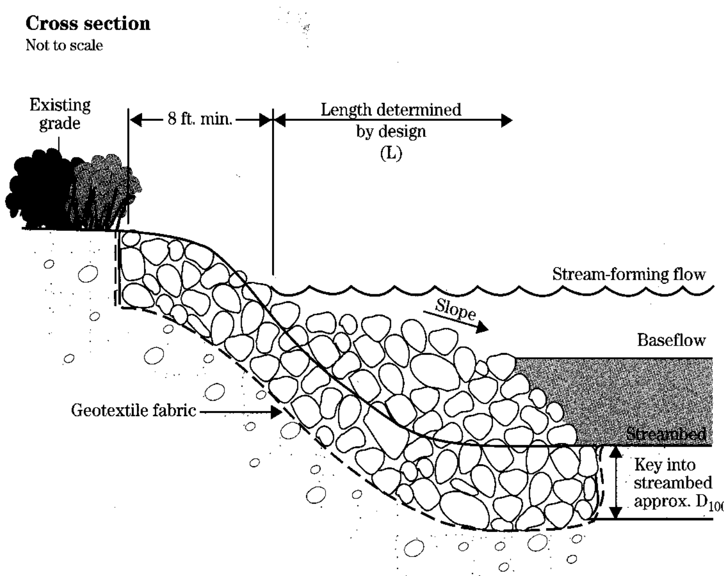
Applications and effectiveness

- Used in limited applications. Effective in control of bank erosion on small stream bends along the outer bank.
- Requires less rock and stream disturbance than jetties.
- Improve fish habitat (especially when vegetated).
- Can be combined with soil bioengineering practices.
- Can be complex and expensive due to need for heavy equipment.

Fig. 16



***** For bendway weirs the slope angles upstream 5° to 20°.
***** For stream barbs the slope angles upstream 20° to 45°.



* For bendway weir slope is negligible.

NAME	Type of Protection and Where Applicable										Problems Addressed							
	Decrease Force	Increase Resistance	Immediate Protection	Protection Below or at Waterline	Streambank	Shoreline	Flat Banks Finished ≤ 2:1	Steep Banks Finished ≥ 2:1	Holes, Local Slumps	Natural Materials Present	Toe Erosion, Undercutting	Wildlife Habitat	Aquatic Habitat	Water Quality Sediment Trap	Saturated Soil	Bare Bank	Ice Damage	Overbank Erosion
Soil Bioengineering																		
Live Stakes		1			1	1	1		1			1		1	1	1		1
Live Fascines		1			1	1	1			1		1		1	1	1		1
Branchpacking	1	1	1		1	1	1		1	1		1	1	1	1	1		
Vegetated Geogrids		1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1
Live Cribwall / Lunkers		1	1	1	1	1		1			1	1	1	1	1	1	1	1
Brushmattress		1	1		1	1				1		1		1	1	1		1
Live Siltation	1					1				1				1				
Reed Clumps		1				1						1		1		1		1
Coconut Fiber Rolls		1	1	1	1	1					1	1	1	1				
Structural																		
Rock Riffle	1	1	1	1	1		1	1			1		1	1			1	
Tree Revetment	1	1	1	1	1					1	1	1	1				1	
Log, Rootwad, Boulder Revetment	1	1	1	1	1					1		1	1	1			1	
Dormant Post Planting	1	1	1	1	1					1	1	1			1	1		1
Rock Riprap		1	1	1	1	1	1				1				1	1	1	1
Rock Gabions			1	1	1	1	1	1			1		1		1	1	1	
Stream Barbs / Bendway Weirs	1		1	1	1		1				1		1	1			1	