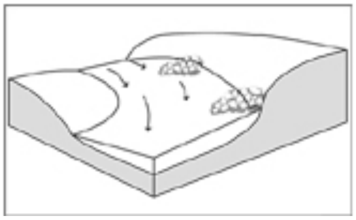
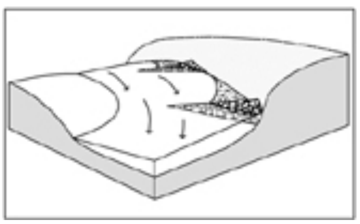
RIVER TRAINING STRUCTURES

SPUR DIKES



Spur dikes, deflectors or groins are transverse structures that extend into the stream from the bank and reduce erosion by deflecting flows away from the bank. Transverse river training structures often provide pool habitat and physical diversity. Two to five structures are typically placed in series along straight or convex bank lines where flow lines are roughly parallel to the bank. Spurs, groins, and deflectors have no specific design criteria regarding crest height, crest slope or upstream angle and therefore differ from vanes and bendway weirs. Earthen core spur dikes are groins constructed with a soil core armored by a layer of stone. Deflectors can also be constructed from natural materials, such as large woody debris (LWD), or LWD embedded with rock, and designed to provide biologic benefits and habitat restoration. Stone spurs capped with a prism of earth reinforced with live fascines are referred to as "live booms."

VANES



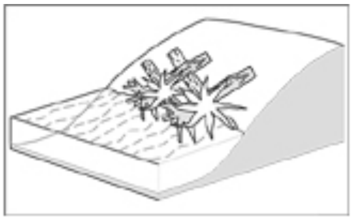
Rock vanes are discontinuous, redirective structures angled upstream 20 to 30 degrees. Generally, two or three vanes are constructed along the outer bank of a bend in order to redirect flows near the bank to the center of the channel. Typically, vanes project 1/3 of the stream width. The riverward tips are at channel grade, and the crests slope upward to reach bankfull stage elevation at the key. Rock vanes can preclude the need for rock armor and increase vegetative techniques as the high flows are redirected away from the bank. Vanes can increase cover, backwater area, edge or shoreline length, and the diversity of depth, velocity and substrate. Variations include Cross Vanes and Rock Vanes with J-hooks.

BENDWAY WEIRS

Bendway weirs are discontinuous, redirective, structures usually constructed of rock, designed to capture and then safely direct the flow through a meander bend. A minimum of five structures are typically placed in series (the series are known as “weir fields”) along straight or convex bank lines. Bendway weirs differ from spurs and vanes in that they form a control system that captures and directs the streamflow through the weir field, usually all the way through the bend (hence the name bendway weirs). Bendway weirs are generally longer (1/3 – 1/2 stream width) and lower than barbs or spurs, flat crested and are designed to be continuously submerged or at least be overtopped by the design flows. Transverse river training structures often provide pool habitat and physical diversity.

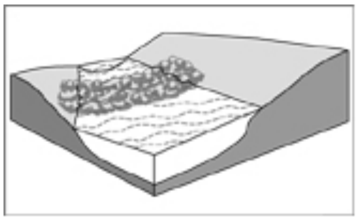
LARGE WOODY DEBRIS STRUCTURES

Large woody debris (LWD) structures (aka engineered log jams) made from felled trees may be used to deflect erosive flows and promote sediment deposition at the



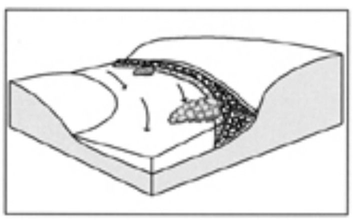
base of eroding banks. Root wads, consisting of a short section of trunk and attached root bole, can also be used or incorporated into the structures. Using the classical spur design criteria and methods, the placement of LWD can be designed to achieve optimum benefit for both aquatic habitat and bank protection.

STONE WEIRS



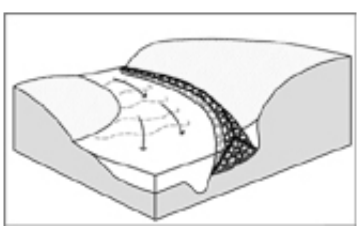
Stone weirs are structures that span the stream and produce a drop in the water surface elevation. These structures are frequently made of angular quarried stone, but logs, sheet piling, concrete, boulders and masonry are also quite common. Well-constructed stone weirs can prevent or retard channel bed erosion and upstream progression of "knickpoints" and headcuts, as well as providing pool habitats for aquatic biota. Stone weirs or similar grade control structures are often intended to raise or elevate the bottom of incised channels, with the ultimate goal of elevating a dropping water table. Variations on stone weirs that have additional habitat benefits are Newbury Rock Riffles and Cross Vanes.

LONGITUDINAL STONE TOE WITH SPURS



A longitudinal stone toe has proven cost-effective in protecting lower banks and creating conditions leading to stabilization and re-vegetation of steep, caving banks. A large body of evidence indicates, however, that intermittent structures such as spurs tend to provide aquatic habitats superior to those adjacent to continuous structures like a stone toe. This technique represents an effort to achieve erosion control benefits available from a continuous stone toe and habitat benefits associated with spurs.

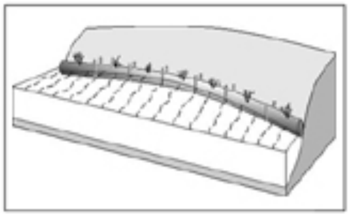
LONGITUDINAL STONE TOE



A longitudinal stone toe (aka longitudinal peaked stone toe protection (LPSTP)) is continuous bank protection consisting of a stone dike placed longitudinally at, or slightly streamward of the toe of an eroding bank. The cross section of the stone toe is usually triangular in shape. The success of this method depends upon the ability of stone to self-adjust or "launch" into scour holes formed on the stream side of the revetment. The stone toe does not need to follow the bank toe exactly, but should be designed and placed to form an improved or "smoothed" alignment through the stream bend. Longitudinal stone toes usually require much less bank disturbance and the bank landward of the toe may be revegetated by planting or natural succession. Brushlayering and Willow Post and Poles are excellent candidates for use with this technique.

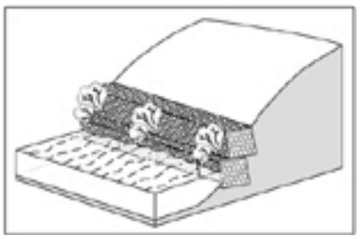
COCONUT FIBER ROLLS

Coconut fiber (coir) rolls are manufactured, elongated cylindrical structures that are placed at the bottom of stream banks to help prevent erosion and scour. The



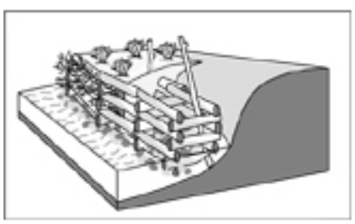
coconut husk fibers are bound together with geotextile netting with 35 cm or 40 cm (12 in or 18 in) diameters and lengths of 6 meters (20 ft). Coir is fairly long-lasting, typically 5-7 years, but must be designed with riparian revegetation to attain permanent solutions. Proper anchoring is critical and generally coir rolls are not recommended for areas with high velocities and shear. Brushlayering and Live Stakes are good candidates for combining with coconut fiber rolls.

VEGETATED GABION BASKETS



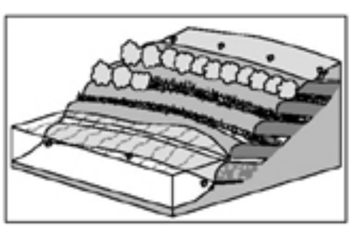
Gabions are rectangular baskets made of twisted or welded-wire mesh that are filled with rock. These flexible and pervious structures can be used individually or stacked like building blocks to reinforce steep banks. Used alone, rock-filled gabions provide insufficient habitat benefit. However, woody vegetation, such as brushlayering, post and poles, can be incorporated by inserting the cuttings all the way through the basket during filling, and penetrating the native subsoil. The woody vegetation can provide additional reinforcement and longevity to the structure while helping to mitigate for loss of habitat.

LIVE CRIBWALL



A cribwall is a gravity retaining structure consisting of a hollow, box-like interlocking arrangement of structural beams (e.g., logs). The interior of the cribwall is filled with rock or soil. In conventional cribwalls, the structural members are fabricated from concrete, wood logs, and dimensioned timbers (usually treated wood). In live cribwalls, the structural members are usually untreated log or timber members. The structure is filled with a suitable backfill material and live branch cuttings are inserted through openings between logs at the front of the structure and imbedded in the crib fill. These cuttings eventually root inside the fill and the growing roots gradually permeate and reinforce the fill within the structure.

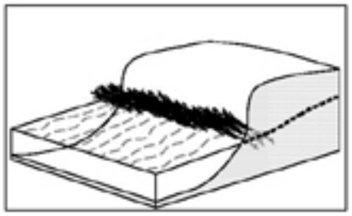
VEGETATED MECHANICALLY STABILIZED EARTH



This technique consists of live cut branches (brushlayers) interspersed between lifts of soil wrapped in natural fabric, e.g., coir, or synthetic geotextiles (Turf Reinforcement Mats (TRMs) or Erosion Control Blankets (ECBs)) or geogrids. The live brush is placed in a criss-cross or overlapping pattern atop each wrapped soil lift in a manner similar to conventional brushlayering (see Technique: Live Brushlayering). The fabric wrapping provides the primary reinforcement in a manner similar to that of conventional mechanically stabilized earth (MSE). The live, cut branches eventually root and leaf out providing vegetative cover and secondary reinforcement as well.

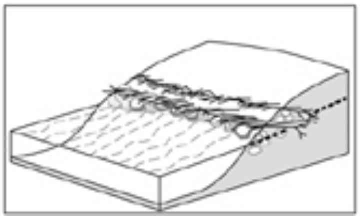
LIVE SILTATION

Live siltation is a bioengineering technique involving the installation of a living or



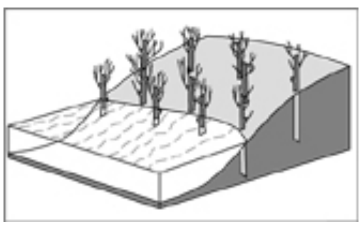
a non-living brushy system at the water's edge. Willow cuttings are the most common. Live siltation construction is intended to increase roughness at the stream edge thereby encouraging deposition and reducing bank erosion. The embedded branches and roots also reinforce the bank, reduce geotechnical failure while the branches and leaves provide cover, aquatic food sources and organic matter.

LIVE BRUSHLAYERING



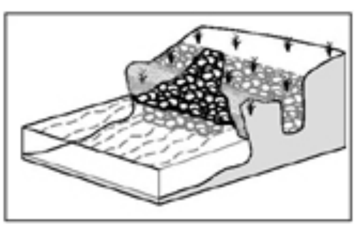
Live brushlayers are rows of live woody cuttings that are layered, alternating with successive lifts of soil fill, to construct a reinforced slope or embankment. Vertical spacing depends on slope gradient and soil conditions. Live Brushlayering provides enhanced geotechnical stability, improved soil drainage, superior erosion control and is one of the most effective ways to establish vegetation from live cuttings. Live brushlayering is an excellent candidate for combining with other streambank stabilization measures.

WILLOW POSTS AND POLES



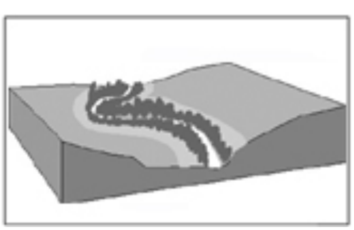
Posts and pole plantings are methods intended to provide mechanical bank protection. Willow and cottonwood species are recommended for their ability to root and grow, particularly if they are planted deep into the streambanks. Larger and longer than live stakes, the posts and poles can provide better mechanical bank protection during the period of plant establishment. Dense arrays of posts or poles can reduce velocities near the bank or bed surface, and long posts or poles reinforce banks against shallow mass failures or bank slumps. Posts and poles are also excellent candidates for combination with other structural methods e.g., LWD Structures, Vegetated Gabion Baskets, Live Cribwall, and Cross Vanes.

TRENCH FILL REVETMENT



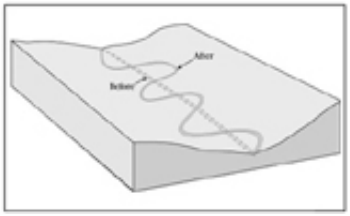
Trench fill revetments are constructed by excavating a trench along the top of the bank and placing stone riprap in the trench. As the bank erodes, the stone is undercut and "launches" down the bank line, resulting in a more gradual, protected slope. Earth removed for excavation of the trench may be used to cover the riprap, thus completely concealing it until it is launched. This technique might be chosen if access to the stream reach is restricted due to legal or environmental issues.

VEGETATED FLOODWAYS



Confining floodwaters to a broad floodway bordered by levees or topographic highs is attractive because the portion of the floodway not normally inundated can support vegetation and thus provide wildlife habitat or recreational opportunities. Floodways may be created by constructing levees, floodwalls, or by excavation. Excavation consists of creating terraces or benches along an existing channel or a completely new flood channel (bypass). Roadway embankments sometimes serve a dual purpose by defining a floodway.

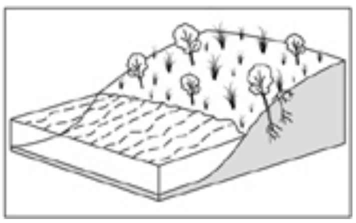
MEANDER RESTORATION



Meanders are broad, looping (sinuous) bends in a stream channel. Meandering is a form of slope adjustment with more sinuous channel paths leading to decreased reach gradient. Fluvial and ecological functions are integrally related to the highly diverse spatial and temporal patterns of depth, velocity, bed material and cover found in meanders. Generally speaking, streams with natural meander bends do not require grade control measures. Meander restoration consists of reconstructing meandering channels that have been straightened or altered by man.

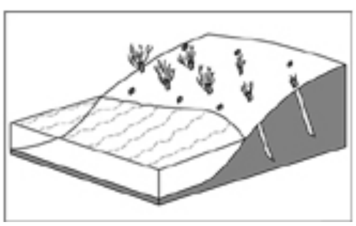
BANK ARMOR AND PROTECTION

VEGETATION ALONE



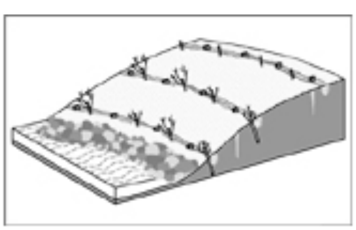
Vegetation can be viewed as a living, organic ground cover consisting of grasses/legumes, forbs, and/or woody plants. Vegetation is established on bare soils in order to help prevent surficial erosion, minimize shallow seated mass movement, provide habitat, and enhance aesthetics or visual appearance. Vegetation can be used alone under special circumstances but it also lends itself well to conjunctive use with other erosion control techniques in a mutually beneficial manner. Living plants can be used in conjunction with nearly every type of groundcover.

LIVE STAKING



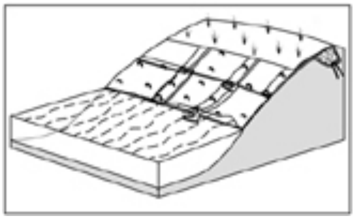
Live stakes are very useful as a revegetation technique, a soil reinforcement technique, and as a way to anchor erosion control materials. They are usually cut from the stem or branches of willow species and the stakes are typically 0.5-1.0 m (1.5 – 3.3 ft) long. The portion of the stem in the soil will grow roots and the exposed portion will develop into a bushy riparian plant. This technique is referred to as Joint Planting when the stakes are inserted into or through riprap. Live staking is an excellent candidate for combination with other techniques.

LIVE FASCINES



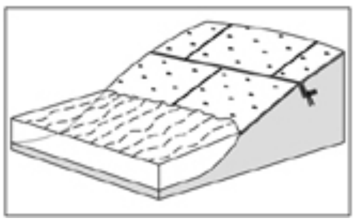
Live fascines are bundles of live (and non-living) branch cuttings placed in long rows in shallow trenches across the slope on contour or at an angle. Fascines are intended to grow vegetatively while the terraces formed will trap sediment and detritus, promoting vegetative establishment. Fascines can be utilized as a resistive measure at the stream edge and for erosion control on long bank slopes above annual high water. Fascines are also an effective way to anchor Erosion Control Blankets (ECBs) and Turf Reinforcement Mats (TRMs).

TURF REINFORCEMENT MATS



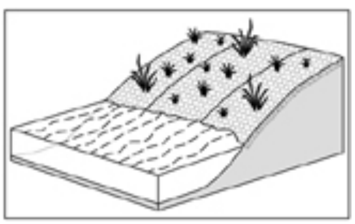
Turf Reinforcement Mats (TRMs) are similar to Erosion Control Blankets, but they are more permanent, designed to resist shear and tractive forces, and they are usually specified for banks subjected to flowing water. The mats are composed of ultraviolet (UV) stabilized polymeric fibers, filaments, and/or nettings, integrating together to form a three-dimensional matrix 5 to 20 mm (.2 to .79 in) thick. TRMs are a biotechnical practice, intended to work with vegetation (roots and shoots) in mutually reinforcing manner. As such, vegetated TRMs can resist higher tractive forces than either vegetation or TRMs can alone.

EROSION CONTROL BLANKETS



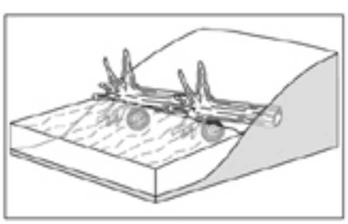
Erosion Control Blankets (ECBs) are a temporary rolled erosion control product consisting of flexible nets or mats, manufactured from both natural and synthetic materials, which can be brought to a site, rolled out, and fastened down on a slope. ECBs are typically manufactured of fibers such as straw, wood, excelsior, coconut, or a combination, and then stitched to or between geosynthetic or woven natural fiber netting. Various grades of biodegradable fibers and netting can be specified depending on required durability and environmental sensitivity.

GEOCELLULAR CONTAINMENT SYSTEMS



Geocellular Confinement Systems (GCS) are flexible, three-dimensional, high density polyethylene (HDPE) honeycomb-shaped earth-retaining structures that can be expanded and backfilled with a variety of materials to mechanically stabilize surfaces. They can be used flat, as channel or slope lining, or stacked to form a retaining wall. Maximum slope for walls is generally 2V:1H, although they have been installed as steep as 0.5V:1H and even 1V:1H in some cases. GCS provide very little habitat enhancements alone, therefore these systems must be combined with vegetation to be considered environmentally-sensitive. Live staking and joint planting are excellent choices for combining techniques.

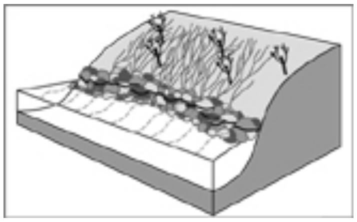
ROOTWAD REVETMENTS



Rootwad and tree revetments are structures constructed from interlocking tree materials. These structures are continuous and resistive type methods, distinguishable from discontinuous and redirective methods such as Large Woody Debris (LWD) structures or rootwad deflectors. Rootwad revetments and tree revetments are primarily intended to resist erosive flows and are usually used on the outer bank of a meander bend when habitat diversity is desirable and tree materials are available and naturally-occurring.

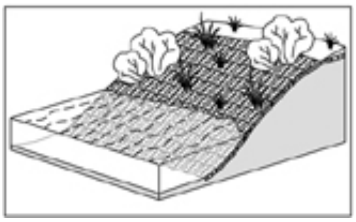
LIVE BRUSH MATTRESS

A live brush mattress is a thick blanket (15-30 cm (6-12 in)) of live brushy cuttings and soil fill. The mattresses are usually constructed from live willow branches or



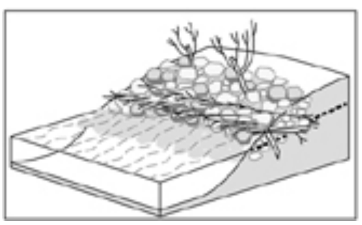
other species that easily root from cuttings. Brush mattresses are used to simultaneously revegetate and armor the bank. The dense layer of brush increases roughness, reducing velocities at the bank face, and protecting it from scour, while trapping sediment and providing habitat directly along the waters' edge. Brush mattresses are an excellent candidate for combining with structural techniques such as rock toe protection.

VEGETATED ARTICULATED CONCRETE BLOCKS



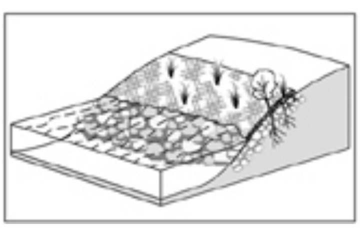
An Articulated Concrete Block (ACB) system consists of durable concrete blocks that are placed together to form a matrix overlay or armor layer. Articulated block systems are flexible and can conform to slight irregularities in slope topography caused by settlement. The blocks are placed on a filter course (typically a geofabric) to prevent washout of fines through the blocks. ACBs provide very little habitat enhancements alone, therefore these systems must be combined with vegetation to be considered environmentally-sensitive. Vegetation in the form of live cuttings or grass plugs is inserted through openings in the blocks into the native soil beneath the blocks.

VEGETATED RIPRAP



A layer of stone and/or boulder armoring that is vegetated, optimally during construction, using pole planting, brushlayering, and live-staking techniques. The goal of this method is to increase the stability of the bank, while simultaneously establishing riparian growth within the rock and overhanging the water, to provide shade, water quality benefits, and fish and wildlife habitat. Vegetative riprap combines the widely accepted, resistive and continuous rock revetment techniques with deeply-planted biotechnical techniques.

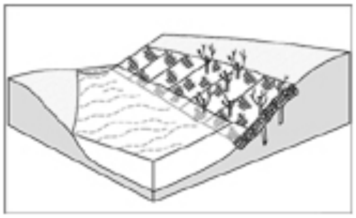
SOIL & GRASS COVERED RIPRAP



Two configurations have been used: (1), an ordinary riprap blanket is covered with a layer of soil 30-60 cm (1-2 ft) thick from the top of the revetment down to base flow elevation, or (2), a crown cap of soil and plant material is placed over a riprap toe running along the base of a steep bank, effectively reducing bank angle. Soils used for fill should not be highly erosive. A variety of methods may be used to establish plant materials including hydroseeding, seeding and mulching, sodding, and incorporation of willow cuttings or root stock in the fill materials.

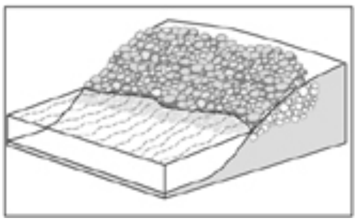
VEGETATED GABION MATTRESS

Gabion mattresses differ from gabion baskets as they are shallow, (0.5-1.5 m (20-60 in)) deep, rectangular containers made of welded wire mesh, and filled with rock. Gabion mattresses are not stacked but placed directly and continuously on the prepared banks. They are intended to protect the bed or lower banks of a



stream against erosion. A gabion mattress can be used as either a revetment to stabilize a streambank, or when used in a channel, to decrease the effects of scour. Live cuttings are introduced through the rock filled mattress and inserted into native soil beneath.

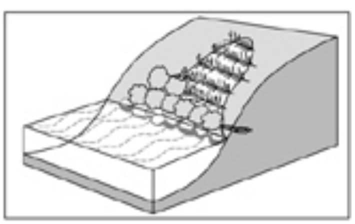
COBBLE OR GRAVEL ARMOR



Cobble or gravel armor is a resistive technique, similar to riprap revetment that uses naturally-occurring rock. Cobbles are natural stones larger than 6.5 cm (2.5 in) in diameter that have been rounded by the abrasive action of flowing water, while gravel is material smaller than cobble, but larger than sand (larger than about 5 mm(0.2 in)). Rounded river cobble or gravel blanket presents a more natural appearance, and can be as effective as riprap revetment for areas with relatively lower tractive forces and velocities.

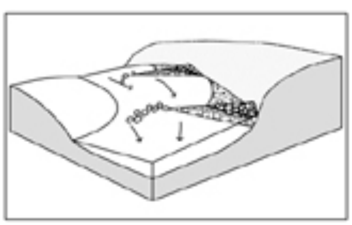
RIPARIAN BUFFER AND STREAM CORRIDOR OPPORTUNITIES

LIVE GULLY FILL REPAIR



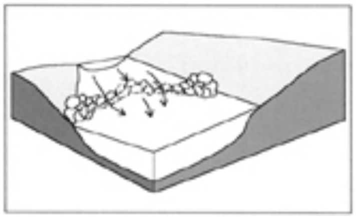
Live Gully Fill Repair consists of alternating layers of live branch cuttings and compacted soil. This reinforced fill can be used to repair small gullies. The method is similar to branch packing (a method for filling small holes and depressions in a slope), but is more suitable for filling and repairing elongated voids in a slope, such as gullies. Gully treatment must include correcting or eliminating the initial cause of the gully as well as the gully itself. Gullies are likely to have tributary gullies that also require treatment.

VANES WITH J HOOKS



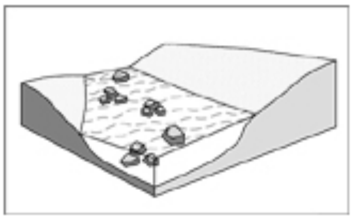
Vanes with J-Hooks are actually rock vanes modified to enhance the instream habitat benefits. They are redirective, upstream-pointing deflection structures whose tip is placed in a “J” configuration and partially embedded in the streambed so that they are submerged even during low flows. The rock vanes have demonstrated effectiveness in reducing near-bank velocities by redirecting the thalweg toward the center of the channel. The “J” structures are intended to create scour pools and thereby improve substrate complexity. The scour usually results in a “tail out” deposition of gravel (riffle) which may provide spawning habitat.

CROSS VANES



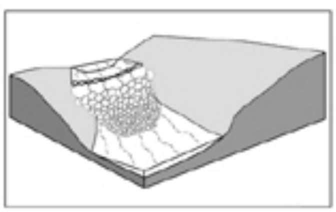
Cross vanes (aka. vortex weirs) are "V" shaped, upstream pointing, rock structures stretching across the width of the stream. Cross vanes redirect water away from the streambanks, and into the center of the channel. This serves to decrease shear stress on unstable banks, as well as create aquatic habitat in the scour pools formed by the redirected flow. Cross vanes are designed to be overtopped at all flows. The lowest part of the structure is the vortex of the "V", which is at the point farthest upstream. The crests are sloped 3-5% with the ends of the vanes keyed into the streambanks at an elevation approximate to annual high water or bankfull stage. This shape forms a scour pool inside of the "V". Cross vanes are particularly useful for modifying flow patterns, enhancing in-stream habitat, substrate complexity and providing in grade control. Double cross vanes (W weirs) are a variation suitable for wider channels.

BOULDER CLUSTERS



Large boulders may be placed in various patterned clusters within the base flow channel of a perennial stream. Natural streams with beds coarser than gravel often feature large roughness elements like boulders that provide hiding cover and velocity shelters for fish and other aquatic organisms. If a constructed or modified channel lacks such features, adding boulder clusters may be an effective and simple way to improve aquatic habitat.

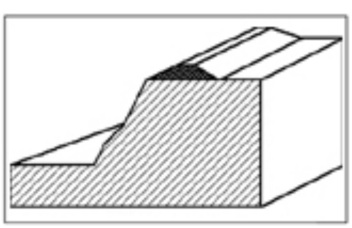
NEWBURY ROCK RIFFLES



Newbury rock riffles are ramps or low weirs with long aprons made from riprap or small boulders that are constructed at intervals along a channel approaching natural riffle spacing (5 to 7 channel widths). The structures are built by placing rock fill within an existing channel. The upstream slope of the rock fill is typically much steeper than the downstream slope, which creates a longitudinal profile quite similar to natural riffles. These structures provide limited grade control, pool and riffle habitat, and visual diversity in otherwise uniform channels.

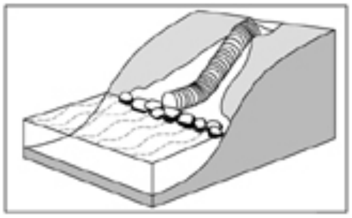
SLOPE STABILIZATION

DIVERSION DIKE



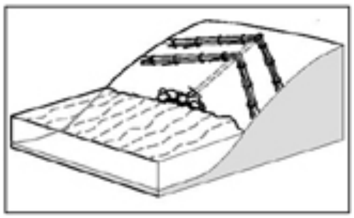
A diversion dike is a low berm (or ditch and berm combination) that is constructed along the crest or top of a stream bank. The purpose of a diversion is to intercept and divert concentrated runoff away from the face of a steep slope or streambank. Diversion dikes are constructed from compacted earthen fill and should be used on drainage areas of 2 ha (5 ac) or less. In addition to protecting the face of a streambank from overbank runoff, diversions may also improve general slope stability by preventing runoff from infiltrating into and saturating the bank.

SLOPE DRAIN



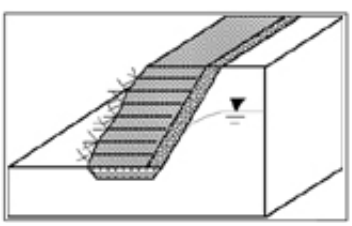
A slope drain is a drainage system used to collect and transport storm runoff down the face of a slope. This system usually consists of a berm at the top of the slope or streambank and a flexible pipe with end sections and outlet protection. A pipe slope drain is constructed with corrugated pipes (polymeric or metallic) and can be temporary or permanent. Slope drains are commonly used to: 1) temporarily convey runoff down the face of a steep slope until permanent protection and/or cover can be established, 2) prevent further cutting of a gully, and 3) serve as a permanent drainage-way down a steep slope where visual appearance is not a factor.

LIVE POLE DRAIN



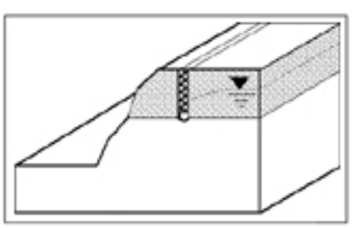
Live pole drains are live, growing and often long-lived drainage systems composed of bundles (fascines) of live branches (commonly willow). Live pole drains placed in areas where excess soil moisture results in soil instability. They are also used to treat small drainage gullies. Live Pole Drains collect subsurface drainage and concentrated surface flow and channel it to the base of the bank. Once established, their drainage function is increased, as the plants absorb much of the water that is conducted along their stems. Because they are long and fibrous, the bundles act like a conduit. As the fascines begin to root and sprout the root system acts like a filter medium, stabilizing fine particles and reducing piping and sapping. Live pole drains provide drainage and stabilization immediately after installation, and once established, produce roots, which further stabilize bank and levee slopes.

CHIMNEY DRAIN



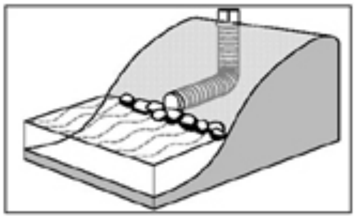
A chimney drain is a subsurface drainage course placed between a natural slope or streambank and an earthen buttress fill or other retaining structure (e.g., log cribwall). A drainage blanket, sloped sheet drain, and strip drain are types of subsurface drainage courses. Typically, a chimney drain is a near-vertical drain that feeds into a collection system at its base, whereas a sloped sheet drain is inclined back at an angle. A subsurface drain may be continuous across the slope, or it may consist of discontinuous drainage strips that are placed against the natural slope at periodic intervals.

TRENCH DRAIN



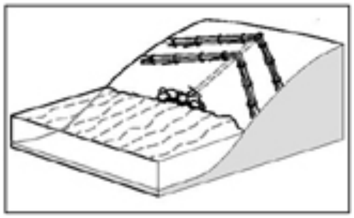
A drainage trench excavated parallel to and just behind the crest of a stream bank. Ideally, the bottom of the trench should be keyed into an impermeable layer in the slope. The trench should be backfilled with a coarse graded aggregate that meets filtration criteria; i.e., it should allow unimpeded flow of groundwater while excluding fines. Alternatively, the trench can first be lined with a filter fabric that meets the filtration requirements and then be backfilled with a coarse aggregate. The purpose of the trench is to intercept and divert shallow seepage away from the face of the streambank.

DROP INLET



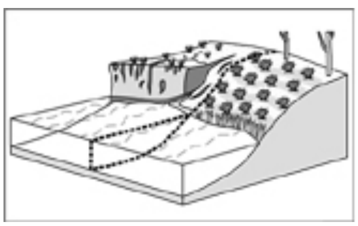
Concentrated overbank runoff can be a major cause of erosion, especially along deeply incised channels. Runoff passing over the top of banks frequently triggers gully development and expansion, and water that is ponded at the top of high, steep banks, and infiltrates or seeps into the ground behind the slope face is often a major factor in erosion by piping or slope failure. Gully erosion and downcutting can be addressed using a drop inlet, which is a water control structure that consists of an L-shaped corrugated pipe passing through an earthen embankment placed at the downstream end of the gully.

FASCINES WITH SUBSURFACE INTERCEPTOR DRAIN



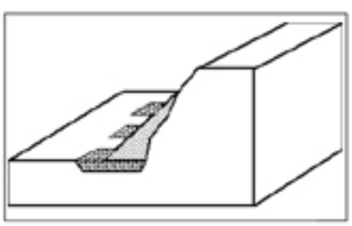
Rows of drainage fascines (aka. live pole drains) are installed off contour along a slope. Drainage fascines are widely-used to help dewater landslides, small gullies, and on very wet sites where there is evidence of substantial subsurface seepage that is causing piping and slope instability. As the seepage and drainage becomes concentrated, the fascines can be connected to a subsurface drain consisting of a perforated pipe wrapped in a geo-composite drainage medium, and placed at the bottom of a trench. The trench is backfilled with clean, coarse aggregate or gravel which is oriented downslope. There is significant evidence that live drainage fascines, usually constructed from willow cuttings, are long-lived once established.

SLOPE FLATTENING



Flattening or bank reshaping stabilizes an eroding streambank by reducing its slope angle or gradient. Slope flattening is usually done in conjunction with other bank protection treatments, including installation of toe protection, placement of bank armor, re-vegetation or erosion control, and/or installation of drainage measures. Flattening or gradient reduction can be accomplished in several ways: 1) by removal of material near the crest, 2) by adding soil or fill at the bottom, or 3) by placing a toe structure at the bottom and adding a sloping fill behind it. Right-of-way constraints may limit or preclude the first two alternatives because both entail either moving the crest back or extending the toe forward.

STONE-FILL TRENCHES



Stone-fill trenches are rock filled trenches placed at the base of a streambank, usually within a failed section of the toe. A series of trenches are excavated at or within the toe of the slope in a direction perpendicular to the stream. The trenches are backfilled with crushed rock or stone. The toe of the slope is then reconstructed by placing and compacting earthen fill within and atop the stone-fill trenches. A small, longitudinal riverside plug or stone dike should be used between the stone trenches to help contain and protect the toe of the earthen fill placed between and atop the stone trenches.

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