

4.8 Stream and Wetland Protection

General Information

All streams, rivers, lakes, and wetlands are regulated waters in Kentucky. In addition, most small upland drainageways that carry flowing water during part of the year are also regulated, and activities that affect sinkholes and other karst features may be subject to regulatory oversight for certain activities.

In general, no construction activities should occur on the banks or within the channels of these waterways without specific permit coverage provided by the USACE and the KYDOW. This includes activities such as clearing vegetation from streambanks, placing culverts or temporary creek crossings, channelizing or straightening streams, filling wetlands with soil, or placing dams or sediment barriers across streams.

The best approach for dealing with streams, wetlands, and other water bodies on construction sites is to designate them and their vegetated buffers as *do not disturb* zones by flagging them off-limits for vehicles and equipment. This can be done on construction plans by designating these areas as *buffer zones*—see the fact sheet that follows for additional information.

Construction activities that seek to stabilize or restore damaged streambanks can use the other fact sheets in this section for information on vegetative practices. These are often accompanied structural measures such as gabion baskets/mattresses, turf reinforcement mats, and rock (see fact sheets on those topics).

Small stabilization or restoration projects can follow the information in the fact sheets for guidance on how to proceed with structural or vegetative approaches. Larger projects involving significant stream channel work (i.e., ≥ 200 feet) should be based on stream geomorphological and flow analyses to ensure that vegetative and structural installations are not washed out.



Vegetative measures—armored with permanent turf reinforcement mats or geogrid structures—are preferred over riprap for restoring or stabilizing stream banks. All work within stream channels and wetlands requires permit coverage by the USACE and the KYDOW.

Plan sheets and work orders for projects near streams and wetlands should specify the posting of “do not mow” warning signs along vegetated buffer areas. Flagging buffer zones during construction helps keep equipment away from areas where violations of federal or state clean water rules might occur.



Trees, Shrubs, and Herbaceous Vegetation for Streams and Wetlands

Use native species for vegetated areas, landscaping, and stream or wetland buffer areas wherever possible. Native species can provide year-round attractive scenery, important habitat, pollutant buffering, and structural stability for soils. Native trees and shrubs are adapted to Kentucky's climate and will not need as much care and maintenance as ornamentals or nonnatives. In addition, prices for native species are often as low or lower than other landscaping plant material.

For best results, protect soils where trees and shrubs will be planted by marking off areas and restricting equipment movement and resulting soil compaction. Compacted soils, low soil organic matter, and low fertility might require soil amendments and preparation before planting. Use species from the list below, or consult local UK Extension Service or Natural Resources Conservation Service (NRCS) offices for more information. The species below are suggested for planting along creek banks, lake shores, rivers, wetlands, and other riparian areas.

Suggested Riparian Plant Species

Tree	Species
Pin Oak	<i>Quercus palustris</i>
Cherrybark Oak	<i>Quercus pagoda</i>
Bur Oak	<i>Quercus macrocarpa</i>
Swamp Chestnut Oak	<i>Quercus michauxii</i>
Shingle Oak	<i>Quercus imbricaria</i>
Northern Red Oak	<i>Quercus rubra</i>
Post Oak	<i>Quercus stellata</i>
Red Maple	<i>Acer rubrum</i>
Green Ash	<i>Fraxinus pennsylvanica</i>
Shellbark Hickory	<i>Carya laciniata</i>
Blackgum	<i>Nyssa sylvatica</i>
American Elm	<i>Ulmus americana</i>
Eastern Cottonwood	<i>Populus deltoides</i>
Black Walnut	<i>Juglans nigra</i>
River Birch	<i>Betula nigra</i>
Yellow Poplar	<i>Liriodendron tulipifera</i>
Persimmon	<i>Diospyrus virginiana</i>
Shrubs	
Arrow-wood	<i>Viburnum dentatum</i>
American Plum	<i>Prunus americana</i>
Deciduous Holly	<i>Ilex decidua</i>
Gray Dogwood	<i>Cornus racemosa</i>
Silky Dogwood	<i>Cornus amomun</i>
Spicebush	<i>Lindera benzoin</i>
Sassafras	<i>Sassafras albinum</i>
Herbaceous Plants	
Rice Cutgrass	<i>Leersia oryzoides</i>
Managrass	<i>Glyceria striata</i>
Spangle Grass	<i>Chasmanthium latifolium</i>
Barnyard Grass	<i>Echinochloa crus-galli</i>
Switchgrass	<i>Panicum virgatum</i>
Annual Rye	<i>Secale cereale</i>
Wild Rye	<i>Elymus virginicus</i>
Deertongue Grass	<i>Panicum clandestinum</i>
Panic Grass	<i>Panicum microcarpon</i>
Kentucky Cane	<i>Bamboo Arundinaria gigantea</i>

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4.8.1 Buffer Zones



Stream buffer zones can be enhanced with plantings of native trees and shrubs, which also help to stabilize banks and mediate erosive scour forces. Permanent TRMs, geogrid structures, or rock can be used to provide supplemental armoring.



Definition

Buffer zones are setback requirements that establish no-disturbance protection zones along and around streams, wetlands, rivers, ponds, and lakes.

Purpose

The purpose of a buffer zone or setback is to restrict activities near waterways and to maintain a vegetative buffer strip so that soil disturbance is avoided and waterways retain the natural filtration, structural protection, and infiltration capacity offered by natural vegetated buffers.

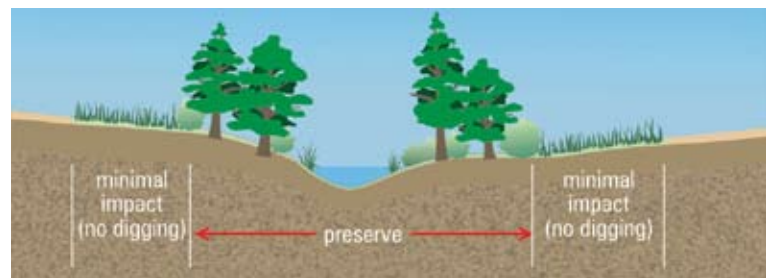
Design Criteria

Wherever feasible, site plans should specify buffer zones along existing site drainage features such as upland swales, ditches, intermittent and ephemeral (i.e., flowing only after rains or during snowmelt) streams, ponds, wetlands, sinkholes, lakes, rivers, and the like. Establishing buffer zones along existing drainage features preserves the drainage system, which promotes greater site stability, less erosion, higher aesthetic potential, increased habitat value, and more economical site development.

Site development design should attempt to *lay in* desired structures such as buildings, roads, utilities, and so forth with minimal disturbance to the existing drainage system and its adjacent vegetated buffer zone. Where this is not possible, site plans can specify that newly constructed drainage features be vegetated with native material, with new buffer zones established around the new drainage system (see the Vegetated Buffer section).

Some jurisdictions have mandatory setback requirements regarding limits of disturbance near water bodies and karst features. Check with the local planning and zoning office before working near waterways. Recommended setbacks from waterways are shown in the table on the following page.

Zones for a Vegetated Stream Buffer



Buffer zone widths vary according to stream size. In general, the near-bank area (20–40 ft for streams, 50–100 ft for rivers) should contain an undisturbed mix of native trees, shrubs, and herbaceous vegetation. The upgradient secondary buffer zone can be managed as mowed grass or hay land, or planted with no-mow native grasses.

Recommended Setbacks From Top of the Streambank or Lakeshore

Bank Slope	Soil Type Along Banks		
	Sandy	Silty	Clays
Very Steep (2:1 or more)	100 ft	80 ft	60 ft
Steep (4:1 or more)	80 ft	60 ft	40 ft
Moderate (6:1 or more)	60 ft	40 ft	30 ft
Mostly Flat (less than 10:1)	40 ft	30 ft	20 ft

Construction Specifications

See the section on Vegetated Filter Strips (next) in this manual.

Inspection and Maintenance

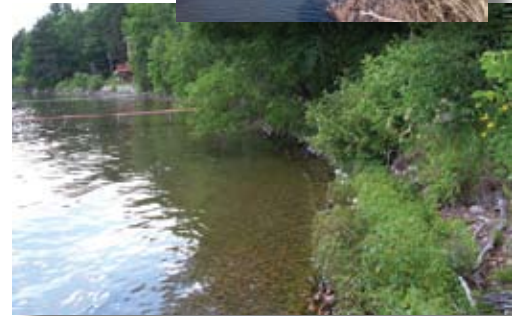
See the section on Vegetated Filter Strips (next) in this manual.



Native trees and shrubs can resist scour forces that cause streambank and lakeshore erosion. Management of these areas should include only removal of invasive species.



Vegetated buffers provide excellent protection against sediment from muddy sheet flows. Control of concentrated flows of runoff through the buffer is also required.



*Kentucky cane (*Arundinaria gigantea*, above) and other native grasses can slow down and filter sediment runoff. Buffers that are too narrow (right) offer little protection against high water bank erosion.*



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4.8.2 Filter Strips



Vegetated filter strips can be designed into projects as attractive natural areas, with showy wildflowers and interesting fall colors. These amenities are in addition to the important functions of intercepting, filtering, and processing contaminants in storm runoff.

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Definition

A filter strip is a planted strip of native grasses or other vegetation adjacent to and upgradient from a drainage ditch, stormwater system inlet, or natural water body such as a stream, river, lake, wetland, or sinkhole. They can also be used to protect lawns and paved areas. Filter strips are typically managed as a *natural* vegetative filter rather than mowed turf grass.

Purpose

The purpose of a vegetated filter strip is to act as a natural, vegetated buffer (see the Buffer Zone section) in reducing the amount of sediment in incoming runoff, the velocity of the runoff, and the temperature of the runoff during hot weather. Vegetated filter strips promote stormwater infiltration, deposition of sediment, absorption of other pollutants, and decomposition of organics to reduce or assimilate pollutants in the runoff.

Vegetated Filter Strip Width Recommendations for Kentucky

Stream Type	Conditions	Minimum Buffer Width	General Considerations
Urban streams	> 25% imperviousness in drainage area	25 ft each bank	At least two-thirds of the buffer—nearest to the water—should be undisturbed native or natural vegetation.
Suburban streams	10% to 25% imperviousness in drainage area	50 ft each bank	
Rural streams	< 10% imperviousness in drainage area	≥ 60 ft each bank	Remainder can be permanent managed vegetation.
Large rivers	Rivers with floodplains > 500 ft wide	≥ 100 ft each bank	
Wetlands	For sloping sites, add more buffer	25 to 50 ft	Avoid turf grass in managed area if possible; use native grasses, wildflower mixes. Mow annually or less.
Sinkholes or other karst features	Will vary according to size and flow characteristics	25 to 50 ft radius	

Design Criteria

Filter strips should be used only to address potential water quality problems associated with overland (sheet) flow. They are not effective in removing sediment from concentrated flows unless those flows are dispersed on flat ground before discharge into the filter strip.

- Vegetative filter strips cannot be expected to remove all sediment or adequately protect adjacent areas from sediment damage when used alone. Vegetative filters should be considered only as one component of the erosion and sediment control system.
- If vegetative filter strips are proposed as a sediment control device and they do not already exist, they must be planned and established before initiating general land-disturbing activities if possible.
- Minimum filter strip width should be 25 feet for urban streams, 50–75 feet for suburban and rural streams, and at least 100 feet for large rivers. Plans should show the location, width, and length of filter strips. The type of vegetation and specifications for soil preparation and seeding must be included. If existing vegetation is to be used, plans for protecting or improving it must be provided.
- The width of filter strips expected to treat runoff from long slopes should be at least one-fourth the length of the slope for slopes up to 20 percent and at least half the slope length for steeper areas.

Material Specifications

When establishing new seeded areas, consideration must be given to aesthetics and wildlife needs and soil conditions on the site. Native grass and wildflower mixtures are attractive, commercially available, and can be seeded with standard equipment for the most part.

- It is easier and cheaper to protect and preserve existing areas than to establish new ones. Existing grass wildflower, or grass/legume areas to be used as filter strips should be flagged off as a *buffer zone* (see the Buffer Zone section). Equipment and vehicular traffic in these areas should be restricted to avoid damage to vegetation. Vegetation should be dense and well established with no bare spots.
- Seed species for native grass and wildflower mixes are available from county extension and NRCS offices. Specify quality seed mixtures selected on the basis of climate, soils, drainage, shading, and other factors. Note that taller grass mixtures might not be appropriate near residential areas because of security concerns regarding visibility.
- Specify planting of grasses and forbs at the same time. Seeding rates will vary by species, but should generally be specialized and low, unlike agricultural seeding rates. Consider a cover/nursery crop of annual or short-lived native species (e.g., rye) to protect the site until grasses and wildflowers emerge.
- Seed should be from current production, no more than one year old, and free of mold or insects and disease. Seed origin should be furnished and have characteristics similar to the site. Seed collected or grown in the region is usually best.

The following chart provides a list of alternative grass and grass/legume mixtures for projects not using other native grass/wildflower mixes:

Filter Strip Seeding Mixture and Site Suitability Chart

Seeding Mixture	Seeding Rate Lbs/Acre	Soil Suitability
1. Alfalfa or Red Clover Plus Timothy or Orchardgrass or Bromegrass	10 10 4 6 6	Well Drained
2. Ladino Clover Plus Timothy or Orchardgrass or Bromegrass	½ 4 6 8	Wet or Well Drained
3. Tall Fescue	40	Wet or Well Drained
4. Reed Canarygrass Plus Tall Fescue	15 10	Wet

Construction Specifications

When planting filter strips, prepare the seedbed, incorporate fertilizer (if necessary), and apply mulch consistent with the seeding sections of this manual. Filter strips using areas of existing vegetation must be overseeded, as necessary, with the above mixtures to obtain an equivalent density of vegetation. The over seeding must be accomplished before the land disturbing activity if no grading will occur in the area. See the Permanent Seeding section of this manual for further details. For areas to be seeded in native grass and wildflower mixes, use the following approach:

Vegetation removal before seeding—If undesirable vegetation exists on the site, kill with nonselective, nonresidual herbicide, a glyphosate without surfactant if possible. After evidence of kill (7–14 days) mow to 2 inches. Mow or rake off.

Avoid soil disturbance—Avoid deep tillage, which pulls up new weed seed to compromise plantings. Scarify soil no deeper than one-half inch, on the contour, to reduce weed and erosion problems. No-till planters are now available to plant into existing dead stubble. Avoid adding imported topsoils unless it is certified to be weed-free.

Soil amendments—Amendments should be limited because of cost concerns. Fertilizers assist weed growth. Native forbs and grasses, if matched to the site, should establish without fertilizers if moisture is available. Amendments, if used, should be monitored for potential runoff impacts. Addition of peat moss has not proven beneficial to these plantings over time. Addition of native mychorizae has proven beneficial.

Equipment—Follow the seed distributor’s instructions for planting. Specialized drills, broadcasters, and hydroseeders are available. Choose carefully and experiment on small areas to determine the best approach. The bottom line is that the seed germinates only if it makes contact with the soil and moisture.

Follow-up—Cover the seed by harrowing, dragging, raking or cultipacking. Mulch with weed-free straw or hay or native grass straw. Use ECBs on long, steep slopes if mulch and netting will not suffice. Avoid irrigation unless experiencing periods of drought, when supplementary watering might be in order. A high (6–8 inches) mowing once or twice during the first season reduces weed competition.

Inspection and Maintenance

Inspect filter strips regularly to ensure that a healthy vegetative growth is maintained. Any bare spots or spots where sediment deposition could lead to the destruction of vegetation must be repaired.

If necessary, filter strips must be fertilized once each year in the fall. Construction traffic must not be permitted to drive upon filter strips.

Filter strips should be managed as natural type vegetated areas, with an annual or biennial mowing regimen (typically mowed during the fall), regular litter removal if needed, and reseeding of vegetation where necessary.



These are good examples of vegetated filter strips along a small swale (left) and large stream (below). Protect these areas during construction with flagging ribbon or signs.



Filter strips along lakes and ponds (left) can include mowed access areas for fishing and other activities. Where severe scour forces are present, protect planted filter strips with turf reinforcement mats or other armoring to prevent bank erosion (below).

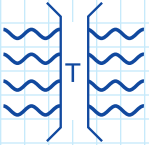


4.8 Stream and Wetland Protection

4.8.3 Temporary Stream Crossing



Temporary stream crossings require a USACE Clean Water Act section 404 permit. Avoid or minimize removal of vegetation and excavation at the crossing site. Cover all bare soil areas with straw or ECBs. Cover the approaches on both sides (25 ft minimum) with No. 2 stone.



Definition

A temporary stream crossing is a temporary structural span installed across a flowing stream use by construction traffic. Structures can include bridges, round pipes, or pipe arches.

Purpose

The purpose of a temporary stream crossing is to provide a means for construction traffic to cross flowing streams without damaging the channel or banks and to keep sediment generated by construction traffic out of the stream.

Design Criteria

Temporary stream crossings are applicable to flowing streams with drainage areas less than one square mile. Structures that must handle flow from larger drainage areas must be designed by a licensed professional engineer.

- Temporary stream crossings must be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed. Choose crossing sites at straight channel sections (i.e., riffles or glides, not pools) with stable banks and channel bottoms if possible. Avoid areas where trees will need to be removed.
- Such structures are subject to the rules and regulations of the USACE for in-stream modifications (404 permits) and the KYDOW (401 certification).
- The span must be designed to withstand the expected loads from heavy construction equipment that will cross the structure.
- The structure must be large enough to convey the peak flow expected from a 2-year, 24-hour storm without appreciably altering the stream flow characteristics. The structure may be a span, a culvert, or multiple culverts.
- Where culverts are installed, rock must be used to form the crossing (i.e., not soil). The depth of the rock cover over the culvert must be equal to one-half the diameter of the culvert or 12 inches, whichever is greater. The area around the crossing must be protected from erosion using the mulching and seeding erosion control measures specified in this manual. The slope of the culvert must be at least one-quarter inch per foot.

- The approaches to the crossing structure must consist of stone pads at least 25 feet in length also covered with KYTC No. 2 stone.
- Crossing structures can be bridges or culverts/pipes of any material that can support the fully loaded equipment expected. The minimum sized culvert must be 24 inches.

Construction Specifications

- Clearing and excavation of the streambed and banks must be minimized. Do not grade and grub the site. For best results, remove by hand or chainsaw only the vegetation growing within the approach pads and crossing area. Place pipe or structure at the crossing location, and place rock on approach pads and crossing pipe/structure.
- The approaches to the structure must consist of stone pads with a minimum thickness of 6 inches, a minimum width equal to the width of the structure and a minimum approach length of 25 feet on each side.

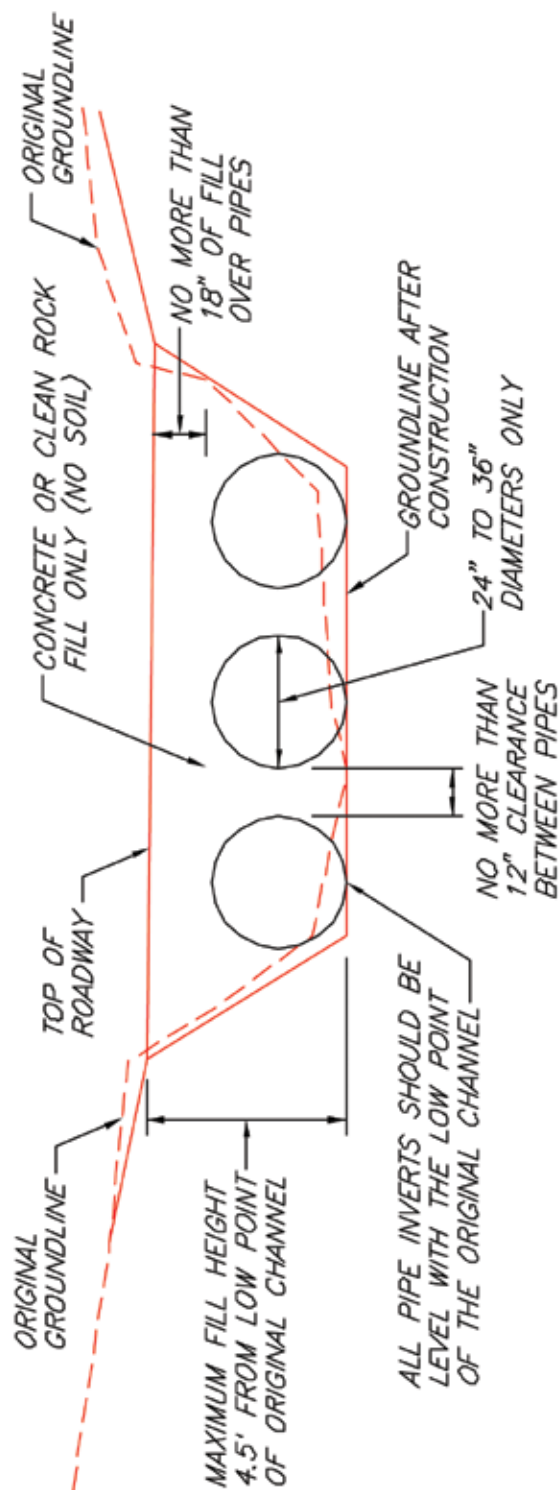
Inspection and Maintenance

- The structure must be inspected after every rainfall greater than one-half inch and at least once a week. Repair all damages immediately.
- The structure must be removed as soon as it is no longer necessary for project construction. Take care during removal not to damage shrubs, trees, and other vegetation that was left intact when the crossing was built.
- Upon removal of the structure, the stream must immediately be restored to its original cross-section and properly stabilized with vegetation, mulch, ECBs, or TRMs as necessary.



Here are several poor temporary crossing examples (above and right). Temporary crossing areas should not be grubbed and stripped if possible. Bare soil areas should be covered with straw or ECBs (top right).





NOTES

1. THIS IS A CONCEPTUAL DRAWING. THE NUMBER AND SIZE OF PIPES AND OTHER DETAILS WILL VARY DEPENDING ON SPECIFIC SITE CONDITIONS.
2. THE PIPES AND BACKFILL MUST BE CONTAINED WITHIN THE STREAM CHANNEL AS SHOWN ABOVE. DURING THE CONSTRUCTION OF THE APPROACHES AND ACCESS ROADWAYS ACROSS THE FLOODPLAIN, UNSTABLE AND UNCONSOLIDATED MATERIALS UNSUITABLE FOR ROADWAYS MAY BE EXCAVATED AND REPLACED WITH RIPRAP, CRUSHED STONE, OR OTHER STABLE ROAD CONSTRUCTION MATERIALS. THIS MAY ONLY BE DONE, HOWEVER, WITH THE FOLLOWING PROVISIONS: (1) THE DISPOSAL OF EXCESS, UNCONSOLIDATED MATERIALS THUS EXCAVATED MUST BE OUTSIDE OF THE FLOODPLAIN AND (2) THE FINISHED SURFACE OF THE COMPLETED ROAD MAY BE NO MORE THAN THREE INCHES (3") ABOVE THE PRE-CONSTRUCTION SURFACE OF THE FLOODPLAIN AT ANY POINT BEYOND THE TOP OF BANKS.

STREAM CROSSING

**KY DIVISION OF WATER
LOW-WATER CROSSING**

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4.8.4 Bioengineering: Live Staking



Live stakes (center) of willow or other selected hardwoods can be cut during the dormant season and driven into stream banks or shore areas to stabilize erodible soils. Note that some hardwood species require special preparation to ensure growth. All species require contact with moist soil along the lower portions of the live stake.



Definition

Live stake planting involves inserting and tamping live, rootable vegetative tree or shrub cuttings (e.g., willow, ash, alder) into moist streambanks in a manner that allows the stake to take root and grow.

Purpose

Live stakes create a root mat that stabilizes the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. Growing stakes also provide physical armoring of streambanks against high-velocity flows. This practice is commonly used in conjunction with other practices to provide for a more stable site condition (i.e., used to anchor blankets, coir mats, TRMs, straw rolls). Live stakes can be used for the following:

- Repair of small earth slips and slumps.
- Gullies and stream channels can be live-staked. Areas best suited to staking are the bottoms and banks of small gullies and bare gully banks.
- Live stakes can be inserted or driven through interstices or openings in gabions, riprap, articulated block, or cellular confinement systems.

Vegetative Streambank Stabilization

Vegetative streambank stabilization, also known as bioengineering, includes a variety of measures designed to reduce erosion by installing protective vegetation and a few strategically placed structural components such as ECBs, TRMs, geotextiles, tree roots, and other materials.

Vegetative streambank stabilization can incorporate significant structural components such as gabion baskets and mattresses, slope toe protection rock, and cellular geogrid applications. However, the focus for this BMP is to minimize the appearance of so-called “hard armoring” such as rock and gabions and to maximize the “soft look” of trees, shrubs, and other vegetation. The selection, installation, and maintenance of vegetative material is the key to success.

All streambank stabilization practices, structural and vegetative, are subject to Clean Water Act section 404 permit coverage issued by the USACE and KYDOW Clean Water Act section 401 Water Quality Certification and Floodplain Permits.

- Live willow stakes can be used to anchor and enhance the effectiveness of willow wattles, straw rolls, coir rolls, turf reinforcement mats, coir mats, and other erosion control materials.
- Willow staking enhances conditions for natural invasion and the establishment of other plants from the surrounding plant community.
- Willow establishment can improve aesthetics and provide wildlife habitat.
- As a temporary measure, live willow staking performs an important function of stabilizing and modifying the soil, serving as a pioneer species until other plants become established.
- Several species of willow will grow from cuttings in less favorable soil conditions such as road fills and gullies in bare denuded land. Even in very unfavorable sites willow cuttings will often grow vigorously for a few years before they die out.

Design Criteria

Willows have several different growth forms, from shrubs to large trees. Small- to medium-sized, shrub-type and rhizomatous or creeping-type willows are used for planting channel banks. Upland willow species are found in relatively dry areas and should be used on similar sites. Tree-type willows are selected for the upper bank and floodplain area.

Live stakes can be specified for streambanks with slopes of 3H:1V or flatter. Steeper slopes will require grooving or benching and ECBs that can withstand expected shear stresses. The following table shows recorded shear stress withstood by live staking.

Bank Materials and Shear Stress Limits (Live Stakes)

Bank Material	Shear (lb/ft ²)
Live stakes in riprap (immediately after construction)	2.04
Live stakes in riprap (after 3–4 seasons)	6.12
Coarse gravel and stone cover with live cuttings (immediately after construction)	1.02
Coarse gravel and stone cover with live cuttings (after 3–4 seasons)	5.1
Willow cuttings/willow stakes	2.1

Source: Salix Applied Earthcare - Erosion Draw 5.0

- Live stake harvest and installation should be performed during the dormant season, late fall to early spring.
- Use site reconnaissance to identify willow species, growth form, soil and site conditions on adjacent sites and compare their conditions to the construction site. Planting will be more successful as soil, site and species selected match stable, vegetated nearby sites.
- If native willows are not found in the vicinity, live staking might not be a good option.
- Choose plant material adapted to the site conditions and confirm the availability of plant material that will be used on site before construction begins.

Construction Specifications

Harvesting

- Stakes must be harvested and planted when the willows (or other chosen species) are dormant. This period is generally from late fall to early spring or before the buds start to break.
- When harvesting cuttings, select healthy, live wood that is reasonably straight. Harvest live wood at least one-year-old or older. Avoid suckers of the current year's growth because they lack sufficient stored energy reserves to sprout consistently. The best wood is 2–5 years old with smooth bark that is not deeply furrowed.
- Stakes should be cut so that a terminal bud scar is within 1–4 inches of the top. At least two buds or bud scars must be above the ground after planting.
- Cuttings should generally be three-quarters of an inch in diameter or larger depending on the species, and 2 to 3 feet in length. Highest survival rates are obtained from using cuttings 2–3 inches in diameter. Larger diameter cuttings are needed for planting into rock riprap. Cuttings of small diameter stock (up to 1.5 inches) must be 18 inches long minimum. Thicker cuttings should be longer.
- Make clean cuts with unsplit ends. Trim branches from cutting as close as possible. The butt end (i.e., end closest to the ground) of the cutting must be pointed or angled and the top end (away from the soil) must be cut square, to aid in soil penetration, tamping, and knowing which end is up.
- The top, square cut can be painted and sealed by dipping the top 1–2 inches into a 50-50 mix of light colored latex paint and water. Sealing the top of the stake will reduce the possibility of desiccation and disease, assure the stakes are planted with the top up, and make the stakes more visible for subsequent planting evaluations.

Installation

- Install live stakes only on streambanks that have been graded and prepared for planting. ECB installation is strongly recommended for bank areas below the 2-year peak flow line; ECBs are recommended for upper portions of the bank. Stone toe protection is recommended for the toe of the slope at the waterline.
- Stakes must not be allowed to dry out. The cuttings should be installed the same day they are harvested. If this is not possible, they should be soaked in water for a minimum of 24 hours. Stakes can be stored outdoors for a few days in a cool place under damp straw. For longer storage, refrigerate (do not freeze), keep moist, and use as soon as possible.
- Use an iron stake, bar, or other suitable instrument to make a pilot hole in firm soil. Plant stakes 1–3 feet apart, closer on steeper slopes and on the outside of bends, farther apart on flatter slopes and the inside of bends. No less than one-half of total length must be into the ground. Set the stake as deep as possible into the soil, preferably with 80 percent of its length into the soil and in contact with midsummer water table.
- It is essential to have good contact between the stake and soil for roots to sprout. Tamp the soil around the cutting. Do not damage the buds, strip the bark, or split the stake during installation. Split or damaged stakes must be removed and replaced.
- Stakes must be planted with butt-ends into the ground. Leaf bud scars or emerging buds should always point up.

Inspection and Maintenance

- All temporary and permanent erosion and sediment control practices must be maintained and repaired as needed to assure continued performance of their intended function.
- Replace stakes that do not sprout after 45 days if possible, or wait until the following dormant season to harvest and replant.
- Streambanks and steep slopes are highly susceptible to erosion and damage from significant storm events. Willow stakes alone provide very little initial site protection during the establishment period. Use TRMs for temporary protection until stakes are established and to protect any bare areas.
- Periodic inspection repair and maintenance will be required during the first 2 years or until the vegetation is established.



This is a sprouting willow stake. To avoid upside-down installation of stakes, require that the lower ends be cut at an angle, with the upper end cut flat, i.e., perpendicular to stake length.

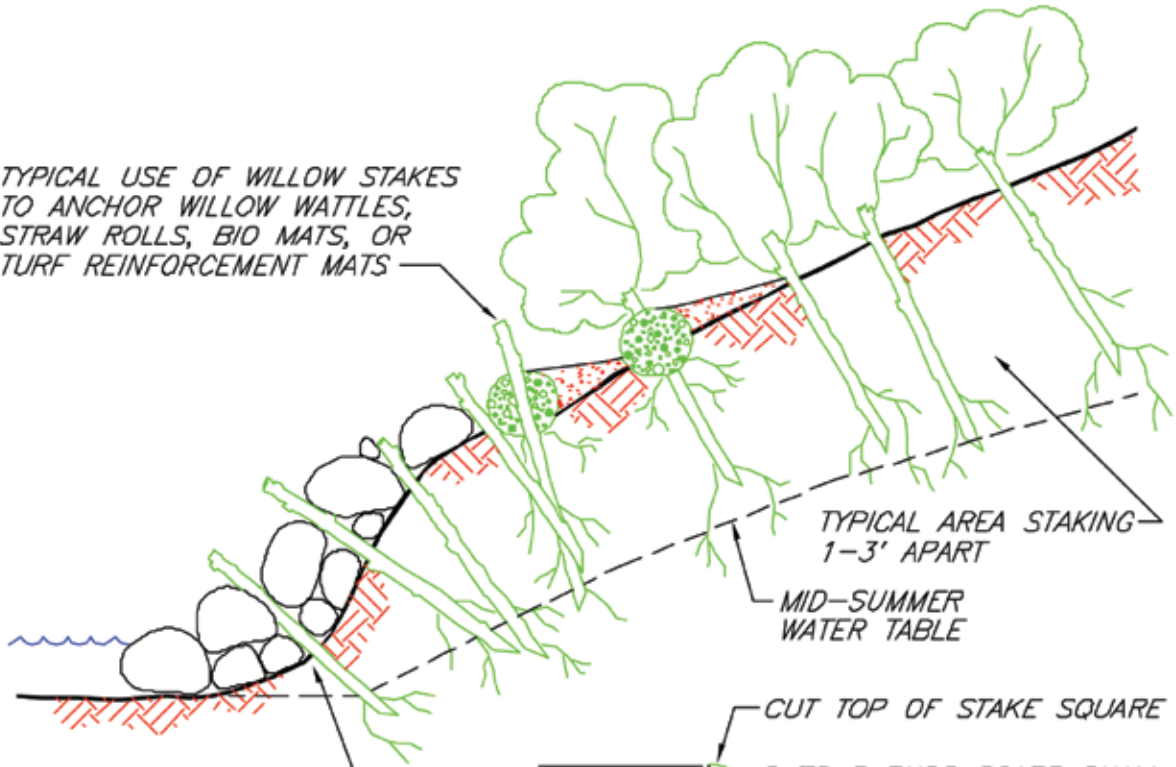


Willow stakes and other woody vegetation planted along the water's edge provide structural protection for colonization by other species, which promotes stable banks and improves habitat.



Soil wrap stabilization of steep stream bank using geotextile wrapping in 2 ft lifts. Live stakes can be driven into prepared banks using a dibble bar or iron stake to create a guide hole.

TYPICAL USE OF WILLOW STAKES TO ANCHOR WILLOW WATTLES, STRAW ROLLS, BIO MATS, OR TURF REINFORCEMENT MATS



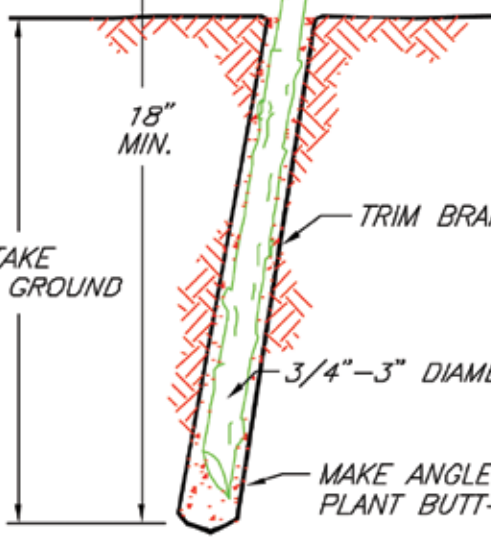
TYPICAL AREA STAKING 1-3' APART

MID-SUMMER WATER TABLE

TYPICAL - DRIVE OR PLANT WILLOW STAKES THROUGH OPENINGS IN RIPRAP OR GABIONS

CUT TOP OF STAKE SQUARE

2 TO 5 BUDS SCARS SHALL BE ABOVE THE GROUND. ADDITIONAL LENGTH SHOULD BE REMOVED.



18" MIN.

TRIM BRANCHES CLOSE

3/4" - 3" DIAMETER

MAKE ANGLED CUT AT BUTT-END, PLANT BUTT-END DOWN

PLANT 80% OF STAKE LENGTH INTO THE GROUND

NOTES:

1. HARVEST AND PLANT STAKES DURING THE DORMANT SEASON.
2. USE HEALTHY, STRAIGHT AND LIVE WOOD AT LEAST 1 YEAR OLD.
3. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION, USE A PILOT BAR IN FIRM SOILS.
4. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
5. TAMP THE SOIL AROUND THE STAKE.

NOT TO SCALE

LIVE STAKING

SOURCE: SALIX APPLIED EARTHCARE - EROSION DRAW 5.0

4.8 Stream and Wetland Protection

4.8.5 Wattles (Live Fascines)



Installation of live fascines along bank area, before backfilling. Fascines provide quick, thick growth to stabilize banks and can be specified where willow or other suitable plant material is plentiful and erosive forces are moderate. Use turf reinforcement mats in areas where bank shear stress exceeds 2 pounds per square foot.



Definition

Wattles or live fascines are long, small-diameter, live branch cuttings, usually willows, bound together into long, cigar-shaped bundles and buried in shallow trenches to help stabilize slopes and streambanks.

Purpose

Thickly vegetated wattle and fascine bundles reduce erosion and stabilize streambank slopes in several ways:

- The wattle bundles, binding rope, and stakes are all structural components that combine to physically stabilize the surface layers of the slopes by resisting hydraulic and gravitational forces.
- Wattle bundles prevent rills and gullies by reducing the effective slope length, which dissipates the energy of water moving downslope. Wattles immediately reduce surface erosion.
- The terraces formed by a series of wattles trap sediment, detritus, and seed. Infiltration is increased as runoff is slowed, and on dry sites, this increases the available water for plant establishment.
- Vegetation establishment is enhanced because wattling provides a suitable microsite for plants by reducing surface erosion, increasing infiltration rates and by forming a series of terraces with shallower slope angles.

Wattling can be used for road fills, road cuts, gullies or slumped areas, eroded slopes or eroding streambanks as follows:

- Repair of small earth slips and slumps or to protect slopes from shallow slides 1–2 feet deep.
- Wattling can be used to stabilize entire cut or fill slopes, step-grades or small benches, or localized gully areas of slopes along water bodies.
- Wattling can be installed during construction (dormant season) or as a remedial action on existing slopes.
- Wattling is useful on slopes requiring other planting materials such as woody vegetation, transplants, grasses, and forbs. Wattling also enhances conditions for natural invasion and the establishment of other plants from the surrounding plant community.

Design Criteria

Wattles can be specified for streambanks with slopes of 3H:1V or flatter. Steeper slopes will require grooving, step-grading, or benching and ECBs that can withstand expected shear stresses. The following chart shows recorded shear stress withstood by willow wattles and fascines.

Bank Materials and Shear Stress Limits (Wattles)

Bank Material	Shear (lb/ft ²)
Wattles (coarse sand between)	0.2
Wattles (gravel between)	0.31
Wattles (parallel or oblique to current)	1
Fascine revetment	1.4
Live fascine (immediately after construction)	1.22
Live fascine (after 3–4 seasons)	1.63
Fascine	2.1

Source: Salix Applied Earthcare - Erosion Draw 5.0

Choose plant material adapted to the site conditions and confirm the availability of plant material that will be used on-site before construction begins.

- The ideal plant materials for wattling are those that (1) root easily; (2) are long, straight and flexible; and (3) are in plentiful supply near the job site. Willow makes ideal wattling material.
- Wattle material harvesting and installation should be performed during the dormant season—late fall to early spring. Use site reconnaissance to identify appropriate willow or other species, growth form, soil and site conditions on adjacent sites, and compare their conditions to the construction site. Planting will be more successful as soil, site and species selected match stable, vegetated nearby sites.
- When choosing live willow material for bioengineering applications, remember that young (less than one year old) wood or suckers will often sprout easier under optimum conditions but healthy, older wood (1 to 4 years old) has greater vegetative (energy) reserves necessary to consistently sprout, and the older wood is much stronger. If possible, mix younger wood with older wood for the bioengineering application so that a majority of the material is 1 to 4 years old.
- Willows have several different growth forms, from shrubs to large trees. Small- to medium-sized shrub-type and rhizomatous or creeping-type willows are used for planting channel banks. Upland willow species are found in relatively dry areas and should be used on similar sites. Tree-type willows are selected for the upper bank and floodplain area.
- Spacing of contour trenches (wattles) is determined by soil type, potential for erosion, and slope steepness. Addition of rock toe slope protection where water surface meets the streambank is often helpful in reducing scour and bank slump. Installation of mulch or ECBs on slopes flatter than 4:1 and TRMs on steeper slopes is highly recommended.

General Installation Guidelines for Wattles

Slope	Slope distance between wattles feet	Recommended maximum slope length feet
1:1 to 1.5:1	3–4	15
1.5:1 to 2:1	4–5	20
2:1 to 2.5:1	5–6	30
2.5:1 to 4:1	6–8	40
3.5:1 to 4:1	8–12	50
4.5:1 to 5:1	10–20	60

Source: Salix Applied Earthcare - Erosion Draw 5.0

Construction Specifications

Wattle Preparation

- Cuttings must be harvested and planted when the willows, or other chosen species, are dormant. This period is generally from late fall to early spring.
- Choose plant materials that are adapted to the site conditions from species that root easily. A portion (up to 50 percent) of the bundle can be of material that does not root easily or dead material.
- The cuttings should be long (3 feet minimum), straight branches up to 1.5 inches in diameter. Trimmings of young suckers and some leafy branches can be included in the bundles to aid filtration. The number of stems varies with the size and kind of plant material.
- Cuttings must be tied together to form bundles, tapered at each end, 6–30 feet in length, depending on site conditions or limitations in handling.
- The completed bundles should be 6–12 inches in diameter, with the growing tips and butt ends oriented in alternating directions.
- Stagger the cuttings in the bundles so that the tips are evenly distributed throughout the length of the wattle bundle.
- Wattle bundles must be compressed and tightly tied with rope or twine of sufficient strength and durability. Polypropylene *tree rope* approximately 3/16 inch diameter provides the necessary strength and durability.
- Wattle bundles must be tied 12–15 inches apart.
- For optimum success, wattles should be pre-soaked for 24 hours or installed on the same day they are harvested and prepared. The wattles should be installed within 2 days after harvest unless pre-soaked. Wattles must be stored in the shade and under cover or under water. They are live material and should be treated as such.

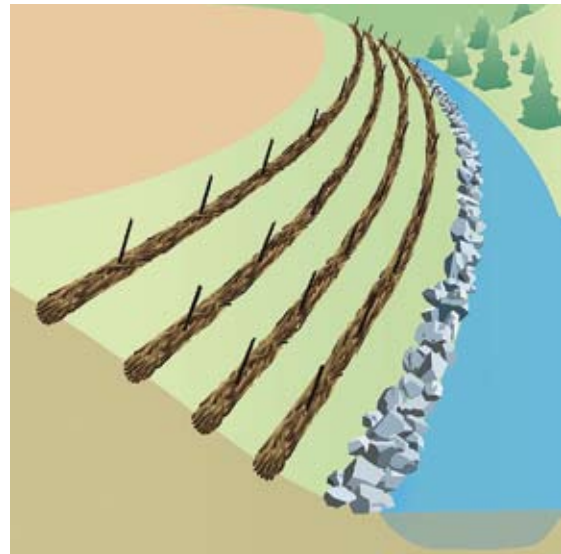
Installation

- Work must progress from the bottom to the top of the slope. See the design section for spacing and use of blankets/mats on slopes.
- Perform any slope repairs, such as gully repair, slope scaling, diversion dike, gabion, or toe wall construction, before installing the wattle.
- Beginning at the base of the slope, dig a trench on contour. The trench must be shallow, about one-half the diameter of the wattle. The trench width will vary from 12–18 inches depending on the slope angle.

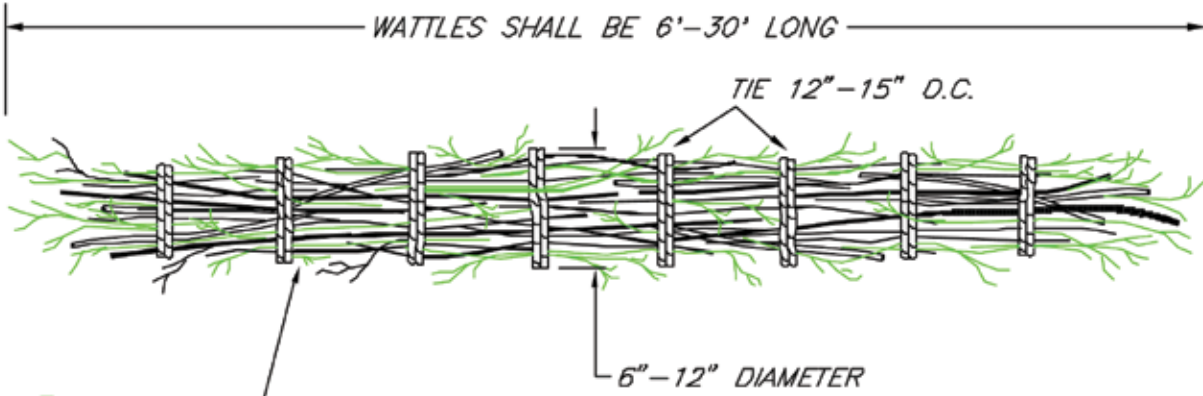
- Install wattles into trenches dug into the slope on contour. Place the wattles immediately after trenching to reduce desiccation of the soil.
- Wattles must be staked firmly in place with one row of construction stakes on the downhill side of the wattling, not more than 3 feet apart. A second row of stakes must be placed through the wattles, near the ties, at not more than 5 feet apart.
- Overlap the tapered ends of adjacent wattles so the overall wattle thickness of the wattle is uniform. Two stakes must be used at each bundle overlap such that a stake can be driven between the last two ties of each wattle.
- Live stakes, if specified, are generally installed on the downslope side of the bundle. Drive the live stakes below and against the bundle between the previously installed construction stakes.
- Proper backfilling is essential to the successful rooting of the wattles. Backfill wattles with soil from the slope or trench above. The backfill must be worked into the wattle interstices and compacted behind and below the bundle by walking on and working from its wattling terrace.
- Place moist soil along the sides of the live bundle. The top of the bundle should be slightly visible when the installation is completed.
- Repeat the preceding steps for each row, up to the top of the slope.
- Plant the slope with other vegetation (e.g., live stakes, tree seedlings) as specified.
- Seed and mulch slope. Shallow slopes, generally 3:1 or flatter can be seeded and mulched by hand. Steeper slopes should have seed applied hydraulically, and the mulch must be anchored with tackifier or other approved methods if TRMs are not used.

Inspection and Maintenance

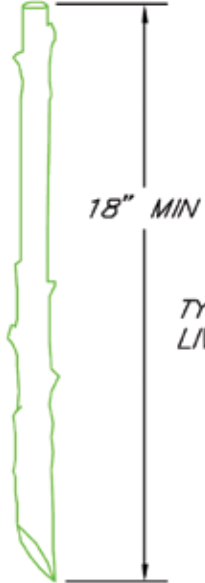
- Inspect and maintain the wattle installations regularly, particularly during the first year.
- Repairs must be made promptly. Stakes that loosen because of saturation of the slope or frost action must be reinstalled.
- Rills and gullies around or under wattles must be repaired. Use ECBs or TRMs if necessary to control scouring and gullying.
- Repairs to vegetative practices must be made promptly.
- All temporary and permanent erosion and sediment control practices must be maintained and repaired as needed to assure continued performance of their intended function.



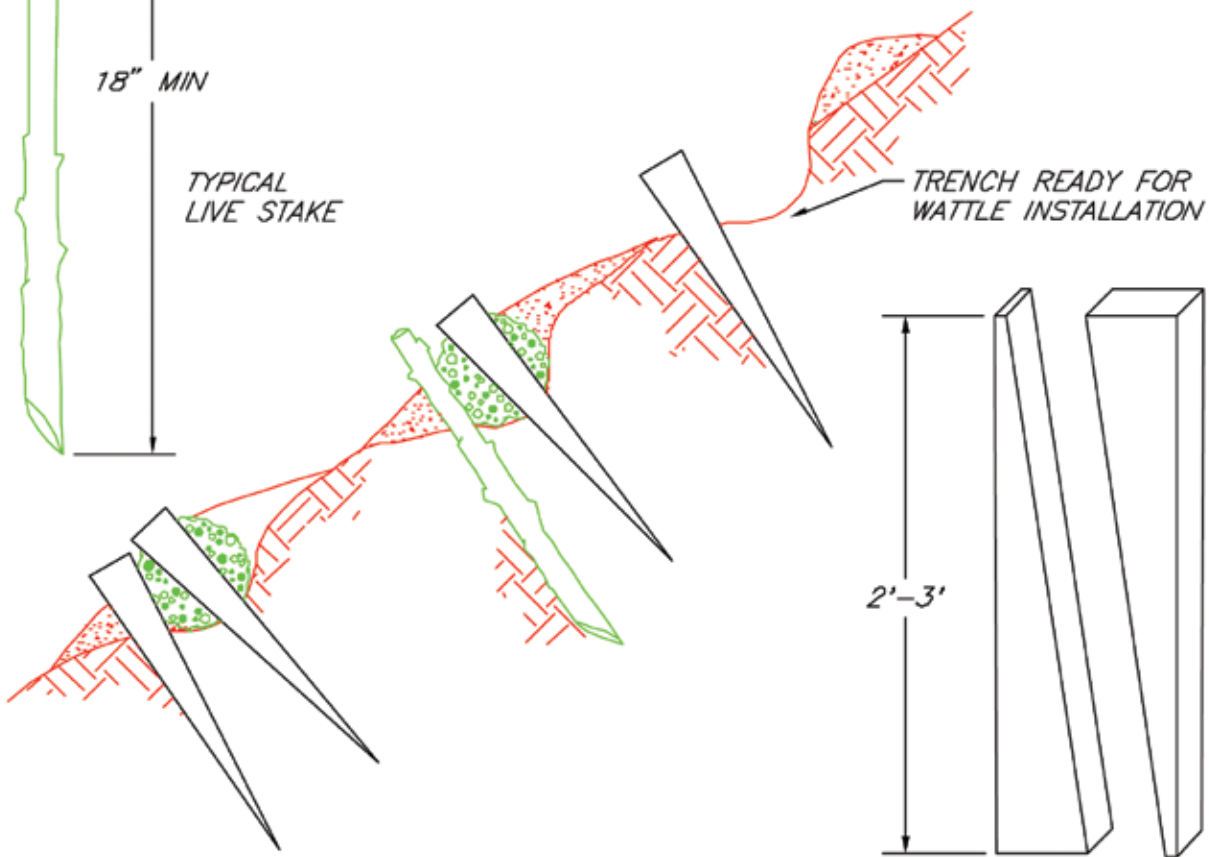
Coconut logs, fiber rolls, and other products can be used in conjunction with wattles to ensure adequate protection while plant material is becoming rooted. Follow manufacturer's installation information.



PREPARE WATTLES WITH 1/4" - 1 1/2" CUTTINGS, WITH ALTERNATING BUTT-ENDS AND TIED SECURELY WITH TWINE OR ROPE.



TYPICAL LIVE STAKE



TRENCH READY FOR WATTLE INSTALLATION

2'-3'

NOTES:

1. HARVEST AND INSTALL WATTLES DURING DORMANT SEASON.
2. INSTALL WATTLES ON SLOPE CONTOURS.
3. ALL WORK PROCEEDS FROM THE BOTTOM OF THE SLOPE TO THE TOP.
4. FILL OR PARTIALLY COVER WATTLE WITH SOIL FROM SLOPE OR TRENCH ABOVE.
5. COMPACT AND WORK SOIL INTO COMPLETED WATTLES.

TYPICAL CONSTRUCTION STAKE
SAW 2X4 LUMBER ON DIAGONAL

NOT TO SCALE

**WATTLE
(LIVE FASCINE)**

SOURCE: SALIX APPLIED EARTHCARE -
EROSION DRAW 5.0

4.8 Stream and Wetland Protection

4.8.6 Brushlayering



Brushlayering is similar to installation practices for live fascines. As in other vegetative practices using woody material, willows are preferred because of their low price, wide availability, and hardiness. Supplement brush layers with TRMs if bank shear stress exceeds 2 lbs per sq ft.

Definition

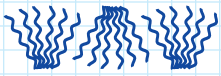
Brushlayering is the installation of cuttings or branches of easily rooted tree species, which are layered between successive lifts of soil fill to construct a reinforced slope or embankment.

Purpose

This technique is used to stabilize slopes, particularly road fill slopes where construction has or will result in unstable soil conditions. The brushlayer branches, especially after rooting, reinforce slopes by serving as tensile inclusions that provide frictional resistance to sliding or other types of displacement. The protruding brush retards runoff and reduces surface erosion.

Brushlayering is best used concurrently with construction of fill slopes or embankments. Cuttings are placed by hand, while heavy equipment is used to fill and compact each successive lift of soil fill. Brushlayering is similar in principle to other reinforced earth practices except that the reinforcing material is live branches. This practice is also a good remedial action intended to repair gullies or existing slopes. Brushlayering performs several functions for erosion control, earth reinforcement, and slope stability:

- Breaking up the slope length into a series of shorter slopes separated by rows of brush layer
- Reinforcing the soil with the unrooted branch stems
- Reinforcing the soil as roots develop, adding significant resistance to sliding or shear displacement
- Providing slope stability and allowing vegetative cover to become established
- Trapping debris on the slope
- Aiding infiltration on dry sites and drying excessively wet sites
- Adjusting the site's microclimate, thus aiding seed germination and natural regeneration
- Redirecting and mitigating adverse slope seepage by acting as horizontal drains



Design Criteria

Brushlayering is specified where significant streambank grading work or new streambank construction occurs. Live branch cuttings are oriented perpendicularly to the slope contour (i.e., up and down the hill), placed in a series of stair-step trenches on the slope, and covered with soil. The following chart shows recorded shear stress withstood by brushlayering.

Brush Materials and Shear Stress Limits (Brush Layers)

Brush Material	Shear (lb/ft ²)
Willow brushlayer (immediately after construction)	0.41
Willow brushlayer (after 3–4 seasons)	2.86
Willow cuttings/willow stakes	2.1

Source: Salix Applied Earthcare - Erosion Draw 5.0

- Plant material harvest and installation should be performed during the dormant season, late fall to early spring.
- Use site reconnaissance to identify willow or other species, growth form, soil and site conditions on adjacent sites and compare their conditions to the construction site. Planting will be more successful as the soil, site conditions and species selected match stable and vegetated nearby sites.
- The ideal plant materials are those that (1) root easily; (2) are long, straight and flexible; and (3) are in plentiful supply near the job site. Willow makes ideal material.
- Choose plant material adapted to the site conditions and confirm the availability of plant material that will be used on site before construction begins.
- When choosing live willow material for bioengineering applications, remember that young (less than one year old) wood or suckers will often sprout easier under optimum conditions but healthy, older wood (1 to 4 years old) has greater vegetative (energy) reserves necessary to consistently sprout, and the older wood is much stronger. If possible, mix younger wood with older wood for the bioengineering application so that a majority of the material is 1 to 4 years old.
- Willows have several different growth forms—from shrubs to large trees. Small- to medium-sized shrub-type and rhizomatous or creeping-type willows are used for planting channel banks. Upland willow species are found in relatively dry areas and should be used on similar sites. Tree-type willows are selected for the upper bank and floodplain area.
- If branch cuttings are not pre-soaked for at least 24 hours, then they must be harvested no earlier than 48 hours before installation. Cuttings must be kept moist and cool at all times between cutting and installation. All cuttings need to be thoroughly wet and covered with moistened wrapping before being transported.
- Construction personnel must be made aware that brushlayering uses live plant material and must be treated as such.
- Spacing between the brushlayers is determined by the erosion potential of the slope (i.e., soil type, rainfall, and length and steepness of the slope). Spacing can be from 3 to 8 feet. On long slopes, brushlayer spacing should be closer at the bottom and spacing can increase near the top of the slope.

- Slopes flatter than 4H:1V can be layered, seeded, and protected with mulch or ECBs. Steeper slopes will require turf reinforcement mats below the 2-year peak flow line. Steep slopes (1H:1V) should not exceed approximately 30 feet in slope length. Reinforced earth design guidelines suggest that the slope height should not exceed three times the width of the reinforced volume. Therefore, for brushlayering with 6–8 foot long cuttings, the slope height should not exceed 18–24 feet.
- Stabilization of slopes on the outside bends of streams will likely require vegetative, structural, or other armoring in addition to brushlayering, to handle the higher-flow velocities and shear stresses encountered.

Construction Specifications

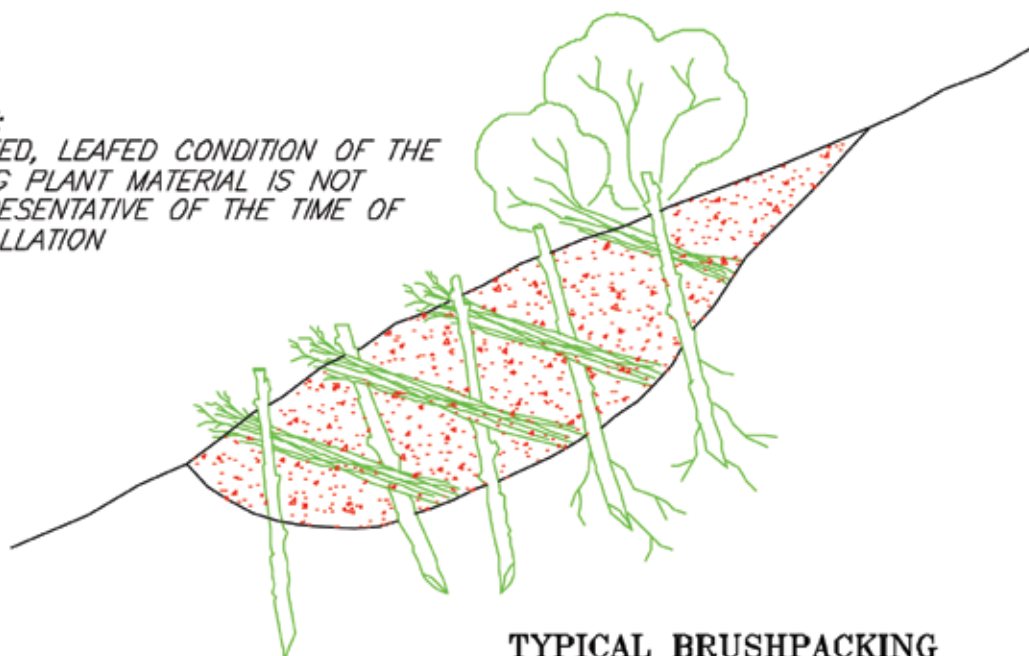
Cuttings must be harvested and planted when the willows, or other chosen species, are dormant. This period is generally from late fall to early spring. Choose plant materials that are adapted to the site conditions from species that root easily.

- Branch cuttings must be 4–8 feet long, 3/4–2 inches diameter. Presoak cuttings for a minimum of 24 hours before installing.
- Complete grading and other work on streambank slopes. Install rock or other toe protection if specified in construction plans. Prepare first (lowest elevation) bench, removing soil or using it to backfill toe protection zone. The surface of the bench must be sloped so the outside (near stream) edge is higher than the inside (bank) edge, so that the butt ends of the cuttings angle down slightly into the slope.
- Place branch cuttings, 3–8 inches thick, in a crisscross or over lapping configuration. The growing tips must protrude 6–12 inches from the slope face with the butt end dipping into the slope.
- Immediately cover brushlayer with 6 inches of fill soil and compact according to construction specifications. For ease of installation, use soil excavated from the bench immediately upslope to cover cuttings placed in the lower bench excavations. Water the soil cover immediately to wet the cuttings and achieve adequate compaction.
- Earth moving equipment must not travel directly over the cuttings. Six inches of soil must be maintained between the brushlayer and equipment at all times.
- Fill and compact the soil placed above the brushlayer in successive lifts, maximum 6–8 inches deep. Install the next brushlayer 3-8 feet above the previous row.
- Seed and mulch the slope, or install erosion control blanket or turf reinforcement mat as needed. Shallow slopes, generally 3:1 or flatter might be seeded and mulched by hand. Steeper slopes should have seed applied hydraulically, and the mulch must be anchored with tackifier or other approved methods of TRMs are not used.

Inspection and Maintenance

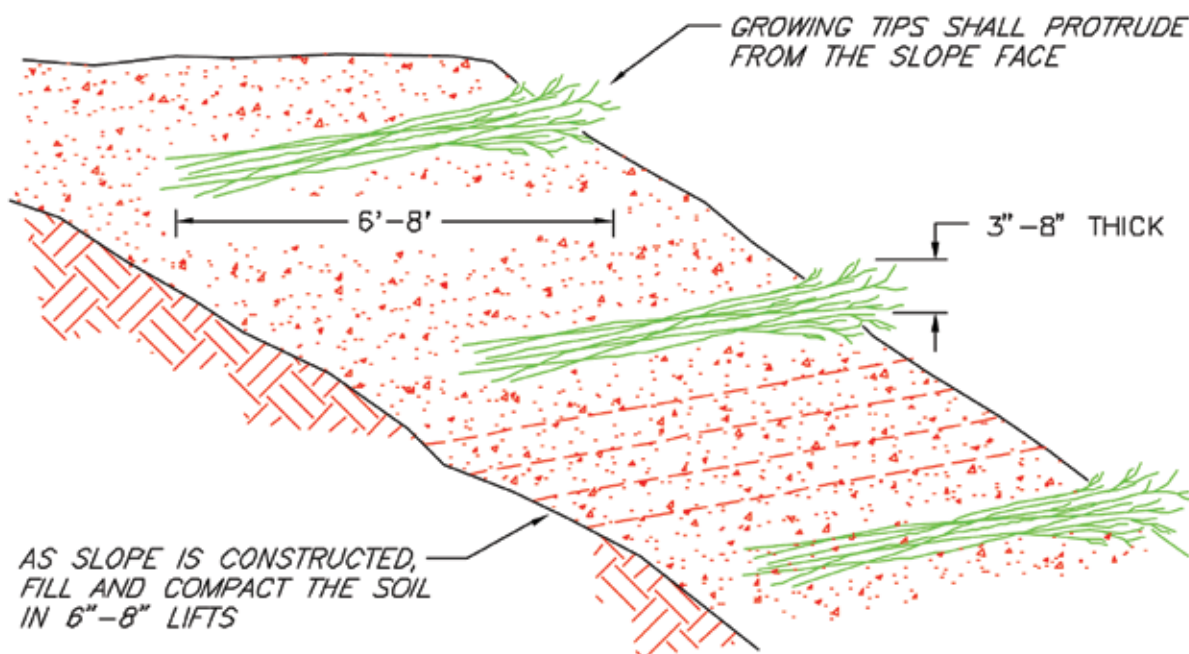
Regularly inspect and maintain bioengineering installations, particularly during the first year. To prevent major problems from developing, promptly correct any failures.

NOTE:
 ROOTED, LEAFED CONDITION OF THE
 LIVING PLANT MATERIAL IS NOT
 REPRESENTATIVE OF THE TIME OF
 INSTALLATION



TYPICAL BRUSHPACKING

COVER BRUSHLAYER IMMEDIATELY WITH
 6" OF FILL SOIL, WATER AND COMPACT
 ACCORDING TO SPECIFICATIONS



**TYPICAL BRUSHLAYERING
 WITH SLOPE CONSTRUCTION**

BRUSHLAYERING

SOURCE: SALIX APPLIED EARTHCARE -
 EROSION DRAW 5.0