APPENDIX E

EROSION PREVENTION BMPS

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SCHEDULING – EP-1

Scheduling involves sequencing construction activities and the installation of erosion and sediment control measures to reduce the amount and duration of soil exposed to erosion by wind, rain, runoff and vehicle tracking. The timing of soil-disturbing activities and the timing of implementation of BMPs are both critical to the prevention of accelerated erosion and transport of sediment off-site. The scheduling of grading should take into account the rainy season and should minimize the length of the time that soils are left exposed, and reduce the total area of exposed soil during the rainy season. Consideration should be given to phasing the grading and construction so that critical areas (such as highly erodible soils, areas adjacent to receiving waters, etc.) are not disturbed until the non-rainy season, and so the entire area that is disturbed at any one time is kept to a size that can be controlled effectively.

Construction Specifications:

- The optimum grading period is when the chance for precipitation is minimized (e.g., the non-rainy season), particularly for the critical areas. If precipitation is likely during grading, minimize the length of time that soils are exposed, and the total area of exposure.
- Materials used for erosion and sediment control shall be on site at all times.
- Take the following measures when precipitation is forecast:
    - Minimize the length of time that the soils are left exposed.
    - Reduce the total area of exposed soil.
    - Protect critical areas such as drainage channels, streams, and natural water courses.
    - Stabilize exposed areas quickly.
- The schedule shall clearly show how regional precipitation trends relate to soil-disturbing and re-stabilization activities. The construction schedule shall be incorporated into the Erosion and Sediment Control Plan.
- The schedule shall include detail on the implementation and deployment of temporary soil stabilization measures, temporary sediment controls, tracking controls, wind erosion controls, non-storm water pollution controls (including waste management and materials pollution controls).
- The schedule shall also include dates for significant long-term operations or activities that may have planned non-storm water discharges such as dewatering, saw cutting, grinding, drilling, boring, crushing, blasting, painting, hydro-demolition, mortar mixing, bridge cleaning, etc.
- Develop the sequencing and timetable for the start and completion of each item such as site clearing and grubbing, grading, excavation, paving, pouring foundations, installing utilities, etc., to minimize the active construction area during the rainy season.
- Schedule major grading operations when the chances of precipitation are minimized when practical.
- Schedule the installation, removal, or modification of run-on controls and flow conveyance structures for the non-rainy season or when there is a low probability of precipitation to reduce the likelihood of uncontrolled flow across and from the site.
- Stabilize non-active areas after the cessation of soil-disturbing activities or prior to the onset of precipitation in accordance with local requirements.
- Monitor the weather forecast for rainfall.
- When rainfall is predicted, adjust the construction schedule to allow the implementation of soil stabilization and sediment controls and sediment treatment controls on all disturbed areas prior to the onset of rain.
- Be prepared year-round to deploy soil stabilization and sediment control practices. Erosion may be caused during dry seasons by unseasonable rainfall, wind, and vehicle tracking. Keep the site stabilized year-round, and retain and maintain sediment trapping devices in operational condition.
- Sequence trenching activities so that most open portions are closed before new trenching begins.
- Incorporate staged seeding and re-vegetation of graded slopes as work progresses.
- Consider scheduling when establishing permanent vegetation (appropriate planting time for specified vegetation).

Inspection and Maintenance:

- Verify that work is progressing in accordance with the schedule. If progress deviates, take corrective actions.
- Amend the schedule when changes are warranted.
- Amend the schedule to show updated information on the deployment and implementation of construction site BMPs.

PRESERVATION OF EXISTING VEGETATION / BUFFER STRIPS – EP-2

Maintaining existing vegetation or placing vegetative buffer strips can have numerous benefits for stormwater quality, erosion and sediment control, as well as landscape beautification, dust control, noise reduction, shade and watershed protection.

Construction Specifications:

Preservation of Existing Vegetation:

Timing

- Preservation of existing vegetation shall be provided prior to the commencement of clearing and grubbing operations or other soil-disturbing activities in areas identified on the plans to be preserved, especially on areas designated as Environmentally Sensitive Areas (ESAs) or where no construction activity is planned or will occur at a later date.
- Limits of clearing and grubbing should be clearly marked prior to any grading or clearing activities.
- Preservation of existing vegetation shall conform to scheduling requirements and local permitting agency requirements.

Design and Layout

- Mark areas to be preserved with temporary fencing made of orange polypropylene that is stabilized against ultraviolet light. The temporary fencing shall be at least 3.2. ft (1 meter) tall and shall have openings not larger than 2 in by 2 in (50 mm by 50 mm).
- Fence posts shall be either wood or metal as appropriate for the intended purpose. The post spacing and depth shall be adequate to completely support the fence in an upright position.
- Minimize the disturbed areas by locating temporary roadways to avoid stands of trees and shrubs and to follow existing contours to reduce cutting and filling.
- Consider the impact of grade changes to existing vegetation and the root zone.
- Construction materials, equipment storage, and parking areas shall be located where they will not cause root compaction.
- Keep equipment away from trees to prevent trunk and root damage at least to drip line.
- Maintain existing irrigation systems.
- Employees and subcontractors shall be instructed to honor protective devices. No heavy equipment, vehicular traffic, or storage piles of any construction materials shall be permitted within the drip line of any tree to be retained. Removed trees shall not be felled, pushed, or pulled into any retained trees. Fires shall not be permitted within 100 ft (30 m) of the drip line of any retained trees. No toxic or construction materials (including paint, acid, nails, gypsum board, chemicals, fuels, and lubricants) shall be stored within 50 ft (15 m) of the drip line of any retained trees, nor disposed of in any way which would injure vegetation.

Trenching and Tunneling

- Trenching shall be as far away from tree trunks as possible, usually outside of the tree drip line or canopy. Curve trenches around trees to avoid large roots or root concentrations. If roots are encountered, consider tunneling under them. When trenching and/or tunneling near or under trees to be retained, tunnels shall be at least 18 in (450 mm) below the ground surface, and not below the tree center to minimize impact on the roots.
- Tree roots shall not be left exposed to air; they shall be covered with soil as soon as possible, protected, and kept moistened with wet burlap or peat moss until the tunnel and/or trench can be completed.

- The ends of damaged or cut roots shall be cut off smoothly.
- Trenches and tunnels shall be filled as soon as possible or in accordance with local requirements. Careful filling and tamping will eliminate air spaces in the soil which can damage roots.
- Remove any trees intended for retention if those trees are damaged seriously enough to affect their survival.
- After all other work is complete, fences and barriers shall be removed last. This is because protected trees may be destroyed by carelessness during the final cleanup and landscaping.

Vegetative Buffer Strips:

- Vegetated buffer strips (vegetated filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants (e.g., total and dissolved metals) to settle and partially infiltrate into underlying soils. With proper design and maintenance, filter strips can provide relatively high pollutant removal.
- Designate watercourse buffer-filter strips on the site design plan.
- The width of a buffer strip (i.e., flow path length) shall be maximized to the extent feasible with a 15 foot suggested minimum width. Buffer strips shall be sized in accordance with site conditions and local requirements.

SURFACE ROUGHENING – EP-3

Surface roughening involves roughening surface soils by mechanical methods including sheepsfoot rolling, track walking, scarifying, stair stepping, and imprinting. All slopes prepared by surface roughening must meet engineering compaction requirements required by the project design and local grading requirements. This BMP is intended to only affect surface soils and is not intended to compromise slope stability or overall compaction.

Construction Specifications:

Cut Slope Roughening:

- Stair-step grade or groove the cut slopes that are steeper than 3:1.
- Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in toward the vertical wall.
- Do not make individual vertical cuts more than 2 feet (0.6 m) high in soft materials or more than 3 feet (0.9 m) high in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run across the slope, on the contour.

Fill Slope Roughening:

- Place on fill slopes with a gradient steeper than 3:1 in lifts not to exceed 8 inches (0.2 m), and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4-6 inches (0.1-0.2 m) deep.
- Use grooving or tracking to roughen the face of the slopes, if necessary.
- Do not blade or scrape the final slope face.

Roughening for Slopes to be Mowed:

- Slopes which require mowing activities shall not be steeper than 3:1.
- Roughen these areas to shallow grooves by track walking, scarifying, sheepsfoot rolling, or imprinting.
- Make grooves close together (less than 10 inches (0.3 m)), and not less than 1 inch (25.4 mm) deep, and perpendicular to the direction of runoff (i.e., parallel to the slope contours).
- Excessive roughness is undesirable where mowing is planned.

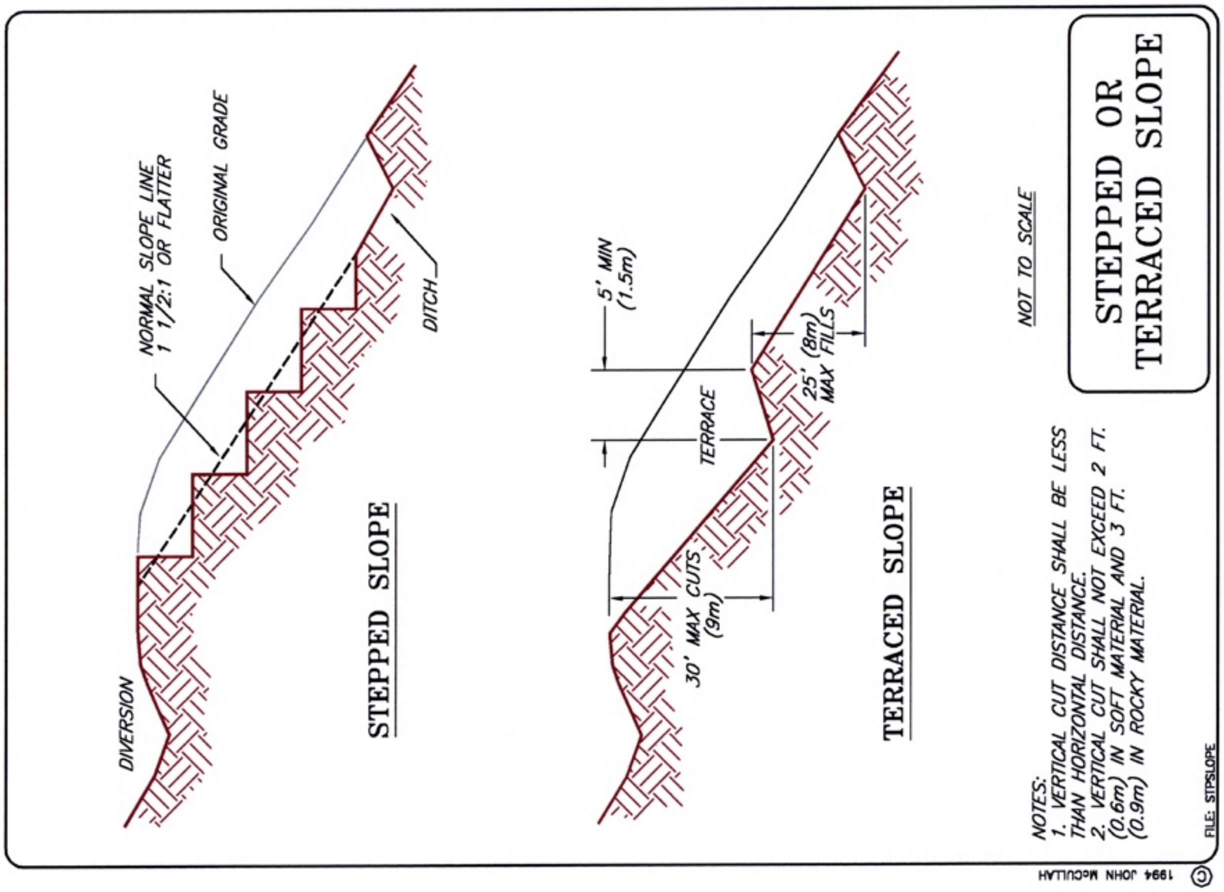
Roughening With Tracked Machinery:

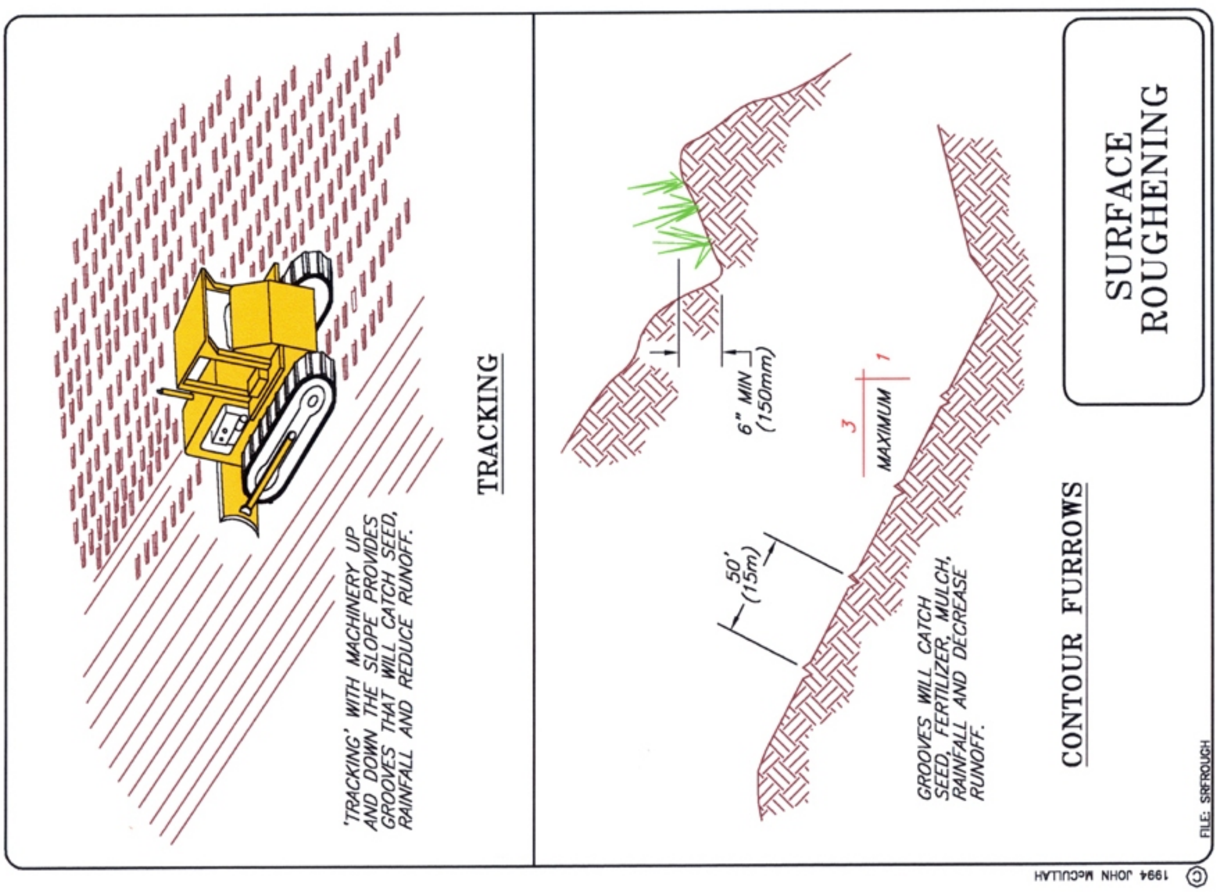
- Limit roughening with tracked machinery to soils with a sandy textural component to avoid undue compaction of the soil surface.
- Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.
- Seed and mulch roughened areas as soon as possible to obtain optimum seed germination and growth.

Minimum BMP standards are presented in the attached detail.

Inspection and Maintenance:

Check the seeded slopes for signs of erosion such as rills and gullies. Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.


STEPPED OR TERRACED SLOPE
NORMAL SLOPE LINE 1 1/2:1 OR FLATTER
ORIGINAL GRADE
DIVERSION
DITCH
STEPPED SLOPE
5' MIN (1.5m)
TERRACE
30' MAX CUTS (9m)
25' (8m) MAX FILLS
TERRACED SLOPE
NOT TO SCALE
NOTES:
1. VERTICAL CUT DISTANCE SHALL BE LESS THAN HORIZONTAL DISTANCE.
2. VERTICAL CUT SHALL NOT EXCEED 2 FT. (0.6m) IN SOFT MATERIAL AND 3 FT. (0.9m) IN ROCKY MATERIAL.
FILE: STPSLOPE
© 1994 JOHN McCULLAH


SURFACE ROUGHENING
'TRACKING' WITH MACHINERY UP AND DOWN THE SLOPE PROVIDES GROOVES THAT WILL CATCH SEED, RAINFALL AND REDUCE RUNOFF.
TRACKING
6" MIN (150mm)
3
1
MAXIMUM
50' (15m)
GROOVES WILL CATCH SEED, FERTILIZER, MULCH, RAINFALL AND DECREASE RUNOFF.
CONTOUR FURROWS
FILE: SRFROUGH
© 1994 JOHN McCULLAH

TOPSOILING – EP-4

Topsoiling is the practice of stripping and stockpiling existing topsoil and then spreading it in graded areas to encourage future vegetation growth.

Construction Specifications:

Planning:

- Determine whether the quality and quantity of available topsoil justifies selective handling and in consideration of local requirements.
- Soils of the textural class of loam, sandy loam, and silt loam are best; sandy clay loam, silty clay loam, clay loam, and loamy sand are fair. Do not use heavy clay and organic soils such as peat or muck as topsoil.

Stripping and Stockpiling:

- Strip topsoil only from those areas that will be disturbed by excavation, filling, or compacting by equipment. A 4-6 inch (0.1-0.2 m) stripping depth is common, but depth varies depending on the site.
- Determine depth of stripping by taking soil cores at several locations within each area to be stripped. Topsoil depth generally varies along a gradient from hilltop to toe of the slope.
- Put sediment basins, diversions, and other controls into place before stripping.
- Select stockpile location to avoid slopes, natural drainage ways, and traffic routes. On large sites, re-spreading is easier and more economical when topsoil is stockpiled in small piles located near areas where they will be used.
- Use sediment fences or other barriers where necessary to retain sediment.
- Protect topsoil stockpiles by temporarily seeding and/or mulching as soon as possible to assure the stored material is not unnecessarily exposed and allowed to erode. Use locally grown and native seed stocks when possible that are mycorrhizal-dependent.
- Topsoil stockpiles should be low n height (ideally <1 meter) and flat and be used within 6 months to promote healthy soil organisms and microbes. Stockpiles not used within 6 months should be reseeded with a species that is mycorrhizal-dependent to avoid the development of anaerobic conditions in the stockpile. In addition, topsoil stockpiles can be turned periodically to keep organisms alive for larger stockpiles and during extremely hot weather.

Spreading:

- Before spreading topsoil, establish erosion and sediment control practices such as diversions, berms, dikes, waterways, and sediment basins.
- Where the pH of the existing subsoil is 6.0 or less, or the soil is composed of heavy clays, incorporate agricultural limestone in amounts recommended by soil tests or specified for the seeding mixture to be used. Incorporate lime to a depth of at least 2 inches (51 mm) by disking. Ensure that all of the lime mixture is incorporated into the soil to minimize direct contact with storm water runoff and handle lime in accordance with manufacturing recommendations or NS-7 (Materials Delivery and Storage).
- Immediately prior to spreading the topsoil, loosen the subgrade by disking or scarifying to a depth of at least 3 inches (76 mm), to ensure bonding of the topsoil and subsoil. If no amendments have been incorporated, loosen the soil to a depth of at least 6 inches (0.15 m) before spreading topsoil.
- Uniformly distribute topsoil to a minimum compacted depth of 2 inches (51 mm) on 3:1 slopes and 4 inches (0.1 m) on flatter slopes.
- Do not spread topsoil while it is frozen or muddy or when the subgrade is wet or frozen.
- Correct any irregularities in the surface that result from topsoiling or other operations to prevent the formation of depressions or water pockets.
- Compact the topsoil enough to ensure good contact with the underlying soil, but avoid excessive compacting, as it increases runoff and inhibits seed germination. Light packing with a roller is recommended where high maintenance turf is to be established.

TEMPORARY SEEDING AND PLANTING EP-5

Temporary seeding and planting consists of the establishment of temporary vegetative cover on disturbed areas to reduce erosion by seeding with appropriate and rapidly growing annual grasses and forbs.

Construction Specifications

Conditions Where Practice Applies

- Cleared or graded areas that are exposed and subject to erosion for extended periods (e.g., 14 to 30 days depending on local requirements).
- Cleared or graded areas exposed to seasonal rains.
- Areas that will not be subjected to heavy wear by construction equipment.
- Temporary seeding is encouraged whenever possible to aid in reducing erosion on construction sites. Temporary seeding is an important component of "phased" construction activities. Permanent seeding shall be applied to areas intended to be left dormant for a year or more.

The following chart shows recorded shear stress and velocities withstood by grass mixtures and applications.

Bank Material/Protection	**Shear**		**Velocity**			**Reference**
	lb/ft^2	**N/m^2**	**ft/s**	**m/s**		
Sandy Loam	0.0167		1.75	0.53	Design	Temple, 1980
Silt Loam	0.0218		2	0.61	Design	Temple, 1980
Alluvial silts	0.0218		2	0.61	Design	Temple, 1980
Ordinary firm loam	0.0341		2.5	0.76	Design	Temple, 1980
Very light loose sand, no vegetation or protection			1-1.5	.3-.46	Limit	Fortier & Scobey, 1926
Average sandy soil			2-2.5	.61-.76	Limit	Fortier & Scobey, 1926
Stiff clay, ordinary gravel soil			4-5	1.2-1.5	Limit	Fortier & Scobey, 1926
Bermuda grass, erosion resistant soils, 0-5% slope			8	2.4	Design	USDA, 1947
Bermuda grass, erosion resistant soils, 5-19% slope			7	2.1	Design	USDA, 1947
Bermuda grass, erosion resistant soils, over 10% slope			6	1.8	Design	USDA, 1947
Bermuda grass, easily eroded soils, 0-5% slope			6	1.8	Design	USDA, 1947
Bermuda grass, easily eroded soils, 5-10% slope			5	1.5	Design	USDA, 1947
Bermuda grass, easily eroded soils, over 10% slope			4	1.2	Design	USDA, 1947
Grass mixture, erosion resistant soils, 0-5% slope			5	1.5	Design	USDA, 1947
Grass mixture, erosion resistant soils, 5-10% slope			4	1.2	Design	USDA, 1947
Grass mixture, easily eroded soils, 0-5% slope			4	1.2	Design	USDA, 1947
Grass mixture, easily eroded soils, 5-10% slope			3	0.91	Design	USDA, 1947

1” riprap	0.33	16			Limit	Chen & Cotton, 1988
2” riprap	0.67	33			Limit	Chen & Cotton, 1988
6” riprap	2	98			Limit	Chen & Cotton, 1988
12” riprap	4	196			Limit	Chen & Cotton, 1988
Dense sod, fair condition (class D/E), moderately cohesive soil	0.35	17			Limit	Austin & Theisen, 1994
Bermuda grass, fair stand <12 cm tall, dormant	0.9	44			Limit	Parsons, 1963
Bermuda grass, good stand <12 cm tall, dormant	1.1	54			Limit	Parsons, 1963
Bermuda grass, excellent stand 20 cm tall, dormant	2.7	132			Limit	Parsons, 1963
Bermuda grass, excellent stand 20 cm tall, green	2.8	137			Limit	Parsons, 1963
Bermuda grass, excellent stand >20 cm tall, green	3.2	156			Limit	Parsons, 1963
12.5 cm of excellent growth of grass/woody veg on outside bend	1	49			Limit	Parsons, 1963
Flume trials, fabric reinforced vegetation – failed after 50 hours	5	244			Limit	Theisen, 1992
Flume trials, fabric reinforced vegetation – failed after 8 hours	8	391			Limit	Theisen, 1992
Sod revetment, short period of attack	0.41	20.09			Design	Schoklitsch, 1937
Wattle (coarse sand between)	0.2	9.8			Design	Schoklitsch, 1937
Wattles (gravel between)	0.31	15.19			Design	Schoklitsch, 1937
Wattles (parallel or oblique to current)	1	49			Design	Schoklitsch, 1937
Fascine revetment	1.4	68.6			Design	Schoklitsch, 1937
Cribs with stone	30	1470			Design	Schoklitsch, 1937
Turf (immediately after construction)	0.2	10			Limit	Schiechtl & Stern, 1994
Turf (after 3-4 seasons)	2.04	100			Limit	Schiechtl & Stern, 1994

Site Considerations

- Prior to seeding, install necessary erosion control practices such as temporary continuous berms, diversion dikes, channels, and sediment basins.
- Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.
- Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover. Consider mixes because they are more adaptable than single species.
- Check with local municipalities for local specifications and requirements prior to seeding and planting.

- Mulching is commonly used with seeding practices for temporary cover and to aid in the establishment of vegetation.
- Temporary seeding also prevents costly maintenance operations on other erosion control systems. For example, sediment basin maintenance (clean-out) will be reduced if the drainage area has temporary vegetative cover when grading and construction are not taking place. (Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as diversion dikes, and sediment basins)
- To reduce the amount of fertilizer, pesticides and other inputs needed, choose adapted varieties based on environmental conditions, management level desired, and the intended use. Check with local municipalities prior to use of fertilizer or pesticides.

Timing

The proper time to seed is dependent upon the climate of the area and the species of seed selected. To determine seeding dates for temporary cover, consult the seed supplier.

Seed Mixes

- All seed should be selected in accordance with local municipality requirements.
- Select plants appropriate to the season and site conditions.
- The seeding rates are based on a minimum acceptable pure live seed (PLS) of 80%. When PLS is below 80% adjust rates accordingly.
- Legumes should be inoculated with the proper rhizobium bacteria before planting. Pellet inoculated seed can be purchased or inoculation can be done in the field. Use only fresh, age dated inoculate specifically labeled for use with the legume you are using.

Site Preparation

- Grade as needed and feasible to permit the use of equipment for seedbed preparation.
- Install needed erosion control practices, such as sediment basins, diversion dikes and channels, prior to seeding. Divert concentrated flows away from seeded areas.
- Soil tests should be done to determine the nutrient and pH content of soil. Depending on the results of soil tests, soil management may be necessary to adjust the pH to between 6.5 and 7.0 (for most conditions). All lime, fertilizer and other soil amendments should be added following sound soil management practices.
- Surface roughening: If the area has been recently loosened or disturbed, no further roughening is required. When the area is compacted, crusted or hardened the soil should be loosened with discing, raking or harrowing. Tracking with bulldozer cleats is very effective on sandy soils.
- Hydroseeding and hydraulic planting generally require less seedbed preparation.
- Generally, slopes steeper than 2:1 that cannot have good seedbed preparations with equipment will require hydraulic planting techniques.
- Seed to soil contact is the key to good germination. Prepare a 3-5 inch (76-127 mm) deep seedbed, with the top 3-4 inches (76-102 mm) consisting of topsoil. Note that the earth bed upon which the topsoil is to be placed should be at the required grade.
- The seedbed should be firm but not compact. The top 3 inches (76 mm) of soil should be loose, moist and free of large clods and stones. For most applications, all stones larger than 2 inches (51 mm) in diameter, roots, litter and any foreign matter should be raked and removed. The topsoil surface should be in reasonably close conformity to the lines, grades and cross sections shown on the grading plans.

Hydroseeding site in September 2003

December 2003

April 2004

Planting:

- Seed should be applied as soon after seedbed preparation as possible, when the soil is loose and moist.
- Always apply seed before mulch, unless seed is applied with a hydraulic matrix or bonded fiber matrix (See BMP EP-8, Mulches).
- Apply seed at the rates specified using calibrated spreaders, cyclone seeders, mechanical drills, or hydroseeders so the seed is applied uniformly on the site.
- If seed is applied with a bonded fiber matrix, apply BFM from multiple directions to adequately cover the soil. Application from a single direction can result in shadowing, uneven coverage, and failure of the BFM.
- Apply fertilizer if required. Seed and fertilizer should be incorporated into the soil by raking or chain dragging, or otherwise floated, then lightly compacted to provide good seed-soil contact.
- Straw mulch, erosion control blankets or mulch and tackifiers/soil binders should be applied over the seeded areas.

***Inspection and Maintenance**:*

- Newly seeded areas need to be inspected frequently to ensure the grass is growing. Areas that fail to establish cover adequate to prevent sheet and rill erosion will be reseeded as soon as such areas are identified. Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.
- If the seeded area is damaged due to concentrated runoff, additional practices may be needed.
- Temporary vegetated areas will be maintained until permanent vegetation or other erosion control practices can be established.

PERMANENT SEEDING AND PLANTING EP-6

Permanent seeding involves the establishment of a permanent, perennial vegetative cover on disturbed areas from seed. Refer to BMP EP-21 for installation of sod. Planting of shrubs, trees, and container plants should be conducted in accordance with project landscaping specifications and local requirements.

The use of native, indigenous, or naturally-occurring grasses is recommended for biotechnical works. These "native" grasses have evolved in a manner that will not compete with or preclude the establishment, or natural recruitment, of naturally-occurring woody vegetation. Establishment of permanent vegetation provides natural erosion and sediment control by trapping particulates, slowing runoff velocities and enhancing infiltration. Permanent vegetation also is beneficial for long-term aesthetics and wildlife habitat.

Construction Specifications

Conditions Where Practice Applies

- Graded, final-graded or cleared areas where permanent vegetative cover is needed to stabilize the soil. Permanent seeding with perennial grasses is recommended when fibrous and deeply rooted are needed to provide slope and soil reinforcement.
- Slopes designated to be treated with erosion control blankets should be seeded first.
- Grass-lined channels or waterways designed to be treated with turf reinforcement mats, fiber roving systems, or other channel liners will require special grass blends.

Materials

Proper seed selection is very important. Choose climatically adapted perennial species that are long-lived, hearty and require low inputs of fertilizer, irrigation and mowing. You may consider a locally occurring species for native grass establishment. Consider seed blends because they are more adaptable.

Use seeds appropriate to the season and site conditions. Use a seed blend, which include annuals, perennials and legumes. Legumes should be inoculated with the proper rhizobium bacteria before planting. Pellet inoculated seed can be purchased or inoculation can be done in the field. Unless otherwise specified by local requirements, use seed rates based on minimum pure live seed (PLS) of 80%. When PLS is below 80% adjust rates accordingly. Consult a local seed supplier, landscape architect, or erosion control specialist for appropriate seed blends. Seed should be selected in accordance with local regulations.

Installation

The probability of successful plant establishment can be maximized through good planning, knowledge of soil characteristics, selection of appropriate seed blends for the site, good seedbed preparation, and timely planting. Prior to seeding, install necessary erosion control practices such as diversion dikes, channels, and sediment basins. Site area should be at final grade and not be disturbed by future construction activities.

Timing

- Apply permanent seeding on areas left dormant for 1 year or more.
- Apply permanent seeding when no further disturbances are planned.
- To determine optimum seeding schedule, consult a local agronomist or erosion control specialist.
- Apply permanent seeding before seasonal rains or freezing weather is anticipated.
- Use dormant seeding for late fall or winter seeding schedules.

Seed Mixes

- Use seeds appropriate to the season and site conditions.
- Consult local agronomist or erosion control specialists for seed mix.
- Use a seed blend to include annuals, perennials and legumes.

- Use seed rates based on pure live seed (PLS) of 80%. When PLS is below 80% adjust rates accordingly.

Site Preparation

- Bring the planting area to final grade and install the necessary erosion control BMPs (i.e., sediment basins and temporary diversion dikes).
- Divert concentrated flows away from the seeded area.
- Conduct soil test to determine pH and nutrient content. Roughen the soil by harrowing, tracking, grooving or furrowing.
- Apply amendments as needed and permitted by local municipalities to adjust pH to 6.0-7.5. Incorporate these amendments into the soil. Prepare a 3-5 in (76-127 mm) deep seedbed, with the top 3-4 in (76-102 mm) consisting of topsoil. The seedbed should be firm but not compact. The top three inches of soil should be loose, moist and free of large clods and stones. The topsoil surface should be in reasonably close conformity to the lines, grades and cross sections shown on the grading plans.

Planting:

- Seed to soil contact is the key to good germination.
- Seed should be applied immediately after seedbed preparation while the soil is loose and moist. If the seedbed has been idle long enough for the soil to become compact, the topsoil should be harrowed with a disk, spring tooth drag, spike tooth drag, or other equipment designed to conditions the soil for seeding.
- Harrowing, tracking or furrowing should be done horizontally across the face of the slope.
- Always apply seed before applying mulch, unless using a hydraulic matrix or bonded fiber matrix where seed is mixed with mulch prior before application.
- Apply seed at the rates specified using calibrated seed spreaders, cyclone seeders, mechanical drills, or a hydroseeder so the seed is applied uniformly on the site.
- Broadcast seed should be incorporated into the soil by raking or chain dragging, and then lightly compacted to provide good seed-soil contact.
- Apply fertilizer as specified and allowed by local municipalities.
- Apply mulch or erosion control blanket, as specified, over the seeded areas.

Inspection and Maintenance

- Newly seeded areas need to be inspected frequently to ensure the grass is growing.
- If the seeded area is damaged due to runoff, additional stormwater measures may be needed.
- Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.
- Irrigation/watering should be used as necessary and recommended to establish vegetation in accordance with local regulations.

MYCORRHIZAE AND BIOFERTILIZERS EP-7

Biofertilizers and mycorrhizae are very important to any revegetation effort, as they help to rebuild the living soil that can get damaged by any earthwork. Most desirable species will have a very difficult time out competing weeds without mycorrhizae, or the slowly released nutrients provided by biofertilizers.

Biofertilizers

Biofertilizers are fertilizers containing living microorganisms, which increase microbial activity in the soil. Often, organic food is included to help the microbes get established.

Important functions of soil microbes:

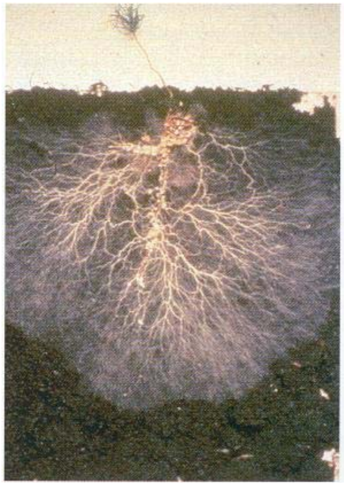
- Convert ambient nitrogen into forms that the plants can use (Nitrate and Ammonia),
- Increase soil porosity by gluing soil particles together.
- Defend plants against pathogens by out-competing pathogens for food.
- Saprophytic fungi in the soil break leaf litter down into usable nutrients.

The high soil porosity (large spaces between soil particles) caused by microbes is important, because it aids water infiltration. If pore spaces are too small, they cannot break the surface tension of a water droplet, and water will run off, instead of saturating the soil, where it can be taken up by plant roots.

Chemical fertilizers are often over-applied, and end up polluting the water because they are not used up. The chemicals are less expensive in the short term, but must be continuously reapplied, and are therefore more expensive over the long-term.

A combination of chemical fertilizers and biofertilizers gives the plants a jump-start and maintains them until the microbes can get established.

Mycorrhizal Fungi



Mycorrhizal fungi form a bridge between the roots and the soil, gathering nutrients from the soil and giving them to the roots. There are two major types of mycorrhizae: Ectomycorrhizal Fungi (EM) and Endomycorrhizal Fungi (AM). While both types penetrate the plant roots, ectomycorrhizae spread their hyphae between root cells, while endomycorrhizae hyphae penetrate root cells. Ectomycorrhizae hosts include members of the Pine, Oak and Beech families, as well as few others in scattered families, and involves a “higher” (often mushroom-forming) fungus. ECM-dominated forests tend to be low in species diversity compared to arbuscular (AM) forests, and have a thick layer of organic debris on the forest floor.

Endomycorrhizae are the most common, and are found in grasses, shrubs, trees including redwood and cedar, most domestic plant species and many other members of the forest understory. EM fungi are usually specific to a certain host species, but most species of endomycorrhizae will form relationships with almost any AM host plant, and is therefore much easier to specify. There are four major plant families that usually do not form mycorrhizae: *Amaranthaceae* (Pigweed family), *Brassicaceae* (Mustard family), *Chenopodiaceae* (Goosefoot family) and *Zygophyllaceae* (Caltrop family). These plant families are well known as weeds. Therefore, if you do not ensure an adequate supply of mycorrhizae, you may inadvertently inhibit growth of desirable species and allow for rapid growth of undesirable species.

Relationships between Biofertilizers and Mycorrhizal Fungi

Plant roots secrete "food" for bacteria and fungi, which attracts nematodes (worms) to the roots, because nematodes eat bacteria and fungi, and excrete Nitrogen, Sulphur and Phosphorus in a form that the plants can use. The nematodes only keep 1/6 of the nitrogen that they process – 5/6 is excreted to the plant. Once the nematodes have excreted the nutrients, the hyphae of the mycorrhizal fungi pick them up and transfer them into the plant. Because of this symbiotic relationship, the least-leachable form of Nitrogen you can apply is bacteria and fungi, and bacteria are the most Nitrogen-rich organisms on earth.

AM hyphae pick up more nutrients than just those excreted by nematodes, however. One of the most beneficial properties of AM mycorrhizae is its ability to "mine" the soil great distances from the roots for nutrients, especially those, such as Phosphorus, that are poorly mobile in the soil. AM Mycorrhizae also assist in picking up water further away from the roots, and block pest access to roots.

Mycorrhizae also benefit plants indirectly by enhancing the structure of the soil. AM hyphae excrete gluey, sugar-based compounds called Glomalin, which helps to bind soil particles, and make stable soil aggregates. This gives the soil structure, and improves air and water infiltration, as well as enhancing carbon and nutrient storage.

Most natural, undisturbed soils have an adequate supply of mycorrhizae for plant benefits; however, the following practices can reduce mycorrhizae populations to inadequate levels.

- Erosion
- Grading
- Excavation
- Occupation with non-Mycorrhizal plants (weeds)
- Loss of original topsoil

The best way to be sure that appropriate mycorrhizal levels exist in soil onsite is to get a soil sample analyzed for mycorrhizal presence.

To maintain healthy mycorrhizae populations (Peters, 2002):

- Do not apply too much phosphorus, as high levels will limit mycorrhizal effectiveness, low to moderate levels, or slow-release phosphorus will maximize plant benefits.
- Limit fungicide use, as some fungicides damage AM fungi.
- Limit soil disturbance, as disruption of the hyphae in the soil limits water and nutrient movement into the root.

Application

Endomycorrhizae should be applied at a rate of 3,600,000 propagules per acre (8,900,000 propagules per hectare), which equates to 60 lbs per acre (67.5 kg/ha) or 1.4 lbs/1000 ft^2, assuming the standard 120 propagules/cc. Mycorrhizae is most frequently applied via hand seeding, seed drilling, hydroseeding, broadcast and till, planting, or as a nursery medium.

If installing container plants, packets of mycorrhizae may be planted along with the plant, at a rate of 1 packet per foot of plant height or container width (RTI, 2003).

Maintenance / Inspection

No maintenance should be necessary, although if plants do not appear to be growing vigorously, analysis of mycorrhizal density in the soil can help to determine if you need to apply more.

MULCHES – EP-8

Mulching is the process of applying bulk materials to the soil surface to reduce rainfall impact, increase infiltration and in some cases, aid in revegetation. Common types of mulch include vegetable fibers, green material, hydraulic mulches from recycled paper or wood fibers, hydraulic matrices, and straw mulch. Mulches may include a tackifier to increase the longevity of the application.

Construction Specifications:

- Mulch should be used for temporary applications only; permanent erosion control measures should also be applied.
- Prior to application, roughen embankment and fill areas by rolling with a crimping or punching type roller or by track walking. Track walking shall only be used where other methods are impractical.
- Avoid mulch over-spray onto the traveled way, sidewalks, lined drainage channels, and existing vegetation.

Wood Fiber Mulch – Materials and Application Procedures

- Wood fiber mulch is a component of hydraulic applications. It is usually used in combination with seed and fertilizer. It is typically applied at the rate of 2,000 to 4,000 lb/ac (2,250 to 4,500 kg/ha) with 0-5% by weight of a stabilizing emulsion or tackifier (e.g., guar, psyllium, acrylic copolymer) and applied as a slurry. This type of mulch is manufactured from wood or wood waste from lumber mills or from urban sources.
- Wood fiber mulch can be specified with or without a tackifier; previous work has shown that wood fiber mulches with tackifiers have better erosion control performances.
- Materials for wood fiber based hydraulic mulches and hydraulic matrices shall conform to Oregon DOT Standard Specifications Sections 01030.15 and 01030.16 and local municipality requirements and specifications.

Recycled Paper Mulch – Materials and Application Procedures

- Recycled paper mulch contains fibers of shorter length than wood fiber mulches and is typically made from recycled newsprint, magazine, or other waste paper sources. It is a component of hydraulic applications and is usually used in combination with seed and fertilizer. It is typically applied at the rate of 1 to 2 tons/ac (2,250 to 4,500 kg/Ha). It can be specified with or without a tackifier.

Green Material – Materials and Application Procedures

- This type of mulch is produced by recycling vegetation trimmings such as grass, shredded shrubs and trees. Methods of application are generally by hand, although pneumatic methods are available. Mulch shall be composted to kill weed seeds.
- It may be used as a temporary ground cover with or without seeding.
- The green material shall be evenly distributed on site to a depth of not more than 2 in (50 mm).

Hydraulic Matrix – Materials and Application Procedures

- Hydraulic matrix is a combination of wood fiber mulch and a tackifier applied as a slurry. It is typically applied at the rate of 2,000 to 4,000 lb/ac (2,250 to 4,500 kg/ha) with 5-10% by weight of a stabilizing emulsion or tackifier (e.g., guar, psyllium, acrylic copolymer).
- Materials for wood fiber based hydraulic mulches and hydraulic matrices shall conform to Oregon DOT Standard Specifications Sections 01030.15 and 01030.16 and local municipality requirements and specifications.
- Hydraulic matrices require 24 hours to dry before rainfall occurs to be effective unless approved by Oregon DEQ.

Bonded Fiber Matrix – Materials and Application Procedures

- Bonded fiber matrix (BFM) is a hydraulically-applied system of fibers and adhesives that upon drying forms an erosion-resistant blanket that promotes vegetation, and prevents soil erosion. BFMs are typically applied at rates from 3,000 to 4,000 lb/ac (3,400 to 4,500 kg/ha) based on the manufacturer's recommendation. The biodegradable BFM is composed of materials that are 100% biodegradable. The binder in the BFM shall also be biodegradable and shall not dissolve or disperse upon re-wetting. Typically, biodegradable BFMs should not be applied immediately before, during or immediately after rainfall if the soil is saturated. Depending on the product, BFMs require 12 to 24 hours to dry to become effective.
- BFM should be selected and used in accordance with local municipality requirements and specifications.
- Apply bonded fiber matrices from multiple directions to adequately cover the soil. Application from a single direction can result in shadowing, uneven coverage, and failure of the BFM.

Straw Mulch - Materials

- All materials shall conform to Oregon DOT Standard Specifications Sections 01030.15(b) and any local municipality requirements.
- Straw shall be derived from wheat, rice, or barley. The straw mulch contractor shall furnish evidence that clearance has been obtained from the County Agricultural Commissioner, as required by law, before straw obtained from outside the county in which it is to be used is delivered to the site of the work. Straw that has been used for stable bedding shall not be used.

Straw Mulch – Application Procedures

- Apply loose straw at a minimum rate of 4,000 lb/ac (3,570 kg/ha), or as indicated in the project's Erosion and Sediment Control Plan, either by machine or by hand distribution.
- The straw mulch must be evenly distributed on the soil surface.
- Avoid placing straw onto the traveled way, sidewalks, lined drainage channels, walls, and existing vegetation.
- Anchor the mulch in place by using a tackifier (preferred) or by "punching" it into the soil mechanically (incorporating).
- If using a tackifier to anchor the straw mulch in lieu of incorporation, roughen embankment or fill areas by rolling with a crimping or punching-type roller or by track walking before placing the straw mulch. Track walking should only be used where rolling is impractical.
- A tackifier acts to glue the straw fibers together and to the soil surface. The tackifier shall be selected based on longevity and ability to hold the fibers in place (see Oregon DOT Standard Specifications Section 01030.16).
- A tackifier is typically applied at a rate of 125 lb/ac (140 kg/ha). In windy conditions, the rate is typically 178 lb/ac (200 kg/ha).
- Straw mulch with tackifier shall not be applied during or immediately before rainfall.
- Methods for holding the straw mulch in place depend upon the slope steepness, accessibility, soil conditions and longevity. If the selected method is incorporation of straw mulch into the soil, then do as follows:
  - Applying and incorporating straw shall follow the requirements in Oregon DOT Standard Specifications Section 01030.48(b) and any local municipality's specifications and requirements.
  - On small areas, a spade or shovel can be used.
  - On slopes with soils, which are stable enough and of sufficient gradient to safely support construction equipment without contributing to compaction and instability problems, straw may be "punched" into the ground using a knife-blade roller or a straight bladed coulter, known commercially as a "crimper."
  - On small areas and/or steep slopes, straw may also be held in place using plastic netting or jute. The netting shall be held in place using 11 gauge wire staples, geotextile pins or wooden stakes. Refer to EP-10, "Erosion Control Blankets and Mats."

Inspection and Maintenance:

- Maintain an unbroken, temporary mulched ground cover throughout the period of construction when the soils are not being reworked. Inspect before expected rain events and repair any damaged ground cover and re-mulch exposed areas of bare soil.
- The key consideration in maintenance and inspection is that the mulch needs to last long enough to achieve erosion control objectives. Mulch is a temporary ground cover and not suitable for long-term erosion control.
- Maintain an unbroken, temporary mulched ground cover while disturbed soil areas are non-active. Repair any damaged ground cover and re-mulch exposed areas.
- Reapplication of mulch and tackifier may be required by Oregon DEQ and local municipalities to maintain effective soil stabilization over disturbed areas and slopes.
- After any rainfall event, maintain all slopes to reduce or prevent erosion.

Construction Specifications

A compost blanket is a layer of compost designed to prevent erosion, especially rills and gullies that may form under more traditional methods of erosion control. In many cases, a compost blanket can be more effective at vegetation establishment, weed suppression and erosion control than an Erosion Control Blanket (ECB) or Hydroseeding. Compost blankets can be applied by hand, conveyor system or compost spreader; however, the most cost-effective and efficient method is the use of a pneumatic delivery system, i.e. a compost blower truck.

Purpose

A compost blanket is used on slopes to prevent raindrop erosion and in some cases, to increase infiltration rates. A trademarked form of a compost blanket, the Rexius EcoBlanket™ increased infiltration rates and decreased sediment delivery by 99% as compared to bare soil, in a study conducted by the San Diego State Erosion Control Laboratory. The success of compost blankets is dependent upon the blanket not being undermined by water; this can be accomplished by keying in the top of the blanket, or the use of a compost berm or sock at the top of the slope.

EcoBlanket™ Photo Courtesy of Rexius

When applied correctly, compost blankets provide nearly 100% surface coverage.

Compost binds heavy metals and can break hydrocarbons down into carbon, salts and other unharmful compounds. Many communities now have municipal recycle or "Greenwaste" programs whereby vegetation is diverted from landfills and quality compost is manufactured.

Advantages

Compost blankets can be more effective than ECBs, because they come in better contact with the underlying soil, reducing the chance of rill formation.

Compost is organic, biodegradable, renewable, and can be left onsite. This is particularly important near streams.

Compost does not generally leach nutrients. Field tests in Connecticut have shown that run-off from compost treated sites has very low soluble salts, and all metals and nutrients are well within pollution leaching limits.

Compost has been shown to suppress weeds.

Conditions Where Practice Applies

Testing has shown that compost blankets are effective on up to a 2:1 slope. For steeper slopes, there are products designed to enhance adhesion of the compost to the slope, but the effectiveness of such products are unknown. Adding components such as a tackifier, or using compost blankets in conjunction with other techniques such as compost berms as slope interrupters can increase the allowable steepness of the slope to be treated. However, slopes of this steepness would likely require customized stabilization techniques recommended by an engineer.

Photo Courtesy of Texas DOT

Compost blankets should be extended 3-6 feet over the top shoulder of the slope to prevent water from flowing underneath.

Compost blankets should not be applied in areas of concentrated flow, and can be used in conjunction with compost berms or socks.

Blankets can be applied in a variety of thicknesses from ½" to 4", depending upon the intended purpose. As a general rule, the more precipitation an area receives, the thicker the application.

For best vegetation establishment, a depth of 1 ½" is optimum. For maximum unvegetated erosion control, use thicker blankets.

Compost Specifications:

There are many types of compost, all with different properties, so it is best to determine what application the compost is being used for. Compost can be derived from feedstocks, biosolids, leaf and yard trimmings, manure, wood, or mixed solid waste, and must be treated with heat to remove pathogens and destroy noxious weeds.

One of the most important criteria for quality compost is the temperature it was "cooked" at and the duration of composting. For instance, California Compost Regulations require that "windrowed compost" be kept at 131°F for 15 days and turned 5 times. Compost manufactured in bags is referred to as "in vessel" which the regulations require be kept at 131°F for only 5 days. Quality compost will then be cured for 60 days (D.Carvalo, personal communication, 2004).

All types of vegetation have different nutrient or moisture needs; therefore, a compost sample should be inspected by a qualified individual and compost specifications modified as necessary. For compost blankets, compost should have the specifications presented in Table 1 (AASHTO).

Compost that is too dry is harder to apply, while that which is too wet is heavier and harder to transport. In drier areas, use compost with higher moisture content; in wet areas, use the drier compost, as it will absorb water.

Organic matter content: The percentage of carbon based materials in finished compost should range between 40-70%. However, Texas DOT specifies no less than 70%.

Compost must be weed and pesticide free, with manmade materials comprising less than 1%.

Installation

- Compost blankets can be applied in a variety of ways, however the most efficient and cost-effective way is through the use of a pneumatic blower truck.
- Prepare the slopes by removing loose rocks, roots, clods, stumps and debris over 2" in diameter.
- Trackwalk slopes if feasible before application.
- For very steep slopes (2H:1V to 1V:1V), compost berms can be installed along the contour at intervals over the compost blanket in much a similar manner as fiber rolls and tackifier applied to improve effectiveness .

Photo courtesy Texas DOT

Table 1. Compost Specifications.

Parameters [1,4]	Reported as (Units of measure)	Surface mulch to be Vegetated	Surface Mulch to be left Unvegetated
pH [2]	pH units	5.0-8.5	N/A
Soluble Salt Concentration [2] (electrical conductivity)	dS/m (mmhos/cm)	Maximum 5	Maximum 5
Moisture Content	%, wet weight basis	30-60	30-60
Organic Matter Content	%, wet weight basis	25-65	25-100
Particle Size	% passing a selected mesh size, dry weight basis	3" (75mm), 100% passing 1" (25 mm), 90% to 100% passing ¾" (19mm), 65%-100% passing ½" (6.4mm), 0%-75% passing Maximum particle length of 6 (152mm)	3" (75mm), 100% passing 1" (25 mm), 90% to 100% passing ¾" (19mm), 65%-100% passing ½" (6.4mm), 0%-75% passing Maximum particle length of 6 (152mm)
Stability [3] Carbon Dioxide Evolution Rate	Mg CO 2 -C per g OM per day	<8	N/A
Physical Contaminants (man-made inerts)	%, dry weight basis	<1	<1

[1]Recommended test methodologies are provided in Test Methods for the Examination of Composting and Compost (TMECC, the US Composting Council)

[2]Each specific plant species requires a specific pH range. Each plant also has a salinity tolerance rating, and maximum tolerable quantities are known. When specifying the establishment of any plant or turf species, it is important to understand their pH and soluble salt requirements, and how they relate to the compost in use.

[3]Stability/Maturity rating is an area of compost science that is still evolving, and as such, other various test methods could be considered. Also, never base compost quality conclusions on the result of a single stability/maturity test.

[4]Landscape architects and project (field) engineers may modify the allowable compost specification ranges based on specific field conditions and plant requirements.

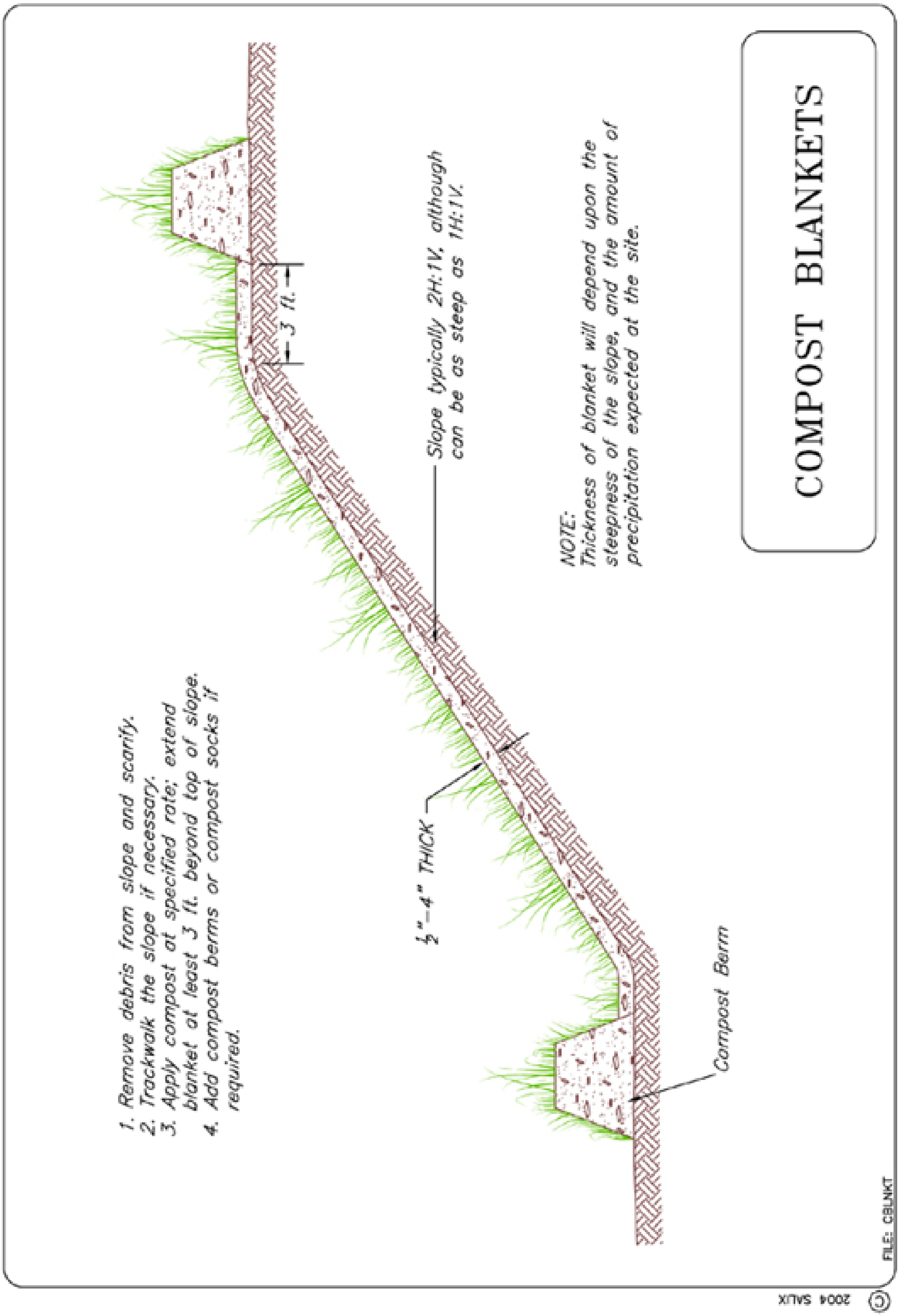
Compost Blanket Application Rates (AASHTO)

Rainfall/ Flow Rate	Total Precipitation and Rainfall Erosivity Index	Application Rate for Vegetated[1] Compost Blanket	Application Rate for Unvegetated* Compost Surface Mulch
Low	1-25" 20-90	½ - ¾" (12.5 mm x 19 mm)	1"-1 ½" (25 mm – 37.5 mm)
Average	26-50" 91-200	3/4 – 1" (19 mm x 25 mm)	1 ½" – 2" (37 mm – 50 mm)
High	51" and above 201 and above	1-2" (25 mm x 50 mm)	2-4" (50 mm – 100 mm)

[1] These lower application rates should only be used in conjunction with seeding, and for compost blankets applied during the prescribed planting season for the particular region.

Inspection and Maintenance

- Inspect blankets after each rain event.
- Re-apply blanket material if needed.
- Blankets can be hydroseeded if vegetation fails to establish.


1. Remove debris from slope and scarify.
2. Trackwalk the slope if necessary.
3. Apply compost at specified rate; extend blanket at least 3 ft. beyond top of slope.
4. Add compost berms or compost socks if required.
3 ft.
Slope typically 2H:1V, although can be as steep as 1H:1V.
½"–4" THICK
NOTE:
Thickness of blanket will depend upon the steepness of the slope, and the amount of precipitation expected at the site.
Compost Berm
COMPOST BLANKETS
FILE: CBLNKT
© 2004 SALIX

EROSION CONTROL BLANKETS AND MATS – EP-10

Erosion control blankets and mats (a.k.a., rolled erosion control products - RECPs) provide erosion control by protecting the bare soil from rainfall impact, increasing infiltration and promoting vegetation by protecting seeds from predators and moderating soil temperature. Erosion control blankets and mats can be biodegradable or synthetic and can be temporary or permanent erosion control applications.

Construction Specifications:

Site Preparation:

- Proper site preparation is essential to ensure complete contact of the protection matting with the soil.
- Site preparation should be performed in accordance with any local municipality requirements and specifications.
- Grade and shape area of installation.
- Remove all rocks, clods, vegetative or other obstructions so that the installed blankets, or mats will have direct contact with the soil.
- Prepare seedbed by loosening 2-3 inches (50.8-76.2 mm) of topsoil above final grade.
- Incorporate amendments, such as lime and fertilizer, into soil according to soil test and the seeding plan.

Materials:

Erosion control blankets are grouped into three types: biodegradable, non-biodegradable, and a combination of synthetic and biodegradable.

BiodegradableRECPs

Biodegradable RECPs are typically composed of jute fibers, curled wood fibers, straw, coconut fiber, or a combination of these materials.

- Jute Mesh: Jute is a natural fiber that is made into a yarn which is loosely woven into a biodegradable mesh. It is designed to be used in conjunction with vegetation and has longevity of approximately one year. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.
- Curled Wood Fiber: Excelsior (curled wood fiber) blanket material should consist of machine produced mats of curled wood excelsior with 80 percent of the fiber 6 inches (15 cm) or longer. The excelsior blanket should be of consistent thickness. The wood fiber should be evenly distributed over the entire area of the blanket. The top surface of the blanket should be covered with a photodegradable extruded plastic mesh. The blanket should be smolder resistant without the use of chemical additives and shall be non-toxic and non-injurious to plant and animal life. Excelsior blanket should be furnished in rolled strips, a minimum of 4 feet (122 cm) wide, and should have an average weight of 0.1 lb/ft^2 (0.5 kg/m^2), ±10 percent, at the time of manufacture. Excelsior blankets should be secured in place with wire staples. Staples should be made of 0.12 inches (3.05-mm) steel wire and should be U-shaped with 8 inches (20 cm) legs and 2 inches (5 cm) crown. Always follow the manufacturer's recommendation on staple types, patterns and the number to use per square yard or meter.
- Straw: Straw blanket should be machine-produced mats of straw with a lightweight biodegradable netting top layer. The straw should be attached to the netting with biodegradable thread or glue strips. The straw blanket should be of consistent thickness. The straw should be evenly distributed over the entire area of the blanket. Straw blanket should be furnished in rolled strips a minimum of 6.5 feet (2 meters) wide, a minimum of 80 feet (25 meters) long and a minimum of 0.05 lbs/ft^2 (0.27 kg/m^2). Straw blankets should be secured in place with wire staples. Staples should be made of

0.12 inches (3.05-mm) steel wire and should be U-shaped with 8 inches (20 cm) legs and 2 inches (5 cm) crown.

- Wood Fiber: Wood fiber blanket is comprised of biodegradable fiber mulch with extruded plastic netting held together with adhesives. The material is designed to enhance revegetation. The material is furnished in rolled strips, which should be secured to the ground with U-shaped staples or stakes in accordance with manufacturers' recommendations.
- Coconut Fiber: Coconut fiber blanket should be machine-produced mats of 100 percent coconut fiber with biodegradable netting on the top and bottom. The coconut fiber should be attached to the netting with biodegradable thread or glue strips. The coconut fiber blanket should be of consistent thickness. The coconut fiber should be evenly distributed over the entire area of the blanket. Coconut fiber blanket should be furnished in rolled strips with a minimum of 6.5 feet (2 meters) wide, a minimum of 80 feet (25 meters) long and a minimum of 0.05 lbs/ft^2 (0.27 kg/m^2). Coconut fiber blankets should be secured in place with wire staples. Staples should be made of 0.12 inches (3.05-mm) steel wire and should be U-shaped with 8 inches (20 cm) legs and 2 inches (5 cm) crown.
- Coconut Fiber Mesh: Coconut fiber mesh is a thin permeable membrane made from coconut or corn fiber that is spun into a yarn and woven into a biodegradable mat. It is designed to be used in conjunction with vegetation and typically has longevity of several years. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.
- Straw Coconut Fiber: Straw coconut fiber blanket should be machine-produced mats of 70 percent straw and 30 percent coconut fiber with a biodegradable netting top layer and a biodegradable bottom net. The straw and coconut fiber should be attached to the netting with biodegradable thread or glue strips. The straw coconut fiber blanket should be of consistent thickness. The straw and coconut fiber should be evenly distributed over the entire area of the blanket. Straw coconut fiber blanket should be furnished in rolled strips a minimum of 6.5 feet (2 meters) wide, a minimum of 80 feet (25 meters) long and a minimum of 0.05 lbs/ft^2 (0.27 kg/m^2). Straw coconut fiber blankets should be secured in place with wire staples. Staples should be made of 0.12 inches (3.05-mm) steel wire and should be U-shaped with 8 inches (20 cm) legs and 2 inches (5 cm) crown.

Non-Biodegradable RECPs

Non-biodegradable RECPs are typically composed of polypropylene, polyethylene, nylon or other synthetic fibers. In some cases, a combination of biodegradable and synthetic fibers is used to construct the RECP. Netting used to hold these fibers together is typically non-biodegradable as well.

- Plastic Netting: Plastic netting is a lightweight biaxially-oriented netting designed for securing loose mulches like straw or paper to soil surfaces to establish vegetation. The netting is photodegradable. The netting is supplied in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.
- Plastic Mesh: Plastic mesh is an open-weave geotextile that is comprised of an extruded synthetic fiber woven into a mesh with an opening size of less than 0.2 inches (0.5 cm). It is used with revegetation or may be used to secure loose fiber such as straw to the ground. The material is supplied in rolled strips, which should be secured to the soil with U-shaped staples or stakes in accordance with manufacturers' recommendations.
- Synthetic Fiber with Netting: Synthetic fiber with netting is a mat that is comprised of durable synthetic fibers treated to resist chemicals and ultraviolet light. The mat is a dense, three-dimensional mesh of synthetic (typically polyolefin) fibers stitched between two polypropylene nets. The mats are designed to be revegetated and provide a permanent composite system of soil, roots, and geomatrix. The material is furnished in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.
- Bonded Synthetic Fiber: This type of product consists of three-dimensional geomatrix nylon (or other synthetic) matting. Typically it has more than ninety percent open area, which facilitates root growth. Its tough root-reinforcing system anchors vegetation and protects against hydraulic lift and shear

forces created by high volume discharges. It can be installed over prepared soil, followed by seeding into the mat. Once vegetated, it becomes an invisible composite system of soil, roots, and geomatrix. The material is furnished in rolled strips that should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Combination Synthetic and Biodegradable RECPs

Combination synthetic and biodegradable RECPs consist of biodegradable fibers, such as wood fiber or coconut fiber, with a heavy polypropylene net stitched to the top and a high-strength continuous-filament geomatrix or net stitched to the bottom. The material is designed to enhance revegetation. The material is furnished in rolled strips, which should be secured with U-shaped staples or stakes in accordance with manufacturers' recommendations.

Seeding:

- Seed area before blanket installation for erosion control and revegetation. Seeding after mat installation is often specified for turf reinforcement application. When seeding prior to blanket installation, all check slots and other areas disturbed during installation must be reseeded.
- Where soil filling is specified, seed the matting and the entire disturbed area after installation and prior to filling the mat with soil.

Anchoring:

- Anchoring of RECPs is the most critical element of installation. Anchoring devices must be selected to be compatible with site soil conditions.
- Where soil conditions are suitable (i.e., topsoil without substantial rocks or cobbles), biodegradable stakes, staples, or pins are preferred. Although biodegradable anchoring devices are preferred they must be compatible with soil conditions to ensure proper blanket installation.
- U-shaped wire staples, metal geotextile stake pins, or triangular wooden stakes can be used to anchor mats to the ground surface. Wire staples shall be a minimum of 11 gauge. Metal stake pins shall be 3/16 inch (4.8 mm) diameter steel with a 1-1/2 inch (38.1 mm) steel washer at the head of the pin. Wire staples and metal stakes shall be driven flush to the soil surface. Two inches of wood staking shall remain above the soil surface. All anchors shall be 6-18 inches (0.2-0.5 m) long and have sufficient ground penetration to resist pullout. Longer anchors may be required for loose soils.

Installation on Slopes:

- Dig initial anchor trench 12 inches (0.3 m) deep and 6 inches (0.2 m) wide across the channel at the lower end of the project area.
- Begin at the top of the slope and anchor its blanket in a 6 inch (0.2 m) deep x 6 inch (0.2 m) wide trench. Backfill trench and tamp earth firmly.
- Unroll blanket down slope in the direction of the water flow.
- The edges of adjacent parallel rolls must be overlapped 2-3 inches (51-76 mm) and be stapled every 3 feet (0.9 m).
- When blankets must be spliced, place blankets end over end (shingle style) with 6 inch (0.2 m) overlap. Staple through overlapped area, approximately 12 inches (0.3 m) apart.
- Lay blankets loosely and maintain direct contact with the soil - do not stretch.
- Blankets shall be stapled sufficiently to anchor blanket and maintain contact with the soil in accordance with manufacturer's and local requirements. Guidelines for installation are as follows: Staples shall be placed down the center and staggered with the staples placed along the edges. Steep

slopes, 1:1 to 2:1, require 2 staples per square yard. Moderate slopes, 2:1 to 3:1, require 1-2 staples per square yard (1 staple, 3 feet on center). Gentle slopes require 1 staple per square yard.

Installation in Channels:

- Dig initial anchor trench 12 inches (0.3 m) deep and 6 inches (0.2 m) wide across the channel at the lower end of the project area.
- Excavate intermittent check slots, 6 inches (0.2 m) deep and 6 inches (0.2 m) wide across the channel at 25-30 foot (7.6-9.1 m) intervals along the channel.
- Cut longitudinal channel anchor slots 4 inches (101 mm) deep and 4 inches (101 mm) wide along each side of the installation to bury edges of matting. Whenever possible extend matting 2-3 inches (51-76 mm) above the crest of channel side slopes.
- Beginning at the downstream end and in the center of the channel, place the initial end of the first roll in the anchor trench and secure with fastening devices at 1 foot (0.3 m) intervals. Note: matting will initially be upside down in anchor trench.
- In the same manner, position adjacent rolls in anchor trench, overlapping the preceding roll a minimum of 3 inches (7.6 cm).
- Secure these initial ends of mats with anchors at 1 foot (0.3 m) intervals, backfill and compact soil.
- Unroll center strip of matting upstream. Stop at next check slot or terminal anchor trench.
- Unroll adjacent mats upstream in similar fashion, maintaining a 3 inch (76 mm) overlap.
- Fold and secure all rolls of matting snugly into all transverse check slots. Lay mat in the bottom of the slot then fold back against itself. Anchor through both layers of mat at 1 inch (25.4 mm) intervals, then backfill and compact soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.

Alternate Installation Method for Slopes <4:1:

- Place two rows of anchors on 6 inch (0.2 m) centers at 25-30 feet (7.6-9.1 m) intervals in lieu of excavated check slots.
- Shingle-lap spliced ends by a minimum of 1 foot (0.3 m) with upstream mat on top to prevent uplifting by water or begin new rolls in a check slot. Anchor overlapped area by placing two rows of anchors, 1 foot (0.3 m) apart on 1 foot (0.3 m) intervals.
- Place edges of outside mats in previously excavated longitudinal slots, anchor using prescribed staple pattern, backfill and compact soil.
- Anchor, fill and compact upstream end of mat in a 12 inch (0.3 m) x 6 inch (0.2 m) terminal trench.
- Secure mat to ground surface using U-shaped wire staples geotextile pins or wooden stakes.
- Seed and fill turf reinforcement matting with soil, if specified.

Soil Filling (if specified for turf reinforcement):

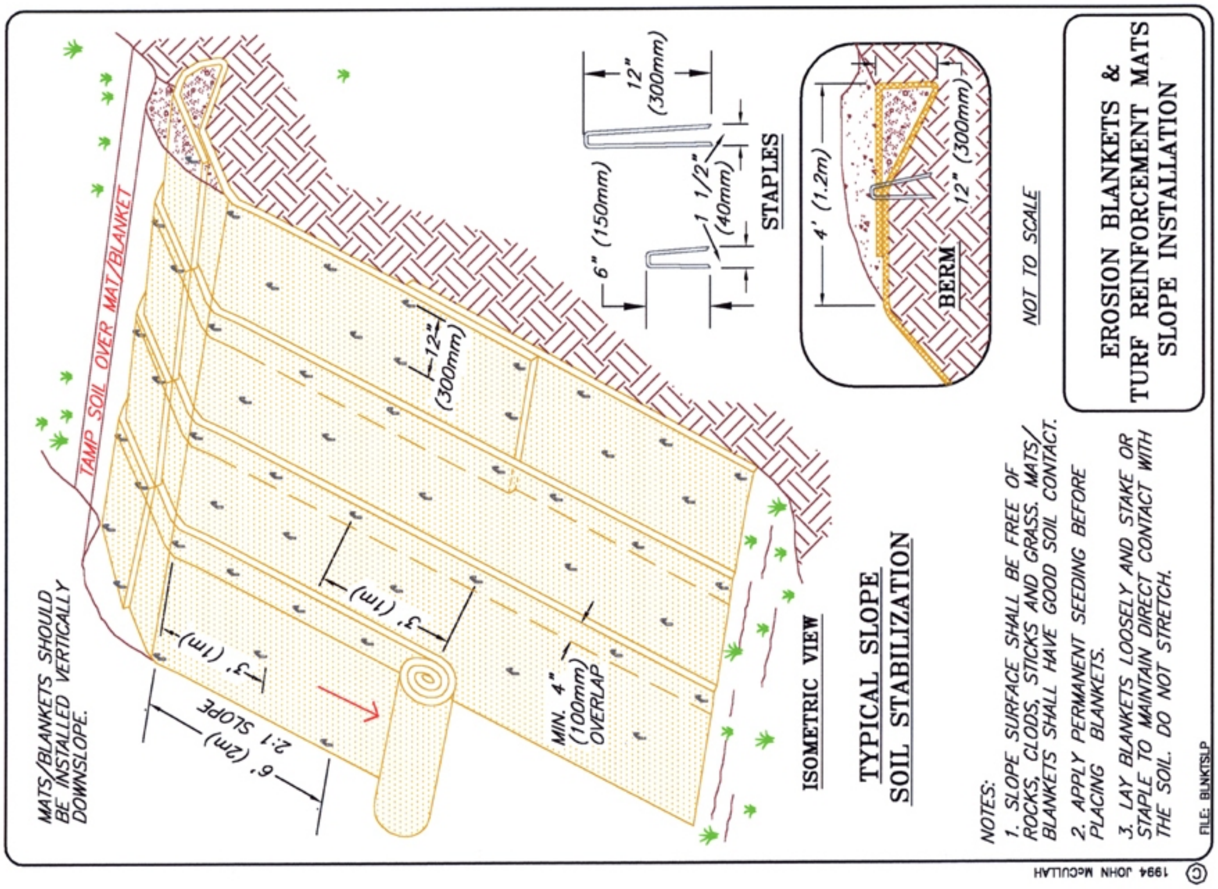
- After seeding, spread and lightly rake 1/2-3/4 inches (12.7-19.1 mm) of fine topsoil into the mat apertures to completely fill mat thickness. Use backside of rake or other flat implement.
- Spread topsoil using lightweight loader, backhoe, or other power equipment. Avoid sharp turns with equipment.

- Do not drive tracked or heavy equipment over mat. Avoid any traffic over matting if loose or wet soil conditions exist.
- Use shovels, rakes or brooms for fine grading and touch up.
- Smooth out soil filling, just exposing top netting of matrix.

Minimum BMP standards are provided on the following detail.

Inspection and Maintenance:

- All blanket and mats shall be inspected following installation and in accordance with permit requirements.
- Inspect installation before, during, and after storm events to check for erosion and undermining. Any failure shall be repaired immediately.
- If washout or breakage occurs, re-install the material after repairing the damage to the slope or drainage way.


EROSION BLANKETS & TURF REINFORCEMENT MATS SLOPE INSTALLATION
TYPICAL SLOPE SOIL STABILIZATION
ISOMETRIC VIEW
MATS/BLANKETS SHOULD BE INSTALLED VERTICALLY DOWNSLOPE.
TAMP SOIL OVER MAT/BLANKET
6' (2m)
2:1 SLOPE
3' (1m)
3' (1m)
12" (300mm)
MIN. 4" (100mm) OVERLAP
STAPLES
6" (150mm)
1 1/2" (40mm)
12" (300mm)
BERM
4' (1.2m)
12" (300mm)
NOT TO SCALE
NOTES:
1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.
FILE: BLNKTSLP
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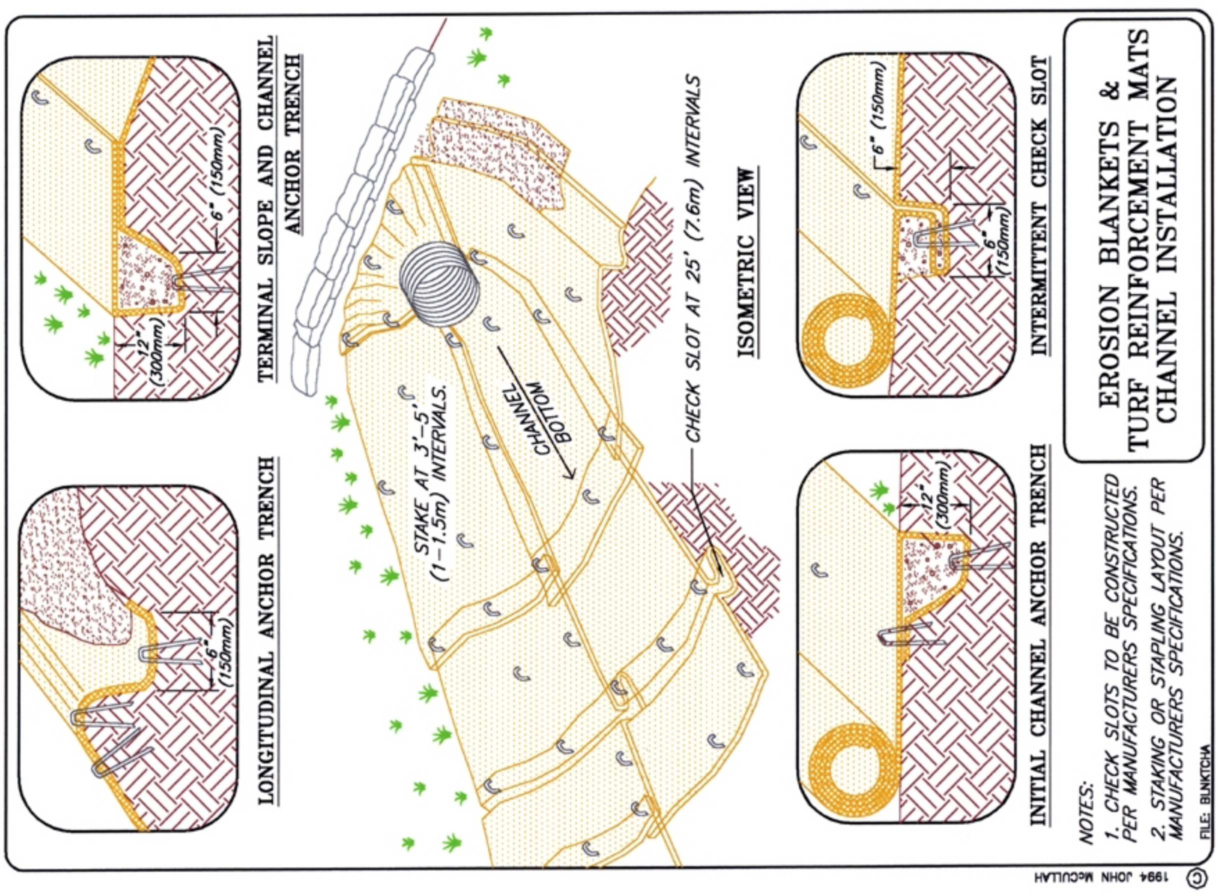
EROSION BLANKETS & TURF REINFORCEMENT MATS CHANNEL INSTALLATION
LONGITUDINAL ANCHOR TRENCH
6" (150mm)
TERMINAL SLOPE AND CHANNEL ANCHOR TRENCH
12" (300mm)
6" (150mm)
ISOMETRIC VIEW
STAKE AT 3'-5' (1-1.5m) INTERVALS.
CHANNEL BOTTOM
CHECK SLOT AT 25' (7.6m) INTERVALS
INITIAL CHANNEL ANCHOR TRENCH
12" (300mm)
INTERMITTENT CHECK SLOT
6" (150mm)
6" (150mm)
NOTES:
1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURERS SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURERS SPECIFICATIONS.
FILE: BLNKTCHA
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Construction Specifications:

General Considerations

- Site-specific soil types will dictate appropriate soil binders to be used.
- A soil binder must be environmentally benign (non-toxic to plant and animal life), easy to apply, easy to maintain, economical, and shall not stain paved or painted surfaces, and conform to the following:
  - o Local municipality specifications and requirements.
  - o Stabilizing emulsion shall be a concentrated liquid chemical that forms a plastic film upon drying and allows water and air to penetrate.
  - o Stabilizing emulsion shall be nontoxic to plant or animal life and nonstaining to concrete or painted surfaces. In the cured state, the stabilizing emulsion shall not be re-emulsifiable.
  - o Stabilizing emulsion shall be miscible with water at the time of mixing and application.
  - o A certificate of compliance for stabilizing emulsion shall be furnished to Oregon DEQ.
- Select a soil binder that is compatible with existing vegetation.
- Performance of soil binders depends on temperature, humidity, and traffic across treated areas.

Selecting a Soil Binder

- Properties of common soil binders used for erosion prevention are provided in Table 1 (see Page 4). Use Table 1 to select an appropriate soil binder.
- Factors to consider when selecting a soil binder include the following:
  - o Suitability to situation - Consider where the soil binder will be applied; determine if it needs a high resistance to leaching or abrasion, and whether it needs to be compatible with any existing vegetation. Determine the length of time soil stabilization will be needed, and if the soil binder will be placed in an area where it will degrade rapidly. In general, slope steepness is not a discriminating factor for the listed soil binders.
  - o Soil types and surface materials - Fines and moisture content are key properties of surface materials. Consider a soil binder's ability to penetrate, likelihood of leaching, and ability to form a surface crust on the surface materials.
  - o Frequency of application - The frequency of application can be affected by subgrade conditions, surface type, climate, and maintenance schedule. Frequent applications could lead to high costs. Application frequency may be minimized if the soil binder has good penetration, low evaporation, and good longevity. Consider also that frequent application will require frequent equipment clean-up.
  - o Cure Time – Consider cure time and minimum drying time in binder selection. Refer to Table 1 and confirm cure time and minimum drying time with manufacture's recommendations.
- After considering the above factors, the soil binders in Table 1 will be generally appropriate as follows:

Plant-Material Based (Short Lived)

- Guar: Guar is a non-toxic, biodegradable, natural galactomannan-based hydrocolloid treated with dispersant agents for easy field mixing. It shall be diluted at the rate of 1 to 5 lb per 100 gallons (1.2 to 1.8 kg per 1,000 liters) of water, depending on application machine capacity. Minimum application rates are as follows (follow manufacturers recommended application rates):

Application Rates for Guar Soil Stabilizer

Slope (V:H):	Flat	1:4	1:3	1:2	1:1
lb/ac	40	45	50	60	70
Kg/Ha:	45	50	56	67	78

- Psyllium: Psyllium is composed of the finely ground muciloid coating of plantago seeds that is applied as a dry powder or in a wet slurry to the surface of the soil. It dries to form a firm but rewettable membrane that binds soil particles together but permits germination and growth of seed. Psyllium requires 12 to 18 hours drying time. Psyllium shall be applied at a rate of 90 to 225 kg/ha (80 to 200 lb/ac), with enough water in solution to allow for a uniform slurry flow.

- Starch: Starch is non-ionic, cold-water soluble (pre-gelatinized) granular cornstarch. The material is mixed with water and applied at the rate of 170 kg/ha (150 lb/ac). Approximate drying time is 9 to 12 hours.

Plant-Material Based (Long Lived)

- Pitch and Rosin Emulsion: Generally, a non-ionic pitch and rosin emulsion has a minimum solids content of 48%. The rosin shall be a minimum of 26% of the total solids content. The soil stabilizer shall be non-corrosive, water-dilutable emulsion that upon application cures to a water-insoluble binding and cementing agent. For soil erosion control applications, the emulsion is diluted and shall be applied as follows:
  - For clayey soil: 5 parts water to 1 part emulsion.
  - For sandy soil: 10 parts water to 1 part emulsion.
- Application can be by water truck or hydraulic seeder with the emulsion/product mixture applied at the rate specified by the manufacturer. Approximate drying time is 19 to 24 hours.

Polymeric Emulsion Blends

- Acrylic Copolymers and Polymers: Polymeric soil stabilizers shall consist of a liquid or solid polymer or copolymer with an acrylic base that contains a minimum of 55% solids. The polymeric compound shall be handled and mixed in a manner that will not cause foaming or shall contain an anti-foaming agent. The polymeric emulsion shall not exceed its shelf life or expiration date; manufacturers shall provide the expiration date. Polymeric soil stabilizer shall be readily miscible in water, non-injurious to seed or animal life, non-flammable, shall provide surface soil stabilization for various soil types without totally inhibiting water infiltration, and shall not re-emulsify when cured. The applied compound shall air cure within a maximum of 36 to 48 hours. Liquid copolymer shall be diluted at a rate of 10 parts water to 1 part polymer and applied to soil at a rate of 1,175 gal/ac (11,000 liters/hectare).
- Liquid Polymers of Methacrylates and Acrylates: This material consists of a tackifier/sealer that is a liquid polymer of Methacrylates and Acrylates. It is an aqueous 100% acrylic emulsion blend of 40% solids by volume that is free from styrene, acetate, vinyl, ethoxylated surfactants or silicates. For soil stabilization applications, it is diluted with water in accordance with manufacturer's recommendations, and applied with a hydraulic seeder at the rate of 20 gal/ac (190 L/ha). Drying time is 12 to 18 hours after application.
- Copolymers of Sodium Acrylates and Acrylamides: These materials are non-toxic, dry powders that are copolymers of sodium acrylate and acrylamide. They are mixed with water and applied to the soil surface for erosion control at rates that are determined by slope gradient:

Application Rates for Copolymers of Sodium Acrylates and Acrylamides

Slope Gradient (V:H)	lb/ac (kg/ha)
Flat to 1:5	3-5 (3.4 – 5.6)
1:5 to 1:3	5-10 (5.6 – 11.2)
1:2 to 1:1	10-20 (11.2 – 22.4)

- Poly-Acrylamide and Copolymer of Acrylamide: Linear copolymer polyacrylamide is packaged as a dry-flowable solid. When used as a stand-alone stabilizer, it is diluted at a rate of 1 lb/100 gal (1.5 kg/1,000 liters) of water and applied at the rate of 5 lb/ac (5.6 kg/ha).
- Hydro-Colloid Polymers: Hydro-Colloid Polymers are various combinations of dry-flowable poly-acrylamides, copolymers and hydro-colloid polymers that are mixed with water and applied to the soil surface at rates of 53 to 62 lb/ac (60 to 70 kg/ha). Drying times are 0 to 4 hours.

Cementitious-Based Binders

Gypsum: This is a formulated gypsum-based product that readily mixes with water and mulch to form a thin protective crust on the soil surface. It is composed of high purity gypsum that is ground, calcined and processed into calcium sulfate hemihydrate with a minimum purity of 86%. It is mixed in a hydraulic seeder and applied at rates 4,000 to 12,000 lb/ac (4,500 to 13,500 kg/ha). Drying time is 4 to 8 hours.

Soil Binders Applications

After selecting an appropriate soil binder, the untreated soil surface must be prepared before applying the soil binder. The untreated soil surface must contain sufficient moisture to assist the agent in achieving uniform distribution. In general, the following steps shall be followed:

- Follow manufacturer's recommendations for application rates, pre-wetting of application area, and cleaning of equipment after use.
- Prior to application, roughen embankment and fill areas by rolling with a crimping or punching type roller or by track walking. Track walking shall only be used where rolling is impractical.
- Consider the drying time for the selected soil binder and apply with sufficient time before anticipated rainfall. Soil binders shall not be applied during or immediately before rainfall.
- Avoid over-spray onto the traveled way, sidewalks, lined drainage channels, sound walls, and existing vegetation.
- Soil binders shall not be applied to frozen soil, areas with standing water, under freezing or rainy conditions, or when the air temperature is below 40^{o}F (4^{o}C) during the curing period.
- More than one treatment is often necessary, although the second treatment may be diluted or have a lower application rate.
- Generally, soil binders require a minimum curing time of 24 hours before they are fully effective. Refer to manufacturer's instructions for specific cure times.
- For liquid agents:
  - Crown or slope ground to avoid ponding.
  - Uniformly pre-wet ground at 0.03 to 0.3 gal/yd^2 (0.14 to 1.4 L/m^2) or according to manufacturer's recommendations.
  - Apply solution under pressure. Overlap solution 6 to 12 in (150 to 300 mm).
  - Allow treated area to cure for the time recommended by the manufacturer; typically, at least 24 hours.
  - In low humidities, reactivate chemicals by re-wetting with water at 0.1 to 0.2 gal/yd^2 (0.5 to 0.9 L/m^2).

Inspection and Maintenance:

- Reapplying the selected soil binder may be needed for proper maintenance. Inspections should be conducted at the frequencies recommended by local municipalities, and should be performed no less than daily in high traffic areas and weekly in lower traffic areas.
- After any rainfall event, maintain all slopes to reduce or prevent erosion.
- Maintain an unbroken, temporary stabilized area while disturbed soil areas are non-active. Repair any damaged stabilized area and re-apply soil binder to exposed areas.

Table 1
Properties of Soil Binders for Erosion Control

Chemicals	Plant Material Based (Short Lived)	Plant Material Based (Long Lived)	Polymeric Emulsion Blends	Cementitious-Based Binders
Relative Cost	Low	Low	Low	Low
Resistance to Leaching	High	High	Low to Moderate	Moderate
Resistance to Abrasion	Moderate	Low	Moderate to High	Moderate to High
Longevity	Short to Medium	Medium	Medium to Long	Medium
Minimum Curing Time before Rain	9 to 18 hours	19 to 24 hours	0 to 24 hours	4 to 8 hours
Compatibility with Existing Vegetation	Good	Poor	Poor	Poor
Mode of Degradation	Biodegradable	Biodegradable	Photodegradable/ Chemically Degradable	Photodegradable/ Chemically Degradable
Labor Intensive	No	No	No	No
Specialized Application Equipment	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher	Water Truck or Hydraulic Mulcher
Liquid/Powder	Powder	Liquid	Liquid/Powder	Powder
Surface Crusting	Yes, but dissolves on rewetting	Yes	Yes, but dissolves on rewetting	Yes
Clean-Up	Water	Water	Water	Water
Erosion Control Application Rate	Varies (1)	Varies (1)	Varies (1)	4,000-12,000lb/ac (4,500-13,500 kg/ha)

(1) Dependant on product, soil type, and slope inclination

STABILIZATION MATS – EP-12

There are several techniques that involve the placement of relatively inexpensive and locally available material to stabilize the ground surface, especially for work around sensitive areas such as wetlands and streams. Types of stabilization mats to consider include brush mats; corduroy mats; and board mats. Stabilization mats reduce tracking from the construction site and create a stable pad for heavy equipment.

Construction Specifications:

- Brush mats – Brush mats are constructed of available slash (brush and trees), crushed in-place to form a mat. Their purpose is to support equipment so that there are minimal short term impacts in excessively wet conditions. This practice is limited to areas where brush is of sufficient thickness and density to stabilize the wetland bottom for vehicular/equipment use. In some cases, the brush mats may be left behind to naturally decay, although it may take 8 to 12 years for them to decay completely. According to a study that examined the effects of brush mat use in wetlands, leaving them in place did not restrict water movement or alter water regimes, and revegetation occurred quickly (McMullen and Burger 1999). The use of brush mats can reduce the need for slash management.
- Corduroy Mats - Corduroy mats are constructed of small logs, brush, or mill slabs placed one after the other, perpendicular to the equipment driving path. These types of mats can spread the load over the entire area of the log or slab and are effective in increasing the load bearing capacity of an area. Flotation increases by using longer pieces of material, particularly small logs or mill slabs. These mats may be practical where logs are readily available. Multiple layers of corduroy may be required in some areas. The use of corduroy mats can reduce the need for slash management.
- Board Mats - Board mats consist of "pallet like" units placed one after the other to form a crude yet rapidly placed stabilized surface. Board mats can be placed, used, and easily removed for temporary stabilization for short term equipment use.

Inspection and Maintenance:

- Corduroy mats, and board mats shall be removed upon completion of work activity. Removal activities should be timed to minimize soil disturbance.
- Brush mats may be left to degrade in place if permitted by the regulatory agency.
- Evidence of increased sedimentation, flow disruption, or other adverse effects of using mats should be periodically inspected for, including following significant rain events. Repairs or changes should be made as needed.
- Equipment / vehicles using mats shall be checked for gas leaks and oil leaks.

WIND EROSION / DUST CONTROL – EP-13

Daily dust control shall be provided as needed to stabilize soil from wind erosion and to reduce dust generated by construction activities. Special attention shall be paid to stockpiled materials. Covering of small stockpiles or areas is an alternative to applying water or other dust palliatives.

Construction Specifications:

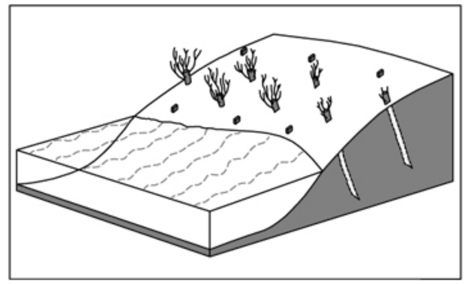
- Dust control shall be provided daily or more often (as deemed necessary based on wind conditions, time of year, and physical conditions of the site) by application of water alone or with addition of magnesium chloride or calcium chloride in accordance with manufacturer's specifications.
- Acrylic co-polymers or other biodegradable products (soil stabilizers/tackifiers) may be used for daily dust control if approved by the project engineer and local regulators.
- Water applied for dust control should be applied evenly and without over-watering which generates runoff and may result in erosion.
- Oil or other petroleum-based products shall not be used for dust control because the oil may migrate into drainage ways or seep into the soil.
- Dust control must be implemented in accordance with local air quality requirements.
- Non-potable water should not be conveyed in tanks or drainpipes that will be used to convey potable water and there should be no connection between potable and non-potable supplies. Non-potable tanks, pipes and other conveyances should be marked "NON-POTABLE WATER – DO NOT DRINK."

Inspection and Maintenance

- Check areas protected to ensure appropriate coverage.
- Reapply water or maintain covers, as necessary to maintain their effectiveness.

LIVE STAKING EP-14

Construction Specifications



Live stakes are pieces of freshly cut woody plant stem planted in the ground or into erosion control or streambank stabilization structures. The branches vary from about 18-36 in (50-100 cm) long, and typically (3/4 - 3 in (20 – 75 mm) in diameter. Pole Planting (seeEP-15) is a related technique, however the poles are much longer (3-15 ft (1-5m) long) and can be installed and arrayed differently.

Live stakes are planted with the terminal buds or leaf nodes pointing up and the basal ends down into the soil. The buried portion of the cuttings develop roots, while the exposed portion produces branches and leaves. Depending on the species, the cuttings can grow into shrubs and/or trees. Because of its ability to root easily, the preferred plant species for live staking is Willow (*Salix* spp.) but Cottonwood (*Poplar* spp.), Dogwood (*Cornus* spp.), Elderberry (*Sambucus* spp), Coyotebrush (*Baccharis* spp), and others have been used successfully.

Conditions Where Practice Applies

Live stakes are useful for the following situations:

1. Live staking is useful as a revegetation technique and for establishing riparian plants in high flow or droughty situations.
2. Live staking can be used in irrigated or non-irrigated conditions with the latter being more prevalent. Irrigation can greatly increase vegetative success. Most often live staking is installed during the dormant season or when climactic or soil moisture conditions are favorable for establishment in non-irrigated conditions.
3. Live stakes provide an environmentally-sensitive anchoring technique for geotextiles and erosion control materials. The anchoring can be temporary or permanent depending on whether the stakes "take root".
4. Adding immediate failure resistance to the soil mass. While providing geotechnical benefits by "buttressing and arching", deep-seated failure planes underneath the bottom end of the cuttings will not usually be affected by live staking. These plants can remove excess soil moisture via evapotranspiration during the growing cycle, however these benefits will not be realized during dormancy.

Materials and Equipment

Live stakes are typically made of woody riparian plant stems, although fleshy plant stems can have some success as well. Willow, cottonwood, and dogwood are the most used woody plants; however, willow cuttings make the best material for live stakes. Willow species choice is highly dependent on locale; the best species for a given site are those found growing near the site. Stakes are typically harvested and planted when the willows, or other chosen species, are dormant, although the cuttings can do well other times of year when soil moisture is available.

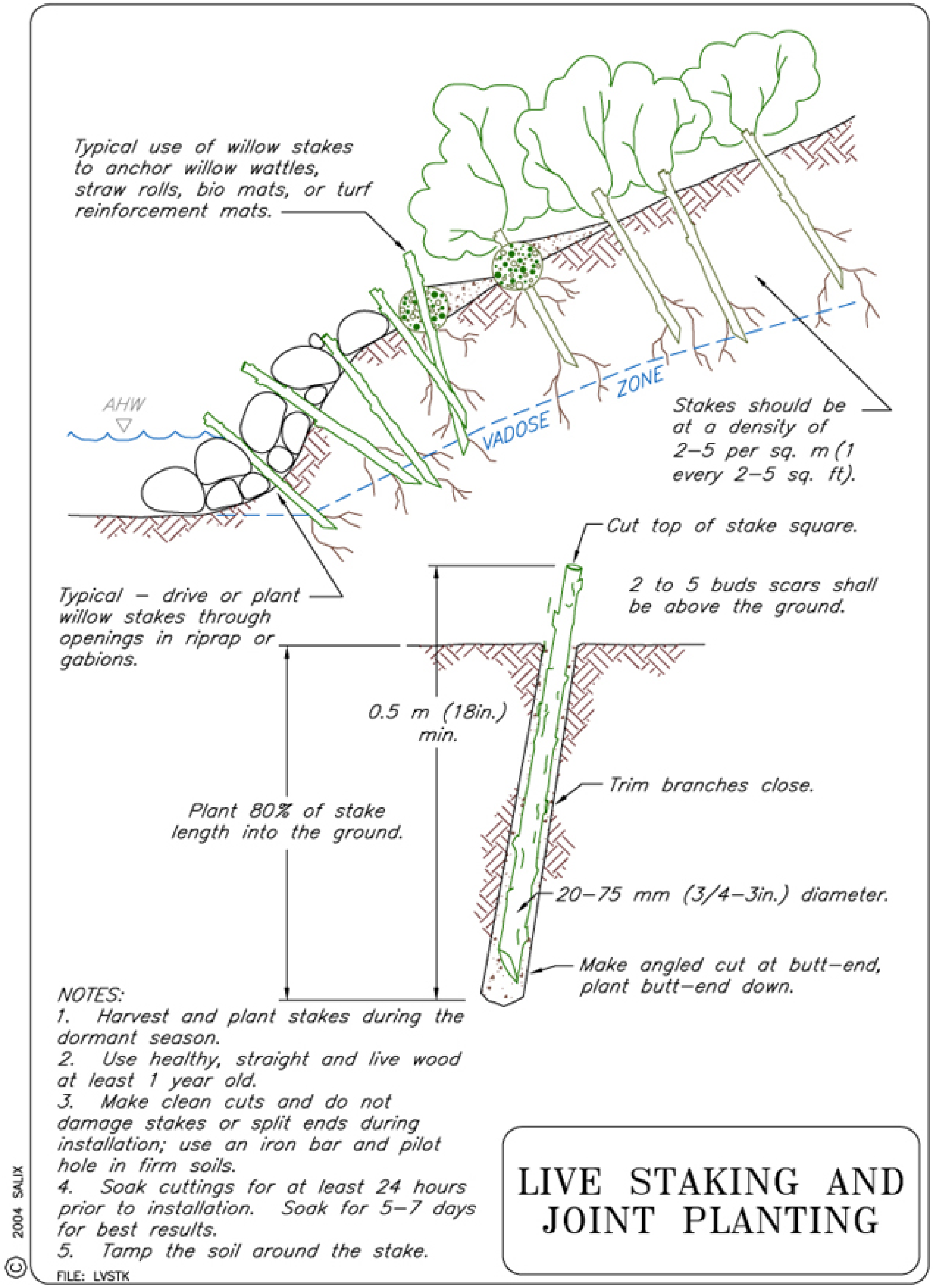
When harvesting cuttings:

- Select healthy, live wood that is reasonably straight, and at least 2 years old.
- Make clean, angular cuts without splitting ends.
- Trim branches from cutting as closely as possible.
- Cuttings should generally be ¾ inch (19 mm) in diameter and a minimum 18 in (50 cm) long, or larger depending on the species.
- The butt end of the cutting should be pointed or angled and the top end should be cut square to help identify the top and bottom when planting.
- The top, square end can be painted and sealed by dipping the top 1-2 in. (2.5 – 5 cm) into a 50-50 mix of light colored latex paint and water. Sealing the top of stake will reduce desiccation, ensure the stakes are planted with the top up, and make the stakes more visible for subsequent planting evaluations.
- Stakes must not be allowed to dry out. All cuttings should be soaked in water for 5-7 days (a minimum of 24 hours) and planted the same day they are removed from the water.

Construction / Installation

- Use an iron stake or bar to make a pilot hole in firm soil.
- Plant the basal ends into the ground, with the leaf bud scars or emerging buds always oriented up. Be careful not to damage the buds, strip the bark, or split the stake during installation.
- Ideally, the stakes should not be planted in rows or at regular intervals, but at random in the most suitable places at a rate of 2-5 cuttings/10ft^2 (2-5 cuttings/m^2). However, if trying to control a group of people planting several thousand stakes, it may be found that it is easier to specify an average set interval.
- Set the stake as deep as possible into the soil, with 80 % of its length into the soil. Deep planting will increase the chances of survival. The stake should never protrude more than 20 % of its length above the ground level to prevent it from drying. The excess stake or any damage or split ends can be cut off after installation. At least 2 buds and/or bud scars should remain above the ground after planting.
- Add soil to the planting hole if necessary to ensure soil contact with the stem. It is important to tamp the soil around the cutting to ensure good soil-stem contact. The best installations, especially on droughty sites, will include "watering in" and slightly compacting the backfill or hole. "Watering in", much like transplanting a container plant, can successfully be accomplished by pouring one to two gallons of water into the soil around the stake and planting hole, then slightly tamping or otherwise jarring the soil. This procedure will ensure complete soil to stem contact.

LIVE STAKING EP-14



Inspection and Maintenance

Stakes should be inspected every few weeks until well established, and irrigation, browse control (from livestock, deer, beavers, etc), pruning, weed control, and fertilization should be implemented as needed.

Common Reasons / Circumstances for Failure

Live staking can fail if vegetation is not handled properly prior to installation, is installed incorrectly (less than 80 % of the cutting in the ground, bud scars facing down, poor soil contact, etc.) or not irrigated or “watered in” when installed in arid areas.

Construction Specifications

Pole Plantings use large diameter cuttings (poles vs. stakes) that are relatively long, 5 to 10 ft (1.5 to 3 m) in length. The cuttings are taken from willow (*Salix spp.*) or cottonwood (*Populus spp.*). The cuttings are intended to sprout and take root, stabilizing the streambank with a dense matrix of roots. Pole plantings are planted deep so they usually require heavy equipment assisted construction techniques. As defined by Schiechtl and Stern, in *Water Bioengineering Techniques*, *1997*, poles are straight, poorly branched stems 3.3 - 8.2 ft (1 - 2.5 m) long.

Conditions Where Practice Applies

Pole planting is suitable for floodplains, streambanks, and other riparian zones. Pole plantings are very useful for highly erodible areas and sites with fluctuating water tables. Pole planting is a useful "stand alone" revegetation technique for replacing and/or reestablishing riparian vegetation and cover. Pole planting is also particularly suitable for conjunctive uses with other streambank stabilization techniques such as vegetated riprap, vegetated gabions, rootwad revetments with vegetated riprap, vegetated deflectors, and longitudinal peaked stone toe protection.

Pole planting areas may need to be accessible to heavy equipment, as the poles should be planted into deep holes. The location of the water table (saturated zone) and vadose zone (moist soil zone including the capillary fringe, located above the saturated zone) should be approximately identified so the pole plantings can access sufficient moisture. Pole plantings are usually planted with a power auger or punch bar ("Stinger").

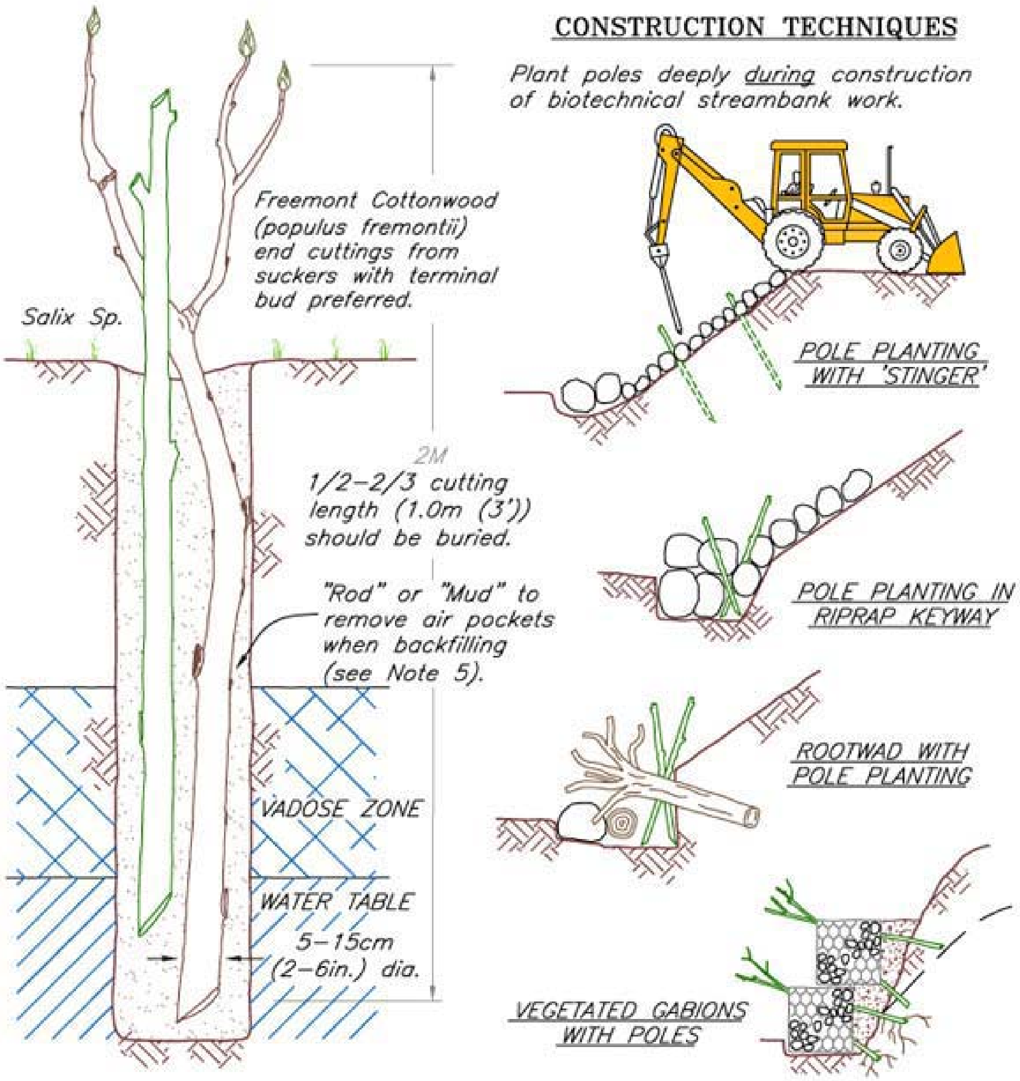
Materials

Cottonwood or willow pole cuttings are the main materials for this technique. A pond or storage area for soaking the cuttings will be necessary. Pole planting techniques may require the use of a power auger, "Stinger", or other method to excavate deep holes. The "Stinger" is a large, pointed metal punch bar that is 4 – 6 in (10-15 cm) diameter, and mounted on a backhoe or hydraulic excavator.

Installation

- Collect and harvest cuttings (ideally during the dormant season) and then soak the poles for 5 to 7 days.
- Plant poles into an augured, "punched", or excavated hole. The holes should extend to approximately 1 ft (30 cm) above the water table and through the vadose zone. This depth can be difficult to determine in areas with reservoirs and streams with widely fluctuating seasonal water levels. In this case, ensure that the ends of the poles reach the low waterline at the time of planting if possible.
- Pole plantings should ideally be installed during the construction of structures. For instance, plant the poles with the placement of riprap, especially into any trenches excavated for keyways or scour trenches. Another example is to plant the poles during riprap placement such that the poles extend through the riprap and backfill and into contact with the "native" bank.
- The backfill can be placed over and around the poles rather than having to "punch" holes through the riprap. Another method is to plant the poles during gabion construction.
- The pole plantings, especially the basal ends, must have good contact with the soil. "Mudding" (filling the hole with water and then adding soil to make a mud slurry) can remove air pockets.

POLE PLANTING EP-15



NOTES:

1. Pole cuttings of willow or cottonwood are longer and have a larger diameter than branch cuttings or live stakes.
2. Larger diameter cuttings have a greater supply of stored energy (stored photosynthesis) than smaller diameter cuttings.
3. Pole cuttings are better suited for highly erodible areas and sites with fluctuating water levels.
4. The pole cuttings should extend through the vadose zone and into the permanent water table. At least 1/2 to 2/3 of the pole should be below the ground, at least 1.0 m (3 ft.), and long enough to emerge above adjacent vegetation.
5. "Muddying" – filling the hole with water and then soil to make a mud slurry can remove air pockets.

WILLOW POSTS & POLES

FILE: WPP

LIVE FASCINES AND BRUSH WATTLES EP-16

Live fascines and brush wattles are bundles of live branch cuttings placed in long rows in shallow trenches across the slope on contour or at an angle. Fascines and brush wattles are used for biotechnical stabilization of slopes and streambanks.

Conditions Where Practice Applies

The technique is applicable where immediate erosion protection is necessary.

This technique works best where flows are sufficient to keep the base of the bundle wet during most of the growing season, but do not exceed the flood tolerance of the fascine.

Construction Specifications

Fascine spacing and configuration vary depending upon slope, exposure and purpose.

- To treat overbank runoff on upper and mid bank areas, rows are installed on the contour.
- To divert runoff in upper and mid bank areas, rows are installed on a gradient.
- To trap sediment, rows are installed along the uphill side of v-ditch or other drainage structures.
- For flood flow protection, rows are installed perpendicular to flow in midbank areas.
- To treat wave erosion, rows are installed parallel to waves.
- On outer bends, and moist, seeping banks, fascines should be installed at an angle of 45 to 60 from horizontal, with the bud ends at the top, pointing upstream. On drier banks, and inner bends, fascines should be installed on contour.

Materials and Equipment

Fascines are made of brushy cuttings (stems that have leaves and twigs) of tree and shrub species capable of vegetative propagation, typically willow species. Plant material harvest and installation must be performed during its dormant season, late fall through early spring, or at other times of year if water is available. The cuttings should be long (3 ft (1 m) minimum), straight brushy branches up to 1 ½ inches (40 mm) in diameter. For optimum success, the fascines should be soaked for 24 hours or installed on the same day they are harvested and prepared (McCullah, 2002).

Construction / Installation

- Cuttings shall be tied together to form bundles, tapered at each end, 6-30 feet (2-10 m) in length, depending on site conditions or limitations in handling. The completed bundles should be 6-12 inches (152.4-304.8 mm) in diameter, with the growing tips and butt ends oriented in alternating directions (for fascines, ends oriented in the same direction).
- Stagger the cuttings in the bundles so that the tips are evenly distributed throughout the length of the bundle.
- Compress and tightly tie the bundle every 1 ft (30 cm) with rope or twine of sufficient strength and durability. Hemp, jute, cotton or other biodegradable rope may be used (McCullah, 2002).
- Installation progresses from the bottom to the top of the slope.
- Install bundles into trenches dug into the slope on contour.
- Spacing of contour trenches (fascines) is determined by soil type, potential for erosion and slope steepness. See Table 1 below for general spacing guidelines.
- The trench shall be shallow, about ½ the diameter of the fascine. The trench width will vary from 12-18 inches (0.30-0.45 m) depending on the slope angle, but should be at least 1 in (2.5 cm) wider than the bundle.

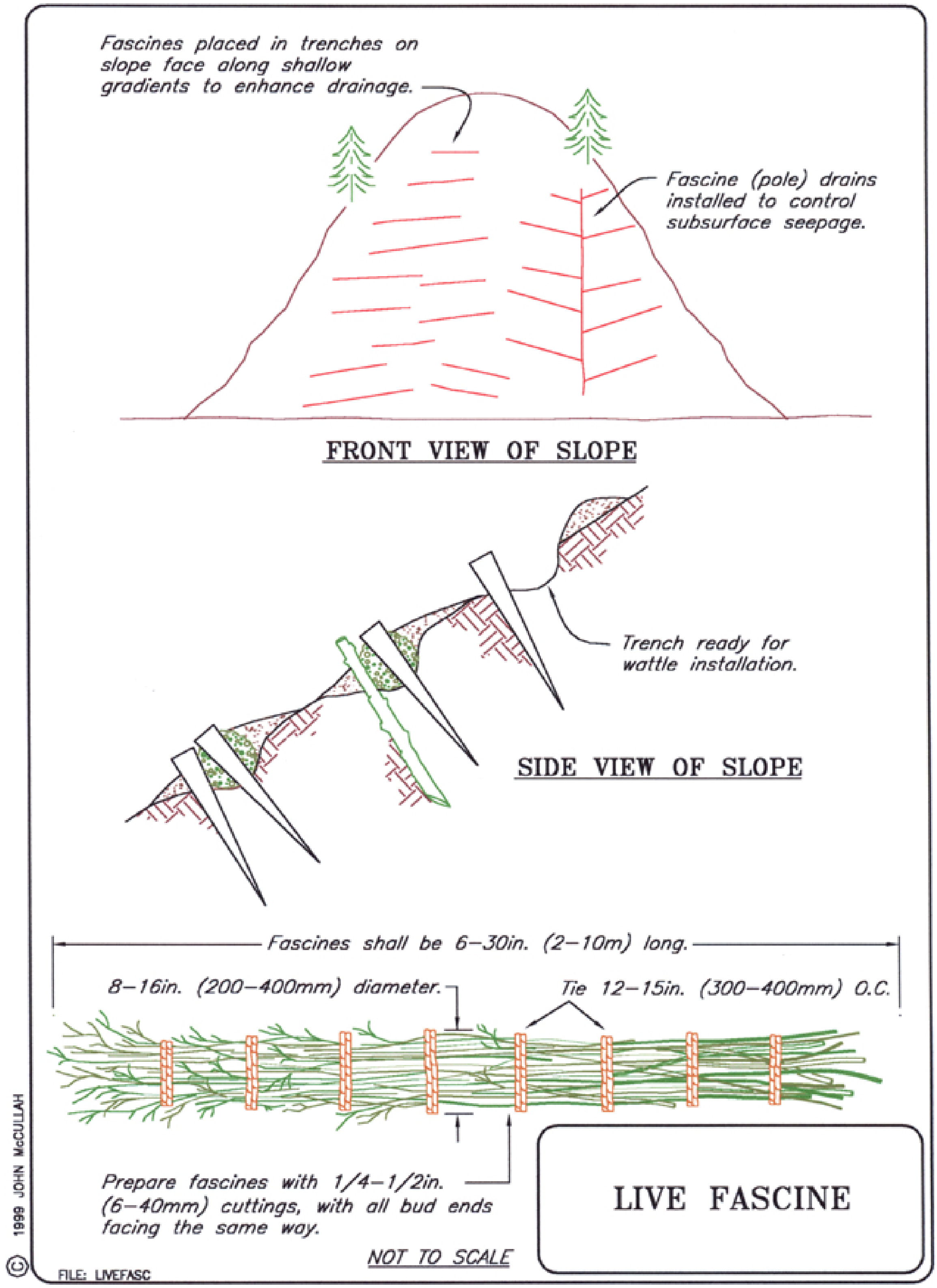

Fascines placed in trenches on slope face along shallow gradients to enhance drainage.
Fascine (pole) drains installed to control subsurface seepage.
FRONT VIEW OF SLOPE
Trench ready for wattle installation.
SIDE VIEW OF SLOPE
Fascines shall be 6–30in. (2–10m) long.
8–16in. (200–400mm) diameter.
Tie 12–15in. (300–400mm) O.C.
Prepare fascines with 1/4–1/2in. (6–40mm) cuttings, with all bud ends facing the same way.
NOT TO SCALE
LIVE FASCINE
© 1999 JOHN McCULLAH
FILE: LIVEFASC

Table 1: General Installation Guidelines

Slope (V:H)	Slope Length Between Fascines (ft (m))
1:1 to 1:1.5	3-4(0.9 – 1.2)
1:1.5 to 1:2	4-5 (1.2 – 1.5)
1:2 to 1:2.5	5-6 (1.5 – 1.8)
1:2.5 to 1:4	6-8 (1.8 – 2.4)
1:3.5 to 1:4	8-12 (2.4 – 3.7)
1:4.5 to 1:5	10-20 (3 – 6)

- In non-cohesive soils, the trench should be lined with a coir erosion control blanket or netting prior to installation of the fascine.
- Fascines shall be staked firmly in place with one row of construction stakes on the downhill side of the bundle, not more than 3 ft (1m) apart. A second row of stakes shall be placed through the fascines, near the ties, at not more than 5 feet (1.5 m) apart.
- Overlap the tapered ends of adjacent bundles at least 18 in (45 cm) so the overall thickness of the fascine is uniform.
- Two stakes shall be used at each bundle overlap, such that a stake may be driven between the last two ties of each bundle. 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.
- Repeat the proceeding steps to the top of the slope, placing moist soil along the sides of the live bundles.
- When finished, all live stakes should be trimmed, such that a maximum of 3 in (7.5 cm) of stake protrudes above the bundle.
- Fascines should be keyed into the bank at least 3 ft (1 m) on both upstream and downstream ends (Sotir & Fischenich, 2001).
- Proper backfilling is essential to the successful rooting of the fascine.
- Backfill bundles with soil from the slope or trench above. The backfill shall be worked into the fascine interstices and compacted behind and below the bundle by walking on and working from its terrace.
- Seed and mulch the slope. Shallow slopes, generally 3:1 or flatter may be seeded and mulched by hand. Steeper slopes can have seed applied hydraulically and the mulch should be anchored with tackifier or other approved methods.

Inspection and Maintenance

Inspections should occur after each of the first few floods, and/or twice the first year, and at least once each year thereafter.

Common Reasons / Circumstances for Failure

Toe erosion and/or flanking can cause loss of the structure, if not combined with a toe protection in areas where shear stresses and velocities exceed limits for the soils underlying the structure. Flanking can be caused by insufficient keying-in of the structure.

BRUSH BOX EP-17

Brush boxes are toe wall or breast wall type retaining structures constructed with branch cuttings, wooden construction stakes, and wire.

Condition Where Practice Applies

Brush boxes are best if constructed on firm ground at the toe of a small slump or along the toe of an oversteepened stream bank. Brush boxes require minimal excavation and require fill behind them. Brush boxes are larger and stronger than wattles and are therefore more suitable for buttressing the base of a slope.

This brush box stabilized the toe of this slide even before the willow became established, and then vegetated the slide.

Materials

The ideal plant materials for brush boxes are those that:

1. Root easily.
2. Are long, straight and flexible.
3. Adapted to the site conditions.
4. Are in plentiful supply near the job site.

Willow (*Salix* spp) makes ideal cutting material. Some species of Coyotebrush (*Baccharis* spp), Dogwood (*Cornus* spp), and Cottonwood (*Populus* spp) also have very good rooting ability.

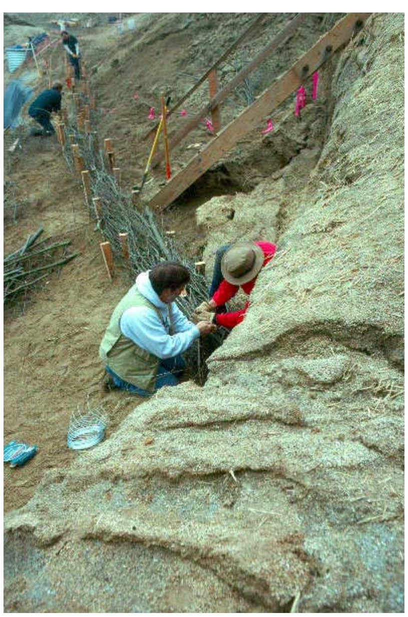
This brush box was made using mostly dead plant materials, and was intended to protect this eroding streambank and encourage siltation.

The cuttings should be very long, 6-12 ft (2-4 m) minimum, with straight branches up to 1 ½ inches (40 mm) in diameter. Trimmings of young suckers and some leafy branches may be included in the bundles to aid filtration. The number of stems varies with the size and kind of plant material. If willow or other rootable species are in short supply, non-rooting woody material may be used to partially fill the box (up to 50%).

Brush boxes require sturdy construction stakes, cut on a diagonal from vertical grained wood capable of being driven into the ground. Cut stakes at least 3 ft (1 m) long. Wire, usually 9 ga or heavier, is required to bind the tops of the stakes together.

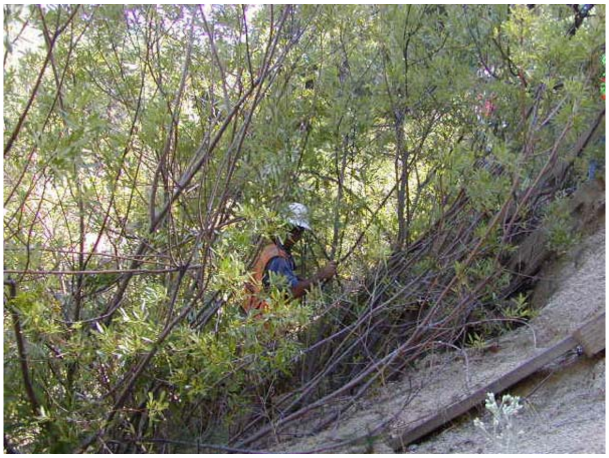
Implementation

- Work shall start at the bottom of the slope. Perform any slope repairs, such as runoff diversions, prior to brush box installation.
- Dig a trench 12-18 inches (0.3-0.5 m) wide and approximately 12 inches (0.3 m) deep along the toe of the slump or stream bank.
- Drive construction stakes, 36-48 inches (0.9-1.2 m) long, into the soil adjacent to the trench wall across from each other, one on the downhill side of the trench and one on the uphill side of the trench. Repeat the procedure by driving pairs of stakes every 2 feet (0.6 m) along the length of the trench. Cut small notches into the stakes, approximately 3 inches (75 mm) from the top.



BRUSH BOX EP-17

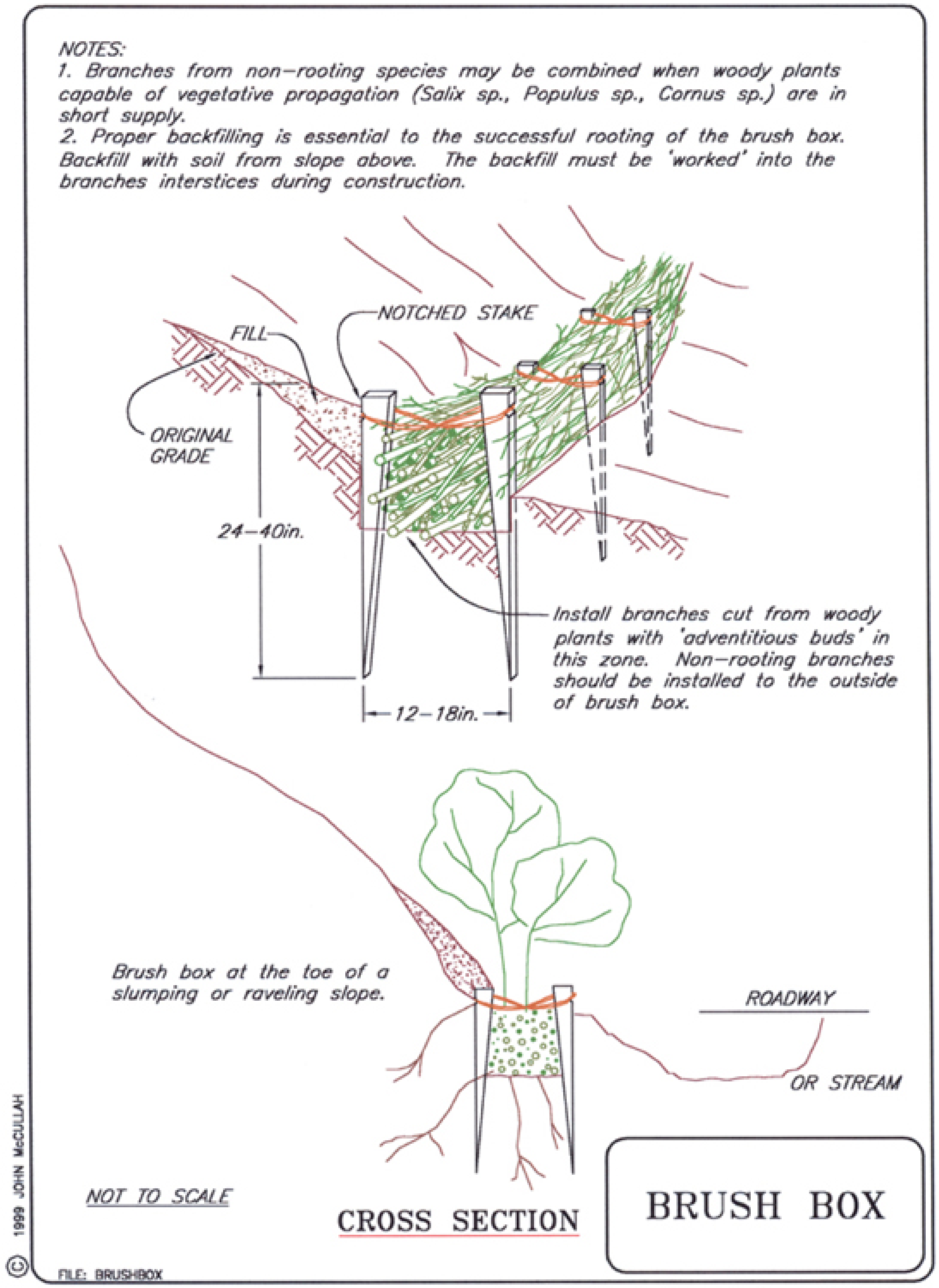
These brush boxes were installed for landslide repair.
("Old Faithful" cut slope project, Hwy 299W, CA, 1992)



The same brush boxes in September of 2003

- Place the cuttings immediately after trenching to reduce desiccation of the soil. Cuttings shall be placed together between the stakes with the growing tips and butt ends oriented in alternating directions. Stagger the cuttings in the box so that the tips are evenly distributed throughout the length of the brush box.
- Compress the cuttings tightly between the stakes and tie the pair of stakes and cuttings together with a strong galvanized wire. Wrap the wire tightly around the stakes at the notches and twist the wire between the stakes to "cinch" the cuttings down. Drive the stakes further into the soil. This procedure will tighten the wires and compress the cuttings into the trench.
- Proper backfilling is essential to the successful rooting of the brush box. Backfill with soil graded from the slope above. Place moist soil along the sides of the live box. The backfill shall be worked into the cutting interstices during construction and compacted behind and below the bundle by walking on and working from brush box terrace.
- Repeat the proceeding steps to the top of the slope. The top of the brush box should be slightly visible when the installation is completed.

BRUSH BOX EP-17



FASCINES WITH SUBDRAINS EP-18

Conditions Where Practice Applies

The system can be considered for use in filled gully areas or tributary swales where groundwater is likely to collect and concentrate. Live fascines are intended to establish shrubs for biotechnical erosion control and are not removed at the end of construction.

Construction Specifications

Rows of fascines are installed on contour on a slope in the conventional manner. In addition, a subsurface drain, oriented downslope and perpendicular to the fascines, is placed in a trench beneath the rows of fascines to intercept and collect seepage. The subsurface drain consists of a perforated pipe wrapped in a geo-composite drainage medium placed at the bottom of a trench. The trench is backfilled with clean, coarse aggregate or gravel

The seepage collection trench is excavated first, and a perforated pipe wrapped in a composite geodrain is placed in the bottom of the trench. The trench is then backfilled with gravel or coarse aggregate. The fascines are installed over and across the trench and subsurface drain. Fascines are prepared and installed in the conventional manner. The geodrain is formed by first wrapping the perforated pipe in a three-dimensional open mat or matrix comprised of semi rigid polymeric fibers, e.g., Enkamat, followed by another wrap of filter fabric or filter cloth. The porous core of the geocomposite should face in towards the pipe, with the filter cloth backing facing outward. All drains should be constructed and installed with clean-out access tubes. The perforated pipe in the subdrain should have sufficient capacity to handle and transmit intercepted groundwater flow or seepage. Guidelines for computing the appropriate size can be determined from published nomographs. Normally, a 4 in (10 cm) diameter polymeric pipe should suffice.

After construction of the drain trench, the live fascines are installed over the trench in the normal manner. Other than the presence of a clean out tube in the treatment including subsurface drainage, both techniques have the same external appearance.

Materials and Equipment

- In addition to the live cuttings required for the fascines, additional materials are also required for manufacturing the drains, viz., perforated polymeric pipe, filter cloth, and a turf reinforcement mat, e.g., Enkamat™, for wrapping the pipe. Stakes must not be allowed to dry out. All cuttings should be soaked in water for 5-7 days (a minimum of 24 hours) and planted the same day they are removed from the water.

Construction / Installation

- The seepage collection trench is excavated first, and a perforated pipe wrapped in a composite geodrain is placed in the bottom of the trench.

- The trench is then backfilled with gravel or coarse aggregate.

- The fascines are installed on contour over and across the trench and subsurface drain. Row spacing guidelines for fascine installations are presented in Table 1.

Table 1. Recommended Spacing for Live Fascines on Slopes

Slope Steepness (V:H)	Slope Distance Between Fascine Rows ft (m)	
	On Contour	On Angle
1:1 to 1:1.5	3-4 (0.9 – 1.2)	2-3 (0.6 – 0.9)
1:1.5 to 1:2	4-5 (1.2 – 1.5)	3-5 (0.9 – 1.5)
1:2 to 1:2.5	5-6 (1.5 – 1.8)	3-5 (0.9 – 1.5)
1:2.5 to 1:3	6-8 (1.8 – 2.4)	4-5 (1.2 – 1.5)
1:3.5 to 1:4	8-9 (2.4 – 2.7)	5-7 (1.5 – 2.1)
1:4.5 to 1:5	9-10 (2.7 – 3.0)	6-8 (1.8 – 2.4)

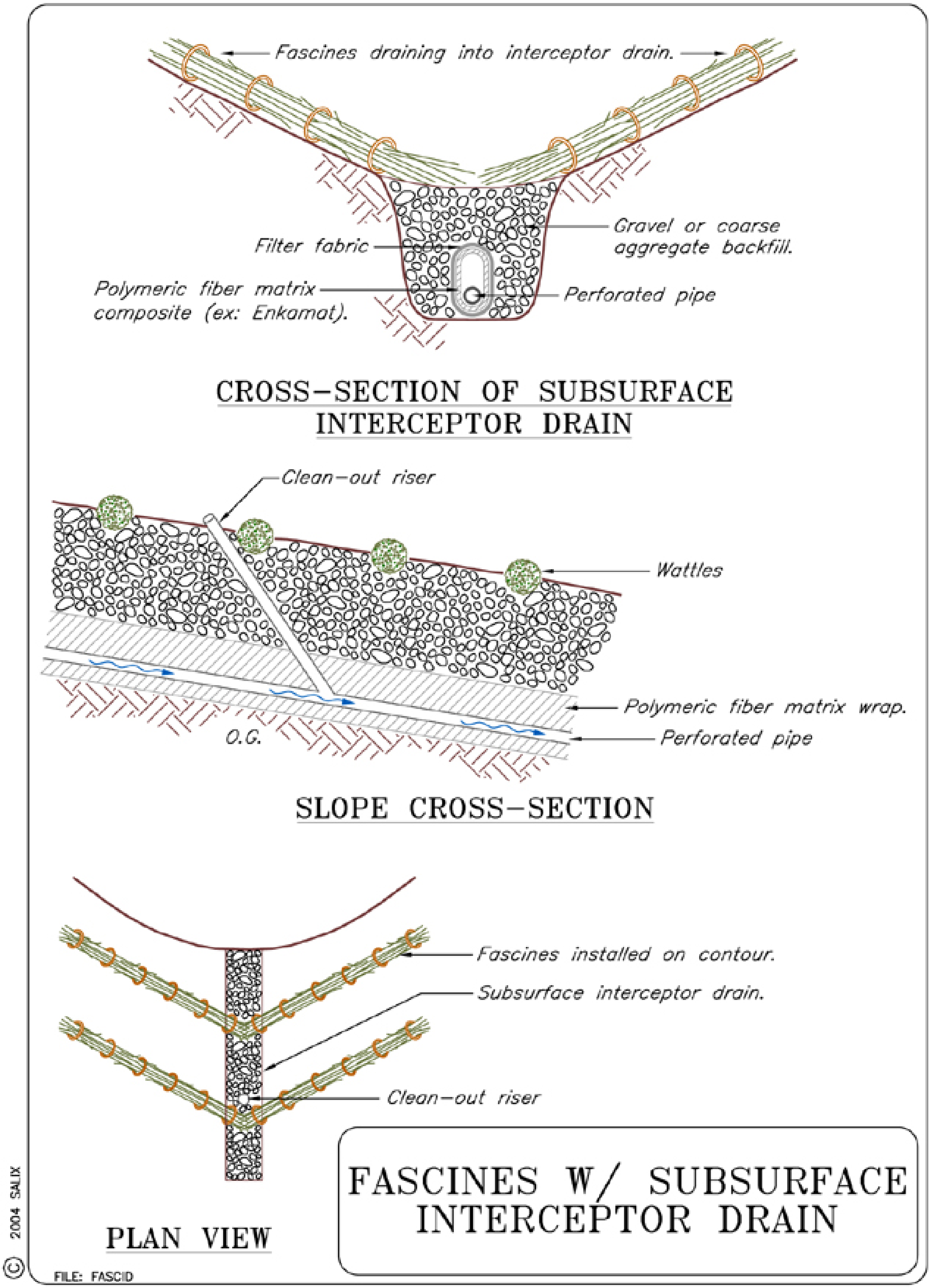
Inspection and Maintenance

- The exit end of the subsurface drain should be checked periodically to insure that water is flowing out of the drain.

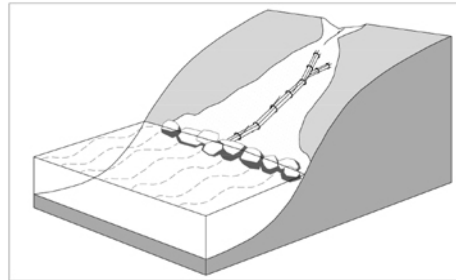
- The subsurface drain pipe should be flushed via the clean-out access tube as-needed if inspection indicates that the drain may be clogged. Flushed materials typically consist of excess groundwater and should be disposed of properly based on site specific conditions and local requirements.

Common Reasons / Circumstances for Failure

The most common reasons for failure are improper design of the interceptor drain placed at the bottom of the axial trench. The perforated pipe should be correctly sized and wrapped with a suitable geodrain composite that excludes fines but that lets water through. Failure to inspect and flush the drain via the clean-out access tube as needed can lead to prolonged clogging and poor performance.


Fascines draining into interceptor drain.
Gravel or coarse aggregate backfill.
Filter fabric
Polymeric fiber matrix composite (ex: Enkamat).
Perforated pipe
CROSS-SECTION OF SUBSURFACE INTERCEPTOR DRAIN
Clean-out riser
Wattles
Polymeric fiber matrix wrap.
Perforated pipe
O.G.
SLOPE CROSS-SECTION
Fascines installed on contour.
Subsurface interceptor drain.
Clean-out riser
PLAN VIEW
FASCINES W/ SUBSURFACE INTERCEPTOR DRAIN
© 2004 SALIX
FILE: FASCID

LIVE POLE DRAINS EP-19



Live pole drains are drainage systems composed of bundles of live willow (*Salix* spp) branches (live fascines or willow wattles) placed in areas where excess soil moisture results in soil instability. They are intended to drain excess water away from an unstable bank.

Conditions Where Practice Applies

Live pole drains are most applicable on streambanks and slopes where excessive soil moisture is causing piping, erosion, or slumping gullies. Live pole drains tend to be used most frequently on outer bends.

Construction Specifications

When designing a project, one must decide whether to use willow wattles or live fascines. Both are constructed of the same size poles, and in the same manner, with the exception of the orientation of the cuttings. Fascines have all the cuttings oriented one way (all butt ends together), while wattles are composed of poles oriented in both directions.

The use of live fascines will facilitate rooting, as cuttings grow best when the tips are pointed uphill. The use of willow wattles, on the other hand, will provide more efficient drainage, as half of the tapering tips are pointed downward, but rooting success will likely be lower. Therefore, one must decide whether the goal of the project is drainage or plant establishment.

Materials and Equipment

Live Pole Drains are essentially willow wattles or fascines constructed with longer than usual poles, with many of the branches left on, and staked with live willow stakes, construction stakes, or a combination of the two. Stakes must not be allowed to dry out. All cuttings should be soaked in water for 5-7 days (a minimum of 24 hours) and planted the same day they are removed from the water.

Construction / Installation

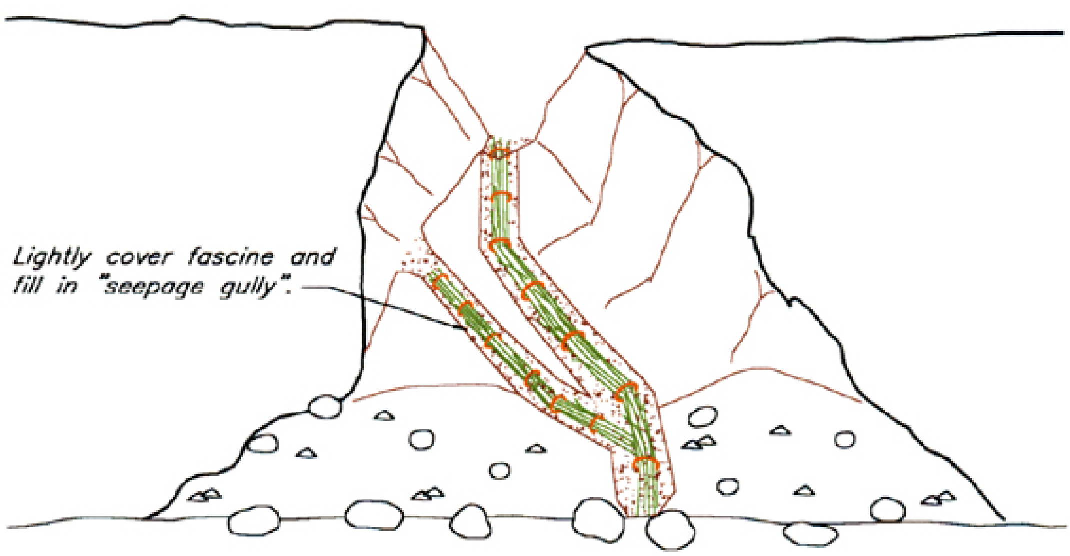
- Place the wattles or fascines in an excavated trench or existing drainage gully in an area of seepage, such that they intercept and control excess moisture on the bank.
- Key the bundles into each other by jamming the ends together firmly and stake into place with live or inert stakes at 3-6 ft (1-2 m) intervals (Sloan, 2001).
- Stakes should be placed near rope ties and in transitional areas for additional support.

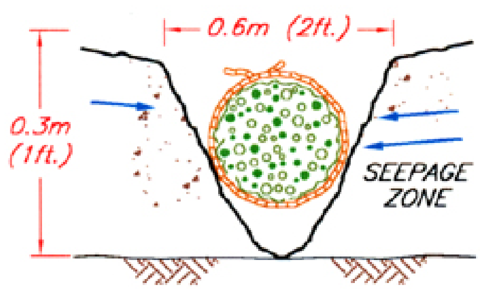
Inspection and Maintenance

Regular inspection and maintenance of wattle installations should be conducted, particularly during the first year, and repairs should be made promptly. Any stakes that loosen because of saturation of the slope or frost action should be re-installed. Rills and gullies around or under wattles should be repaired using Brushlayers and Live Gully Fill Repair as necessary. All temporary and permanent erosion and sediment control practices should be maintained and repaired to assure continued performance of their intended function.

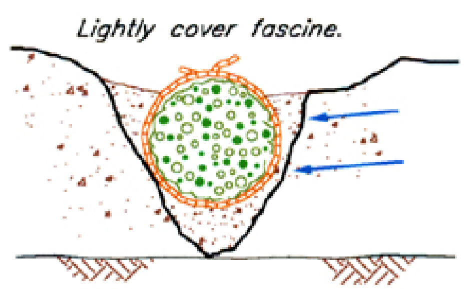
Common Reasons / Circumstances for Failure

Using a subsurface drainage technique, e.g., Live Pole Drains, when a surface runoff control measure is necessary.





Excavate a shallow trench or utilize existing "seepage gully" (small<2ft.^{2}).



Place bundle of cuttings (fascine) in the trench and lightly backfill with native material.

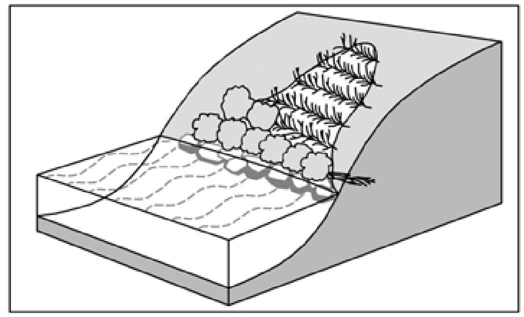
NOTES:

1. Live pole drain is a biotechnical technique which drains excess moisture from the bank and provides an initial cover of woody vegetation.
2. The cuttings used to form the fascines are intended to sprout and grow while the excess moisture continues to drain from the lower end.

LIVE POLE DRAIN

FILE: LIVE POLE DRAIN

Construction Specifications:



In general, gully repair consists of a combination of techniques for stabilizing eroding intermittent or ephemeral channels. These repair techniques taken together include grading, installing drainage and fill, live cuttings, and surface erosion control. 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. Accordingly, consideration should be given to diverting excessive or concentrated runoff away from the gully head area. Gullies are likely to have side gullies that require treatment; however, priority should be given to the main channel.

Conditions Where Practice Applies

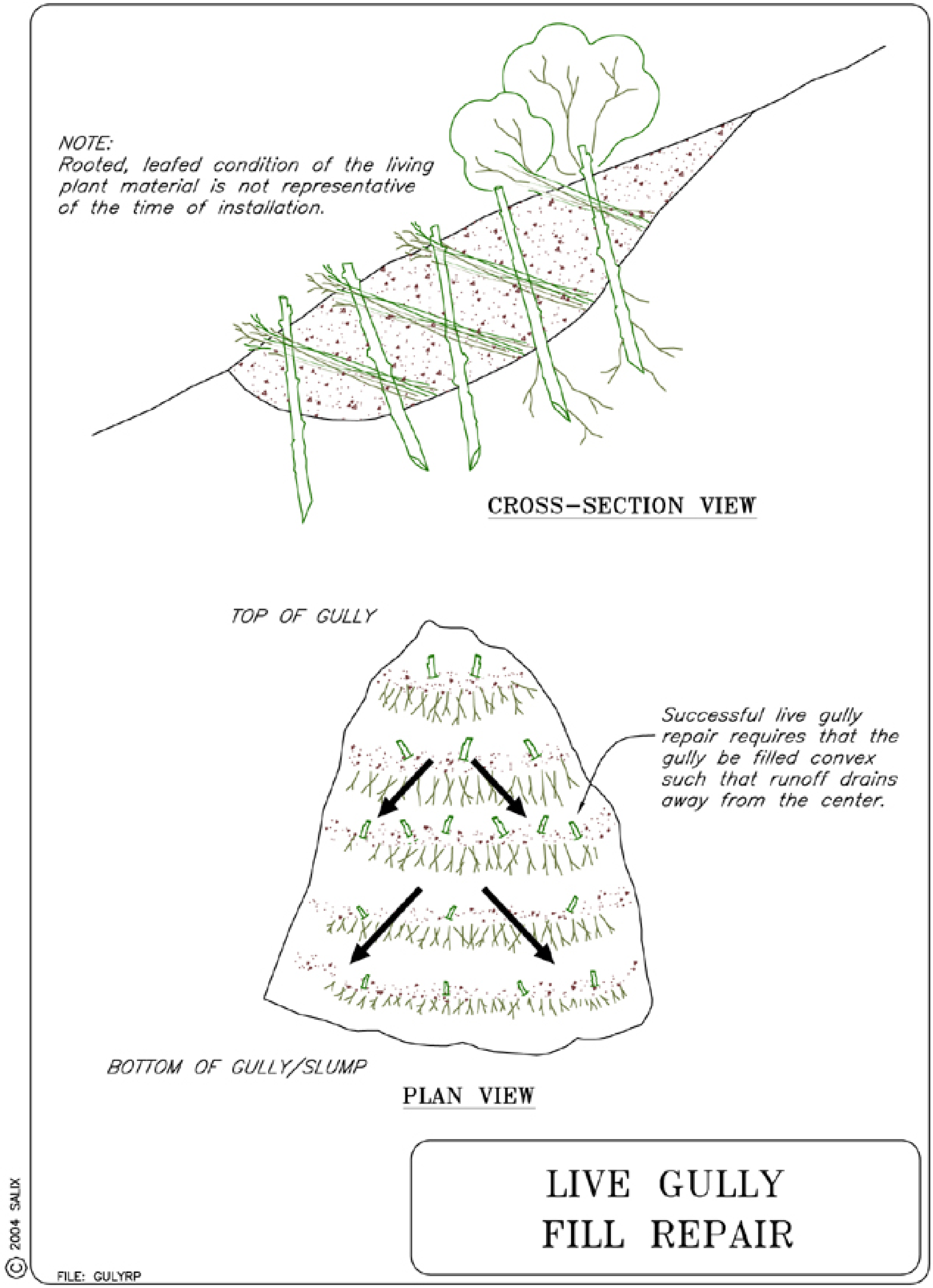
- Live Gully Fill Repair is useful for gullies ranging in depth from about 1 to 6 ft (0.3 to 2 m) deep to 30 ft (10 m) long.
- This repair technique should only be used in channels with intermittent flows. The erosion processes at work in the incised channel, or “gully,” must be correctly identified and understood to make a successful repair.

Design Guidelines / Typical Drawings

- This technique is used to fill small gullies in natural slopes and streambanks.
- Fill placed in the channel should consist of graded and well drained soil.
- Imbedded branches and their secondary roots will reinforce the backfill used to repair the gully and protect it against future washout and scour.
- A subsurface drain may be required if significant amounts of seepage or groundwater enters the gully at its head.
- Surface runoff entering the gully at its head should be intercepted and diverted away from the area.

Materials and Equipment

- Graded and well drained soil for use as fill material.
- Live branch cuttings ranging from 1/2 to 2 inches in diameter.
- The branches should be long enough to touch the undisturbed soil at the bottom (back) of the gully and to protrude slightly beyond the rebuilt slope face.


NOTE:
Rooted, leafed condition of the living plant material is not representative of the time of installation.
CROSS-SECTION VIEW
TOP OF GULLY
Successful live gully repair requires that the gully be filled convex such that runoff drains away from the center.
BOTTOM OF GULLY/SLUMP
PLAN VIEW
LIVE GULLY
FILL REPAIR
© 2004 SALIX
FILE: GULYRP

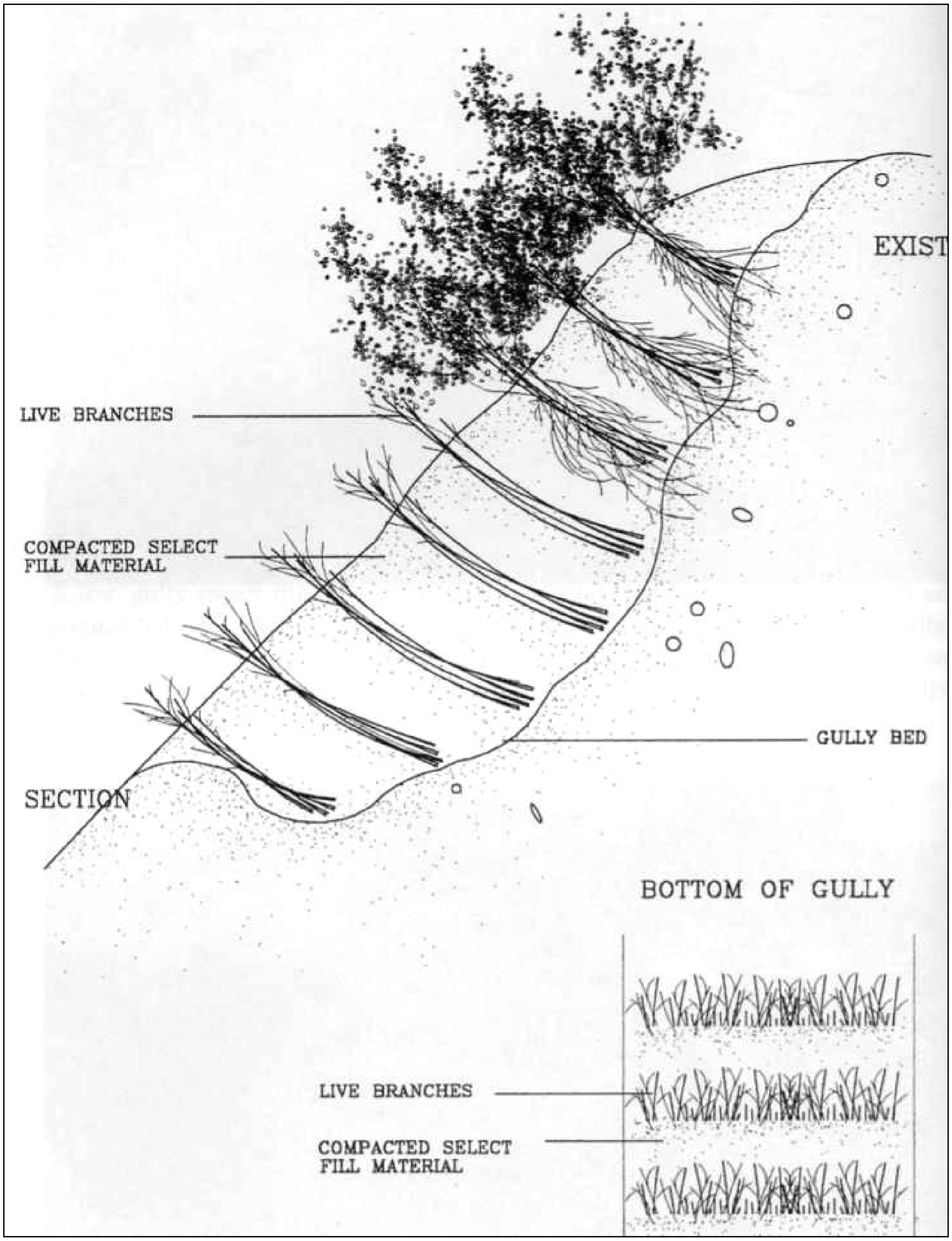


Figure 1. Schematic drawing of established live gully fill repair.

Construction / Installation

Live gully fill repair begins at the lowest point in the gully and proceeds upward. The live branches are inserted between successive lifts of lightly compacted soil. The following guidelines and procedures are recommended when installing a live gully fill repair system:

- Starting at the lowest point of the slope, place a 3- to 4-inch thick layer of branches at the lowest end of the gully and approximately perpendicular to the gully bottom (see Figure 1).
- Cover with a 6- to 8-inch thick layer of fill soil and compact

- Place the live branches in a crisscross fashion. Orient the growing tips toward the slope face with the basal ends lower than the growing tips.
- Follow each layer of branches with a layer of soil; work and compact the soil to ensure intimate contact with the branches and to eliminate large voids in the fill.

Inspection and Maintenance

- Periodically check on stability of gully fill, particularly during the initial vegetative establishment period.
- Check for wet spots or seeps in fill which indicate subsurface seepage problems. Examine surface of fill for evidence of runoff erosion such as rills.
- Make sure that runoff is diverted away from fill during initial stages.

Common Reasons / Circumstances for Failure

The main reason for failure of a Live Gully Fill Repair is saturation and washout of the earthen fill. Prevention of this outcome requires that seepage and runoff be excluded as much as possible from the fill area.

Sodding is the placement of permanent grass cover that has been was grown elsewhere and brought to the site. Sodding involves the placement of "sheets" of pre-established grass. Sodding provides immediate stabilization to an area by covering the soil surface with pre-established sheets of grass, thereby protecting the soil from erosion, enhancing infiltration, filtering sediment and other pollutants, and slowing runoff velocities.

Sodding is appropriate for areas that contained turf or grasses before construction; any graded or cleared area that might erode; and areas where a permanent, long lived plant cover is needed immediately. Sodding may be used in vegetative buffer zones, stream banks, grassed dikes, swales, slopes, outlets, level spreaders, and filter strips and is particularly effective on flood plains, areas adjacent to wetlands or other sensitive water bodies, and on steep, unstable slopes. Natural revegetation may be more appropriate for areas not prone to erosion that have an available seed source.

Construction Specifications:

- Sod should be protected with tarps or other protective covers during delivery and should not be allowed to dry out between harvesting and placement.
- All weeds and debris should be removed before cultivation of the area to be planted and properly disposed.
- After cultivation, installation of irrigation systems, and rough grading are completed, areas to be planted with sod should be fine graded and rolled. Topsoil may be needed in areas where the soil textures are inadequate. Areas to be planted with sod should be smooth and uniform before placing sod. Areas to be planted with sod adjacent to sidewalks, concrete headers, header boards, and other paved border and surface areas should be 1.5 in ± 0.25 in (38 mm ± 6 mm) below the top grade of such facilities after fine grading, rolling, and settlement of the soil. Sod should be placed so that ends of adjacent strips of sod are staggered at least 24 in (600 mm). All edges and ends of sod should be placed firmly against adjacent sod and against sidewalks, concrete headers, header boards, and other paved borders and surfaced areas.
- After placement of the sod, the entire sodded area should be lightly rolled to eliminate air pockets and ensure close contact with the soil. After rolling, the sodded areas should be watered so the soil is moistened to a minimum depth of 4 in (100 mm). Sod should not be allowed to dry out, planted during very hot or wet weather, or placed on slopes that are greater than 3:1:3 (H:V:H) if they are to be mowed.
- If irregular or uneven areas appear before or during the plant establishment period, such areas should be restored to a smooth and even appearance.
- The turf (sod) should be allowed to grow to 3 in (75 mm) high. When the turf reaches this height, it should be mowed to a height of 1 in (25 mm) or as recommended by the grower of the sod. All turf edges—including edges adjacent to sidewalks, concrete headers, header boards, and other paved borders and surfaced areas—should be trimmed to uniform edge not extending beyond the edge of turf or such facilities.
- Mowed and trimmed growth should be removed and disposed of outside the project. Trimming should be repeated whenever the height of the turf exceeds 1 in (25 mm).
- Sod should be healthy and, field grown, containing thatch not more than 0.5 in (13 mm) thick. The age of the sod should be between 8 and 16 months old. The sod should be free from disease, weeds, insects, and undesirable types of grasses and clovers and grown in accordance with any applicable agricultural requirements. Soil upon which the sod has been was grown should contain less than 50 percent silt and clay. Sod should be machine cut at a uniform soil thickness of 0.625 in ±0.25 in (16 mm ± 6 mm), excluding top growth and thatch.
- A certificate of compliance for the sod should be furnished to the contractor.

Inspection and Maintenance

- Inspect sod installations weekly and after significant storm events, until the turf is established.
- Maintenance should consist of mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth.