DESIGN SPECIFICATION

2.5 Bank Stabilization

filtrexx® SUSTAINABLE TECHNOLOGIES

PURPOSE & DESCRIPTION

The Filtrexx® **Bank Stabilization** vegetated soft armoring system is designed to **stabilize banks, and prevent erosion of waterway and shoreline banks**. The bank stabilization system is composed of **GroSoxx®** - heavy duty tubular mesh netting matrix used to contain and stabilize GrowingMedia™ and vegetation. The bank stabilization technology provides structural protection, erosion control, vegetation growth, and vegetation reinforcement in one system. The bank stabilization weight and anchoring system can withstand storm runoff velocities and hydraulic shear stresses similar to traditional soft armoring devices (brush mattresses, coconut fiber logs, turf reinforcement mats), while the injected GrowingMedia and optional drip tape irrigational system ensure establishment and sustainability of both seeded and live stake plantings.

Bank stabilization is specifically designed to establish and reinforce vegetation under intense hydraulic pressure. Once permanent vegetation is established in the bank stabilization system the following management parameters are enhanced:

- structural stability and protection from toe-cutting and sloughing of waterway bank,
- structural stability and protection from mass wasting and sloughing of shoreline from wave action,
- control of erosion from overland runoff, wave action, and shear stress from concentrated flows,
- control of runoff velocity flowing to receiving water,
- dissipation of runoff energy flowing to receiving water,
- sustained vegetation health, and
- sediment, soluble pollutant, and pathogen removal efficiency of runoff flowing to receiving water.

APPLICATION

Bank stabilization is used where waterway and shoreline banks are eroding, have become unstable, or cannot sustain vegetation. Bank stabilization can be used to establish, sustain, and reinforce vegetation in areas of flow and intense hydraulic pressure that typically undermine vegetation growth, such as creeks and streams. Applications where the bank stabilization system is typically required include:

- creek, stream, and riparian bank stabilization,
- pond and lake shoreline stabilization,
- sediment and storm water retention/detention pond bank slope stabilization, or
- riparian, stream bank, tidal creek, and salt marsh restoration, habitat and ecological restoration, and aesthetic revitalization.

Vegetated bank stabilization can also be used to reduce runoff velocity flowing into surface waters. Reducing runoff velocity will decrease soil erosion and increase pollutant removal through trapping, sediment deposition, and plant uptake.

ADVANTAGES AND DISADVANTAGES

Advantages

- Bank stabilization is a vegetated armoring system that stabilizes and prevents erosion of waterway banks and shorelines.
- Bank stabilization can be used in hydraulic shear stress up to 12 lbs/square ft (59 kg/square m).
- Bank stabilization can be used on bank slopes and shorelines up to 1:1.
- Bank stabilization has greater surface contact with soil and bank slopes, relative to rip rap, thereby providing greater protection from erosion.
- Bank stabilization system includes GrowingMedia which establishes, sustains, and provides reinforcement for vegetation, unlike rip rap and other hard armoring devices.
- Bank stabilization is direct seeded at the time of installation.
- Bank stabilization stability and bank protection/erosion prevention are increased when vegetation is establishment within system.
- Vegetated bank stabilization filters sediment, soluble nutrients, heavy metals, petroleum hydrocarbons, pesticides, and pathogens from storm runoff flowing toward surface waters.
- Vegetated bank stabilization slows runoff velocity, which can reduce erosion, and increase sediment deposition and pollutant removal efficiency prior to reaching surface water.
- Vegetated bank stabilization removes pollutants from storm water by plant uptake.
- GrowingMedia in bank stabilization has the ability to bind and adsorb soluble nutrients, metals, and hydrocarbons that may be in stormwater runoff, thereby reducing loading to adjacent receiving waters.
- Microorganisms in GrowingMedia have the ability to degrade organic pollutants and cycle captured nutrients into beneficial and/or less toxic forms.
- Contained GrowingMedia within bank stabilization creates an ideal system for biotechnical engineering projects.
- Humus colloids and organic matter in GrowingMedia provide physical structure for seed, seedlings, and live stakes.
- Humus colloids and organic matter in GrowingMedia provide increased water holding capacity and reduced water evaporation to aid in seed germination, plant sustainability, and the potential for reduced irrigation.
- Low volume, low pressure drip tape irrigation system can be installed within the bank stabilization to promote vegetation establishment.
- Bank stabilization is wrapped in a geotextile (Filtrexx® LockDown™ Netting or FLW Geogrid recommended, see Tables 5.3 and 5.4) or in a geogrid for connective stability to the bank and for added durability to hydraulic conditions.

ADVANTAGES			
	LOW	MED	HIGH
Installation Difficulty		✓	
Bank Stabilization			✓
Vegetation Establishment			✓
Maximum CFS/Shear Stress			✓
Aesthetic Quality			✓
Erosion Control			✓
Soluable Pollutant Control		✓	

- Bank stabilization is a good option for arid and semiarid regions where germination,moisture management, and irrigation can be difficult.
- GrowingMedia provides organic nutrients that slow release for optimum efficiency to establishing vegetation.
- GrowingMedia provides organic nutrients that are less prone to runoff transport and pollution of surface waters, relative to mineral nutrients supplied by fertilizers.
- Bank stabilization is comprised of GrowingMedia which is organic, all natural and locally manufactured.
- Bank stabilization can be easily designed and incorporated as one treatment in a treatment train approach to site or watershed storm water management.
- Bank stabilization may assist in qualification for LEED® Green Building Rating and Certification credits under LEED Building Design & Construction (BD+C), New Construction v4. Awarded credits may be possible from the categories of Sustainable Sites, Water Efficiency, Materials & Resources, and Innovation. *Note: LEED is an independent program offered through the U.S. Green Building Council. LEED credits are determined on a per project basis by an independent auditing committee. Filtrexx neither guarantees nor assures LEED credits from the use of its products. LEED is a trademark of the U.S. Green Building Council.*

Disadvantages
- If bank stabilization does not use Filtrexx GrowingMedia, performance may be diminished.
- If not installed correctly, maintained or used for a purpose or intention that does not meet specifications, performance may be diminished.
- If vegetation does not establish or cover density is low, performance may be diminished.
- Bank stabilization should not be the only form of site or watershed storm water management.
- Bank stabilization may need to be reseeded or live stakes replaced if significant storm flow occurs prior to vegetation establishment or where vegetation fails.
- Bank stabilization performance may be lower prior to vegetation establishment and maturity.
- Bank stabilization installation is a land disturbing activity and can increase sediment loading to surface waters if appropriate sediment control measures are not established during construction phase.
- Bank stabilization should not be used on bank and shoreline slopes greater than 1:1.
- Bank stabilization should not be used on bank or shoreline slopes greater than 3:1 where mowing will be performed to maintain vegetation.
- Bank stabilization may not function in hydraulic shear stresses situations over 12 lbs/square ft (59kg/square m).

MATERIAL CHARACTERISTICS

Filtrexx® Bank Stabilization uses only Filtrexx® Soxx™, photodegradable netting materials available from Filtrexx International, and are the only mesh materials accepted in creating Filtrexx® Bank stabilization for any purpose. For Soxx Material Specifications see Table 5.2.

GROWINGMEDIA™ CHARACTERISTICS

Filtrexx Bank Stabilization uses only Filtrexx® GrowingMedia™ which is a composted material that is specifically designed for stability within the system and establishment and sustainability of vegetation growth. GrowingMedia can be third party tested and certified to meet minimum performance criteria defined by Filtrexx International. Performance parameters include: percent cover of vegetation, water holding capacity, pH, organic matter, soluble salts, moisture content, biological stability, maturity bioassay, percent inert material, bulk density and particle size distribution. For information on the physical, chemical, and biological properties of Filtrexx GrowingMedia refer to Filtrexx GrowingMedia Specification 6.2.

PERFORMANCE

QA/QC material testing of Filtrexx GrowingMedia to ensure specifications are met is conducted by the Soil Control Lab, Inc. Scientific research on vegetated filter strips, slope protection, and Compost FilterSoxxtm has been conducted in recent years. Conservative assumptions can be made regarding bank stabilization in light of performance associated with applied field research and previously mentioned practices. For performance on these practices see Filtrexx® Slope protection, Filtrexx® Sediment control, and supporting technical and research reports. Filtrexx International has conducted research with the Texas Transportation Institute (TTI) of Texas A.M. University to quantify the performance and design limitations of Bank stabilization to aid engineering design professionals. See Table 5.2 for a summary of material specifications and Table 5.5 for a summary of performance testing results and design specifications. *Note: the Contractor is responsible for establishing a working riparian, hydrologic, and/or storm water management system and may, with approval of the Engineer, work outside the minimum construction requirements as needed. Where bank stabilization fails, it shall be repaired or replaced with an effective alternative.*

DESIGN CRITERIA

Function

The primary functions of the bank stabilization system are: to stabilize and prevent erosion of waterway banks and shorelines prior to vegetation establishment, to structurally reinforce seeded and planted vegetation against intense hydraulic pressures and wave action, and to provide an optimum medium for vegetation establishment and sustainability. The bank stabilization system is specifically designed to dissipate the energy from moving water, and establish, reinforce, and sustain vegetation under high velocity flows and shear stresses in concentrated flow applications. The bank stabilization system is unique in that GrowingMedia and seed are injected and contained within the structural armoring system. The mesh containment system allows grass to establish through the matrix, while live plantings (live stakes, plugs, sprigs) can be easily manually inserted into the system without compromising its structural stability. Established roots increase the stability, anchor capacity, and sustainability of the system on the bank or shoreline slope. This system is the ideal biotechnical engineering, wildlife habitat restoration, riparian and ecological restoration, and/or aesthetic enhancement system because the organic GrowingMedia is idea for establishing and sustaining most types of vegetation. The bank stabilization system is specifically designed to make contact with 100% of the soil surface of the waterway bank or shoreline, thereby increasing the structural integrity and preventing erosion of the slope. See Figures 5.1 through 5.5 for design drawing details and staking requirements.

The vegetated bank stabilization system is effective at filtering pollutants from storm runoff potentially entering surface waters due to physical trapping and runoff velocity reduction by the vegetation. Vegetation can increase surface roughness (Manning's n), which can reduce runoff velocity. Large particles are typically removed in greater efficiencies than suspended particles through reducing runoff velocity and constructing/maintaining vegetated buffers. Maintenance is a key consideration, as sediment build-up will significantly reduce the ability of a vegetated bank stabilization to remove pollutants from storm runoff; however, unless sediment accumulation is extreme bank stabilization vegetation will continue to grow in and through deposited sediment.

Humus content within the GrowingMedia has the ability to chemically adsorb and bind soluble pollutants such phosphorus, ammonium-nitrogen, heavy metals, and petroleum hydrocarbons, making them unavailable for plant or animal uptake (Filtrexx Tech Link #3307 and #3308). Additionally, many plants have the ability to take up excess nutrients and pollutants trapped in the vegetation, while microorganisms can decompose and/or incorporate these pollutants into their biomass, making them less toxic to aquatic ecosystems. Organic matter supplied in GrowingMedia increases the diversity and population of microorganisms that can decompose and incorporate captured pollutants.

Planning Considerations

Filtrexx Bank Stabilization should be used as one treatment in a treatment train approach to storm water management, streambank stabilization or riparian restoration.

Dense stands of native vegetation, vegetated buffers, trees, shrubs, and their root masses should be conserved if they are functionally stabilizing the bank and are healthy. Equipment and soil disturbing activities should avoid contact with above and below ground plant material described above.

Infiltration and runoff velocity reduction practices may be installed upslope from the bank stabilization project to reduce storm flows that cause erosion and sediment and soluble pollutant transport to receiving waters.

Surface waters and their banks typically support a diversity of wildlife and often human recreation. Planning should include design for wildlife habitat, aesthetics, and potential human and pet recreation.

Note: any natural (not man-made) waterway or channel stabilization and vegetation project requires permit and approval by the US Army Corp of Engineers, and all defined waterways are regulated through the US Clean Water Act by US EPA. A defined waterway may only have flow during rainfall events, be sure to check with jurisdictional zoning and regulating authorities during planning phase.

Vegetation Selection

Successful planning for any vegetation establishment project should consider aesthetics, wildlife habitat, climate, prevailing weather, temperature, sun exposure, prolonged moisture exposure, available moisture/irrigation requirements, topography, soil type, soil pH, soil amendments, nutrient requirements, drought tolerance, time/coordination with construction phases, site preparation/coordination with construction phases, protection from erosion and sedimentation, concentrated flow and runoff velocity potential, maintenance, and seed mix/plant selection (Fifield, 2001).

Quick establishing annual grasses and legumes are normally specified for temporary and nurse crop applications. Perennial grasses are typically specified for permanent applications, and if possible native grasses should be utilized (Fifield, 2001; USDA-NRCS, 2004) as these will be better adapted to local climate, native soil, and hydrology. If bank stabilization system will be exposed to prolonged moisture, wetland species may be required. *Generally, tall and sturdy grasses are better at reducing runoff velocity and increasing sediment removal than low growing, flexible grasses and legumes* (Grismer et al., 2006; USDA-NRCS, 2004) as they generally increase surface roughness values (Manning's n). *Additionally, deep rooted grasses will be more stable under high storm runoff, high concentrated flow velocity and shear stress, and high energy wave action.*

Bank stabilization is specifically designed for biotechnical engineering applications. GrowingMedia fill within the sock system creates an optimum fertile and structural environment for establishing and sustaining live stakes, tubers, rhizomes, and plugs. A live stake is a 1 to 3 ft (300-900mm) long cutting from a live hardwood tree or shrub and planted vertically into a growing media (KYTC, 2006). Typical live stake species include, willow, poplar, maple, cottonwood, dogwood, sycamore, and oak (KYTC, 2006). Drip tape irrigation installed within the bank stabilization system maintains moisture for plants used in biotechnical engineering projects, particularly in drought prone regions and seasons.

Local landscape architects, NRCS, or cooperative extension should be consulted and used as resources for seed and plant selection. Many state erosion and sediment control and storm water management manuals have specifications for seed and plant selection, seeding rates, and planting requirements. VegSpec, a design program created by the USDA-NRCS, may be a helpful tool for seed and plant selection. It can be accessed at http://vegspec.nrcs.usda.gov/vegSpec/index.jsp.

The hydraulic properties of grasses commonly used in channels have been characterized and grouped by the United Stated Department of Agriculture. Each class, A through E, is determined by height, density and stiffness of the vegetative stand. These properties effect the vegetation's surface roughness (Manning's n) and its ability to withstand hydraulic pressure from concentrated flows (ECTC, 2006). Grass retardance classes and their corresponding permissible shear stress values are defined in the Federal Highway Administration HEC 15.

Table 5.1. FHWA HEC 15 Retardance Class, Stand Height, and Permissible Shear Stress for Grasses used in Channels, Ditches, and Concentrated Flow Applications.

Class	Example of Vegetation	Stand Density	Average Stand Height	Permissible Shear Stress
A	Weeping Lovegrass, yellow bluestem	Excellent	>=76.2 cm (>= 30 in)	177 Pascal (PA) (3.7 lbs/ft2, 18 kg/m2)
B	Bermuda, blue grama, and native grass mixtures	Good	30.5 - 61 cm (12 - 24 in)	100 Pascal (PA) (2.1 lbs/ft2, 10 kg/m2)
C	Bermuda, Kentucky blue grass, centipede grass	Good	15 — 30.5 cm (6 - 12 in)	48 Pascal (PA) (1.0 lbs/ft2, 5 kg/m2)
D	Bermuda, buffalo, grass-legume mixture	Good	5 — 15 cm (2 - 6 in)	28 Pascal (PA) (0.60 lbs/ft2, 3 kg/m2)
E	Bermuda, native grass mixture	Good	<5 cm (< 2 in)	16 Pascal (PA) (0.35 lbs/ft2, 2 kg/m2)

(Source: ECTC - Erosion Control Technology Council, 2006)

Establishing & Sustaining Vegetation

Bank stabilization is seeded at the time of application by injection into GrowingMedia during bank stabilization construction. Nurse crops, such as annual rye, may be considered to establish a quick vegetative cover and root anchor until perennial grasses and/or live stakes are established. Grasses should be mowed and maintained between 4 and 10 in (100-250mm) high, unless otherwise specified. Taller grasses may have higher sediment removal efficiency and sediment storage capacity, and a greater ability to dissipate runoff energy and reduce storm flow velocity relative to low growing or low maintained grasses. Live stakes should be 1 to 3 ft (300-900mm) long and planted vertically with at least 2 in (50mm) of one end planted into a growing media, and spaced 3 to 5 ft (1-1.5m) apart (KYTC, 2006).

Although GrowingMedia typically has a higher water holding capacity than topsoil, irrigation may be required to ensure successful establishment. In arid and semi-arid regions or hot and dry weather regular irrigation may be required. Drip tape irrigation may be installed within the bank stabilization GroSoxx to maintain moisture within GrowingMedia for establishing vegetation or in drought prone regions and seasons.

Bank stabilization GrowingMedia can supply humus, organic matter, beneficial microbes, and slow release organic nutrients that can contribute to increased fertility, plant health and sustainability.

Organic vs. Fertilizer Nutrients

Although most specification and design manuals include fertilizer recommendations or requirements for vegetation, mineral nutrients from fertilizers may not be preferable where vegetation sustainability and water quality are a concern. Bank stabilization provides organic nutrients which are slow release, provide plant micronutrients, and are less likely to be transported in storm runoff to receiving waters – which can lead to pollution and eutrophication of waterways (Faucette et al, 2005).

Weed Establishment

Invasive weed growth has been more closely associated with mineral fertilizer than organic fertilizer fertility practices (Faucette et al, 2004). Vegetation practices should always be inspected for invasive and noxious weeds.

Slope Degree

Bank stabilization can be used effectively on slopes up to 1:1; however, constructed banks typically do not exceed a 2:1 slope. If mowing will be used to manage vegetation the maximum slope is typically 3:1. Bank stabilization can be used effectively for these slope applications.

Runoff Velocity & Shear Stress

Bank stabilization should not be used in areas where runoff velocity or shear stresses will damage or undermine the system. For most grasses a maximum velocity of 4 ft/sec (1.2 m/sec) or a maximum hydraulic shear stress of 2 lbs/ft2 (10 kg/m2) is recommended (MD Storm Water Design Manual, 2000) – unless vegetation reinforcement is utilized. Bank stabilization provides bank protection for a maximum shear stress of 12 lbs/square ft (59 kg/square m).

Traditionally, the flow velocity (ft/sec, m/sec) of a section of concentrated flow has been used to design for bank protection and stabilization. However, using ft/sec (m/sec) does not account for the pressure and stress created by depth of concentrated flow within the channel. Because the pressure created by flow depth is an important variable in bank erosion, using only ft/sec (m/sec) may not be the best criteria to design for bank protection. Permissible shear stress (tractive or frictional force) on channel lining and protection devices may be a better design limit criteria, as shear stress determination includes depth of flow variables. Because shear stress within the area of a channel or bank can be variable, generally the maximum shear stress is used as a design parameter rather than the mean. The area of concentrated flow where shear stress is always greatest is where the depth of flow is greatest (and tractive/frictional force) – the channel bed. Therefore the maximum shear stress of a bank or channel protection device reflects its performance and design limit in the channel bed, which should be sufficient for flow velocity and shear stress along the banks within the same channel.

To determine the maximum shear stress in a stream, creek, or river use:

$$T_{max} = y \times Y \times S$$

Where:

T_{max} = maximum shear stress (lb/sq ft, kg/sq m)
y = density of water (62.4 lb/cu ft, 1011 kg/cu m)
Y = depth of water (ft, m)
S = slope of gradient (ft/ft, m/m)

To determine the mean shear stress in a channel use:

$$T_{mean} = (y \times A \times S)/P$$

Where:

T_{mean} = mean shear stress (lb/sq ft, kg/sq m)
y = density of water (62.4 lb/cu ft, 1011 kg/cu m)
A = cross-sectional area (sq ft, sq m)
S = slope of gradient (ft/ft, m/m)
P = wetted perimeter

To determine velocity of flow in a channel use Manning's Equation:

$$V = (\alpha_1/n) \times R^{2/3} \times S^{1/2}$$

Where:

V = mean velocity of flow (ft/sec, m/sec)
R = hydraulic radius = A/P (ft, m)
A = cross-sectional area (sq ft, sq m)
P = wetted perimeter (ft, m)
S = slope of gradient (ft/ft, m/m)
n = roughness coefficient
α_1 = 1.0 for SI units, 1.496 for English units

Site preparation and application specifications will be described in the following section.

INSTALLATION

1. Bank stabilization shall meet Filtrexx Bank stabilization and Filtrexx Certified GrowingMedia specifications.
2. Call Filtrexx at 877-542-7699 or visit www.filtrexx.com for a current list of installers and distributors of Filtrexx products.
3. Bank stabilization will be placed at locations indicated on plans as directed by the Engineer.
4. Bank stabilization shall be placed in a manner that protects the entire bank or shoreline from erosion and destabilization.
5. Bank stabilization must be installed and stabilized before concentrated flow is allowed to contact bank or slope area.
6. Sediment control devices (such as Filtrexx Sediment Control) shall be installed if construction requires land disturbance or earth moving.
7. Land surface shall be cleared of debris, including rocks, roots, large clods, and sticks prior to bank stabilization installation.
8. Waterway bank or shoreline shall be made smooth prior to

installation of Bank stabilization.

9. Soil bed may be compacted and graded prior to installation.
10. If toe-cutting is an issue at the waterway bed and slope interface, excavation should be performed at the interface below creek bed level to allow placement of Bank stabilization.
11. Excavation should be to a minimum of 1 ft (300mm) below scour line for streams with flow depths of 6 in (150mm) or greater.
12. Bank stabilization is wrapped in a geotextile (Filtrexx LockDown Netting or FLW Geogrid Recommended) or in a geogrid for connective stability to the bank and for added durability to hydraulic conditions.
13. Bank stabilization will be fabricated on-site.
14. On-site fabrication of bank stabilization will ensure a continuous length sock system. Upon completing one section of sock filling (approximately 100-200 ft [30-60m]), the next section shall be 'sleeved' over the completed section by a minimum of 1 ft (300mm). A stake shall be placed in the overlap section, securing the two sections. For joints occurring at or below the waterline, each section will be closed and secured via the Geotextile or Geogrid wrap.
15. Bank stabilization shall be placed parallel to concentrated water flow and perpendicular to wave action, where Soxx are tightly stacked or abutted to prevent water seepage between and underneath the system.
16. For stacking applications, larger diameter bank stabilization GroSoxx will be placed on the bottom of the installation and sequentially smaller diameter GroSoxx placed on top as the construction moves upslope and away from the waterline.
17. Stabilization applications below the waterline will use pea gravel and small rock in the Soxx at the base of the bank stabilization system and GrowingMedia in the GroSoxx where vegetation will be established above the waterline.
18. In areas where waterline fluctuates below and above the GroSoxx, custom soil blends may be used, as directed by the Engineer. Custom soil blends may include GrowingMedia, topsoil, sand, pea gravel, or other small aggregate.
19. Once in place, Bank stabilization Soxx™ shall be lightly compacted to tighten seal between socks and encourage even water flow over the surface of the system.
20. Bank stabilization shall not be installed on banks or shorelines greater than 1:1, and 3:1 if mowing will be conducted to manage vegetation.
21. Above the waterline, stakes shall be installed through the middle of the GroSoxx on a minimum of 5 ft (1.5m) centers, using 2 in (50mm) by 2 in (50mm) by 3 ft (1m) wooden stakes.
22. Above the waterline, alternatively, L-shaped rebar may be installed through the middle of the GroSoxx on 5 ft (1.5m) centers, where the "L" shall be bent to form a hook over the top of the GroSoxx and pounded to fit snug.
23. Above the waterline, stakes shall also be placed at the ends of GroSoxx to hold it in place.
24. Minimum staking depth for sand and silt loam soils shall be 12 in (300mm), and 8 in (200mm) for clay soils.
25. Bank stabilization shall be seeded at the time of application, seed selection will be determined by the Engineer.
26. Seeded bank stabilization should not be installed prior to seasons where growing vegetation is difficult.
27. Seed shall be thoroughly mixed with the GrowingMedia prior to construction or injected into GrowingMedia at time of application.
28. Optional biotechnical engineering with live stakes, tubers, seedlings, or plugs should be conducted after staking is complete.
29. Live stakes should be from a live species and cuttings should be 1 to 3 ft (300-900mm) long.
30. Live stakes should be spaced 5-7 ft (1.5-2.1m)apart, and planted vertically with one end planted through the bank stabilization and at least 2 in (50mm) into native soil.
31. Seeded and/or live staked Bank stabilization shall be thoroughly watered after installation and allowed to settle for 1 week.
32. Drip tape may be installed within the GroSoxx during construction to provide irrigation for establishing vegetation.
33. If drip irrigation system is installed a reliable water source should located and secured.
34. If drip irrigation system is installed and municipal water or a pump will be utilized, a pressure reducer may be required to manage flow and prevent drip tape from bursting.

INSPECTION

Routine inspection should be conducted within 24 hrs of a runoff event for the first year after installation, until permanent vegetation has established, or as designated by the regulating authority. If product dislodgement occurs, or vegetation does not establish, bank stabilization/GroSoxx should be repaired, reseeded, and/or replanted. If bank or shoreline erosion occurs, the area should be repaired immediately. Vegetation practices should always be inspected for noxious or invasive weeds. If sediment accumulation is 25% of the height of the vegetation, sediment removal is recommended. Storm debris and trash should be removed immediately.

MAINTENANCE

1. The Contractor shall maintain the bank stabilization in a functional condition at all times and it shall be routinely inspected.
2. Seeded bank stabilization shall be maintained until a minimum uniform 70% cover of the applied area has been vegetated, permanent vegetation has established, or as required by the jurisdictional agency.
3. Seeded bank stabilization may need to be irrigated in hot and dry weather and seasons, or arid and semi-arid climates to ensure vegetation establishment.
4. Where bank stabilization fails or becomes dislodged, the Contractor will ensure the product is in good contact with the soil and backfill media, repair, and use additional staking if necessary.
5. Where bank or shoreline erosion occurs, the Contractor will regrade the soil if necessary and repair or replace the bank stabilization.
6. Where vegetation does not establish the contractor will reseed, replant, replace live stakes, or provide an approved and functioning alternative.
7. If bank stabilization is only seeded at time of installation live stakes may be added to increase stability, aesthetics, wildlife habitat, and ecological succession.
8. No additional fertilizer or lime is required for vegetation establishment and maintenance.
9. No disposal is required for this product/practice.
10. Bank stabilization shall become part of the permanent landscape.
11. Regular mowing of grass vegetation on seeded bank stabilization to a minimum height of 4 in (100mm) and a maximum height

of 10 in (250mm) will deter invasive weeds, allow sunlight to kill captured pathogens from stormwater, and provide maximum sediment removal efficiency and sediment storage capacity in the vegetation.

12. Storm debris and trash deposited on bank stabilization should be removed immediately.
13. Sediment shall be removed if it reaches 25% of the height of the vegetation (mowed) to prevent diversion of storm runoff and reduction of vegetation health and cover.
14. If drip tape irrigation system is installed, once vegetation is fully established, connections to drip tape irrigation system may be removed, leaving the drip tape inside the GroSoxx. Cut ends of drip tape and discard in approved waste receptacle.

METHOD OF MEASUREMENT

Bid items shall show measurement as Filtrexx® Bank Stabilization/ GroSoxx® installed, as part of the bank stabilization system, per linear ft or linear meter installed, per diameter (8 in [200mm], 12 in [300mm], 18 in [450mm], 24 in [600mm]), or 32 in [800mm]) as specified by the Engineer. Additionally, backfill media shall show measurement as Filtrexx® GrowingMedia™, used as part of the bank stabilization system, per cubic yard or cubic m of material installed.

Engineer shall notify Filtrexx of location, description, and details of project prior to the bidding process so that Filtrexx can provide design aid and technical support.

FIELD APPLICATION PHOTO REFERENCES

Establishing Grass Varieties in Streambank

Tidal Stream Installation with Riparian Vegetation

ADDITIONAL INFORMATION

For other references on this topic, including additional research reports and trade magazine and press coverage, visit the Filtrexx website at filtrexx.com

Filtrexx International, Technical Support
877-542-7699 | www.filtrexx.com | info@filtrexx.com
Call for complete list of international installers and distributors.

REFERENCES CITED & ADDITIONAL RESOURCES

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Table 5.2. Filtrexx SiltSoxx® Mesh Material Specifications.

Material Type	BASIC (5 mil High Density Polyethylene HDPE)	BASIC PLUS (Multi-Filament Polypropylene MFPP)	DURABLE (Multi-Filament Polypropylene MFPP)
Material Characteristic	Photodegradable	Photodegradable	Photodegradable
Design Diameters	8 in (200mm), 12 in (300mm), 18 in (400mm)	8 in (200mm), 12 in (300mm), 18 in (400mm), 24 in (600mm), 32 in (800mm)	5 in (125mm), 8 in (200mm), 12 in (300mm), 18 in (400mm), 24 in (600mm), 32 in (800mm)
Mesh Opening	3/8 in (10mm)	3/8 in (10mm)	1/8 in (3mm)
Tensile Strength (ATSM D4595)[1]	MD: 211 lbs TD: 79 lbs	MD: 236 lbs TD: 223 lbs	MD: 545 lbs TD: 226 lbs
% Original Strength from Ultraviolet Exposure (ASTM G-155)	23% at 1000 hr	100% at 1000 hr	100% at 1000 hr
Functional Longevity/ Project Duration[2]	up to 4 yr	up to 4 yr	up to 5 yr

[1] Tensile Strength is based on 12" diameter using ATSM D4595. See Filtrexx TechLink #3342 for full tensile strength testing.
[2]Functional longevity ranges are estimates only. Site specific environmental conditions may result in significantly shorter or longer time periods.

Table 5.3. Bank Stabilization Performance and Design Specifications Summary.

Design Diameter Design & Performance	8 in (200mm)	12 in (300mm)	18 in (450mm)	24 in (600mm)	32 in (800mm)	Testing Lab/ Reference
Effective Height	6.5 in (160mm)	9.5 in (240mm)	14.5 in (360mm)	19 in (480mm)	26 in (650mm)	Filtrexx International Field Lab
Effective Circumference	25 in (630mm)	38 in (960mm)	57 in (1450mm)	75 in (1900mm)	100 in (2500mm)	Filtrexx International Field Lab
Density	18 lbs/ft (27 kg/m)	45 lbs/ft (68 kg/m)	100 lbs/ft (151 kg/m)	240 lbs/ft (363 kg/m)	300 lbs/ft (450 kg/m)	Filtrexx International Field Lab
Air Space	Testing in Progress	Testing in Progress	Testing in Progress	Testing in Progress	Testing in Progress	Soil Control Lab, Inc
Maximum continuous length	unlimited	unlimited	unlimited	Unlimited	unlimited	
Staking Requirement	10 ft (3m)	10 ft (3m)	10 ft (3m)	10 ft (3m)	10 ft (3m)	Filtrexx International Field Lab
Max. Velocity (ASTM D-6460)	14.5 ft/sec (4.4 m/sec)	14.5 ft/sec (4.4 m/sec)	14.5 ft/sec (4.4 m/sec)	14.5 ft/sec (4.4 m/sec)	14.5 ft/sec (4.4 m/sec)	Texas Transportation Insti- tute- TX A&M.
Max. Hydraulic Shear Stress (ASTM D-6460)	12 lbs/ft2 (59 kg/m2)	12 lbs/ft2 (59 kg/m2)	12 lbs/ft2 (59 kg/m2)	12 lbs/ft2 (59 kg/m2)	12 lbs/ft2 (59 kg/m2)	Texas Transportation Institute TX A&M.
Manning's n (roughness coefficient)	Non-vegetated (0.022); Grass (0.035); Grass + Live Stakes/ young or thin (0.05); Grass + Live Stakes/mature or dense (0.075)	Non-vegetated (0.022); Grass (0.035); Grass + Live Stakes/ young or thin (0.05); Grass + Live Stakes/mature or dense (0.075)	Non-vegetated (0.022); Grass (0.035); Grass + Live Stakes/ young or thin (0.05); Grass + Live Stakes/mature or dense (0.075)	Non-vegetated (0.022); Grass (0.035); Grass + Live Stakes/ young or thin (0.05); Grass + Live Stakes/mature or dense (0.075)	Non-vegetated (0.022); Grass (0.035); Grass + Live Stakes/ young or thin (0.05); Grass + Live Stakes/mature or dense (0.075)	Texas Transportation Institute-TX A&M.
Slope	10%	10%	10%	10%	10%	Texas Transportation Institute- TX A&M.
Media Type	Growing Media™	Growing Media™	Growing Media™	Growing Media™	Growing Media™	Texas Transportation Institute TX A&M.
Sock Material	Multi-Filament Polypropylene	Multi-Filament Polypropylene	Multi-Filament Polypropylene	Multi-Filament Polypropylene	Multi-Filament Polypropylene	Texas Transportation Institute TX A&M.
Vegetation Type	Triple Rye; Bermuda + Green Sprangletop	Triple Rye; Bermuda + Green Sprangletop	Triple Rye; Bermuda + Green Sprangletop	Triple Rye; Bermuda + Green Sprangletop	Triple Rye; Bermuda + Green Sprangletop	Texas Transportation Institute- TX A&M.
Vegetation Cover	70-100%	70-100%	70-100%	70-100%	70-100%	Texas Transportation Institute- TX A&M.

Table 5.4. Characteristics of Filtrexx® LockDown™ Netting.

Support Practice	LockDown™ Netting	LockDown™ Netting	Testing Lab
Purpose	Increase stabilization/ erosion control of Slope protection	Increase stabilization/ erosion control of Slope protection	
Description	Improves performance and allowable slope steepness	Improves performance and allowable slope steepness	
Material Description	5 mm multifilament polypropylene	5 mm monofilament HDPE	
Mesh Description	¾ in (19mm) openings	¾ in (19mm) openings	
Color	Black	Green	
Tensile Strength (ASTM 5035-95)*	32.8 lbs/in2* (2.3 kg/cm2)	1.2 lbs/in2 (0.08 kg/cm2)	Texas Transportation Institute TX A&M.*
Elongation (% relative) (ASTM 5035-95)*	46.5	ND	Texas Transportation Institute TX A&M.*
Functional Longevity	1 – 4 yr	6 mo – 3 yr.	Filtrexx International Field Lab
Roll Size (w x l)	30 ft (9m) x 375 ft (114m)	30 ft (9m) x 375 ft (114m)	
Application Method	Stapled to soil/ Slope protection applied on top	Stapled to soil/ Slope protection applied on top	

Table 5.5. Filtrexx FLW Geogrid Details.

FLW Geogrids are composed of high molecular weight, high tenacity multifilament polyester yarns that are bidirectional and woven into a stable network placed under tension. The high strength polyester yarns are coated with a PVC material. FLW Geogrids are inert to biological degradation and are resistant to naturally encountered chemicals, alkalis and acids. FLW Geogrids are typically used for soil reinforcement applications such as retaining walls, steepened slopes, embankments, sub-grade stabilization, embankments over soft soils and waste containment applications.

FLW 20 Tensile Properties	Test Method	MARV Values (lbs/ft) MD/CMD
Ultimate Strength Machine Direction	ASTM D 6637	2,075
Creep Limited Strength Machine Direction	ASTM D 5262	1,313
T_{al} = Long Term Design Strength Machine Direction	NCMA 97	1,085
Aperture Size - 2.00 x 2.00 (inches)	Measured	N/A

RF Creep - 1.58 RF Durability - 1.10 RF Installation Damage (Soil Type 3) - 1.10

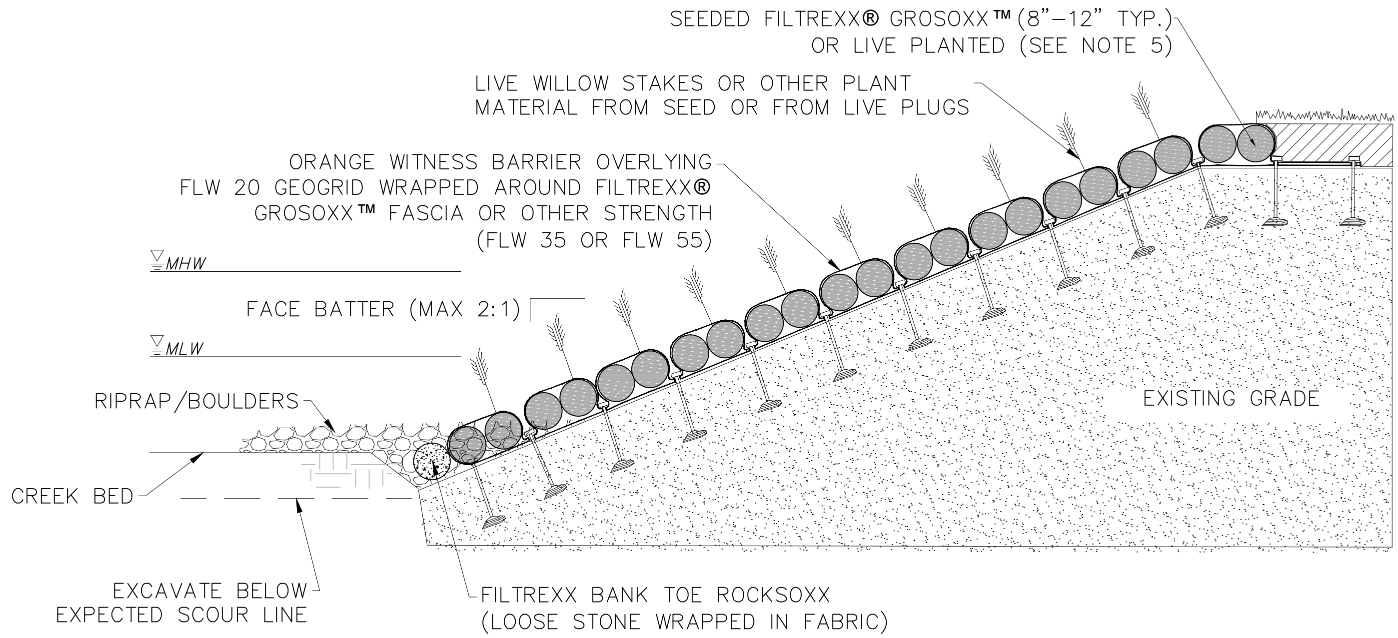
FLW 35 Tensile Properties	Test Method	MARV Values (lbs/ft) MD/CMD
Ultimate Strength	ASTM D 6637	3,600
Creep Limited Strength	ASTM D 5262	2,278
T_{al} = Long Term Design Strength	NCMA 97	1,918
Aperture Size - 2.00 x 2.00 (inches)	Measured	N/A

RF Creep - 1.58 RF Durability - 1.10 RF Installation Damage (Soil Type 3) - 1.08

FLW 55 Tensile Properties	Test Method	MARV Values (lbs/ft) MD/CMD
Ultimate Strength	ASTM D 6637	5,000
Creep Limited Strength	ASTM D 5262	3,165
Tensile Strength @ 5% Strain	ASTM D 6637	1,500
T_{al} = Long Term Design Strength	NCMA 97	2,740
Aperture Size - 2.00 x 2.00 (inches)	Measured	N/A

RF Creep - 1.58 RF Durability - 1.10 RF Installation Damage (Soil Type 3) - 1.05

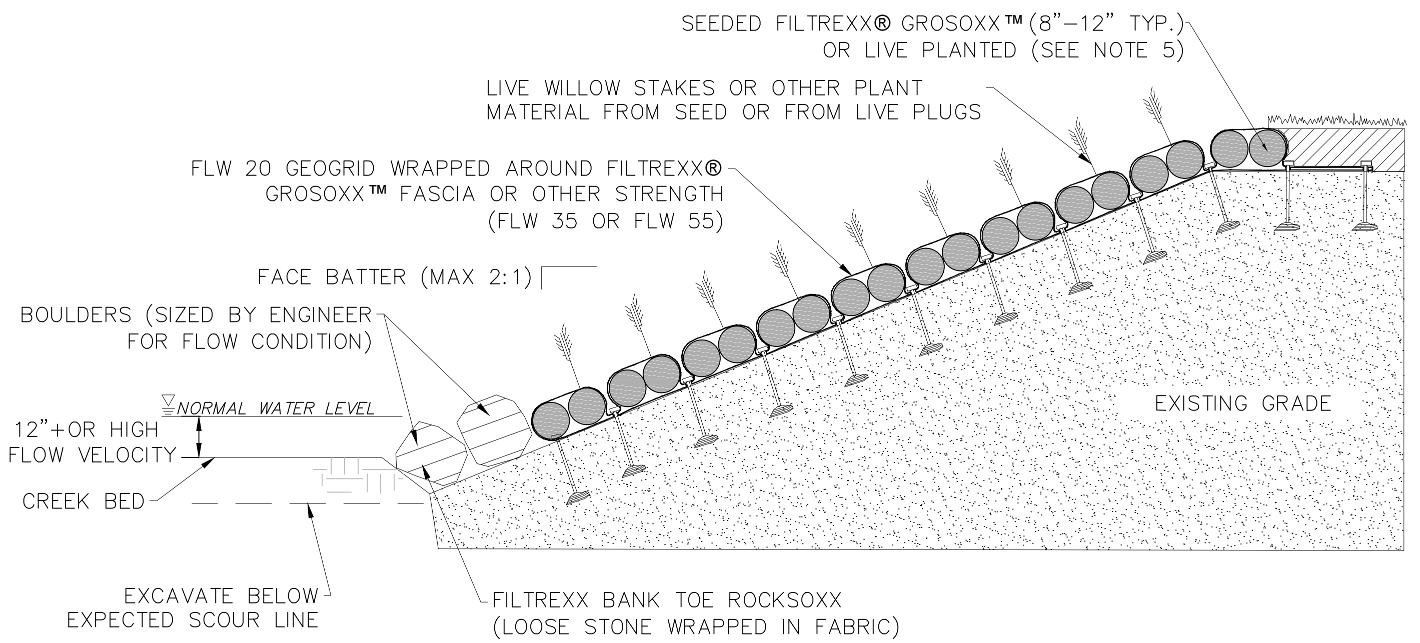
Figure 5.1. Engineering Design Drawing for Filtrexx Bank Stabilization



NOTES:
1. ALL MATERIAL TO MEET FILTREXX® SPECIFICATIONS.
2. GROSOXX™ FILL TO MEET APPLICATION REQUIREMENTS.
3. ALL GROSOXX™ TO BE SEEDED PER LANDSCAPE ARCHITECT'S SPECIFICATIONS.
4. BACKFILL TO BE PLACED PER ENGINEER'S REQUIREMENTS.
5. GEOGRID STRENGTH, LENGTH AND VERTICAL SPACING TO BE DETERMINED BY ENGINEER. GEOGRID – NO STRANDS ARE TO BE CUT DURING PLANTING, ETC. WE RECOMMEND BI-DIRECTIONAL STRENGTH FOR CONSTRUCTION EASE.
6. NATIVE AND DRAINAGE BACKFILL TO BE SEPARATED BY NON-WOVEN FILTER FABRIC.
7. MAXIMUM HEIGHT RECOMMENDED: TEN FEET EXPOSED HEIGHT.
8. FILTREXX® GROSOXX™ DEPENDS ON APPLICATION (SIZE DEPENDENT ON PROJECT)
9. WITNESS BARRIER SHOULD BE OPEN MESH GRID TO PERMIT PLANTING.

filtrexx SUSTAINABLE TECHNOLOGIES	These graphic representations are intended for preliminary design purposes only and are not to be used for construction without the signature of a registered professional engineer.	SCALE: NONE	**FILTREXX EDGESAVER STREAM BANK STABILIZATION SYSTEM**

Figure 5.2. Engineering Design Drawings for Filtrexx Bank Stabilization - Reinforced with Riprap Toe



NOTES:
1. ALL MATERIAL TO MEET FILTREXX® SPECIFICATIONS.
2. GROSOXX™ FILL TO MEET APPLICATION REQUIREMENTS.
3. ALL GROSOXX™ TO BE SEEDED PER LANDSCAPE ARCHITECT'S SPECIFICATIONS.
4. BACKFILL TO BE PLACED PER ENGINEER'S REQUIREMENTS.
5. GEOGRID STRENGTH, LENGTH AND VERTICAL SPACING TO BE DETERMINED BY ENGINEER. GEOGRID – NO STRANDS ARE TO BE CUT DURING PLANTING, ETC. WE RECOMMEND BI-DIRECTIONAL STRENGTH FOR CONSTRUCTION EASE.
6. NATIVE AND DRAINAGE BACKFILL TO BE SEPARATED BY NON-WOVEN FILTER FABRIC.
7. MAXIMUM HEIGHT RECOMMENDED: TEN FEET EXPOSED HEIGHT.
8. FILTREXX® GROSOXX™ DEPENDS ON APPLICATION (SIZE DEPENDENT ON PROJECT)
9. CUT BANK NO STEEPER THAN 2H:1V. FOR STEEPER EMBANKMENTS, REFER TO GREENLOXX SYSTEM.

filtrexx® SUSTAINABLE TECHNOLOGIES	These graphic representations are intended for preliminary design purposes only and are not to be used for construction without the signature of a registered professional engineer.	SCALE: NONE	**FILTREXX EDGESAVER STREAM BANK STABILIZATION SYSTEM - REINFORCED WITH RIPRAP TOE**

Figure 5.3. Staking Details for Filtrexx® Bank Stabilization

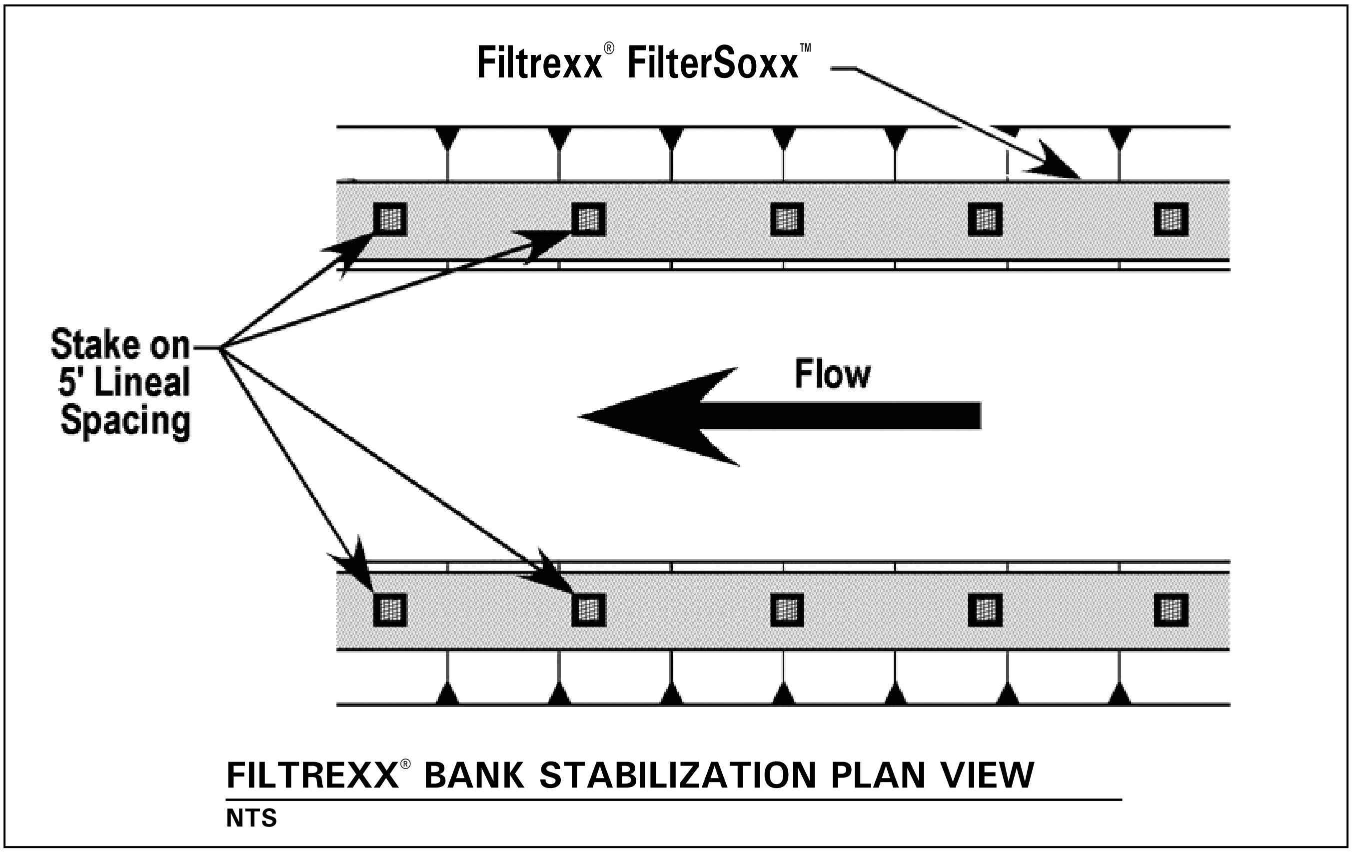


Figure 5.4. Staking Details for Filtrexx Bank Stabilization