

**NATURAL RESOURCES CONSERVATION SERVICE**  
**CONSERVATION PRACTICE STANDARD**  
**STREAMBANK AND SHORELINE PROTECTION**

(Ft.)

**CODE 580**

**DEFINITION**

Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries.

**PURPOSE**

This practice may be applied for one or more of the following purposes:

1. To prevent the loss of land or damage to land uses, or facilities adjacent to the banks of streams or constructed channels, shoreline of lakes, reservoirs, or estuaries including the protection of known historical, archeological, and traditional cultural properties;
2. To maintain the flow capacity of streams or channels;
3. To reduce the offsite or downstream effects of sediment resulting from bank erosion;
4. To improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, and recreation.

**CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to the banks of natural or constructed channels, shorelines of lakes, reservoirs, or estuaries where they are susceptible to erosion and the problem can be solved with relatively simple structural and/or vegetative treatments. It does not apply to erosion problems on main ocean fronts, beaches, or similar areas of complexity not normally within the scope of NRCS authority or expertise.

This practice may be used alone where appropriate, or as a component of a more comprehensive stream corridor restoration project that includes other practices such as channel stabilization, channel realignment, obstruction removal, in-stream fish and wildlife habitat enhancement, and riparian buffers.

**CRITERIA**

**General Criteria Applicable to All Purposes**

Treatments shall be in accordance with all applicable local, state, and federal laws and regulations. Obtain all required state and federal permits prior to the start of construction.

Treatments applied shall seek to avoid adverse effects to endangered, threatened, and candidate species and their habitats, whenever possible.

An assessment of unstable streambank or shoreline sites shall be conducted in sufficient detail to identify the causes contributing to the instability (e.g. livestock access, watershed alterations resulting in significant modifications of discharge or sediment production, in channel modifications such as gravel mining, head cutting, water level fluctuations, boat-generated waves, etc.).

Proposed protective treatments to be applied shall be compatible with improvements being planned or installed by others.

Protective treatments shall be compatible with the bank or shoreline materials, water chemistry, channel or lake hydraulics, and slope characteristics above and below the water line.

End sections of treatment areas shall be adequately anchored to existing treatments or terminated in stable areas.

Protective treatments shall be installed that result in stable slopes. Design limitations of the bank or shoreline materials and type of measure installed shall determine steepest permissible slopes.

Designs will provide for protection of installed treatments from overbank flows resulting from upslope runoff and flood return flows.

Internal drainage for bank seepage shall be provided when needed. Geotextiles or properly designed filter bedding shall be incorporated with structural measures where there is the potential for migration of material from behind the measure.

Treatments shall be designed to account for any anticipated ice action, wave action, and fluctuating water levels.

All disturbed areas around protective treatments shall be protected from erosion. Disturbed areas that are not to be cultivated shall be protected as soon as practical after construction.

**Vegetation.** All areas disturbed during construction shall be vegetated as necessary to prevent erosion. For areas where bioengineering plantings, tidal marsh plantings, or dune plantings will not be installed, use the conservation practice standard for Critical Area Planting (342) to stabilize disturbed soils. Otherwise, use the criteria for vegetation in this standard.

Select vegetative cover to accomplish the intended purpose of the practice and the objectives of the client. Plant types and species shall be selected based on their compatibility in growth rates, shade tolerance, moisture requirements, and other characteristics.

Plant materials shall either be native to Delaware, or introduced and non-invasive (i.e., not likely to spread beyond the planted area and displace native species). When feasible, select locally native plant species and/or species that are beneficial to wildlife. Herbaceous and/or woody plants may be appropriate. For best results, use

species and varieties with proven conservation traits.

Select bioengineering plant materials and tidal marsh plantings from Tables 2 to 4 of this standard. For additional lists of suitable bioengineering plants, and details concerning site preparation and use of these plants, refer to the NRCS Engineering Field Handbook, Chapter 16, *Streambank and Shoreline Protection* and East Region Supplement No. 1. (See the References section of this standard.)

When using unrooted woody plant materials (e.g., whips, fascines, and live stakes), select species that have a rooting ability of "Good" or better. (See Table 2 of this standard.) Species rated as "Fair" can be mixed with better rooting species. For species rated "Poor," use only bare-root or containerized materials.

Select and establish dune plantings based on recommendations in the publication *The Utility and Beauty of Coastal Dunes*. (See the References section of this standard.)

Site preparation and planting to establish vegetative cover shall be done at a time and manner to insure survival and growth of selected species. Provide supplemental moisture if and when necessary to assure early survival and establishment of selected species.

Use Figure 1 and Table 1 of this conservation practice standard to determine the appropriate planting dates for the different types of plant materials.

All plant materials shall be correctly handled before planting. In general, plant rooted and unrooted materials as soon as possible after receiving them from the supplier. For bare-root seedlings, keep the roots moist at all times and keep the plants out of direct sunlight as much as possible. Keep seed cool and dry until planting.

Only viable, high quality seed and planting stock shall be used. Plant materials shall be obtained from commercial sources, or in the case of unrooted woody materials (e.g., whips, live stakes), may be harvested from native stands during the dormant period (generally November - March, depending on location). The method of planting shall include hand or machine planting

techniques, suited to achieving proper depths and placement for the selected plant species.

Protect vegetation from unacceptable impacts due to pests, wildlife, livestock, or fire. Exclude livestock as needed to establish vegetative cover.

Control noxious weeds as required by state law.

### **Additional Criteria for Streambanks**

Stream segments to be protected shall be classified according to a system deemed appropriate by the state. Segments that are incised or that contain the 5-year return period (20 percent probability) or greater flows shall be evaluated for further degradation or aggradation.

A site assessment shall be performed to determine if the causes of instability are local (e.g. poor soils, high water table in banks, alignment, obstructions deflecting flows into bank, etc.) or systemic in nature (e.g. aggradation due to increased sediment from the watershed, increased runoff due to urban development in the watershed, degradation due to channel modifications, etc.). The assessment need only be of the extent and detail necessary to provide a basis for design of the bank treatments and reasonable confidence that the treatments will perform adequately for the design life of the measure.

The level of hydrologic and hydraulic analysis that is used shall be appropriate for the planned measures.

Treatments shall be functional and stable for the design flow, sustainable for higher flow conditions, and shall not induce an increase in natural erosion.

Treatments shall not limit stream flow access to the floodplain. Where flooding is a concern, the effects of protective treatments shall not increase flow levels above those that existed prior to installation.

Changes in channel alignment shall not be made without an assessment of both upstream and downstream fluvial geomorphology that evaluates the effects of the proposed alignment. The current and future discharge-sediment

regime shall be based on an assessment of the watershed above the proposed channel alignment.

Bank protection treatment shall not be installed in channel systems undergoing rapid and extensive changes in bottom grade and/or alignment unless the treatments are designed to control or accommodate the changes. Bank treatment shall be constructed to a depth at or below the anticipated lowest depth of streambed scour.

If the failure mechanism is a result of the degradation or removal of riparian vegetation, stream corridor restoration shall be implemented, where feasible (see Additional Criteria for Stream Corridor Improvement), as well as treating the banks.

Toe erosion shall be stabilized by treatments that redirect the stream flow away from the toe or by structural treatments that armor the toe. Additional design guidance is found in the EFH Part 650, Chapter 16, *Streambank and Shoreline Protection*.

Where toe protection alone is inadequate to stabilize the bank, the upper bank shall be shaped to a stable slope and vegetated or shall be stabilized with structural or soil-bioengineering treatments.

Channel clearing to remove stumps, fallen trees, debris, and sediment bars shall only be performed when they are causing or could cause unacceptable bank erosion, flow restriction, or damage to structures. Habitat forming elements that provide cover, food, pools, and water turbulence shall be retained or replaced to the extent possible.

### **Additional Criteria for Shorelines**

All revetments, bulkheads, or groins are to be no higher than 3 feet (1 meter) above mean high tide or mean high water in non-tidal areas.

Structural shoreline protective treatments shall be keyed to a depth to prevent scour during low water.

For the design of structural treatments, the site characteristics below the waterline shall be evaluated for a minimum of 50 feet (15 meters)

horizontal distance from the shoreline measured at the design water surface.

The height of the protection shall be based on the design water surface plus the computed wave height and freeboard. The design water surface in tidal areas shall be mean high tide.

When vegetation is selected as the protective treatment, a temporary breakwater shall be used during establishment when waves would damage the vegetation.

### **Additional Criteria for Stream Corridor Improvement**

Stream corridor vegetative components shall be established as necessary for ecosystem functioning and stability. The appropriate composition of vegetative components is a key element in preventing excess long-term channel migration in re-established stream corridors.

Treatments shall be designed to achieve habitat and population objectives for fish and wildlife species or communities of concern as determined by a site-specific assessment or management plan. Objectives shall be based on the survival and reproductive needs of populations and communities, which include habitat diversity, habitat linkages, daily and seasonal habitat ranges, limiting factors, and native plant communities. The type, amount, and distribution of vegetation shall be based on the requirements of the fish and wildlife species or communities of concern to the extent possible.

Treatments shall be designed to meet aesthetic objectives as determined by a site-specific assessment or management plan. Aesthetic objectives shall be based on human needs, including visual quality, noise control, and microclimate control. Construction materials, grading practices, and other site development elements shall be selected and designed to be compatible with adjacent land uses.

Treatments shall be designed to achieve recreation objectives as determined by a site-specific assessment or management plan. Safety requirements shall be based on type of human use and recreation objectives.

*Note: Specific programs may dictate criteria in addition to, or more restrictive than, those specified in this standard.*

### **CONSIDERATIONS**

Assess streambank or shoreline protection needs in sufficient detail to identify the causes contributing to the instability. Due to the complexity of such an assessment, an interdisciplinary team should be utilized.

When designing protective treatments, consider the changes that may occur in the watershed hydrology and sedimentation over the design life of the treatments.

Consider the need to stabilize side channel inlets and outlets, and the outlets of tributary streams from erosion.

Consider utilizing debris removed from the channel or streambank into the treatment design when it is compatible with the intended purpose to improve benefits for fish, wildlife, and aquatic systems.

Use construction materials, grading practices, vegetation, and other site development elements that minimize visual impacts and maintain or complement existing landscape uses such as pedestrian paths, climate controls, buffers, etc. Avoid excessive disturbance and compaction of the site during installation.

Consider the type of plant materials in relation to the timing of construction. Seeds may be planted in spring or fall, depending on the species selected. Unrooted plant materials (e.g. whips, fascines, live stakes) and bare-root plants are typically available only during late winter to early spring, and generally must be planted during that time period. Containerized stock may be available during most of the year, but the planting season is often constrained by lack of moisture in summer and frozen soils in winter.

Select plant materials that provide habitat requirements for desirable wildlife and pollinators. The addition of native forbs and legumes to grass mixes will increase the value of plantings for both wildlife and pollinators.

Consider using plant species that have multiple values such as those suited for biomass, nuts, fruit, browse, nesting, aesthetics, and tolerance to locally used herbicides. Avoid species that may be alternate hosts to disease or undesirable pests. Species diversity should be considered to avoid loss of function due to species-specific pests.

Consider treatments that promote beneficial sediment deposition and the filtering of sediment, sediment-attached, and dissolved substances.

Consider maintaining or improving the habitat value for fish and wildlife by including treatments that provide aquatic habitat in the treatment design and that may lower or moderate water temperature and improve water quality.

Consider aquatic habitat when selecting the type of toe stabilization.

Consider maximizing adjacent wetland functions and values with the project design and minimize adverse effects to existing wetland functions and values.

When appropriate, establish a buffer strip and/or diversion at the top of the bank or shoreline protection zone to help maintain and protect installed treatments; improve their function; filter out sediments, nutrients, and pollutants from runoff; and provide additional wildlife habitat.

Livestock exclusion should be considered during establishment of vegetative treatments, and appropriate grazing practices applied after establishment to maintain plant community integrity. Wildlife may also need to be controlled during establishment of vegetative treatments. Temporary and local population control methods should be used with caution and within state and local regulations.

Consider conservation and stabilization of archeological, historic, structural, and traditional cultural properties when applicable.

Consider safety hazards to boaters, swimmers, or people using the shoreline or streambank when designing treatments.

Protective treatments should be self-sustaining or require minimum maintenance.

*This practice has the potential to affect National Register listed cultural resources or eligible (significant) cultural resources. These may include archeological, historic, or traditional cultural properties. Care should be taken to avoid adverse impacts to these resources. Follow NRCS state policy for considering cultural resources during planning.*

## **PLANS AND SPECIFICATIONS**

Plans and specifications for this practice shall be prepared in accordance with the previously listed criteria, and shall contain sufficient detail to ensure successful implementation of this practice. Plans shall include treatments to minimize erosion and sedimentation during construction, and provisions necessary to comply with conditions of any applicable permits. Documentation shall be in accordance with the section "Supporting Data and Documentation" in this standard.

## **OPERATION AND MAINTENANCE**

An Operation and Management (O&M) plan shall be prepared and is the responsibility of the client to implement. The plan shall provide specific instructions for operating and maintaining the practice to insure that it functions properly. It shall also provide for periodic inspections and prompt repair or replacement of damaged components or erosion. Appropriate Fact Sheets may be used as supporting documentation and shall be provided to the client.

At a minimum, the following components shall be addressed in the O&M plan, as applicable:

1. Inspect the site annually, and following each major storm event;
2. Take corrective actions as needed to replace destroyed plant materials or dislodged mulching materials. Reshape and replant areas damaged by high flows. Where vegetative measures have failed, reassess the suitability of the chosen species for the site and the need for structural measures to complement the vegetative measures;
3. Repair damaged structural measures;

4. Remove sediment bars, undesirable vegetation, or other stream obstructions that may be causing unplanned diversion of flow. Depending on the location and extent of the work, federal and state permits may be needed before repairs are made.

### **SUPPORTING DATA AND DOCUMENTATION**

The following is a list of the minimum data and documentation to be recorded in the case file:

1. Location of the practice on the conservation plan map;
2. Assistance notes. The notes shall include dates of site visits, name or initials of the person who made the visit, specifics as to alternatives discussed, decisions made, and by whom.

### **Field Data and Survey Notes**

The following is a list of the minimum data needed:

1. Field location and extent of planned work in linear feet;
2. Plan view sketch;
3. Topographic survey of site;
4. For streambanks, appropriate stream channel profiles and cross-sections to collect necessary data for design analysis, including upstream and downstream of site and any reference sites used;
5. For streams, collection of appropriate channel information for classification purposes where needed, such as field indicators of baseline water surface elevations and bankfull elevations;
6. For shorelines, appropriate cross-sections for design and quantity determination;
7. Inventory of the type and condition of existing vegetation (especially noting invasive or nuisance species), where applicable;

8. Appropriate analysis of bed or base material;
9. Soil investigation logs and notes.

### **Design Data**

Record on appropriate engineering paper. For guidance on the preparation of engineering plans see Chapter 5 of the Engineering Field Handbook, Part 650. The following is a list of the minimum required design data:

1. Plan view including location map, north arrow, all system components, material and construction specifications, spoil areas, sediment control measures, benchmarks, stationing, clearing limits and other details;
2. Determine soil types and any special restrictions;
3. Appropriate hydrologic and hydraulic analysis for the planned system;
4. Dimensions of structural measures;
5. Material specifications including gradation of stone, geotextile class, gabion type, etc.;
6. Planned grades and dimensions shown on cross-sections, profiles, and plan views, as applicable;
7. Disposal methods for woody materials and spoil;
8. Seeding and/or planting requirements, including species selected for each planting area, stocking/seeding rates, and type, age, and size of planting stock to be used (e.g. bare-root seedlings, containerized stock, etc.), shown on plans;
9. Quantities estimate;
10. Show job class on plans;
11. Sediment control notes and details;
12. Permit requirements (if any);
13. Written operation and maintenance plan.

**Utilities Notification**

1. Forms ENG-5 and ENG-6 can be used to assist in tracking utility notifications;
2. Document on CPA-6 initial discussion about the landowner's responsibility to notify Miss Utility;
3. Document on CPA-6 any information from the landowner about the existence and location of known utilities;
4. Document on CPA-6 assurances from the landowner that Miss Utility has been notified, including staking by the utilities.

**Construction Check Data/As-Built Plans**

Record on survey notepaper, NRCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted in red on the as-built plans. Document approval by the designer of any changes from the drawings or specifications before implementation of the change.

The following is a list of minimum data needed for as-built documentation:

1. Documentation of site visits on CPA-6. Include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom;
2. Check notes recorded during or after completion of construction showing grade and cross section of constructed measures;
3. Statement on seeding and other vegetation established;
4. Final quantities and documentation for quantity changes and materials certification;
5. Sign and date check notes and plans by someone with appropriate approval authority. Include statement that practice meets or exceeds plans and NRCS practice standards.

The design folder, as-built drawings, certifications, and specifications shall be filed in the case file.

**REFERENCES**

1. Delaware Cooperative Extension, University of Delaware. January, 2013. *Turfgrass Selections for Delaware*.
2. Delaware Department of Natural Resources and Environmental Control. *The Flora of Delaware Online Database*.  
<http://www.wra.udel.edu/de-flora/Introduction/>
3. Ocean City Dune Stabilization Committee, in cooperation with the Worcester Soil Conservation District and the Natural Resources Conservation Service. February, 1998. *The Utility and Beauty of Coastal Dunes*.
4. USDA, Natural Resources Conservation Service. *Conservation Practice Standards*. Delaware Field Office Technical Guide, Section IV.
5. USDA, Natural Resources Conservation Service. *Guidelines for Planning and Designing Streambank and Shoreline Protection Projects*. National Engineering Handbook, Part 650, Chapter 16, East Region Supplement No. 1.
6. USDA, Natural Resources Conservation Service. *Soil Bioengineering for Upland Slope Protection and Erosion Reduction*. Engineering Field Handbook, Part 650, Chapter 18.
7. USDA, Natural Resources Conservation Service. *Streambank and Shoreline Protection*. Engineering Field Handbook, Part 650, Chapter 16.

FIGURE 1: USDA Plant Hardiness Zones for Delaware



**TABLE 1: Recommended Planting Dates for Delaware <sup>1/</sup>**

Type of Plant Material	Plant Hardiness Zones
	7a and 7b
Seeds - Cool-Season Grasses	Feb 15 to Apr 30 Aug 15 to Oct 31 Nov 1 to Nov 30♦
Seeds – Warm-Season Grasses	Feb 15 to Apr 30♦♦ <i>May 1 to May 31*</i>
Dormant Cuttings; Bare-Root Seedlings <sup>2/</sup>	Feb 15 to Apr 30 <i>May 1 to Jun 30*</i>
Container Plants; Balled-and-Burlapped Stock	Feb 15 to Apr 30 <i>May 1 to Jun 30*</i> <i>Oct 1 to Dec 15*✦</i>

**TABLE 1 NOTES:**

- The planting dates listed are averages for each zone. These dates may require adjustment to reflect local conditions, especially near the boundaries of the zones.
- Dormant cuttings (e.g., whips, fascines, live stakes, poles) and bare-root seedlings may be planted during the growing season, but must be purchased and kept in a dormant condition until planting. Bare-root grasses are the exception—they may be supplied as growing (non-dormant) plants.
  - ♦ Additional planting dates for the lower Coastal Plain, dependent on annual rainfall and temperature trends.
  - ♦♦ Warm-season grasses need a soil temperature of at least 50 degrees F in order to germinate. If soil temperatures are colder than 50 degrees, or moisture is not adequate, the seeds will remain dormant until conditions are favorable. In general, planting during the latter portion of this period allows more time for weed emergence and weed control prior to planting. When selecting a planting date, consider the need for weed control vs. the likelihood of having sufficient moisture for later plantings, especially on droughty sites.
  - \* Additional planting dates during which supplemental watering may be needed to ensure plant establishment.
  - ✦ Frequent freezing and thawing of wet soils may result in frost-heaving of materials planted in late fall if plants have not sufficiently rooted in place. Large container plants and balled-and-burlapped stock may be planted into the winter months as long as the ground is not frozen and soil moisture is adequate.

TABLE 2: Selected List of Woody Plants for Streambank and Shoreline Stabilization

Plant Names	Plant Hardiness Zones <sup>1/</sup>	Geographic Distribution in Delaware <sup>1/</sup>	Planting Zone <sup>2/</sup>	Sun/Shade <sup>3/</sup>	Growth Rate	Height at 20 years	Rooting Ability from Cuttings <sup>4/</sup>	Type of Plant Material Available	Natural Habitat and Other Characteristics
ARROWWOOD <i>Viburnum dentatum</i>	All	Statewide	Mid to Upper Bank	○ - ◐	Fast	10 ft.	Fair	Bare-root, Containerized	Shrub swamps and forested wetlands. Suckers freely. White flowers, bluish-black berries.
BLACK-HAW <i>Viburnum prunifolium</i>	All	Statewide	Upper Bank	○ - ◐	Slow	12 ft.	Poor	Bare-root, Containerized	Upland forests and hedgerows. White flower clusters, blue berries, red fall color. Fruits may remain on shrubs for much of the winter.
BUSH, HIGH-TIDE (GROUNDSEL) <i>Baccharis halimifolia</i>	All	Coastal Plain	Mid to Upper Bank	○	Moderate	10 ft.	Fair	Whips, Fascines, Bare-root, Containerized	Brackish and coastal marshes, usually above MHW. Salinity 0-15 ppt. Has fluffy white seeds. Male flowers & female flowers on separate plants.
BUSH, HIGH-TIDE (MARSH-ELDER) <i>Iva frutescens</i>	All	Coastal Plain	Lower to Mid Bank	○	Moderate	10 ft.	Fair	Whips, Fascines, Bare-root, Containerized	Brackish and coastal marshes, usually above MHW. Salinity 0-15 ppt.
BUTTONBUSH <i>Cephalanthus occidentalis</i>	All	Statewide	Toe	○ - ◐	Slow	8 ft.	Fair - Good	Bare-root, Containerized	Shrub swamps and streambanks. Unusual, round white flowers. Tolerates long periods of inundation.
DOGWOOD, GRAY <i>Cornus racemosa</i>	All	Mostly Piedmont	Mid to Upper Bank	○ - ◐	Fast	10 ft.	Poor	Bare-root, Containerized	Forested wetlands and streambanks. Produces fruit at 3-5 years of age. White flowers with white berries on reddish stalks. Prefers some shade.

TABLE 2: Selected List of Woody Plants for Streambank and Shoreline Stabilization

Plant Names	Plant Hardiness Zones <sup>1/</sup>	Geographic Distribution in Delaware <sup>1/</sup>	Planting Zone <sup>2/</sup>	Sun/ Shade <sup>3/</sup>	Growth Rate	Height at 20 years	Rooting Ability from Cuttings <sup>4/</sup>	Type of Plant Material Available	Natural Habitat and Other Characteristics
DOGWOOD, REDOSIER 'RUBY' <i>Cornus sericea</i>	All	Statewide; uncommon	Toe to Mid Bank	○ - ◐	Fast	8 ft.	Good	Whips, Fascines, Live Stakes, Bare-root, Containerized	Forested wetlands and streambanks. Attractive red stem color. White flowers and fruit.
DOGWOOD, SILKY <i>Cornus amomum</i>	All	Statewide	Lower to Mid Bank	○ - ◐	Fast	10 ft.	Fair	Whips, Fascines, Live Stakes, Bare-root, Containerized	Forested wetlands and streambanks. Produces fruit at 3-5 years of age. White flowers with blue berries. Prefers some shade.
ELDERBERRY <i>Sambucus nigra</i> <i>ssp. canadensis</i> (formerly <i>S. canadensis</i> )	All	Statewide	Toe to Upper Bank	○ - ◐	Fast	12 ft.	Fair	Whips, Fascines, Live Stakes, Bare-root, Containerized	Open, forested wetlands and streambanks. Suitable for use as a secondary component of plantings with willows and dogwoods. Suckers freely.
WILLOW, DWARF 'BANKERS' <i>Salix X cottetii</i>	All	Introduced; not native to U.S.	Toe to Mid Bank	○ - ◐	Fast	5 ft.	Good	Whips, Fascines, Live Stakes, Bare-root, Containerized	Male hybrid (sterile), non-invasive. Semi-prostrate shrub, sends up many branches from the roots to form dense surface cover in 2-3 years.
WILLOW, PURPLEOSIER 'STREAMCO' <i>Salix purpurea</i>	All	Introduced; not native to U.S.	Toe to Upper Bank	○ - ◐	Fast	20 ft.	Excellent	Whips, Fascines, Live Stakes, Poles, Bare-root, Containerized	Non-invasive shrub. 'Streamco' is a male clone, does not root sucker, and does not spread readily beyond the planting site.
WILLOW, PUSSY <i>Salix discolor</i>	All	Statewide	Toe to Mid Bank	○ - ◐	Fast	20 ft.	Very Good	Whips, Fascines, Live Stakes, Poles, Bare-root, Containerized	Forested wetlands and streambanks. Fuzzy flower catkins appear in early spring. Grows rapidly, but does not spread readily beyond the planting site.

TABLE 2: Selected List of Woody Plants for Streambank and Shoreline Stabilization

Plant Names	Plant Hardiness Zones <sup>1/</sup>	Geographic Distribution in Delaware <sup>1/</sup>	Planting Zone <sup>2/</sup>	Sun/ Shade <sup>3/</sup>	Growth Rate	Height at 20 years	Rooting Ability from Cuttings <sup>4/</sup>	Type of Plant Material Available	Natural Habitat and Other Characteristics
WILLOW, SANDBAR 'GREENBANK' <i>Salix exigua</i>	All	Statewide	Toe	○	Fast	15 ft.	Good	Whips, Fascines, Live Stakes, Poles, Bare-root, Containerized	Streambanks and sandbars. <b>Caution:</b> This is a native species that may aggressively spread by root suckering into adjacent areas.
WILLOW, SILKY <i>Salix sericea</i>	All	Statewide	Toe to Mid Bank	○ - ●	Fast	20 ft.	Good	Whips, Fascines, Live Stakes, Poles, Bare-root, Containerized	Forested wetlands and streambanks. Fuzzy flower catkins appear in early spring. Grows rapidly, but does not spread readily beyond the planting site.

## TABLE 2 NOTES:

- The **Plant Hardiness Zones** designate where a species can be successfully planted in Delaware, while the **Geographic Distribution** describes where the species usually occurs under natural conditions.
- Planting Zone:** Recommended area for planting each species, based on tolerance of flooding, long periods of saturation, and drought.  
Toe - at base flow elevation;  
Lower to Mid Bank - just above the baseflow elevation to the two-year flood elevation;  
Upper Bank - above the two-year flood elevation and onto the floodplain.
- Sun - Shade:** Sunlight and shade tolerance for each species.  
○ Full Sun - 6 or more hours of light per day or 4 hours of midday sun;  
● Part Shade - 3 to 6 hours of light per day;  
● Shade - less than 3 hours of light per day.
- Rooting Ability from Cuttings:** Subjective rating of the ability of cut stems of woody plants to root in soil without any special measures (e.g., without the use of a rooting hormone or greenhouse conditions). When using unrooted woody plant materials such as whips, fascines, live stakes, or poles, select species that have a rooting ability of "Good" or better. Species rated as "Fair" can be mixed with better rooting species. For species rated "Poor," use only bare-root or containerized materials.  
Generally, no special site preparation or soil amendments are required at the time of planting. Sites with low fertility, based on results from a soil test, may benefit from top-dressing with fertilizer after leaf-out.

TABLE 3: Selected List of Companion Grasses for Woody Bioengineering Plantings

Plant Names	Recommended Cultivar	Plant Hardiness Zones <sup>1/</sup>	Planting Zone <sup>2/</sup>	Sun/Shade <sup>3/</sup>	Growth Rate	Max. Height	Planting Rate <sup>3/</sup>	Natural Habitat and Other Characteristics
BLUEGRASS, ROUGH <i>Poa trivialis</i>	Laser, Saber	All	Lower to Mid Bank	○ - ●	Moderate	2 ft.	Plant seed at the rate of 10 lbs./acre (0.23 lbs./1,000 SF).	Introduced, cool-season, sod-forming grass. Medium textured, non-competitive. Prefers moist, shady sites; moderately well drained to somewhat poorly drained soils. More shade tolerant than <i>Poa palustris</i> . May be short-lived on the Coastal Plain, especially on drier sites in full sun.
FESCUE, CREEPING RED <i>Festuca rubra</i> var. <i>rubra</i>	Dawson, Jasper, Navigator	All	Mid to Upper Bank	○ - ●	Moderate	2 ft.	Plant seed at the rate of 20 lbs./acre (0.45 lbs./1,000 SF).	Found in shady, upland areas. Native, cool-season, sod-forming grass. Fine textured, non-competitive. Use on upland sites, especially in shady conditions. Prefers well drained to somewhat poorly drained soils. The 'Dawson' variety is salt-tolerant.
MEADOWGRASS, FOWL <i>Poa palustris</i>	Common	All	Lower to Mid Bank	○ - ◐	Moderate	3 ft.	Plant seed at the rate of 10 lbs./acre (0.23 lbs./1,000 SF).	Found in moist, shady sites. Native, cool-season, sod-forming grass. Fine textured, non-competitive. Prefers moderately well drained to somewhat poorly drained soils. May be short-lived on the Coastal Plain, especially on drier sites in full sun.
RYEGRASS, PERENNIAL <i>Lolium perenne</i>	Recommended DE turf-types	All	Mid to Upper Bank	○ - ◐	Fast	2 ft.	Plant seed at the rate of 10 lbs./acre (0.23 lbs./1,000 SF).	Introduced, cool-season grass. Bunch grass with medium longevity. Seedlings establish quickly. Prefers moist sites; moderately well drained to somewhat poorly drained soils.

**TABLE 3: Selected List of Companion Grasses for Woody Bioengineering Plantings**

Plant Names	Recommended Cultivar	Plant Hardiness Zones <sup>1/</sup>	Planting Zone <sup>2/</sup>	Sun/Shade <sup>3/</sup>	Growth Rate	Max. Height	Planting Rate <sup>3/</sup>	Natural Habitat and Other Characteristics
WILD RYE, VIRGINIA <i>Elymus virginicus</i>	Common	All	Lower to Mid Bank	○ - ●	Moderate	3 ft.	Plant seed at the rate of 10 lbs./acre (0.23 lbs./1,000 SF).  This seeding rate is for Pure Live Seed. (Seed is usually sold with awns still attached.)	Found along rivers and streams on moist, shady sites. Native, cool-season grass. Short-lived, coarse textured bunch grass. Seedlings establish quickly, but are not highly competitive with other plantings. Prefers moderately well drained to poorly drained soils.

**TABLE 3 NOTES:**

- The **Plant Hardiness Zones** designate where a species can be successfully planted in Delaware.
- Planting Zone:** Recommended area for planting each species, based on tolerance of flooding, long periods of saturation, and drought.  
Toe - at base flow elevation;  
Lower to Mid Bank - just above the baseflow elevation to the two-year flood elevation;  
Upper Bank - above the two-year flood elevation and onto the floodplain.
- Sun - Shade:** Sunlight and shade tolerance for each species.  
○ Full Sun - 6 or more hours of light per day or 4 hours of midday sun;  
◐ Part Shade - 3 to 6 hours of light per day;  
● Shade - less than 3 hours of light per day.
- Generally, no special site preparation or soil amendments are required at the time of planting. Sites with low fertility, based on results from a soil test, may benefit from top-dressing with fertilizer after grasses germinate and are actively growing.

TABLE 4: Selected List of Native Grasses and Grass-like Plants for Tidal Shoreline Stabilization <sup>1/</sup>

Plant Names	Plant Hardiness Zones <sup>2/</sup>	Geographic Distribution in Delaware <sup>2/</sup>	Planting Zone <sup>3/</sup>	Sun/Shade <sup>4/</sup>	Growth Rate	Max. Height	Planting Rate <sup>3/</sup>	Natural Habitat and Other Characteristics
BEACHGRASS, AMERICAN 'CAPE' <i>Ammophila breviligulata</i>	All	Coastal Plain	Above MHT	○	Fast	3 ft.	Plant containerized plants and bare-root plants 18 to 24 inches apart, in staggered rows. If the site is exposed to severe wind erosion, spacing needs to be reduced to 12 inches.	Upland sites with sandy or other coarse textured soils. Cool-season grass. Strongly rhizomatous. Highly salt tolerant and drought tolerant. Does not tolerate much soil moisture. Use on coastlines for initial stabilization of frontal sand dunes.
BULRUSH, THREE-SQUARE <i>Schoenoplectus pungens</i> (formerly <i>Scirpus pungens</i> )	All	Statewide	Mid-tide to MHT	○	Fast	3 ft.	Plant containerized plants and bare-root plants 12 to 24 inches apart, in staggered rows.	Shallow fresh to brackish marshes and open water fringes. Salinity 0–15 ppt.
CORDGRASS, GIANT <i>Spartina cynosuroides</i>	All	Coastal Plain	Near MHT to above MHT	○	Moderate	10 ft.	Plant containerized plants and bare-root plants 18 to 36 inches apart, in staggered rows.	Upper intertidal zone of tidal marshes, and saturated soils above MHT. Warm-season grass. Up to 0.5 feet of lateral spread can be expected annually. Salinity 0 – 10 ppt.
CORDGRASS, PRAIRIE <i>Spartina pectinata</i>	All	Statewide	Mid-tide to above MHT	○	Fast	6 ft.	Plant containerized plants and bare-root plants in staggered rows 24 to 36 inches apart, with plants 24 inches apart in each row.	Occurs in wet ditches and on upper margins of tidal fresh areas, and in saturated nontidal wetlands. Warm-season grass. Strongly rhizomatous; 5 – 10 feet of lateral spread can be expected annually. Tolerates seasonal dryness once established. Low tolerance to prolonged flooding or ponding. Salinity 0-3 ppt.

TABLE 4: Selected List of Native Grasses and Grass-like Plants for Tidal Shoreline Stabilization <sup>1/</sup>

Plant Names	Plant Hardiness Zones <sup>2/</sup>	Geographic Distribution in Delaware <sup>2/</sup>	Planting Zone <sup>3/</sup>	Sun/Shade <sup>4/</sup>	Growth Rate	Max. Height	Planting Rate <sup>3/</sup>	Natural Habitat and Other Characteristics
CORDGRASS, SALTMEADOW 'AVALON' <i>Spartina patens</i>	All	Coastal Plain	Above MHT	○	Fast	3 ft.	Plant containerized plants and bare-root plants 18 to 36 inches apart, in staggered rows.	Tidal marshes between MHT and the 15-foot elevation above MHT. Warm-season grass. Strongly rhizomatous; up to 2 feet of lateral spread can be expected annually. Salinity 0 – 35 ppt.
CORDGRASS, SMOOTH 'BAYSHORE' <i>Spartina alterniflora</i>	All	Coastal Plain	Mid-tide to MHT	○	Fast	6 ft.	Plant containerized plants and bare-root plants 18 to 36 inches apart, in staggered rows.	Intertidal zone of tidal marshes. Warm-season grass. Up to 2 feet of lateral spread can be expected annually. Salinity 0 – 35 ppt.
PANICGRASS, COASTAL 'ATLANTIC' <i>Panicum amarum</i> var. <i>amarulum</i>	All	Coastal Plain	Above MHT	○	Moderate	6 ft.	Plant containerized plants and bare-root plants in staggered rows 2 to 3 feet apart, with plants 2 feet apart in each row.  Plant seed at the rate of 20 lbs./acre (0.45 lbs./1,000 SF).	Naturally found on dry upland sites. Warm-season grass. Drought tolerant. Moderately salt tolerant. Used extensively for secondary dune stabilization. May be interseeded between rows of American Beachgrass.
RUSH, SOFT <i>Juncus effusus</i>	All	Statewide	Near MHT to above MHT	○	Moderate	3 ft.	Plant containerized plants and bare-root plants 6 to 12 inches apart, in staggered rows.	Upper intertidal zone of tidal fresh marshes, saturated soils above MHT, and in saturated nontidal wetlands. Moderately drought tolerant once established. Salinity to 0.5 ppt (fresh water).

**TABLE 4: Selected List of Native Grasses and Grass-like Plants for Tidal Shoreline Stabilization <sup>1/</sup>**

<b>Plant Names</b>	<b>Plant Hardiness Zones <sup>2/</sup></b>	<b>Geographic Distribution in Delaware <sup>2/</sup></b>	<b>Planting Zone <sup>3/</sup></b>	<b>Sun/ Shade <sup>4/</sup></b>	<b>Growth Rate</b>	<b>Max. Height</b>	<b>Planting Rate <sup>3/</sup></b>	<b>Natural Habitat and Other Characteristics</b>
SWITCHGRASS <i>Panicum virgatum</i> 'BLACKWELL' 'CARTHAGE' 'CAVE-IN-ROCK' 'HIGH TIDE' 'SHELTER'	All	Statewide	Above MHT	○	Moderate	6 ft.	Plant containerized plants and bare-root plants in staggered rows 2 to 3 feet apart, with plants 2 feet apart in each row.  Plant seed at the rate of 20 lbs./acre (0.45 lbs./1,000 SF).	Occurs on upper margins of fresh and brackish tidal marshes. Native, warm-season bunchgrass. Wide range of adaptation from dry uplands to poorly drained sites. Moderately salt tolerant. Salinity 0 – 10 ppt. 'Blackwell,' 'Carthage,' and 'Shelter' varieties are better suited for well-drained to somewhat poorly drained sites. 'Cave-in-Rock' is a lowland type that tolerates droughty soils, but is better suited to wet sites and frequent flooding. 'High Tide' is a Mid-Atlantic ecotype specifically selected for tidal shorelines and streambank stabilization.

**TABLE 4 NOTES:**

- 1. Selected List of Native Grasses and Grass-like Plants:** The term "native" refers to species that occur naturally in one or more geographic regions of Delaware. Due to page limitations, this list is not all-inclusive. There are many other species that may be suitable, depending on site conditions.
- 2. The Plant Hardiness Zones** designate where a species can be successfully planted in Delaware, while the **Geographic Distribution** describes where the species usually occurs under natural conditions.
- 3. Planting Zone:** Recommended area for planting each species, based on tolerance of flooding, long periods of saturation, and drought. Mid-tide – elevation midway between mean low tide (MLT) and mean high tide (MHT); MHT – elevation at mean high tide; Above MHT - above the mean high tide elevation.
- 4. Sun - Shade:** Sunlight and shade tolerance for each species.  
○ Full Sun - 6 or more hours of light per day or 4 hours of midday sun; ◐ Part Shade - 3 to 6 hours of light per day; ● Shade - less than 3 hours of light per day.
- 5.** Generally, no special site preparation or soil amendments are required at the time of planting. Sites with low fertility, based on results of a soil test, may benefit from top-dressing with fertilizer when plants are actively growing.