

USDA
NATURAL RESOURCES
CONSERVATION SERVICE
MARYLAND CONSERVATION
PRACTICE STANDARD
**STREAMBANK AND
SHORELINE PROTECTION**
CODE 580
(Reported by Feet)

DEFINITION

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

PURPOSES

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, and shorelines of lakes, reservoirs, or estuaries;
2. To maintain the flow capacity of streams or channels;
3. 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, recreation.

**CONDITIONS WHERE PRACTICE
APPLIES**

This practice may be applied on the banks of natural or constructed watercourses that are susceptible to erosion due to the action of water, ice or debris, or have been damaged by livestock, human activity, or vehicular traffic. Streambeds must be stable and not subject to excessive degradation and scour, headcutting, or downcutting.

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.

This practice also applies to controlling erosion on the shorelines of lakes, reservoirs, estuaries, and other water bodies where the problem can be solved with relatively simple structural and/or vegetative measures.

This practice does not apply to:

1. Sites with complex erosion problems not normally within the scope of NRCS authority or expertise. Streambank and shoreline protection measures are not suitable for use on complex, unstable sites unless the cause of erosion can be identified and adequately treated;
2. Sites with erosion problems on main ocean fronts, beaches or similar areas of complexity.
3. Sites where failure of streambank or shoreline protection measures would be hazardous to human life, or would result in significant damage to property;
4. Plantings that are intended to function primarily as filter strips or riparian buffers, for which other standards are applicable. (Refer to the Maryland conservation practice standard for Filter Strip, Code 393; and Riparian Forest Buffer, Code 391.)

CONSIDERATIONS

Consider the long-term land use objectives of the client and how the implementation of this practice will affect those objectives.

Assess site conditions in sufficient detail to identify the causes contributing to the streambank or shoreline instability (e.g., watershed alterations resulting in significant modifications of stream flow or sediment production). The complexity of such an assessment may require utilizing an interdisciplinary team to address the problem.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the [Natural Resources Conservation Service - Maryland](#) or visit the [electronic Field Office Technical Guide \(eFOTG\)](#).

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

Consider protecting side channel inlets and outlets from erosion.

Consider treatment measures that will be self-sustaining or will require minimum maintenance.

Consider treatment measures that will maintain or improve the habitat value for fish and wildlife, including those that will improve water quality, reduce water temperature, and provide food and cover.

Consider aquatic habitat when selecting the type of toe stabilization.

Treatments that promote beneficial sediment deposition and the filtering of sediment, sediment-attached, and dissolved substances should be considered.

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.

Consider utilizing debris removed from the channel or streambank in the treatment design.

Livestock exclusion shall 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.

When selecting plant materials, consider using a diverse mix of species in order to improve wildlife habitat, and minimize problems due to species-specific pests.

Also 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.

Identify and evaluate other constraints such as state and federal regulatory requirements for obtaining permits in waters and wetlands, management options, site access, or cost-share program requirements. Specific cost-sharing programs or other funding sources may impose criteria in addition to, or more restrictive than, those specified in this standard. For projects where work is planned below the waterline, do not schedule construction activities to occur in nontidal waters during fish spawning season—this is the instream closure period, as required by state water quality regulations.

Consider the cost and feasibility of various treatment measures versus the value or safety of the property being protected, risk of future damages, and future repair costs. Before considering more expensive options, such as substantial earthmoving and structural measures, give careful consideration to the feasibility of less expensive alternatives such as bioengineering.

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.

CRITERIA

General Criteria

Streambanks and shorelines shall be stabilized by utilizing the following components, either alone or in combination, as appropriate:

1. Live plant materials;
2. Structural materials such as rock, wood, concrete, or geosynthetics.

Design and install protective measures according to a site-specific plan and in accordance with all applicable federal, state and local laws and regulations.

Where deterioration of the streambank or shoreline is caused or accelerated by livestock, human activity, or vehicular traffic, provide appropriate exclusion measures such as fencing or designated travelways for access.

Designs shall provide for protection from upslope runoff. When needed, establish a diversion and/or buffer area at the top of the bank or shoreline protection zone to help maintain and protect installed measures, improve their function, filter out sediments, nutrients, and pollutants from runoff, and provide additional wildlife habitat. Use the Maryland conservation practice standards for Diversion, Code 362; Riparian Forest Buffer, Code 391; Filter Strip, Code 393; and Field Border, Code 386 as appropriate to divert or filter runoff, or provide a protective set-back from the top of bank.

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

Measures shall be designed for anticipated ice action, wave action and fluctuating water levels.

Measures shall be compatible with the bank or shoreline materials, water chemistry, channel or shoreline hydraulics, and slope characteristics both above and below the water line. End sections shall be adequately tied in to existing measures, terminate in stable areas, or be otherwise stabilized.

Protect disturbed areas from erosion as soon as practical after construction. Coordinate the installation of vegetative and structural components as construction progresses to ensure stabilization.

Slope Stability - Measures shall be installed on stable slopes. Bank or shoreline materials and the types of measures installed shall determine maximum slopes.

Steep, unstable slopes and deep undercuts in banks shall be shaped and graded to a stable slope, or structural measures such as rock riprap,

gabions, bulkheads, cribwalls, rootwads, or other appropriate techniques shall be used to provide slope stability. For planting purposes, the steepest acceptable slope is 1.5:1.

Permits - Federal, state, and local regulations may significantly limit management activities in or adjacent to ponds, streams, wetlands and other aquatic areas. Laws pertaining to protection of wetlands and water bodies, and erosion and sediment control may be applicable. Permits or approvals from federal, state, or local government agencies may be needed before any work is performed.

Additional Criteria for Materials

Gabions - Gabions shall meet the materials requirements of the Maryland Department of Transportation, State Highway Administration, Standard Specifications for Construction and Materials, Section 313.

Rock Riprap - Rock riprap shall meet the requirements of Maryland Department of Transportation, State Highway Administration Standard Specification for Construction and Materials, Section 901.02.

Gravel - Crushed rock or gravel shall comply with gradations and quality required by the Maryland Department of Transportation, State Highway Administration, Standard Specifications for Construction and Materials, Section 901.

Concrete - Concrete shall meet the requirements of Maryland Department of Transportation, State Highway Administration Standard Specifications for Construction and Materials, Section 902.10, Mix No. 3.

Structural Backfill - Backfill material shall be free of large rocks (>6 inches), limbs, rubbish, and other debris. Fill shall be placed in horizontal layers no more than 4 inches thick, then compacted by hand tampers or other manually directed compaction equipment. Adequate moisture shall be maintained in the fill material during placement to facilitate compaction.

Soil Stabilization Matting - Biodegradable matting shall be used as needed to provide temporary erosion control until seedlings or other plantings become well established. These

materials are especially applicable where high water velocities are expected.

Matting shall have a uniform thickness and distribution of natural or other biodegradable synthetic fibers or cords that freely allow penetration by water and plant seedlings. The materials shall resist decay for a minimum of 6 months, and shall not contain any harmful chemicals or other materials that may leach into the soil, or reduce the germination and establishment of seedlings.

Biodegradable matting shall be applied on seeded areas and shall be secured to the soil surface according to the manufacturer's instructions.

Permanent geotextiles (non-biodegradable) may also be used where long-term erosion control is needed. These materials shall also be installed according to the manufacturer's instructions.

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 Maryland conservation practice standard for Critical Area Planting, Code 342, to stabilize disturbed soils. Otherwise, the following criteria for vegetation shall apply:

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 Maryland, 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

Streambank protection measures shall be functional for the design flow, and sustainable for higher flow conditions based on acceptable risk. The minimum design discharge shall be the channel capacity or 10-year frequency discharge, whichever is less. A larger design storm may be appropriate when protecting valuable property.

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 the 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 to the extent and detail necessary to provide a basis for design of the bank treatments with reasonable confidence that the treatments will perform adequately for the design life of the measure.

Changes in channel alignment shall not be made without an assessment of both upstream and downstream fluvial geomorphology to evaluate the affects 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.

The level of hydrologic and hydraulic analysis that is used shall be appropriate for the planned measures. Design discharge and/or hydrographs for capacity shall be determined by using analysis methods such as:

1. NRCS Technical Release No. 55 (TR-55);
2. NRCS Technical Release No. 20 (TR-20);
3. U.S. Army Corps of Engineers HEC-1; or,
4. NRCS Engineering Field Handbook, Chapter 2, or other approved methodology.

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, as well as treatment of the banks. (Refer to Additional Criteria for Stream Corridor Improvement.)

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.

Treatments shall be functional and stable for the design flow and sustainable for higher flow conditions.

Treatments 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. Use a water surface profile analysis as needed to determine channel flow characteristics.

Additional Criteria for Shorelines

All revetments, bulkheads, or groins shall be no higher than 3 feet above mean high tide, or mean high water in non-tidal areas.

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

For the design of structural measures, evaluate the site characteristics below the waterline to determine scour potential and migration of base materials for a minimum distance of 50 feet outward from the shoreline, as measured from the design water surface elevation. The height of the protection shall be based on the design water surface elevation plus the computed wave height and freeboard. The design water surface elevation 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 wave run up would damage the vegetation. Use grasses, shrubs, and/or trees as appropriate to reduce wind and wave erosion along shorelines where blowing sand and storm waters may cause erosion damage.

Establishment of vegetation facilitates dune building at ocean, bay frontal, and back bay areas. In these areas, use only specialized plants that are adapted to an environment of salt, high heat in the summer, freezing winter temperatures, lack of nutrients, drought, flooding, erosion, and abrasion by wind-driven sand. Where foot or vehicular traffic is significant, use fencing or other barriers to protect the dune vegetation and enhance the retention of sand.

Additional Criteria for Stream Corridor Improvement

Fish and Wildlife Habitat - Where fish and wildlife habitat improvement is identified as a concern, stream corridor components shall be established as necessary for ecosystem functioning and stability.

Vegetative and structural components 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 feasible, streambank and shoreline protection measures shall be designed so that they connect two or more habitat areas, and provide protective cover and dispersal networks for the desired wildlife species, other animals, and plants.

Use a diverse mix of plants that have multiple values such as those suited for nesting, biomass, fruit, seeds, browse, and shading. To the extent feasible, plantings shall consist of four or more species to provide greater vegetative diversity. For optimum wildlife benefits, use locally native plant species. For additional information concerning the wildlife value of various native species, refer to the Maryland conservation practice standards for Conservation Cover, Code 327; and Wetland Restoration, Code 657.

Aesthetics - Vegetative and structural components 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. Where aesthetic objectives have been identified, construction materials, grading practices, and other site development elements shall be selected and designed to be compatible with adjacent land uses.

Recreation - Treatments shall be designed to achieve recreation objectives as determined by a site-specific assessment or management plan. Measures shall be designed as appropriate to minimize safety hazards to boaters, swimmers, or people using the shoreline or streambank.

Note: Specific cost-sharing programs or other funding sources may impose criteria in addition to, or more restrictive than, those specified in this standard.

PLANS AND SPECIFICATIONS

Plans and specifications for streambank and shoreline protection shall be prepared for specific field sites, according to the Considerations, Criteria, and Operation and Maintenance described in this standard, and will normally be part of the overall conservation plan. Plans and specifications shall include construction plans,

photographs, drawings, job sheets, construction specifications, narrative statements in the conservation plan, and other similar documents, as appropriate. Documentation shall be in accordance with the section "Supporting Data and Documentation" in this standard.

All trees, stumps, rocks or similar materials that will interfere with installing the protective measures shall be removed. Dispose of these materials in a manner consistent with maintaining a quality environment and with proper functioning of the practice.

Plans shall specify the plant species, varieties, form and size, quantities, and spacing/seeding rates to be used, as appropriate. Bioengineering designs shall follow the recommendations contained in the NRCS Engineering Field Handbook, Chapter 16, *Guidelines for Planning and Designing Streambank and Shoreline Protection Projects* and East Region Supplement No. 1. (See the References section of this standard.) Completed Job Sheet(s) can serve as the planting plan and specifications for the practice.

All components of the completed measures shall conform to the lines, dimensions, grades, and slopes shown on the plans or staked on the site. All materials shall be as specified on the construction drawings. The contractor shall be responsible for furnishing materials certification. These certification slips shall be retained with the "as-built" plans.

OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan shall be prepared for each streambank and shoreline protection project. Appropriate Job Sheet(s) may be used to serve as the management plan as well as supporting documentation, and shall be provided to the landowner. 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 the soil surface and replant areas damaged by high flows. Where vegetative efforts have failed, reassess the suitability of the chosen species for the site, and the need for structural measures to complement vegetative measures;
3. Remove sediment bars, undesirable vegetation, or other stream obstructions that may be causing unplanned diversion of flow into the protective measures or other streambank areas. Depending on the location and extent of work, federal and state permits may be needed before repairs are made.

SUPPORTING DATA AND DOCUMENTATION

Planning Information, Field Data, and Survey Notes

The following is a list of the minimum data needed:

1. Field location, extent of planned work in linear feet, conservation plan map showing the location of the practice, and assistance notes. Assistance notes shall include dates of site visits, name or initials of the person who made the visit, alternatives discussed, decisions made, and by whom;
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 baseflow water surface elevations and 2-year storm 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 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;
12. Stream closure dates and other permit requirements;
13. Written operation and maintenance plan.

Construction Check Data/As-Built

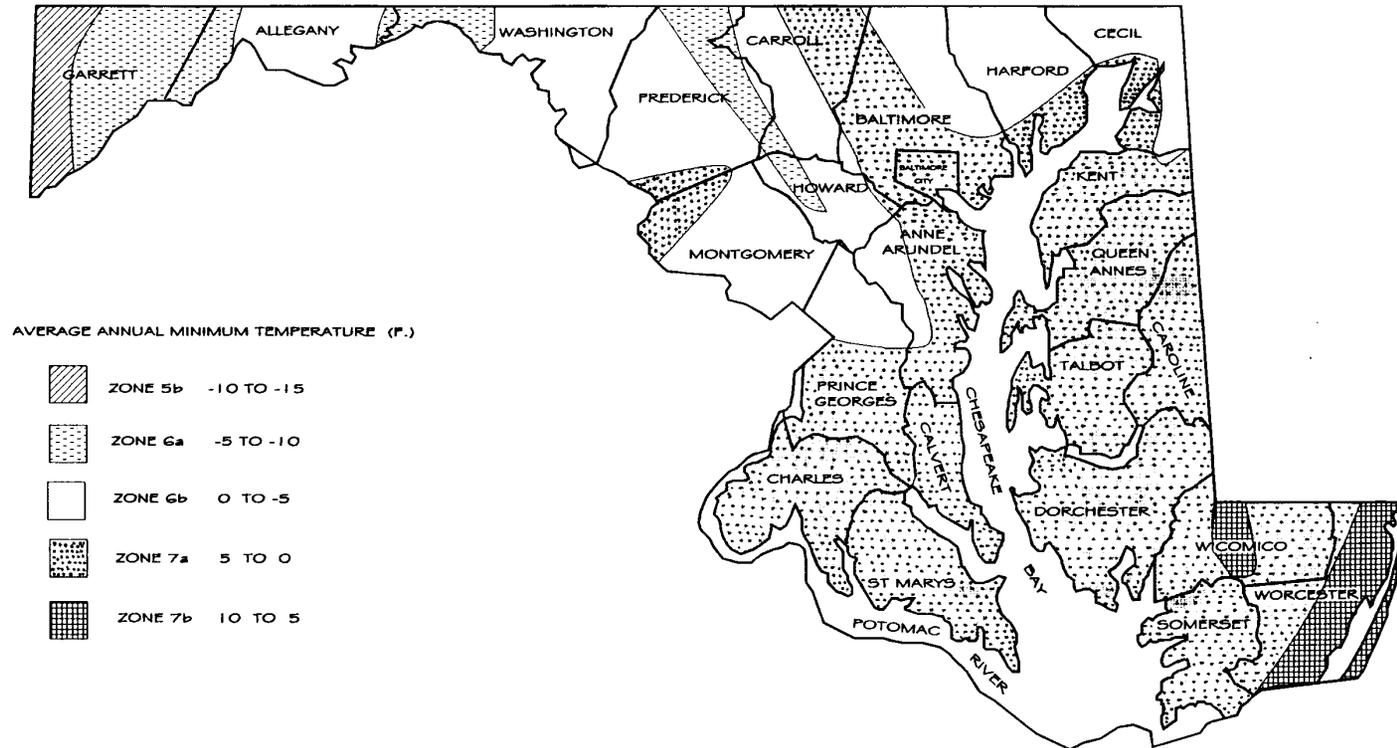
Record on survey note paper, SCS-ENG-28 or other appropriate engineering paper. Survey data will be plotted on plans in red. The following is a list of minimum data needed for as-builts:

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 checknotes and plans by a person with appropriate approval authority. Include statement that practice meets or exceeds plans and NRCS practice standards.

REFERENCES

1. Fish and Wildlife Service, Chesapeake Bay Field Office with the Natural Science Center and Adkins Arboretum, 1995. *Native Plants for Wildlife Habitat*. Annapolis, MD.
2. Maryland Department of Transportation, State Highway Administration, January 2001. *Standard Specifications for Construction and Materials*. Baltimore, Maryland.
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. Tjaden, Robert L., and Glenda M. Weber. *Riparian Buffer Management: Soil Bioengineering or Streambank Restoration for Riparian Forest Buffers*. Fact Sheet 729, University of Maryland, Maryland Cooperative Extension. Available on the internet at:
<http://www.agnr.umd.edu/MCE/Publications/>
5. USDA, Natural Resources Conservation Service. *Conservation Practice Standard for Critical Area Planting, Code 342*. Maryland Field Office Technical Guide, Section IV.
6. USDA, Natural Resources Conservation Service. *Conservation Practice Standard for Diversion, Code 362*. Maryland Field Office Technical Guide, Section IV.
7. USDA, Natural Resources Conservation Service. *Conservation Practice Standard for Field Border, Code 386*. Maryland Field Office Technical Guide, Section IV.
8. USDA, Natural Resources Conservation Service. *Conservation Practice Standard for Filter Strip, Code 393*. Maryland Field Office Technical Guide, Section IV.
9. USDA, Natural Resources Conservation Service. *Conservation Practice Standard for Riparian Forest Buffer, Code 391*. Maryland Field Office Technical Guide, Section IV.
10. USDA, Natural Resources Conservation Service, December, 1996. *National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 16, "Streambank and Shoreline Protection."*
11. USDA, Natural Resources Conservation Service, August, 1998. *National Engineering Handbook, Part 653, Stream Corridor Restoration: Principles, Processes, and Practices*. Prepared by the Federal Interagency Stream Restoration Working Group.
12. USDA, Natural Resources Conservation Service, East Region, September, 1997. *East Region Supplement No. 1, Engineering Field Handbook, Chapter 16, "Guidelines for Planning and Designing Streambank and Shoreline Protection Projects."*

FIGURE 1: USDA Plant Hardiness Zones for Maryland



Plant Hardiness Zones delineate areas where a species can be successfully established based on average annual minimum temperatures.

TABLE 1: Recommended Planting Dates in Maryland ^{1/}			
Type of Plant Material	Plant Hardiness Zones		
	5b and 6a	6b	7a and 7b
Seeds - Cool-Season Grasses	Mar 15 to May 31 Aug 1 to Sep 30	Mar 1 to May 15 Aug 1 to Oct 15	Feb 15 to Apr 30 Aug 15 to Oct 31 Nov 1 to Nov 30♦
Seeds - Warm-Season Grasses	Mar 15 to Jun 15♦♦ Jun 15 to Jun 30* Nov 1 to Dec 1**	Mar 1 to Jun 15♦♦ Jun 15 to Jun 30* Nov 15 to Dec 15**	Feb 15 to May 31♦♦ Jun 1 to Jun 30* Dec 1 to Dec 31**
Unrooted Woody Materials; Bare-Root Plants; Bulbs, Rhizomes, Corms, and Tubers ^{2/}	Mar 15 to May 31 Jun 1 to Jun 30*	Mar 1 to May 15 May 16 to Jun 30*	Feb 15 to Apr 30 May 1 to Jun 30*
Containerized Stock; Balled-and-Burlapped Stock	Mar 15 to May 31 Jun 1 to Jun 30* Sep 1 to Nov 15*✦	Mar 1 to May 15 May 16 to Jun 30* Sep 15 to Nov 30*✦	Feb 15 to Apr 30 May 1 to Jun 30* Oct 1 to Dec 15*✦

TABLE 1 NOTES:

1. 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.
2. When planted during the growing season, most of these materials 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.
 - ♦♦ 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.
 - ** Fall dormant season plantings of warm-season grasses – starting approximately 2 weeks after the first hard freeze (average date based on air temperature reading of 28 degrees F or lower, 50% probability of occurrence). 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.
 - ✦ 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 containerized 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 ^{1/}	Geographic Distribution in Maryland ^{1/}	Planting Zone ^{2/}	Sun/Shade ^{3/}	Growth Rate	Height at 20 years	Rooting Ability from Cuttings ^{4/}	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.
CRANBERRY BUSH <i>Viburnum trilobum</i>	All	Mostly Western Maryland.	Lower to Mid Bank	○	Moderate	12 ft.	Poor	Bare-root, Containerized	Forested wetlands and streambanks. Yellow to red fall color; white flower clusters. Bright red berries.
DOGWOOD, GRAY <i>Cornus racemosa</i>	All	Common in Western MD & 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.

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Plant Names	Plant Hardiness Zones ^{1/}	Geographic Distribution in Maryland ^{1/}	Planting Zone ^{2/}	Sun/Shade ^{3/}	Growth Rate	Height at 20 years	Rooting Ability from Cuttings ^{4/}	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	Common on Coastal Plain & Piedmont	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.
NANNYBERRY <i>Viburnum lentago</i>	5b, 6a, 6b	Mostly Western Maryland.	Mid to Upper Bank	○ - ◐	Slow	20 ft.	Fair - Good	Whips, Fascines, Live Stakes, Bare-root, Containerized	Forested wetlands and streambanks. Often suckers. Creamy white flowers. Berries are blue-black.
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.

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

Plant Names	Plant Hardiness Zones ^{1/}	Geographic Distribution in Maryland ^{1/}	Planting Zone ^{2/}	Sun/ Shade ^{3/}	Growth Rate	Height at 20 years	Rooting Ability from Cuttings ^{4/}	Type of Plant Material Available	Natural Habitat and Other Characteristics
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.
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. Caution: 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 Maryland, 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 very low fertility, based on results from a soil test, may benefit from top-dressing with 300-500 lbs/acre of 10-20-20 fertilizer to stimulate growth and development.

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

Plant Names	Recommended Cultivar	Plant Hardiness Zones ^{1/}	Planting Zone ^{2/}	Sun/ Shade ^{3/}	Growth Rate	Max. Height	Planting Rate ^{3/}	Natural Habitat and Other Characteristics
BLUEGRASS, ROUGH <i>Poa trivialis</i>	Colt, Cypress, Sabre	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, Pennlawn, Flyer, Fortress, Ruby, or Salem	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>	Blazer (II), Pennfine	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 ^{1/}	Planting Zone ^{2/}	Sun/ Shade ^{3/}	Growth Rate	Max. Height	Planting Rate ^{3/}	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 Maryland.
- 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 very low fertility, based on results of a soil test, may benefit from top-dressing with 300-500 lbs./acre of 10-20-20 fertilizer to stimulate growth and development.

TABLE 4: Selected List of Native Grasses and Grass-like Plants for Tidal Shoreline Stabilization ^{1/}

Plant Names	Plant Hardiness Zones ^{2/}	Geographic Distribution in Maryland ^{2/}	Planting Zone ^{3/}	Sun/ Shade ^{4/}	Growth Rate	Max. Height	Planting Rate ^{3/}	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>	6b, 7a, 7b	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	Mostly Coastal Plain and Piedmont	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 ^{1/}

Plant Names	Plant Hardiness Zones ^{2/}	Geographic Distribution in Maryland ^{2/}	Planting Zone ^{3/}	Sun/Shade ^{4/}	Growth Rate	Max. Height	Planting Rate ^{3/}	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 ^{1/}

Plant Names	Plant Hardiness Zones ^{2/}	Geographic Distribution in Maryland ^{2/}	Planting Zone ^{3/}	Sun/ Shade ^{4/}	Growth Rate	Max. Height	Planting Rate ^{3/}	Natural Habitat and Other Characteristics
SWITCHGRASS <i>Panicum virgatum</i> 'BLACKWELL' 'CARTHAGE' 'CAVE-IN-ROCK' '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.

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 Maryland. 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 Maryland, 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 very low fertility, based on results of a soil test, may benefit from top-dressing with 300-500 lbs./acre of 10-20-20 fertilizer to stimulate growth and development.