Sediment Basin
(1064)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

A sediment control device constructed with an engineered outlet, formed by excavation or embankment to intercept sediment-laden runoff and retain the sediment.

II. Purposes

Detain sediment-laden runoff from disturbed areas for sufficient time to allow the majority of the sediment to settle out.

III. Conditions Where Practice Applies

Sediment basins are utilized in areas of concentrated flow or points of discharge during construction activities. Sediment basins shall be constructed at locations accessible for clean out. Site conditions must allow for runoff to be directed into the basin.

Sediment basins are designed to be in place until the contributory drainage area has been *stabilized*[1]. Sediment basins are temporary and serve drainage areas up to 100 acres however other conservation practices are often more economical for smaller drainage areas. For drainage areas smaller than 5 acres sediment traps or ditch checks may be applicable; for design criteria refer to WDNR conservation Practice Standard Sediment Trap (1063) or Ditch Check (1062).

Design to WDNR Conservation Practice Standard Wet Detention Basin (1001) when a permanent stormwater basin is required.

IV. Federal, State, and Local Laws

Users of this standard shall be aware of applicable federal, state, and local laws, rules, regulations, or permit requirements governing the use and placement of sediment basins. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements. Sediment basins meeting these design criteria are deemed 80% effective by design in trapping sediment.

A. **Timing** – Sediment basins shall be constructed prior to disturbance of up-slope areas and placed so they function during all phases of construction. Sediment basins shall be placed in locations where runoff from disturbed areas can be diverted into the basin.

B. **Sizing Criteria** – Properly sized sediment basins are more effective at trapping fine-grained particles than sediment traps. Specific trapping efficiency varies based on the surface area and the particle size distribution of the sediment entering the device. See Figure 1 for clarification of terms. Attachment 1 includes a sample design problem.

1. *Treatment Surface Area* – The surface area of the sediment basin measured at the invert of the lowest outlet. The treatment surface area shall be sized based on the texture of the soil entering the device and the peak outflow during the 1-year, 24-hour design storm using Equation 1:

$$S_a = 1.2 * (q_{out} / v_s)$$

Where:

S_a = Treatment surface area measured at the invert of the lowest outlet of sediment basin (square feet)

q_{out} = Peak outflow (cubic feet / second) during the 1-year, 24-hour design storm for the principal outlet

v_s = Particle settling velocity (feet/second)

1.2 = EPA recommended safety factor.

[1] Words in the standard that are shown in italics are described in X. Definitions. The words are italicized the first time they are used in the text.

Particle settling velocities (*V*s) shall be based on representative soil class as follows:

a. Soil Class 1: $v_s = 1.2*10^{-3}$ ft/sec
b. Soil Class 2: $v_s = 7.3*10^{-5}$ ft/sec
c. Soil Class 3: $v_s = 1.2*10^{-5}$ ft/sec

Note: Particle settling velocities calculated assuming a specific gravity of 2.65 and a water temperature of 68 degrees Fahrenheit.

Soil Class 1 includes particles greater than 20 microns generally corresponding to sand, loamy sand, and sandy loam.

Soil Class 2 includes particles between 5 and 20 microns generally corresponding to loam, silt, and silt loam aggregates as transported in runoff.

Soil Class 3 includes particles between 2 and 5 microns generally corresponding to clay loam, silty clay, and clay aggregates as transported in runoff.

The representative soil class shall be selected based on the dominant textural class of the soil entering the device.

The treatment surface area of sediment basins can be reduced when used in conjunction with water applied polymers. When employing polymers, size the treatment surface area for controlling fine soils (Class 3) using the settling velocity for medium soils (Class 2). When designing for medium sized soils (Class 2) use the settling velocity for coarse soils (Class 1). See WDNR Conservation Practice Standard Sediment Control Water Application of Polymers (1051) for criteria governing the proper use and selection of polymers.

2. Depth below Treatment Surface Area – The depth below the treatment surface area as measured from the invert of the lowest outlet of the sediment basin shall be a minimum of 5 feet deep (2 feet for sediment storage plus 3 feet to protect against scour/ resuspension) and a maximum of 10 feet deep to limit the potential for thermal stratification.

   Due to side slope requirements and safety shelf considerations it maybe difficult to maintain 5 feet of depth for the entire treatment surface area. Therefore, 50% of the total treatment surface area shall be a minimum of 5 feet deep. For basins less than 5,000 square feet, maximize the area of 5 feet depth.

   Interior side slopes below the lowest invert shall be 2:1 (horizontal: vertical) or flatter to maintain soil stability.

   While a permanent pool of water below the lowest invert may form, it is not required to be maintained through irrigation or installation of a liner system.

3. *Active Storage Volume* – The volume above the treatment surface area shall be calculated using one of the following methods:

   a. The method outlined in TR-55 for determining the storage volume for detention basins. This can be accomplished by using Figure 2 where:

      $\mathbf{q_o}$ = Peak outflow (cubic feet / second) during the 1-year, 24-hour design storm for the principal outlet calculated using Equation 1 (see section V.B.1).

      $\mathbf{q_i}$ = Calculated peak inflow or runoff rate (cubic feet / second) during the 1-year, 24-hour design storm.

      Vr = Calculated volume of runoff from the 1-year 24-hour design storm for the entire contributory area with the maximum area of disturbance characterized as bare soil.

      Vs = Is the required active storage volume determined using Figure 2.

b. The active storage volume may be calculated based on routing the 1-year, 24-hour storm provided the principal outlet requirements stipulated in section V.D.2 are maintained. This method will require the use of a model.

Note: Both these methods require iterative calculations.

4. Shape – The length to width ratio of the flow path shall be maximized with a goal of 3:1 or greater. The flow path is considered the general direction of water flow within the basin including the treatment surface area and any forebay.

C. **Embankments** – Earthen embankments shall be designed to address potential risk and structural integrity issues such as seepage and saturation. All constructed earthen embankments shall meet the following criteria.

1. The base of the embankment shall be stripped of all vegetation, stumps, topsoil and other organic matter.

2. Side slopes shall be 3:1 or flatter. The minimum embankment top width shall be adequate to provide structural stability. Where applicable the top width shall be wide enough to provide maintenance access.

3. There shall be a core trench or key-way along the embankment.

4. Any pipes extending through the embankment shall be bedded and backfilled with equivalent soils used to construct the embankment. The bedding and backfill shall be compacted in lifts and to the same standard as the original embankment. Excavation through a completed embankment shall have a minimum side slope of 1:1 or flatter.

5. Measures shall be taken to minimize seepage along any conduit buried in the embankment.

D. **Outlet** – Sediment basins shall have both a principal outlet and an overflow spillway.

1. Timing – Outlets must be constructed in conjunction with the remainder of the basin and must be constructed prior to the basin receiving runoff. Sediment basins are ineffective until the outlet is constructed.

2. Principal Water Quality Outlet – The principal water quality outlet shall be designed to pass the 1-year 24-hour storm without use of the overflow spillway or other outlet structures. The maximum outflow (q_o) from the principal water quality outlet shall be less than or equal to the q_o used in Equation 1 (V.B.1). If the sediment basin is to serve as a permanent stormwater basin, the principal outlet structure can be modified (i.e. removable plates) to meet flow requirements encountered during and after construction; separate outlet structures do not need to be constructed.

Note: Local ordinances may require control of larger storm events such as the 2-year 24 hour storms. In these cases, additional or compound outlets maybe required.

3. Overflow (Emergency) Spillway – An overflow spillway shall be provided consisting of an open channel constructed adjacent to the embankment and built over a stabilized area. The spillway shall be designed to carry the peak rate of runoff expected from a 10-year, 24-hour design storm or one commensurate with the degree of hazard, less any reduction due to flow in the principal outlet. The top of the embankment shall be at least one foot above the design high water level and a minimum of 1 foot above the invert of the overflow spillway. The overflow spillway shall be protected from erosion. Flow from the overflow spillway shall be directed away from the embankment.

4. Outlet Protection – All outlet designs shall incorporate preventive measures for ice damage, trash accumulation, and erosion at the outfall. For orifices less

than 8-inches in diameter, or equivalent, additional measures to prevent clogging are required.

E. **Inlet Protection** – Inlets shall be designed to prevent scour and reduce velocities during peak flows. Possible design options include flow diffusion, plunge pools, directional berms, baffles, or other energy dissipation structures.

F. **Location** – Temporary sediment basins should be located to provide access for cleanout and disposal of trapped sediment.

G. **Removal** – Temporary sediment basins shall be removed after the contributing drainage area has been stabilized. Complete final grading and restoration according to the site plans. If standing water needs to be removed it shall be done in accordance with WDNR Conservation Practice Standard Dewatering (1061).

VI. Considerations

A. When constructing a sediment basin that will also serve as the long-term stormwater detention pond, build the sediment basin to the larger of the two sizes required either for stormwater control or erosion control. In addition, when sizing the outlet structure first design the outlet for the long-term stormwater management requirements then check to satisfy the flow requirements for sediment control during construction. If additional flow restriction is needed consider use of a temporary restriction plates or other measures to avoid having to construct separate outlet structures for the sediment basin and stormwater basin.

B. Over-excavation beyond the required depth in the sediment storage area of the sediment basin may allow for less frequent maintenance. Addition of other measures in the contributing drainage area may reduce sediment accumulation and associated maintenance requirements.

C. The use of a sediment forebay can extend the useful life of the main sediment storage area by trapping the majority of sediment in the forebay area. Separation of the forebay from the rest of the basin requires construction of a submerged shelf (if wet) or a stone or stabilized earthen embankment. The forebay should have a surface area equal to at least 12% of the total basin area.

D. In addition to soil stability issues, interior slopes of sediment basins should be selected based on safety issues commensurate with the degree of hazard.

VII. Plans and Specifications

A. Plans and specifications for installing sediment basins shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

1. Location of sediment basin
2. Schedules and sequence of installation and removal
3. Standard drawings and installation details
4. Control structure detail and layout
5. Sizing of sediment storage area
6. Maintenance requirements

B. All plans, standard detail drawings, or specifications shall include sequence for installation, inspection, and maintenance requirements. The responsible party shall be identified.

VIII. Operation and Maintenance

Sediment basins shall, at a minimum, be inspected weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24-hour period.

A. Sediment shall be removed to maintain the three foot depth of the treatment surface area as measured from the invert of the principal outlet. Sediment may need to be removed more frequently.

B. If the outlet becomes clogged it shall be cleaned to restore flow capacity.

C. Provisions for proper disposal of the sediment removed shall be made.

D. Maintenance shall be completed as soon as possible with consideration to site conditions.

IX. References

Chapter NR 333, Dam and Design Construction.

Hann, Barfield, and Hayes. Design Hydrology and Sedimentology for Small Catchments. Academic Press Inc., 1994.

Robert E. Pitt, Small Storm Hydrology.

US Bureau of Reclamation, Design of Small Dams. http://www.usbr.gov/pmts/hydraulics_lab/pubs/index.cfm.

USDA, Natural Resources Conservation Service, Ponds – Planning, Design, Construction. Agriculture Handbook No. 590, Revised September 1997.

WDNR Conservation Practice Standard 1001 Wet Detention Basin.

X. Definitions

Active Storage Volume (V.B.3) – Is measured from the invert of the lowest outlet to the invert of the emergency spillway.

Stabilized (III) – Means protecting exposed soil from erosion.

Treatment Surface Area (V.B.1) – Is the surface area of the sediment basin measured at the invert of the lowest outlet.

Figure 1:

Clarification of Sediment Basin Terminology

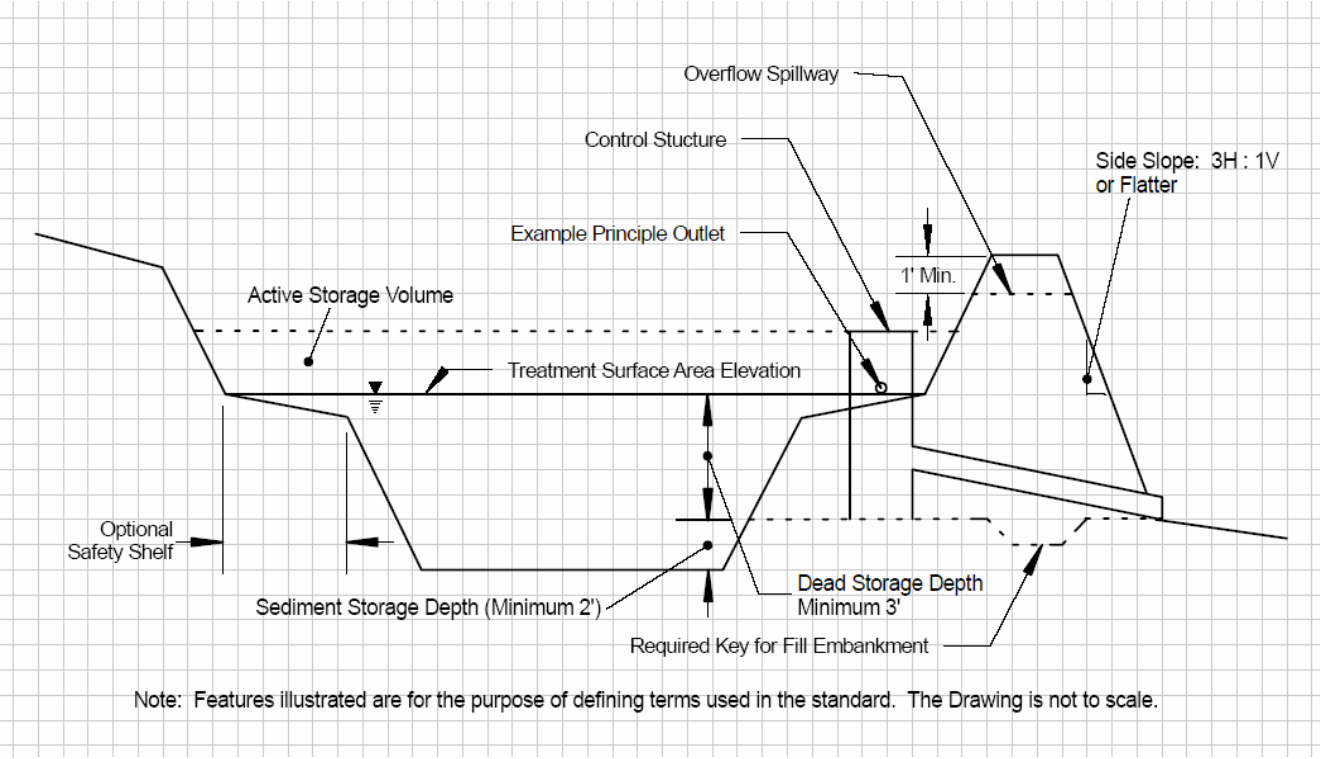
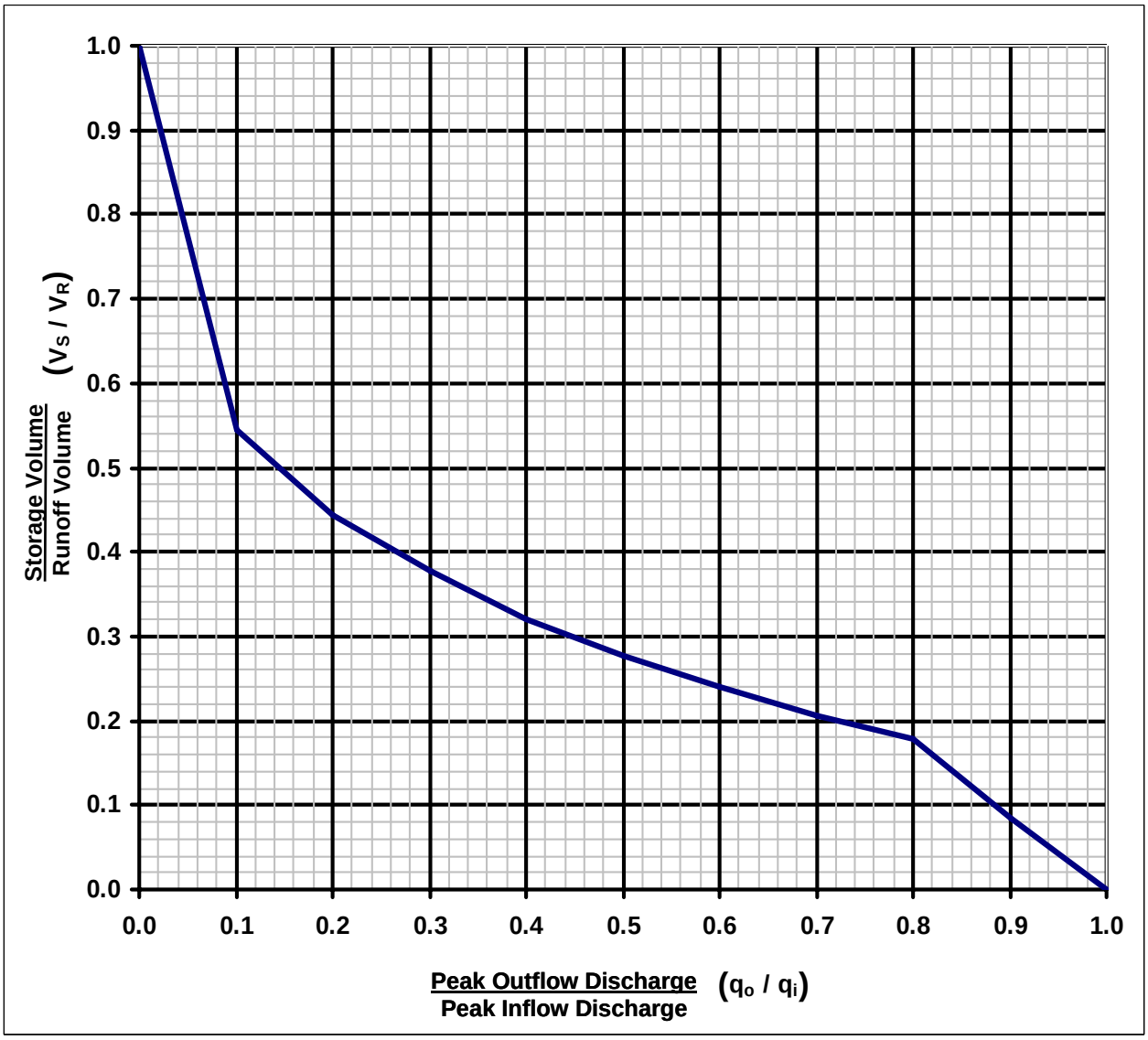


Figure 2:

Approximate Detention Basin Routing for Type II Storms



Source: Technical Release 55, United States Department of Agriculture, Natural Resources Conservation Service. Washington D.C. 1988.

Rainfall Quantities:

Table 1 provides a summary of the 1-year, 24-hour rainfall totals using NRCS mandated TP-40 which has not been updated since 1961. Table 2 provides a summary of more current data from the Rainfall Frequency Atlas of the Midwest published in 1992. Local requirements may dictate the use of one dataset over the other.

Table 1 - Rainfall for Wisconsin Counties for a 1 - year, 24 - hour Rainfall[1]	
Inches of Rainfall	County
2.1 in.	Door, Florence, Forest, Kewaunee, Marinette, Oconto, Vilas
2.2 in.	Ashland, Bayfield, Brown, Calumet, Douglas, Iron, Langlade, Lincoln, Manitowoc, Menominee, Oneida, Outagamie, Price, Shawano, Sheboygan
2.3 in.	Barron, Burnett, Dodge, Fond du Lac, Green Lake, Marathon, Milwaukee, Ozaukee, Portage, Racine, Rusk, Sawyer, Taylor, Washburn, Washington, Waukesha, Waupaca, Waushara, Winnebago, Wood
2.4 in.	Adams, Chippewa, Clark, Columbia, Dane, Dunn, Eau Claire, Jackson, Jefferson, Juneau, Kenosha, Marquette, Pepin, Pierce, Polk, Rock, St. Croix, Walworth
2.5 in.	Buffalo, Green, Iowa, La Crosse, Monroe, Richland, Sauk, Trempealeau, Vernon
2.6 in.	Crawford, Grant, Lafayette
[1]TP - 40 - Rainfall Frequency Atlas of the United States, U.S. Department of Commerce Weather Bureau.	

Table 2 - Rainfall for Wisconsin Counties for a 1 - year, 24 - hour Rainfall[2]		
Zone	Inches of Rainfall	County
1	2.22	Douglas, Bayfield, Burnett, Washburn, Sawyer, Polk, Barron, Rusk, Chippewa, Eau Claire
2	2.21	Ashland, Iron, Vilas, Price, Oneida, Taylor, Lincoln, Clark, Marathon
3	1.90	Florence, Forest, Marinette, Langlade, Menominee, Oconto, Door, Shawano
4	2.23	St. Croix, Dunn, Pierce, Pepin, Buffalo, Trempealeau, Jackson, La Crosse, Monroe
5	2.15	Wood, Portage, Waupaca, Juneau, Adams, Waushara, Marquette, Green Lake
6	1.96	Outagamie, Brown, Kewaunee, Winnebago, Calumet, Manitowac, Fond Du Lac, Sheboygan
7	2.25	Vernon, Crawford, Richland, Sauk, Grant, Iowa, Lafayette
8	2.25	Columbia, Dodge, Dane, Jefferson, Green, Rock
9	2.18	Ozaukee, Washington, Waukesha, Milwaukee, Walworth, Racine, Kenosha
[2]Bulletin 71: Rainfall Frequency Atlas of the Midwest, Midwest Climate Center and Illinois State Water Survey, 1992.		

Attachment 1:
Sample Sediment Basin Design Problem

The proper sizing and design of a sediment basin will often require iterative calculations. The technical standard for sizing sediment basins was written to give the designer as much flexibility as possible in designing the basin while meeting water quality requirements. The governing equation relates the surface area of the sediment basin to the outflow and critical particle settling velocity. The larger the sediment basin outflow, the larger the surface area required to settle the particle. As the outflow is reduced, a smaller surface area is required however the required storage volume dictates how small a surface area can become through the storage depth or hydraulic head acting on the outlet.

The particle settling velocities are listed in the standard requiring the designer to either start with a desired outflow based on an outlet size or an estimated starting surface area. The sample equation below starts with an estimated surface area.

Sample Problem:

A 10 acre site is being developed into condos. Eight acres of the site are being disturbed while 2 acres of forest are remaining undisturbed. The dominate soils on the site are silt loam. The 1-year, 24-hour design storm is 2.25 inches.

Step 1: Calculate runoff volume and peak using TR-55 or approved method.

From TR-55 the curve number (CN) for the disturbed area is 86 and the CN for the forested area is 55 resulting in a composite CN of 80. Using TR-55, the runoff volume calculated for the 1-year 24-hour design storm is 0.7 inches (0.6 acre-feet for the entire 10-acre site). The time of concentration was calculated as 0.4 hours resulting in a peak flow of 6 cfs.

Step 2: Begin sizing sediment basin using Equation 1. The technical standard lists silt loam under particle class 2 with a settling velocity of $7.3*10^{-5}$ ft/sec. We are also going to assume a starting surface area of 0.25 acres (10,890 ft^2). An alternative approach is to assume an outflow velocity.

$SA = 1.2 * (q_{out} / v_s)$
Solve for q_{out}: $10{,}980\ ft^2 = 1.2 * (q_{out} / 7.3*10^{-5}\ ft/sec)$
$q_{out} = 0.67$ cfs

Step 3: Using Figure 2: Approximate Detention Basin Routing for Type II Storms determines the volume of storage (V_S) needed.

$q_{out} = 0.67$ cfs (calculated in Step 2)
$q_{in} = 6.0$ cfs (peak flow calculated using TR-55 in Step 1)
$V_R = 0.6$ acre-feet (volume of runoff calculated using TR-55 in Step 1)
$q_{out} / q_{in} = 0.67$ cfs / 6.0 cfs = 0.11. Using Figure 2 with a $q_{out} / q_{in} = 0.11$, the V_S/V_R is determined to be 0.54. Therefore the $V_S = 0.54 * 0.6$ acre-feet = 0.324 acre-feet (14,113 ft^3)

Step 4: Check configuration: Calculate maximum head on outlet using surface area and volume.

SA = 10,890 ft^2 and a V_S = 14,113 ft^3 we get a depth (H) of 1.29 feet = 14,113 ft^3 / 10,890 ft^2

Step 5: Size Outlet: Assuming an orifice type outlet calculate the size needed to meet the q_{out} calculated in Step 1 and the H calculated in Step 4.

Using the orifice equation: $q_{out} = C*A*(2gH)^{1/2}$ with C=0.6 (coefficient) , A = Area = ft^2, g = 32.2, and H = hydraulic head expressed in feet.

$q_{out} = 0.6*A*(2*32.2* H)^{1/2}$ so $0.66 = 0.6*A*(2*32.2*1.29)^{1/2}$ therefore A = .12 ft^2

An area of 0.12 ft^2 corresponds to an orifice outlet of 4.7 inches in diameter.

Step 6: Iteration: While the above solution works, the sediment basin has not been optimally sized and we have an orifice diameter that is not a standard pipe size. An iterative approach can be used to reduce the surface area of the sediment basin and obtain a more common orifice diameter. We can assume a 4-inch orifice since it is close to diameter calculated in Step 5 and we can start with the depth we calculated in Step 4. The iterations below each represent Steps 2 through 5.

Iteration 1:

$q_{out} = 0.43 (H)^{1/2} = 0.43 (1.29)^{1/2} = 0.48$ cfs which is less than the 0.66 cfs calculated in Step 1. Therefore, we can go back to Step 1 and repeat the sizing procedure and downsize the sediment basin.

$SA = 1.2 * (q_{out} / v_s) = 1.2 * (0.48 \text{ cfs} / 7.3*10^{-5} \text{ ft/sec}) = 7{,}890 \text{ ft}^2$

Using Figure 2:
q_{out} = 0.48 cfs
q_{in} = 6.0 cfs (peak flow calculated using TR-55 in Step 1)
V_R = 0.6 acre-feet (volume of runoff calculated using TR-55 in Step 1)

q_{out} / q_{in} = 0.48 cfs / 6.0 cfs = 0.08. Using Figure 2 with a q_{out} / q_{in} = 0.08, the V_S/V_R is determined to be 0.62. Therefore the V_S = 0.62 * 0.6 acre-feet = 0.372 acre-feet (16,204 ft^3)

SA = 7,890 ft^2 and a V_S = 16,204 ft^3 we get a depth (H) of 2.05 feet = 16,204 ft^3 / 7,890 ft^2

$q_{out} = 0.43 (H)^{1/2} = 0.43 (2.05)^{1/2} = 0.61$ cfs which is more than the 0.48 cfs we used so iterate.

Iteration 2:

$SA = 1.2 * (q_{out} / v_s) = 1.2 * (0.61 \text{ cfs} / 7.3*10^{-5} \text{ ft/sec}) = 10{,}027 \text{ ft}^2$

Using Figure 2:
q_{out} = 0.61 cfs
q_{in} = 6.0 cfs (peak flow calculated using TR-55 in Step 1)
V_R = 0.6 acre-feet (volume of runoff calculated using TR-55 in Step 1)

q_{out} / q_{in} = 0.61 cfs / 6.0 cfs = 0.10 Using Figure 2 with a q_{out} / q_{in} = 0.10, the V_S/V_R is determined to be 0.54. Therefore the V_S = 0.54 * 0.6 acre-feet = 0.324 acre-feet (14,113 ft^3)

SA = 10,027 ft^2 and a V_S = 14,113 ft^3 we get a depth (H) of 1.41 feet = 14,113 ft^3 / 10,027 ft^2

$q_{out} = 0.43 (H)^{1/2} = 0.43 (1.41)^{1/2} = 0.51$ cfs which is less than the 0.61 cfs we used so we are OK or we can iterate again until we have q_{out} that are almost identical.

After Iteration 2, we have a sediment basin with a SA = 10,027 ft^2 and a V_S = 14,113 ft^3. We have a principal water quality outlet consisting of a 4-inch orifice. This design meets the water quality requirements of the technical standard.

Interim Manufactured Perimeter Control and Slope Interruption Products
(1071)

Wisconsin Department of Natural Resources
Conservation Practice Standard

I. Definition

Manufactured perimeter control and slope interruption products include a variety of products designed to detain or slow the flow of sediment-laden sheet flow runoff from small areas of disturbed soil. This definition does not include sediment bale barriers or silt fence which are covered under Conservation Practice Standards 1055 and 1056 respectively.

II. Purpose

The purpose of the installation of these products is to reduce uninterrupted slope length to slow the velocity of runoff so as to retain transported sediment from disturbed areas.

III. Condition Where Practice Applies

A. This standard applies to the following conditions:

1. Where only *sheet and rill erosion* occurs unless the product is listed as approved for use in concentrated flow areas (channel erosion) as a ditch check on the Wisconsin Department of Transportation (WisDOT) Erosion Control Product Acceptability List (PAL) and is designed and installed in accordance with WDNR Technical Standard 1062. All products that are not approved for use in concentrated flow areas and are to be installed on a slope that terminates in a channel shall be installed at an elevation no lower than 6 inches above the design flow depth of the channel.

2. Where usage is limited to 12 consecutive months.

3. Where conditions allow for proper installation as outlined in the Criteria Section V and maintenance as outlined in Criteria Section VIII.

B. Under no circumstance should products be used in the following applications:

1. Below the ordinary high watermark or placed perpendicular to flow in streams.

2. Where the maximum gradient upslope of the product is steeper than 50% (2:1).

IV. Federal, State and Local Laws

Users of this standard shall be aware of potentially applicable federal, state and local laws, rules, regulations or permit requirements governing manufactured perimeter control and slope interruption products. This standard does not contain the text of federal, state, or local laws.

V. Criteria

This section establishes the minimum standards for design, installation and performance requirements. Only products approved by the Wisconsin Department of Commerce (Commerce) for use on projects regulated under the Uniform Dwelling Code or products listed on the WisDOT PAL for use as ditch checks, perimeter control, or slope interruption will be accepted for use in this standard. The Commerce approval process is outlined in the document titled “Wisconsin Department of Commerce Manufactured Perimeter Control and Slope Interruption Product Approval Process (Commerce product approval process).”

A. **Product Classes** – Products are organized into product classes based on the installed product height as illustrated on Figure 1. Product classes are specified in Table 1.

Table 1	
Product Height Class	**Installed Height Above Grade (inches)**
Class I	Mat Products
Class II	6-9
Class III	10-15
Class IV	16-20
Class V	>20

B. **Placement**

1. Products should be placed on the contour whenever possible. J-hooks may be used for sloping installations of log-type products. See Figure 1 for installation illustrations for log-type products.

2. Products should not be placed perpendicular to the contour.

3. The ends of product installations should be extended upslope to prevent water from flowing around the ends of the product.

4. Products that are placed on a curved alignment shall be installed at a large enough radius of curvature to prevent kinking.

C. **Entrenchment**

1. *Log – Type Products*

a) Disturbed Ground – Log-type products installed on disturbed ground shall be entrenched a minimum of 2 inches to ensure continuous ground contact.

b) Vegetated Ground – Log-type products installed on vegetated ground may be installed without entrenchment. All gaps and ruts creating an undercutting situation shall be filled with soil or log-type product filter media.

c) Frozen Ground

i. No entrenchment required.

ii. Only products approved for installation on frozen ground under the Commerce product approval process or listed in the WisDOT PAL for installation on frozen ground may be installed on frozen ground.

iii. Products installed on frozen ground shall be assessed for effectiveness upon ground thaw and staked or replaced as needed.

2. *Other Products* – Products other than log-type products shall be entrenched as required by the manufacturer or as specified under Commerce product approval stipulations.

D. **Overlap** – Minimum 24 inches or as required by the manufacturer if more restrictive. Overlap should be shingled in the direction of flow. See Figure 1.

E. **Support** – Stake or anchor as needed to maintain constant ground contact along the entire length of product at all times and to prevent lateral movement and/or floatation. Staking or anchoring shall be performed per manufacturer's recommendations or as specified under Commerce or WisDOT product approval stipulations.

F. **Product Stacking** – Products shall not be stacked individually on top of one another. Products may be stacked in a "pyramid" manner (i.e., one on top of two) or for operation and maintenance purposes as stipulated in Section VIII.C.

G. **Maximum Spacing –** The spacing in direction of slope shall not exceed the maximum slope lengths for the appropriate slope as specified in Table 2.

Table 2					
	Max. Spacing (ft) per Product Class				
Slope	**I**	**II**	**III**	**IV**	**V**
0-2%	30	30	55	75	100
2.1-5%	25	25	40	55	75
5.1-10%	15	15	30	40	50
10.1-33%	NA	10	15	20	25
>33%	NA	5	10	15	20

Notes:
1. NA = Not Allowed
2. Products from a higher class are suitable for applications in a lower class.
3. Manufacturer's recommendations for maximum slope and maximum spacing should be used if more restrictive than the guidelines established above.

H. Products should be installed prior to disturbing the upslope area and/or when changes in disturbed slope or slope length require the installation of additional products.

I. The width of mat type products used for perimeter control/slope interruption shall be as specified in the product approval from Commerce or as specified in the WisDOT PAL.

J. **Filter Media**

1. Filter media used in any product shall be non-toxic and may not present a hazard to human health or the environment.

2. Filter media shall be compatible with any substance for which it is expected to come into contact with during use.

3. Polymer used in any product shall conform to WDNR Technical Standard 1050 and/or 1051 as applicable.

4. Filter media consisting of reused materials that are regulated as solid waste under ch. NR 500, Wisconsin Administrative Code shall have received an exemption under s. NR 500.08(5), Wisconsin Administrative Code prior to use in an erosion control product.

5. Compost used in any product shall conform to WDNR Specification S100 compost.

VI. Considerations

A. To protect products from damage in areas of active construction or heavy traffic, products should be flagged, marked or highlighted to improve visibility.

B. To help ensure effectiveness, products should be inspected and repaired as necessary prior to forecasted rain events.

C. Vehicular traffic should be diverted around the product unless allowed under the manufacturer's specifications.

D. When products are used to divert runoff, discharge should be made to a stabilized area or sediment control practice.

E. Products may be used in conjunction with other practices such as Seeding for Construction Site Erosion Control (1059), Non-channel Erosion Mat (1052), Mulching for Construction Sites (1058), or Vegetative Buffer for Construction Sites (1054) to enhance performance.

VII. Plans and Specifications

A. Plans and specifications for installing products shall be in keeping with this standard and shall describe the requirements for installing the product to achieve its intended purpose. The plans and specifications shall address the following:

1. Location of product

2. Contributory drainage area

3. Schedules

4. Product specifications

5. Standard drawings and installation details

6. Restoration after removal

B. All plans, standard detail drawings, or specifications shall include a schedule for installation, inspection, and maintenance. The responsible party shall be identified.

VIII. Operation and Maintenance

A. Products shall be inspected at least weekly and within 24 hours after every precipitation event that produces 0.5 inches of rain or more during a 24-hour period.

B. If the product becomes undermined, the voids shall be backfilled with soil and compacted to establish continuous contact between the ground and product.

C. If sediment reaches ½ of the log-type product height, the sediment shall be removed or a second log-type product may be positioned immediately upslope and in contact with the original log-type product.

D. If a product rolls out of position, the product shall be repositioned and secured with additional stakes.

E. Holes, rips or tears in the fabric of a log-type product less than 12 inches in any direction and located within the top 1/3 of the product may be repaired by stitching or wrapping a new piece of fabric around the product and securing. Sections of log-type product with holes, rips, or tears greater than or equal to 12 inches in any direction or located within the bottom 2/3 of the product shall be removed and replaced with new product or a second log-type product may be placed immediately upslope with a minimum 24 inches of overlap beyond the hole, rip, or tear.

F. Pinched, settled, or deformed log-type products may be re-contoured to their original diameter by hand if possible or a second log-type product shall be placed immediately upslope with a minimum 24-inch overlap beyond the deformation.

G. Destroyed or irreparable sections of log-type product shall be removed and replaced with new log-type product or a second log-type product may be placed immediately upslope with a minimum 24-inch overlap beyond the deformation.

H. Mat products shall be replaced when visible sediment covers 50% of the installed width or if damaged or degraded. A second mat may be placed immediately adjacent to or on top of the first mat in lieu of replacement.

I. Once the area the product is serving has been stabilized, the product should be removed and disposed of in accordance with relevant Federal, State, or Local regulations and per the manufacturer's recommendations.

IX. References

WDNR Technical Standard 1050 – Land Application of Anionic Polyacrylamide

WDNR Technical Standard 1052 – Non-channel Erosion Mat

WDNR Technical Standard 1054 – Vegetative Buffer for Construction Sites

WDNR Technical Standard 1055 – Sediment Bale Barrier (Non-Channel)

WDNR Technical Standard 1056 – Silt Fence

WDNR Technical Standard 1058 – Mulching For Construction Sites

WDNR Technical Standard 1059 – Seeding For Construction Site Erosion Control

WDNR Technical Standard 1062 – Ditch Check (Channel)

Wisconsin Department of Commerce Manufactured Perimeter Control and Slope Interruption Product Approval Process (http://www.commerce.state.wi.us/SB/docs/SB-SoilErosionControlInterruptProc.pdf)

Wisconsin Department of Transportation Erosion Control Product Acceptability List (http://www.dot.wisconsin.gov/business/engrserv/pal.htm)

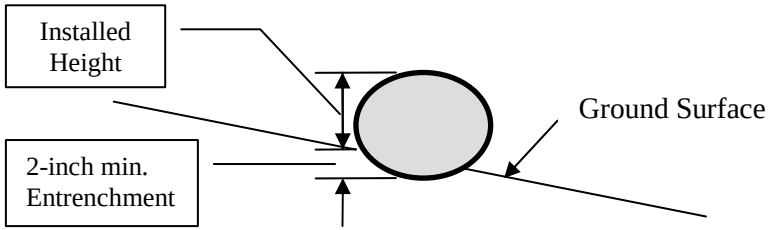
X. Definitions

Channel Erosion: The deepening and widening of a channel due to soil loss caused by flowing water. As rills become larger and flows begin to concentrate, soil detachment occurs primarily as a result of shear.

Sheet and Rill Erosion (III.A.1.): Sheet and rill erosion is the removal of soil by the action of rainfall and shallow overland runoff. It is the first stage in water erosion. As flow becomes more concentrated rills occur. As soil detachment continues or flow increases, rills will become wider and deeper forming gullies.

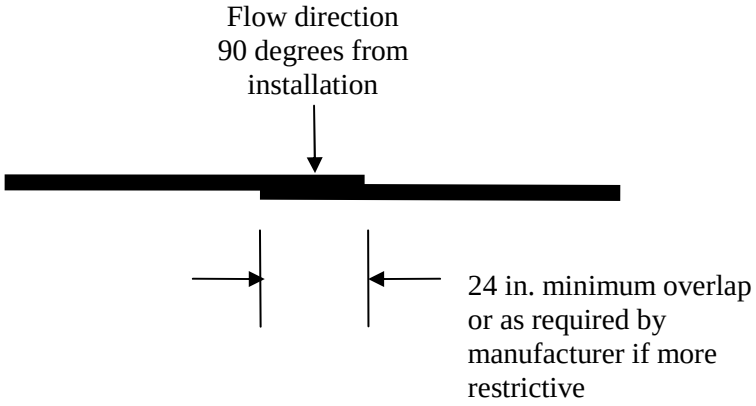
Log-Type Products: Sediment control products constructed of an outer sock of geotextile or other type of netting or permeable containment media surrounding an inner filtering media.

Mat Products: Low profile products consisting of one or more layers of fibrous material designed to slow and filter runoff.

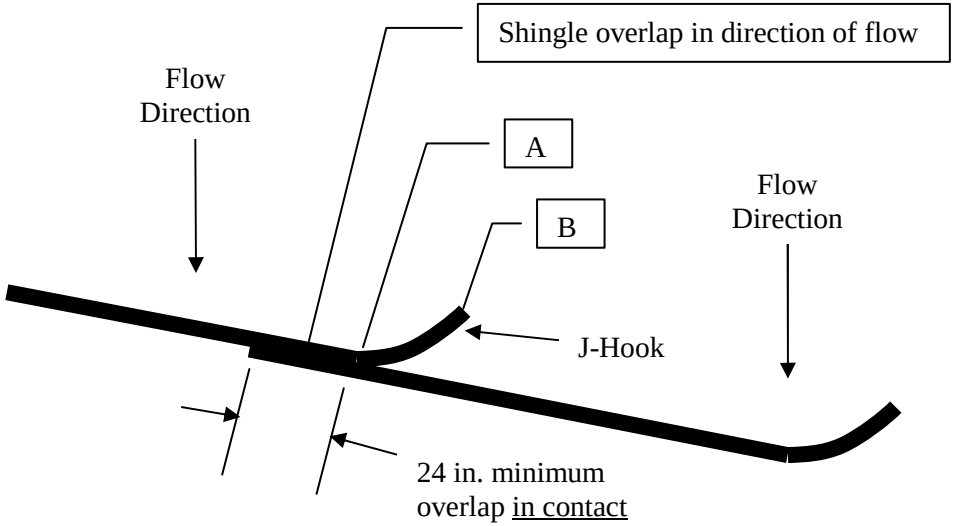


Note:
Installed height is measured from the upslope ground surface to the top of the product. Due to settlement and/or deformation, the installed height may not be equivalent to the nominal diameter of the product.

CROSS SECTION



TYPICAL INSTALLATION
(Plan View)



Notes:
1. J-hooks shall be installed so that the ground-product interface elevation at location B is higher than the top of product elevation at location A to create a weir at point A.
2. J-hooks shall be installed every 2 vertical feet of drop along the length of the installation.
3. Stake overlap as required by manufacturer.

SLOPING INSTALLATION
(Plan View)

FIGURE 1
LOG-TYPE PRODUCT INSTALLATION ILLUSTRATION

Appendix 10

WDNR Quarterly Visual Inspection – Field Sheet Form 3400-176A

State of Wisconsin
Department of Natural Resources

Quarterly Visual Inspection - Field Sheet

Form 3400-176A (R 3/01)

This form is for your own use and should be kept as part of your Storm Water Pollution Prevention Plan. It **does not** have to be submitted to the Department unless requested. If false information from quarterly visual inspections is reported to the Department, you could be subject to penalties up to $10,000 pursuant to s. 283.91(4), Wis. Stats.

Use one form per outfall.

Quarterly Visual Inspections at each storm water discharge outfall on your site can be a valuable assessment tool and are required by the Tier 1 and Tier 2 Industrial Storm Water General Permits. This inspection should be performed when sufficient runoff occurs during daylight hours. Try to make observations within the first 30 minutes after runoff begins discharging from the outfall, or as soon as practical, but no later than 60 minutes. If you find visible pollution, note the probable source and list any possible Best Management Practices that could be used to reduce or eliminate the problem.

Make any necessary changes to your **Storm Water Pollution Prevention Plan** as needed.

Facility Name			
Street Address	City	State	ZIP Code
Name of Person Conducting Inspection		Inspection Date	
Employer		Telephone Number	
Outfall Number (make reference to site map)	Description of Outfall (e.g., ditch, concrete pipe, grassed swale, etc.)		
Time of Rainfall Event	Time of Visual Inspection	**Optional:** Amount of Rainfall at the Time of Observation (nearest tenth of an inch)	

Describe your observations. An easy way to conduct this inspection is to use a glass jar to collect a sample of the storm water being discharged from the facility and visually inspect the water. Include any observations of color, odor, turbidity, floating solids, foam, oil sheen or any other visual indicators of storm water pollution and the probable sources of any observed storm water contamination.

Color:	☐ Clear	☐ Red	☐ Yellow	☐ Brown	☐ Other:
Odor:	☐ None	☐ Musty	☐ Sewage	☐ Rotten Egg	☐ Other:
Clarity:	☐ Clear	☐ Cloudy	☐ Opaque	☐ Suspended Solids	☐ Other:
Floatables:	☐ None	☐ Foam	☐ Garbage	☐ Oily Film	☐ Other:
Deposits / Stains:	☐ None	☐ Oily	☐ Sludge	☐ Sediments	☐ Other:

Comments:

This outfall could not be evaluated during this quarter due to the following reason:

Appendix 11

WisDOT Standard Specifications for Seeding and Mulching;
NRCS Planting and Wetland Practice Standards

Section 630 Seeding

630.1 Description

(1) This section describes preparing seed beds and furnishing and sowing the required seed on slopes, appurtenances, and other areas, and on borrow pits and material disposal sites.

(2) This section also describes furnishing and sowing temporary seed mixture on the slopes and appurtenances of temporary embankments and roadways.

630.2 Materials

630.2.1 Seed

630.2.1.1 General Requirements

(1) Conform to the Wisconsin statutes and Wisconsin administrative code chapter ATCP 20 regarding noxious weed seed content and labeling.

http://docs.legis.wi.gov/statutes/statutes/

http://docs.legis.wi.gov/code/admin_code/atcp/020/20.pdf

(2) Use seed within one year of the test date appearing on the label.

(3) Seed mixtures 70, 70A, 75, and 80 contain wild type forbs and grasses. Wild type is defined as seed that is derived directly from native, wild stock, including seed that was wild collected and placed into production or has been harvested directly from native stands.

630.2.1.2 Purity and Germination

(1) Test seed according to the methods and procedures used for sampling and analyzing seed for purity, germination, and noxious weed seed content specified in the current edition of Rules for Testing Seed, published by the Association of Official Seed Analysts.

630.2.1.3 Inoculation

(1) Inoculate legume seed (white clover, red clover, ladino clover, alsike clover, alfalfa, partridge pea, purple prairie clover, Canada tick-trefoil, and lupine) unless it has been pre-inoculated by the vendor. Follow the inoculation instructions that come with the culture purchases. If applying the seed according to method B, 630.3.3.2, treat seeds requiring inoculation with 5 times the quantity of inoculant recommended in the instructions.

(2) Avoid exposure of the culture or inoculated seed to the sunlight, and in no case shall any exposure exceed 1/2 hour.

630.2.1.4 Storing Seed

(1) Store any seed delivered before use in a way that protects it from damage by heat, moisture, rodents, or other causes. Discard and replace any previously tested and accepted seed that becomes damaged.

630.2.1.5 Seed Mixtures

630.2.1.5.1 Right of way

630.2.1.5.1.1 Permanent

####### 630.2.1.5.1.1.1 Composition

(1) Seed mixtures for use on the right of way and easements shall, unless specified otherwise, be composed of seeds of the purity, germination, and proportions, by weight, as given in the Table of Highway Seed Mixtures and the Table of Native Seed Mixtures.

(2) Use seed of the species and varieties listed below. If no variety is listed, there will be no restriction on the variety furnished, except as follows:

1. Species composed of pure live seed (PLS) shall contain no named or improved varieties. PLS shall be grown in Wisconsin or northern Illinois, northeastern Iowa, or eastern Minnesota. Seed produced out-of-state must be grown in one of the following counties:

1.1 From northern Illinois:

Boone	Bureau	Carroll	Cook	De Kalb	Du Page	Grundy
Henry	Jo Daviess	Kane	Kendall	Lake	La Salle	Lee
McHenry	Ogle	Putnam	Rock Island	Stevenson	Whiteside	Will
Winnebago						

1.2 From northeastern Iowa:

Allamakee	Benton	Black Hawk	Bremer	Buchanan	Cedar	Chickasaw
Clayton	Clinton	Delaware	Dubuque	Fayette	Floyd	Howard

Jackson	Johnson	Jones	Linn	Mitchell	Muscatine	Scott
Winneshiek						

1.3 From eastern Minnesota:

Aitkin	Anoka	Carlton	Carver	Chisago	Dakota	Dodge
Fillmore	Goodhue	Hennepin	Houston	Isanti	Kanabec	La Sueur
Mille Lacs	Mower	Olmsted	Pine	Ramsey	Rice	Scott
Sherburne	Steele	Wabasha	Washington	Winona	Wright	

2. PLS for seed mixtures 70, 70A, 75, and 80 shall be packaged separately by species and clearly labeled with the vendor's name, species common and botanical names, gross weight, percent PLS, year of harvest and any specialized treatments that have been applied to ensure or enhance germination. If PLS is not listed, determine PLS by multiplying the percent germination times the percent purity.
3. Minimum percent purity for native for species is 90 percent. If a listed species is not available, substitutions may be made with engineer's approval and must be documented.

(3) Mix native species at the project site. Clean and debeard seeds having awns or excessive hairs before mixing.

SPECIES COMMON NAME	SPECIES BOTANICAL NAME	ACCEPTABLE VARIETIES
Kentucky Bluegrass	Poa pratensis	Low Maintenance
Red Fescue	Festuca rubra	Creeping
Hard Fescue	Festuca ovina	Improved
	var. duriuscula	
Tall Fescue	Festuca arundinacea	Improved turf type
Salt Grass	Puccinella distans	Fult’s
	Puccinella distans	Salty
Redtop	Agrostis alba	
Timothy	Phleum pratense	
Canada Wild Rye[1]	Elymus canadensis	
Perennial Ryegrass	Lolium perenne	
Perennial Ryegrass	Lolium perenne	Improved Fine
Annual Ryegrass	Lolium multiflorum	
Alsike Clover	Trifolium hybridum	
Red Clover	Trifolium pratense	
White Clover	Trifolium repens	
Japanese Millet	Echinochola crusgalli	
	var. frumentacea	
Annual Oats	Avena sativa	
Alfalfa	Medicago sativa	
Bromegrass	Bromus inermis	
Orchardgrass	Dactylis glomerata	
Ladino Clover	Trifolium repens	Ladino
	var. latum	
Agricultural Rye	Secale cereale	
Winter Wheat	Triticum aestivum	

[1] Pure live seed

TABLE 630-1 HIGHWAY SEED MIXTURES

SPECIES	PURITY minimum %	GERMINATION minimum %	MIXTURE PROPORTIONS in percent				
			NO.10	NO.20	NO.30	NO.40	NO.60
Kentucky Bluegrass	98	85	40	6	10	35	
Red Fescue	97	85	25		30	20	
Hard Fescue	97	85		24	25	20	
Tall Fescue	98	85		40			
Salt Grass	98	85			15		
Redtop	92	85	5				
Timothy	98	90					12
Canada Wild Rye		PLS[1]					10
Perennial Ryegrass	97	90	20	30			
Improved Fine Perennial Ryegrass	96	85			20	25	
Annual Ryegrass	97	90					30
Alsike Clover	97	90					4
Red Clover	98	90					4
White Clover	95	90	10				
Japanese Millet	97	85					20
Annual Oats	98	90[1]					20

[1] Substitute winter wheat for annual oats in fall plantings started after September 1.

TABLE 630-2 NATIVE SEED MIXTURES

SPECIES		SPECIES BOTANICAL NAME	PURITY & GERMINATION minimum %	MIXTURE PROPORTIONS in percent			
				NO. 70	NO. 70A	NO. 75	NO. 80
FORBES	Canada Anemone	*Anemone canadensis*	PLS	2			
	Butterflyweed	*Asclepias tuberosa*	PLS		2		
	New England Aster	*Aster novae-angliae*	PLS	2	2		
	Partridge-pea	*Chamaecrista (Cassia) fasciculata*	PLS		2		
	Purple Prairie Clover	*Dalea (Petalostemum) purpurea*	PLS	2	2	4	
	Canada Tick-trefoil	*Desmodium canadense*	PLS	2			
	Flowering Spurge	*Euphorbia corollata*	PLS		2		
	Wild Geranium	*Geranium maculatum*	PLS	2			
	Western Sunflower	*Helianthus occidentalis*	PLS	3	2		
	Rough Blazingstar	*Liatris aspera*	PLS		2		
	Prairie Blazingstar	*Liatris pycnostachya*	PLS	2			
	Lupine	*Lupinus perennis*	PLS		3		
	Wild Bergamot	*Monarda fistulosa*	PLS	2			
	Horse Mint	*Monarda punctata*	PLS		2		
	Yellow Coneflower	*Ratibida pinnata*	PLS	2	2		
	Blackeyed Susan	*Rudbeckia hirta*	PLS			1	
	Showy Goldenrod	*Solidago speciosa*	PLS	2	2		
	Spiderwort	*Tradescantia ohiensis*	PLS	2	2		
	Golden Alexanders	*Zizia aurea*	PLS	2			
GRASSES	Big Bluestem	*Andropogon gerardi*	PLS	15	15	10	
	Sideoats Grama	*Bouteloua curtipendula*	PLS	15	20	20	25
	Canada Wildrye	*Elymus Canadensis*	PLS	15	15	35	23
	Slender Wheatgrass	*Elymus trachycaulus*	PLS				20
	Junegrass	*Koeleria macrantha*	PLS		5		
	Annual Ryegrass	*Lolium multiflorum*	[1]			10	10
	Switchgrass	*Panicum virgatum*	PLS				10
	Salt Grass	*Puccinella distans*	[1]				2
	Little Bluestem	*Schizachyrium (Andropogon) scoparium*	PLS	15	20	10	10
	Indiangrass	*Sorgastrum nutans*	PLS	15		10	
ALTERNATE FORBES	Sky Blue Aster	*Aster azureus*	PLS	[2]	[2]		
	White Wild Indigo	*Baptisia leucantha*	PLS	[2]	[2]		
	Pale Purple Coneflower	*Echinacea pallida*	PLS	[2]	[2]		
	White Prairie Clover	*Petalostemum candidum*	PLS	[2]	[2]		
	Stiff Goldenrod	*Solidago rigida*	PLS	[2]	[2]		
	Hoary Vervain	*Verbena stricta*	PLS	[2]	[2]		

[1] Provide the minimum purity and germination specified in 630.2.1.5.1.1.1(3) in the table of highway seed mixtures.

[2] The contractor may, if the engineer approves, substitute an alternate forb for a required forb that is not available using the same percentage as specified for the required forb. Use a different alternate forb for each

unavailable required forb. Provide documentation showing that a required forb is not available before using an alternate.

630.2.1.5.1.1.2 Mixture

(1) The contractor shall select a seed mixture or mixtures that meet with the engineer's approval, and unless specified otherwise in the contract, shall conform to the following:

1. Use seed mixture No. 10 where average loam, heavy clay, or moist soils predominate.
2. Use seed mixture No. 20 where light, dry, well-drained, sandy, or gravelly soils predominate and for all high cut and fill slopes generally exceeding 6 to 8 feet, except where using No. 70.
3. Use seed mixture No. 10 or No. 20 on all ditches, inslopes, median areas, and low fills, except where using No. 30 or No. 70.
4. Use seed mixture No. 30 for medians and on slopes or ditches generally within 15 feet of the shoulder where a salt-tolerant turf is preferred.
5. Use seed mixture No. 40 in urban or other areas where a lawn type turf is preferred.
6. Use seed mixture No. 60 only on areas, the contract designates or the engineer specifies. Use it as a cover seeding for newly graded wet areas or as a nurse crop for specified wetland seed mixtures. The contractor shall not apply it to flooded areas.
7. Use seed mixture Nos. 70 and 70A on slopes and upland areas the contract designates or the engineer specifies. Use seed mixture No. 70 on loamy soils and seed mixture No. 70A on sandy soils.
8. Use seed mixture No. 75 where native grasses are desired for erosion control.
9. Use seed mixture No. 80 on inslopes where a salt tolerant seed mix containing native grasses is desired.

630.2.1.5.1.2 Temporary

(1) Under the Seeding Temporary bid item, use a temporary seed mixture conforming to 630.2.1.5.1.4. Use oats in spring and summer plantings. Use winter wheat or rye for fall plantings started after September 1.

630.2.1.5.1.3 Nurse Crop

(1) If seeding bare soil with either mixture 70, 70A, 75, or 80, include the Seeding Nurse Crop bid item.

630.2.1.5.1.4 Borrow Pits and Material Disposal Sites

(1) For seeding borrow pits and material disposal sites beyond the right of way, use seed mixtures conforming to seed mixture 10, 20, 70, 70A, or 75 of 630.2.1.5.1.1 or a borrow pit mixture composed of seeds of the species, purity, germination and proportions, by weight as given below:

PERMANENT

SPECIES	% MINIMUM PURITY	% MINIMUM GERMINATION
Alfalfa	98	90
Bromegrass	85	85
Orchardgrass	80	85
Timothy	98	90
Red Clover	98	90
Alsike Clover	97	90
Ladino Clover	95	90
Kentucky Bluegrass	98	85

TEMPORARY

SPECIES	% MINIMUM PURITY	% MINIMUM GERMINATION
Annual Oats	98	90
Agricultural Rye	97	85
Winter Wheat	95	90

NURSE CROP

SPECIES	% MINIMUM PURITY	% MINIMUM GERMINATION
Annual Oats	98	90
Annual Ryegrass	97	90
Winter Wheat	95	90

(2) For the borrow pit mixture use, by weight, 60 percent temporary species seeds and 40 percent permanent species seeds.

(3) For the temporary component, use any combination of temporary seeds listed in the table above.

(4) For the permanent component, use seeds from not more than 4 of the permanent species listed in the table above in any combination.

(5) When nurse crop is required for spring seeding before June 15, use annual oats. For fall seeding after October 15, use winter wheat, or annual ryegrass.

630.3 Construction

630.3.1 General

(1) If not protecting with a mulch cover, perform seeding, except Nos. 60, 70 and 70A mixtures at times of the year when temperature and moisture conditions are suitable for seeding, except during midsummer.

(2) Perform seeding, except Nos. 60, 70 and 70A mixtures, in conjunction with mulching as specified in 627 at any time the engineer allows.

(3) The contractor may perform seeding of Nos. 60, 70 and 70A mixtures at any time soil conditions are suitable, except between June15 and October 15, unless the engineer allows otherwise.

(4) Perform seeding with the selected seed mixture, sown at the specified rate.

630.3.2 Preparation of Seed Bed

(1) Complete grading, shouldering, topsoiling, and fertilizing, if part of the work under contract, before permanent seeding, except the contractor may place the fertilizer and seed mixture in one operation if using equipment designed for the purpose.

(2) Just before seeding, work the area being seeded with discs, harrows, or other appropriate equipment to obtain a reasonably even and loose seedbed. Place topsoil as specified in 625.3.3.

630.3.3 Sowing

(1) Select the method of sowing from either method A, method B, method C, or an appropriate combination of methods A, B, and C. Obtain the engineer's approval for the sowing method and specific procedures used for each seed mixture used before sowing that mixture.

630.3.3.1 Method A

(1) Sow the selected seed mixture using equipment adapted to the purpose, or by scattering it uniformly over the areas to be seeded. Lightly rake or drag to cover the seed with approximately 1/4 inch of soil. After seeding, lightly roll or compact the areas using suitable equipment, preferably the cultipacker type, when the engineer judges the seedbed too loose, or if the seedbed contains clods that might reduce seed germination. The contractor shall not roll slopes steeper than 1:3.

(2) If scattering seed by hand, perform this work with satisfactory hand seeders and only when the air is calm enough to prevent seeds from blowing away.

630.3.3.2 Method B

(1) Sow or spread the seed upon the prepared bed using a stream or spray of water under pressure and operated from an engineer-approved machine designed for that purpose. Place the selected seed mixture and water into a tank, provided within the machine, in sufficient quantities that when spraying the seed on a given area it is uniformly spread at the required application rate. During this process, keep the tank contents stirred or agitated to provide uniform distribution. Spread the tank contents within one hour after adding the seed to the tank. The engineer will reject seed that remains mixed with the water for longer than one hour. The engineer will not require dragging or rolling.

630.3.3.3 Method C

(1) For spring seeding of seed mixtures 70 and 70A into existing ground cover, mow existing vegetation to 4 inches or less in height 2 to 4 weeks before seeding. Ten to 14 days after mowing, spray with vegetation control herbicide conforming to 632.2.12.

(2) For fall seeding of seed mixtures 70 and 70A into existing ground cover, mow existing vegetation to 4 inches or less in height 4 to 6 weeks before seeding. Ten to 14 days after mowing, spray with vegetation control herbicide conforming to 632.2.12. Retreat with vegetation control herbicide 10 to 14 days after initial application if live vegetation persists.

(3) Seed with a rangeland type drill with one or more seed boxes that can be calibrated independently to deliver different sized seeds uniformly at the required rate and equipped with a rear-mounted press wheel for each seed drop tube. If seeding into existing vegetation or thatch, use a rangeland type drill equipped with a no-till attachment that can cut through the vegetation or thatch in front of the V disc and seed drop tube. If the configuration of the area to be seeded allows, apply seed at 1/2 the specified seed rate and apply the second 1/2 in a perpendicular direction.

630.3.3.4 Borrow Pits and Material Disposal Sites

(1) Seed borrow pits, and material disposal sites off the right of way, with the selected seed mixture specified in 630.2.1.5.1.4. Consult with the landowner or the landowner's agent when selecting the seed mixture.

630.3.3.5 Seeding Rates

630.3.3.5.1 Right of way

(1) Use the following sowing rate for seeds in pounds per 1000 square feet:

- Seed mixture No. 10 at 1.5 pounds
- Seed mixture No. 20 at 3 pounds
- Seed mixture No. 30 at 2 pounds
- Seed mixture No. 40 at 2 pounds
- Seed mixture No. 60 at an equivalent seeding rate of 1.5 pounds[1]
- Seed mixture No. 70 or 70A at 0.4 pounds
- Seed mixture No. 75 at an equivalent seeding rate of 0.7 pounds[1]
- Seed mixture No. 80 at an equivalent seeding rate of 0.8 pounds[1]
- Temporary seeding at 3 pounds
- Nurse crop seeding at 0.8 pounds

[1] Determine the actual seeding rate by multiplying the equivalent seeding rate by the sum of the unadjusted and adjusted percentages of the various species in the seed mixtures as sown.

(2) The unadjusted percentage equals the minimum percent of purity and germination specified in the table of seed mixtures contained in 630.2.1.5.1.1.1 for the applicable species.

(3) Obtain the adjusted percentage for each of the PLS species by dividing the specified percentage of the species by the product of the percent of purity and the percent of germination for each of the PLS species as delivered.

630.3.3.5.2 Borrow Pits and Material Disposal Areas

(1) For seeding borrow pits and material disposal off the right of way, sow the seed mixtures specified in 630.2.1.5.1.4 at the following rates per pound per 1000 square feet:

- Seed mixture No. 10 at 0.75 pound
- Seed mixture No. 20 at 1 pound
- Seed mixture No. 70 or 70A at 0.4 pounds
- Seed mixture No 75 at 0.7 pounds
- Borrow pit mixture at 1.5 pounds

630.3.3.6 Establishment Period for Native Seeding

(1) During the growing season after planting seed mixture 70 or 70A, mow all seeded areas twice as the engineer directs. Mow vegetation back to 6 inches when it has reached a height of at least 12 inches.

(2) During the growing season after planting seed mixture 70 or 70A, eradicate the following species from the seeded areas as soon as they become evident:

SPECIES COMMON NAME	SPECIES BOTANICAL NAME
Musk thistle	Carduus nutans
Spotted knapweed	Centaurea maculosa
Canada thistle	Cirsium arvense
Bull thistle	Cirsium vulgare
Field bindweed	Convolvulus arvensis
Leafy spurge	Euphorbia esula
Sweetclover	Melilotus species
Wild parsnip	Pastinaca sativa

(3) Eradicate by hand pulling or by applying a vegetation control herbicide conforming to 632.2.12 to individual plants.

630.4 Measurement

(1) The department will measure the Seeding bid items by the pound acceptably completed.

(2) The department will measure quantities based on net weights of seed shipments, or on quantities weighed on department-approved scales the contractor furnishes.

(3) The department will make deductions for all quantities wasted or not actually incorporated in the work according to the contract.

(4) The department will determine the equivalent pounds of seed furnished and applied by dividing the actual pounds of seed applied by the sum of the unadjusted and adjusted percentages of the various species in the seed mixture sown.

(5) The department will use the unadjusted and adjusted percentages determined in 630.3.3.5.1.

630.5 Payment

(1) The department will pay for measured quantities at the contract unit price under the following bid items:

ITEM NUMBER	DESCRIPTION	UNIT
630.0100 - 0199	Seeding (mixture)	LB
630.0200	Seeding Temporary	LB
630.0300	Seeding Borrow Pit	LB
630.0400	Seeding Nurse Crop	LB

(2) Payment for the Seeding bid items is full compensation for providing, handling, and storing all seed; for providing the required culture and inoculating seed as specified; and for preparing the seed bed, sowing, covering and firming the seed. If the landowner does not want the pit or material disposal site seeded, or seeded with any of the mixtures allowed, the department will not pay for fertilization or seeding of those areas.

Section 627 Mulching

627.1 Description

(1) This section describes furnishing, placing, and anchoring a mulch cover, usually in connection with seeding the surfaces of the roadway.

627.2 Materials

(1) Mulching material consists of straw or hay in an air-dry condition, wood excelsior fiber, wood chips, or other suitable material of a similar nature that the engineer approves, and is substantially free of noxious weed seeds and objectionable foreign matter.

(2) If using tackifier, the department will prequalify it before use. Select tackifiers from the department's erosion control product acceptability list (PAL). The contractor may obtain a copy of the department's PAL and the prequalification procedure for products not on the department's PAL.

627.3 Construction

627.3.1 General

(1) Unless directed otherwise, place the mulch on the specified area within 2 days after completing the seeding.

(2) The contractor shall not perform mulching during periods of excessively high winds that might preclude proper mulch placement.

(3) Place the mulch loosely or open enough to allow some sunlight to penetrate and air to slowly circulate, but thick enough to shade the ground, conserve soil moisture, and prevent or reduce erosion.

(4) Maintain the mulched areas and repair all areas damaged by wind, erosion, traffic, fire or other causes.

627.3.2 Placing

(1) The contractor may perform the work as specified in one of the following ways: Method A, Method B, or Method C, or a combination of the 3, unless a specific method is specified in the contract.

627.3.2.1 Method A, Netting

(1) Uniformly spread the mulching material over the designated areas to a loose depth of 1/2 to 1 1/2 inches. Use a specific rate of application; dependent on the character of the material, that results in a cover conforming to the requirements specified above in 627.3.1. Loosen or make fluffy the mulch material from compacted bales before spreading in place. Unless directed otherwise, begin mulching at the top of the slopes and proceed downward.

(2) Securely anchor straw or hay mulch by using engineer-approved netting anchored to the ground with pegs or staples to prevent it from floating as the vegetation grows. Instead of this anchorage, the contractor may secure mulch by heavy biodegradable twine fastened by pegs or staples to form a grid with 6 to 10 feet spacing.

(3) The contractor may use department-approved erosion control mats, listed in the department's PAL, instead of separately applying mulch and netting.

627.3.2.2 Method B, Tackifier

(1) Treat straw or hay with a tackifier, blow from a machine, and uniformly deposit over designated areas in one operation. Place straw or hay uniformly over the area 1/2 to 1 inch deep, using 1/2 to 3 tons of mulch per acre. Mix and place tackifier according to the department's PAL. Within the above limits, the engineer will determine, on the job, the application rate of the mulch and the tackifier, and the engineer may vary the rates during mulching to produce the desired results. Use an engineer-approved machine to place the mulch that blows or ejects by constant air stream a controlled quantity of mulch and applies a spray of tackifier to partially coat the straw or hay, sufficient to hold together and keep in place the deposited straw or hay. The contractor may apply the tackifier as an overspray in a separate operation after placing the straw or hay.

(2) Apply wood fiber, wood chips, or similar material with engineer-approved blowing machines, or other engineer-approved methods, that place a controlled quantity of mulch uniformly over the area 1/2 to 1 1/2 inches deep. Treat areas receiving wood chip mulch, with one pound of available nitrogen per 1000 square feet before or after applying the chips.

(3) Throughout the process, feed the mulch material into the blowing machine to produce a constant and uniform ejection from the discharge spout, and operate in a position to produce mulch of uniform depth and coverage.

627.3.2.3 Method C, Crimping

(1) Spread the straw or hay mulch uniformly over the designated areas to a loose depth of 1/2 to 1 1/2 inches, using 1/2 to 3 tons of mulch per acre, by blowing from a machine, as specified in Method B, or by other engineer-approved methods.

(2) Immediately after spreading, anchor the mulch in the soil by using a mulch crimper consisting of a series of dull, flat discs with notched edges. Space the 20 inch diameter discs at about 8 inch centers. Equip the crimper with a ballast compartment to allow adjusting the weight for depth control.

(3) Impress the mulch into the soil 1 1/2 to 2 1/2 inches deep in one pass of the crimper. The department will not allow mulch crimpers to operate on slopes so steep that damage to the mulch, seedbed, or soil occurs. Anchor the mulch on these areas by one of the following methods: Method A or Method B. Equip and operate tractors to minimize disturbing or displacing the soil. This process may require more than one pass of the crimper to ensure adequate anchoring of the mulch.

(4) The contractor shall not use Method C if it cannot impress the mulch to a minimum of 1 1/2 inch.

627.4 Measurement

(1) The department will measure Mulching acceptably completed by the square yard or by the ton, whichever the contract specifies.

(2) If measured by the square yard, the measured quantity equals the number of square yards of surface area that the contractor applied the mulch.

(3) If measured by the ton, the measured quantity equals the number of tons of mulch provided, placed, and acceptably completed.

(4) Tackifiers or nitrogen used for treating mulch are incidental to the cost of the work.

627.5 Payment

(1) The department will pay for measured quantities at the contract unit price under the following bid items:

ITEM NUMBER	DESCRIPTION	UNIT
627.0200	Mulching	SY
627.0205	Mulching	TON

(2) Payment for Mulching is full compensation for providing materials, including tackifiers or nitrogen; for all hauling, treating, placing, spreading, and anchoring of the mulch material; and for maintaining the work and repairing all damaged areas.

(3) If the contractor opts to use department-approved erosion control mats instead of separately applying mulch and netting, the department will pay for it at the contract unit price for Mulching only.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

Critical Area Planting

Code 342

(Ac)

DEFINITION

Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal seeding/planting methods.

PURPOSE

- Stabilize areas with existing or expected high rates of soil erosion by wind or water.
- Stabilize stream and channel banks, pond and other shorelines, earthen features of structural conservation practices.
- Stabilize areas such as sand dunes and riparian areas.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to highly disturbed areas such as—

- Active or abandoned mined lands.
- Urban restoration sites.
- Construction areas.
- Conservation practice construction sites.
- Areas needing stabilization before or after natural disasters such as floods, hurricanes, tornados, and wildfires.
- Eroded banks of natural channels, banks of newly constructed channels, and lake shorelines.
- Other areas degraded by human activities or natural events.

CRITERIA

General Criteria Applicable to All Purposes

Site preparation. Conduct a site investigation to identify any physical, chemical, or biological conditions that could affect the successful establishment of vegetation.

Clear areas to be planted of unwanted materials and smooth or shape, if needed, to meet planting purpose(s).

Prepare a suitable seedbed for all seeded species. Rip compacted layers and re-firm the soil prior to seedbed preparation, as needed.

As site conditions dictate, when grading slopes, stockpile topsoil to be redistributed over area to be planted.

Species selection. Select species for seeding or planting that are suited to local site conditions and intended uses, and common to the site or location.

Selected species will have the capacity to achieve adequate density and vigor to stabilize the site within an appropriate period.

Establishment of vegetation. Plant seeds using the method or methods best suited to site and soil conditions.

Limit sod placement to areas that can naturally supply needed moisture or sites that can be irrigated during the establishment period. Place and anchor sod using techniques to ensure that it remains in place until established.

Specify species, rates of seeding or planting, legume inoculation, minimum quality of planting stock (e.g., pure live seed (PLS) or stem caliper), method of seedbed preparation, and method of establishment before application. Use only viable, high-quality seed or planting stock.

Seed or plant at a time and in a manner that best ensures establishment and growth of the selected species.

Plant during approved times for the species to be used.

Apply soil amendments (e.g., lime, fertilizer, compost) according to the requirements in the local Field Office Technical Guide.

Mulch or otherwise stabilize (e.g., polyacrylamide (PAM)) plantings as necessary to ensure successful establishment.

Additional Criteria to Stabilize Stream and Channel Banks, Pond and Other Shorelines, Earthen Features of Structural Conservation Practices

Bank and channel slopes. Shape channel side slopes so that they are stable and allow establishment and maintenance of desired vegetation.

A combination of vegetative and structural measures may be necessary on slopes steeper than 3:1 to ensure adequate stability.

Species selection. Plant material used for this purpose must—

- Be adapted to the hydrologic zone into which they will be planted.
- Be adapted and proven in the regions in which they will be used.
- Be compatible with existing vegetation in the area.
- Protect the channel banks but not restrict channel capacity.

Establishment of vegetation. Specify species, planting rates, spacing, methods and dates of planting based on local planting guides or technical notes.

Identify and protect desirable existing vegetation during practice installation.

Use a combination of vegetative and structural practices with living and inert material when flow velocities, soils, and bank stability preclude stabilization by vegetative establishment alone. Use Conservation Practice Standard (CPS) Streambank Stabilization (Code 580) for the structural measures.

Control existing vegetation on a site that will compete with species to be established vegetatively (e.g.. bare-root, containerized, ball-and-burlap, potted) to ensure successful establishment of the planted species.

Plant streambank stabilization vegetation in accordance with the NRCS Engineering Field Handbook Part 650, Chapter 16, “Streambank and Shoreline Protection,” and Chapter 18, “Soil Bioengineering for Upland Slope Protection & Erosion Reduction.”

Site protection and access control. Restrict access to planted areas until fully established.

Additional Criteria to Stabilize Areas Such As Sand Dunes and Riparian Areas

Plants for sand dunes and coastal sites must be able to survive being buried by blowing sand, sand blasting, salt spray, salt water flooding, drought, heat, and low nutrient supply.

Include sand trapping devices such as sand fences or brush matting in the revegetation/stabilization plans where applicable.

CONSIDERATIONS

Species or diverse mixes that are adapted to the site and have multiple benefits should be considered. Native species may be used when appropriate for the site.

To benefit pollinators and other wildlife, flowering shrubs and wildflowers with resilient root systems and good soil-holding capacity also should be considered for incorporation as a small percentage of a larger grass-dominated planting. Where appropriate consider a diverse mixture of forbs to support pollinator habitat.

Planning and installation of other CPSs such as Diversion (Code 362), Obstruction Removal (Code 500), Subsurface Drain (Code 606), Underground Outlet (Code 620), or Anionic Polyacrylamide Application (Code 450) may be necessary to prepare the area or ensure vegetative establishment.

Areas of vegetation established with this practice can create habitat for various type of wildlife. Maintenance activities, such as mowing or spraying, can have detrimental effects on certain species. Perform management activities at the times and in a manner that causes the least disruption to wildlife.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for each field or management unit according to the criteria and operation and maintenance sections of this standard. Record practice specifications using approved Implementation Requirements document.

Address the following elements in the plan, as applicable, to meet the intended purpose(s):

- Practice purpose(s)
- Site preparation
- Topsoil requirements
- Fertilizer application
- Seedbed/planting area preparation
- Timing and method of seeding/planting
- Selection of species
- Seed/plant source
- Seed analysis/pure live seed (PLS)
- Seeding rate/plant spacing
- Mulching, PAM, or other stabilizing materials
- Supplemental water needed for establishment
- Protection of plantings
- Describe successful establishment (e.g., minimum percent ground/canopy cover, percent survival, stand density)

OPERATION AND MAINTENANCE

- Control access to the area to ensure the site remains stable.
- Protect plantings shall be protected from pests (e.g., weeds, insects, diseases, livestock, or wildlife) as necessary to ensure long-term survival.
- Inspections, reseeding or replanting, and fertilization may be needed to ensure that this practice functions as intended throughout its expected life.
- Observe establishment progress and success at regular intervals until the practice has met the criteria for successful establishment and implementation.
- Description of successful establishment (e.g., minimum percent ground/canopy cover, percent survival, stand density).

REFERENCES

Federal Interagency Stream Restoration Working Group. 1998. Stream corridor restoration: principles, processes, and practices. USDA NRCS National Engineering Handbook, Part 653.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WETLAND CREATION

(Ac.)

CODE 658

DEFINITION

The creation of a wetland on a site location that was historically non-wetland.

PURPOSE

To establish wetland hydrology, vegetation, and wildlife habitat functions on soils capable of supporting those functions.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies only to sites where hydric soils do not exist and the objective is to establish specific wetland functions.

This practice does not apply to:

- The treatment of point and non-point sources of water pollution (Constructed Wetland – Code 656).
- The rehabilitation of a degraded wetland or the reestablishment of a former wetland so that soils, hydrology, vegetative community, and habitat are a close approximation of the original natural condition and boundary that existed prior to the modification. (Wetland Restoration – Code 657).
- The rehabilitation of a degraded wetland, the reestablishment of a former wetland, or the modification of an existing wetland, where specific wetland functions are augmented beyond the original natural conditions; possibly at the expense of other functions. (Wetland Enhancement – Code 659).
- The management of fish and wildlife habitat created under this standard.

CRITERIA

General Criteria Applicable to All Purposes

The purpose, goals, and objectives of the creation shall be clearly defined in the creation plan, including soils, hydrology, vegetation and fish and wildlife habitat criteria that are to be met and are appropriate for the site and the project objectives.

The soils, hydrology and vegetative conditions existing on the site, the adjacent landscape, and the contributing watershed shall be documented in the planning process.

The nutrient and pesticide tolerance of the plant and animal species likely to occur shall be considered where known nutrient and pesticide contamination exists. Sites suspected of containing hazardous material shall be tested to identify appropriate remedial measures. If remedial measures are not possible or practicable, the practice shall not be planned.

Water rights, if applicable, shall be assured prior to creation.

Upon completion, the site shall meet the appropriate wetland criteria and provide wetland functions as defined in the project's objectives.

Invasive species, federal/state listed noxious plant species, and nuisance species (e.g., those whose presence or overpopulation jeopardize the practice) shall be controlled on the site. The establishment and/or use of non-native plant species shall be discouraged.

Criteria for Soils

Created wetlands shall be located in landscape positions and soil types capable of supporting the planned wetland functions.

Changes to soil hydrodynamic and bio-geochemical properties such as permeability, porosity, pH, or soil organic carbon levels shall be made as needed to meet the planned objectives.

Criteria for Hydrology

The hydroperiod, hydrodynamics, and dominant water source shall meet the project objectives. The creation plan shall document the adequacy of available water sources based on groundwater investigation, stream gage data, water budgeting, or other appropriate means.

The work associated with the wetland shall not adversely affect adjacent properties or other water users unless agreed to by signed written letter, easement or permit.

Timing and level setting of water control structures required for the establishment and maintenance of vegetation, soil, and wildlife and fish habitat functions shall be determined.

Other structural practices, macrotopography and/or microtopography may be used to meet the planned objectives.

Macrotopographic features, including ditch plugs installed in lieu of re-filling surface drainage ditches, shall meet the requirements of other practice standards to which they may apply due to purpose, size, water storage capacity, hazard class, or other parameters. If no other practice standard applies, they shall meet the requirement s for Dike – Code 356 unless there is no potential for damage to the feature or other areas on or off site due to erosion, breaching, or overtopping.

Water control structures that may impede the movement of target aquatic species or species of concern shall meet the criteria in Fish Passage – Code 396.

Criteria for Vegetation

Hydrophytic vegetation planned to meet the selected wetland functions shall be compatible with the planned soil and hydrologic conditions. Preference shall be given to native wetland plants with localized genetic material.

Where natural colonization of acceptable species can realistically be expected to occur within five years, sites may be left to revegetate naturally. If not, the appropriate species will be established by seeding or planting.

Adequate substrate material and site preparation necessary for proper establishment of the selected plant species shall be included in the plan.

Where planting and/or seeding is necessary, the minimum number of native species to be established shall be based upon the types of vegetative communities present and the vegetation type planned. To achieve habitat diversity and minimize the adverse effects of climate, disease, and other limiting factors, several species adapted to the site will be established. Seeding rates shall be based upon the percentage of pure live seed and labeled with a current seed tag from a registered seed laboratory identifying the germination rate, purity analysis, and other seed statistics.

CONSIDERATIONS

Hydrology Considerations

Consider the general hydrologic effects of the restoration, including:

- Impacts on downstream stream hydrographs, volumes of surface runoff, and groundwater resources due to changes of water use and movement created by the restoration.

Consider the impacts of water level management, including:

- Increased predation due to concentrating aquatic organisms, including herptivores, in small pool areas during drawdowns.
- Increased predation of amphibians due to high water levels that can sustain predators.
- Decreased ability of aquatic organisms to move within the wetland and from the wetland area to adjacent habitats, including anadromous fish and herptivores, as water levels are decreased.
- Increases in water temperature on-site, and in off-site receiving waters.

- Changes in the quantity and direction of movement of subsurface flows due to increases or decreases in water depth.
- The effect changes in hydrologic regime have on soil bio-geochemical properties; including oxidation/reduction, maintenance of organic soils, and salinity increase or decrease on adjacent areas.
- The potential for water control structures, dikes, and macrotopographic to negatively impact aquatic organism passage.

Vegetation Considerations

Consider:

- The relative effects of planting density on wildlife habitat versus production rates in woody plantings.
- The potential for vegetative buffers to increase function by trapping sediment, cycling nutrients, and removing pesticides.
- The selection of vegetation for the protection of structural measures that is appropriate for wetland function.
- The selection of vegetation for the protection of structural measures that is appropriate for wetland function.
- The potential for invasive or noxious plant species to establish on bare soils after construction and before the planned plant community is established.

Soil Considerations

Consider changes of physical soil properties, including:

- Increasing or decreasing saturated hydraulic conductivity by mechanical compaction or tillage, as appropriate.
- Incorporating soil amendments.
- The effect of construction equipment on soil density, infiltration, and structure.

Consider changes in soil bio-geochemical properties, including:

- Increasing soil organic carbon by incorporating compost.
    - Increasing or decreasing soil pH with lime, gypsum, or other compounds.

Wildlife Habitat Considerations

Consider:

- The addition of coarse woody debris on sites to be restored to woody plant communities for an initial carbon source.
- The potential to restore habitat capable of supporting wildlife with the ability to control disease vectors such as mosquitoes.
- The potential to establish fish and wildlife corridors linking the site to adjacent landscapes, streams and waterbodies and to increase the sites colonization by native flora.
- The need to provide barriers to passage for unwanted or predatory wildlife species.

PLANS AND SPECIFICATIONS

Plans and specifications for this practice shall be prepared for each site. Plans and specifications shall be recorded using approved specifications sheets, job sheets, or other documentation. The plans and specifications for structural features will include, at a minimum, a plan view, quantities, and sufficient profiles and cross-sections to define the location, line, and grade for stakeout and checkout. Plans and specifications shall be reviewed and approved by staff with appropriate job approval authority.

OPERATION AND MAINTENANCE

A separate Operation and Maintenance Plan will be prepared for sites that have structural features. The plan will include specific actions for the normal and repetitive operation of installed structural items, especially water control structures, if included in the project. The plan will also include the maintenance actions necessary to assure that constructed items are maintained as constructed for the life of the project. It will include the inspection schedule, a list of items to inspect, a checklist of potential damages to look for, recommended repairs, and procedures for documentation.

Management and monitoring activities needed to ensure the continued success of the wetland functions may be included in the above plan, or in a separate Management and Monitoring Plan. In addition to the monitoring schedule, this plan may include the following:

- The timing and methods for the use of fertilizers, pesticides, prescribed burning, or mechanical treatments
- Circumstances when the use of biological control of undesirable plant species and pests (e.g. using predator or parasitic species) is appropriate, and the approved methods.
- Actions which specifically address any expected problems from invasive or noxious species
- The circumstances which require the removal of accumulated sediment.
- Conditions which indicate the need to use haying or grazing as a management tool, including timing and methods.

REFERENCES

Executive Order 13112, Invasive Species, February 3, 1999. Federal Register: vol.64, no.25. Feb. 8, 1999.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WETLAND ENHANCEMENT

(Ac.)

CODE 659

DEFINITION

The rehabilitation or re-establishment of a degraded wetland, and/or the modification of an existing wetland.

PURPOSE

To provide specific wetland conditions to favor specific wetland functions and targeted species by:

- hydrologic enhancement (depth duration and season of inundation, and/or duration and season of soil saturation).
- vegetative enhancement (including the removal of undesired species, and/or seeding or planting of desired species).

CONDITIONS WHERE PRACTICE APPLIES

This practice applies on any degraded or non-degraded existing wetland where the objective is specifically to enhance selected wetland functions.

This practice *does not* apply to the following where the intention is to:

- treat point and non-point sources of water pollution (Constructed Wetland, code 656);
- rehabilitate a degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to original conditions (Wetland Restoration, code 657);
- create a wetland on a site that historically was not a wetland (Wetland Creation, code 658); and,
- Fish Pond Management, code 399.

CRITERIA

General Criteria Applicable to All Purposes

The purpose, goals and objectives of the enhancement shall be clearly outlined, including the soils, hydrology and vegetation criteria that are to be met and are appropriate for the site and the project purposes.

The impact of this practice on existing non-degraded wetland functions and/or values will be evaluated. A functional assessment procedure (i.e., National Food Security Act Manual Subpart D, 526.46 or Maine Wildlife Habitat Evaluation Procedures or, when required for permit issuance, the USCOE New England District Methodology) will document benchmark conditions and expected impacts (negative and positive).

The soils, hydrology and vegetative characteristics existing on the site and the contributing watershed shall be documented before enhancement of the site begins.

The site will be monitored and adaptively managed to insure enhancement is achieved.

Where known nutrient and pesticide contamination exists, species selected will be tolerant of these conditions.

Sites containing hazardous material shall be cleaned prior to the establishment of this practice. Appropriate actions to clean sites suspected of containing hazardous wastes shall be based on soil tests.

Invasive species, federal/state listed noxious plant species, and nuisance species (e.g., those whose presence or overpopulation jeopardize the practice) shall be controlled at less than 15%

coverage. The establishment and/or use of non-native plant species shall be discouraged.

Any use of fertilizers, mechanical treatments, grazing (flash), pesticides and other chemicals shall assure that the intended purpose of the wetland enhancement shall not be compromised.

Chemicals to control pests will be evaluated with NRCS' Windows Pesticide Screening Tool (WIN-PST), and negative affects minimized (see Table 1 of the NRCS conservation practice standard *Pest Management*, code 595).

Management of vegetation will avoid disturbance to ground nesting species during the primary nesting season which extends from April 15 to August 1.

All activities planned under this practice shall comply with applicable federal, tribal, state, and local laws, rules and regulations.

Criteria for Hydrologic Enhancement

The hydrology of the site (defined as the rate and timing of inflow and outflow, source, duration, frequency, and depth of flooding, ponding or saturation) shall meet the project objectives. An adequate source of water must be available to meet hydrology designs.

Timing and level setting of water control structures is required for the establishment of desired hydrologic conditions for management of vegetation and for optimum wildlife and fish use.

Existing drainage systems will be utilized, removed or modified and maintained as needed to achieve the intended purpose.

Criteria for Vegetative Enhancement

Establish native, locally adapted hydrophytic vegetation typical for the wetland type(s) being enhanced. Native wetland species and, where available, recommended means of establishment are in Section IV, C. Tools of the NRCS' electronic Field Office Technical Guide (eFOTG) for Maine.

Where natural colonization of desired species will dominate within 5 years, natural regeneration can be left to occur.

Invasive species, federal/state listed noxious plant species, and nuisance species occur near the enhancement site, quickly establish vegetative cover and cover disturbed ground to reduce the likelihood the site will be invaded.

Adequate substrate material and site preparation necessary for proper establishment of the selected plant species shall be included in the design.

If the targeted hydrophytic vegetation is predominantly herbaceous, several species adapted to the site shall be established. Herbaceous vegetation may be established by a variety of methods including, but not limited to: plugs, seedlings, bulbs, rhizomes/cuttings, mechanical or aerial seeding, topsoiling, organic mats, etc., over the entire site, or a portion of the site and at densities and depths appropriate.

For forested wetland establishment, reforestation shall simulate the number and diversity of native species typical of the wetland based on a local reference site.

Seeding rates shall be based upon percentage of pure live seed within 6 months of planting.

When vegetation is managed by flash grazing, grazing plan will be prescribed.

CONSIDERATIONS

Dike (356), Structure for Water Control (587), Wetland Wildlife Habitat Management (644), and other facilitating practices may be used to enhance the performance of this practice.

Consider enhancement of existing wetlands if: high priority fish and wildlife habitat will be enhanced, degraded natural wetland conditions and functions will be enhanced; or, public safety is a concern.

Consider manipulation of water levels to control unwanted vegetation.

Consider effect enhancement will have on disease vectors such as mosquitoes.

The inclusion of microtopography can achieve changes in depth and duration of flooding without changing extent of surface area.

Consider effect of volumes and rates of runoff, infiltration, evaporation and transpiration on the water budget.

Consider effects on downstream flows or aquifers that would affect other water uses or users.

Consider effects on fish and wildlife habitats that would be associated with the practice.

Consider linking wetlands by corridors wherever appropriate to enhance the wetland's use and colonization by the flora and fauna.

Establishing vegetative buffers on surrounding uplands can reduce sediment and soluble and sediment-attached contaminant delivery by runoff and/or wind.

Consider effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

Soil disturbance associated with the installation of this practice may increase the potential for invasion by unwanted species.

On sites where woody vegetation will dominate, consider adding 1 to 2 dead snags, tree trunks or logs per acre to provide structure and cover for wildlife and a carbon source for food chain support.

For discharge wetlands, consider underground upslope water and/or groundwater source availability.

When determining which species to plant, consider microtopography and the different hydrology levels.

Consider whether desired vegetation and seral stage can be maintained by water level manipulation alone or whether management by mechanical means or flash grazing is needed and are feasible options.

Consider the effects that location, installation and management may have on subsurface cultural resources.

Consider the effect of water control structures on the ability of fish to move in and out of the wetland.

Consider the effects that water level draw drowns will have on the mortality of aquatic species.

Consider timing of water control to mimic the natural hydrological regime of the area, further enhancing the habitat for aquatic species.

Consider design modifications that will limit potential negative impacts of wetland plants and animals on the project.

PLANS AND SPECIFICATIONS

Specifications for this practice shall be prepared for each site and shall describe the requirements for applying the practice to achieve its intended purpose(s). Specifications shall be recorded using approved specifications sheets, job sheets, narrative statements in the conservation plan, or other equivalent documentation. The following minimum components shall be included:

- statement of landowner's goals and objectives;
- an assessment of the functions and values of the wetland and impacts of this practice installation on the wetland and other natural and cultural resources;
- description of soils, hydrology and vegetative characteristics existing on the site and the contributing watershed Location of roads, property boundaries, protected areas;
- engineering designs, as needed;
- any needed water or vegetation management to maintain desired wetland conditions, functions and values; and,
- other requirements listed in the site specific Scope of Work and Operation and Maintenance Plan..

Plans and specifications should be reviewed by staff with appropriate training in design and implementation of wetland enhancement.

OPERATION AND MAINTENANCE

The following actions shall be carried out to insure that this practice functions as intended throughout its expected life. These actions include normal repetitive activities in the application and use of the practice (operation), and repair and upkeep of the practice (maintenance).

Biological control of undesirable plant species and pests (e.g., using predator or parasitic species) should be implemented where available and feasible.

Follow an inspection and monitoring schedule to assess embankments and structures for damage and whether enhancement is achieved.

Remove accumulated sediment that is compromising wetland function and value.

Maintain desired vegetation. and control unwanted vegetation.

Minimize activities that will harm or destroy vegetative cover and degrade wetland function and value.

Other site specific requirements listed in the Operation and Maintenance Plan.

REFERENCES

Executive Order 13112, Invasive Species, February 3, 1999. Federal Register: vol.64, no.25. Feb. 8, 1999.

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Appendix 12

NRCS Field Handbook Excerpts: Live Siltation Construction, Reed Clump Installation, and Plants for Soil Bioengineering

***(iii) Brushmattress*—**Brushmattresses for shorelines perform a similar function as those for streambanks. Therefore, effectiveness and construction guidelines are similar to those given earlier in this chapter, with the following additions.

Applications and effectiveness

- May be effective in lake areas that have fluctuating water levels since they are able to protect the shoreline and continue to grow.
- Able to filter incoming water because they also establish a dense, healthy shoreline vegetation.

Installation

- After the trench at the bottom has been dug and the mattress branches placed, the trench should be lined with geotextile fabric.
- Secure the live fascine, press down the mattress brush, and place the fabric on top of the brush.
- At this point, install the live and dead stout stakes to hold the brush in place. A few dead stout stakes may be used in the mattress branch and partly wired down before covering the fabric. This helps in the final steps of covering and securing the brush and the fabric.

***(iv) Live siltation construction*—**Live siltation construction is similar to brushlayering except that the orientation of the branches are more vertical. Ideally live siltation systems are approximately perpendicular to the prevailing winds. The branch tips should slope upwards at 45 to 60 degrees. Installation is similar to brushlayering (see Engineering Field Handbook, chapter 18 for a more complete discussion of a brushlayer).

Live siltation branches that have been installed in the trenches serve as tensile inclusions or reinforcing units. The part of the brush that protrudes from the ground assists in retarding runoff and surface erosion from wave action and wind (figs. 16–52 and 16–53).

Applications and effectiveness

Live siltation systems provide immediate erosion control and earth reinforcement functions, including:

- Providing surface stability for the planting or establishment of vegetation.
- Trapping debris, seed, and vegetation at the shoreline.
- Reducing wind erosion and surface particle movement.
- Drying excessively wet sites through transpiration.
- Promoting seed germination for natural colonization.
- Reinforcing the soil with unrooted branch cuttings.
- Reinforcing the soil as deep, strong roots develop and adding resistance to sliding and shear displacement.

Construction guidelines

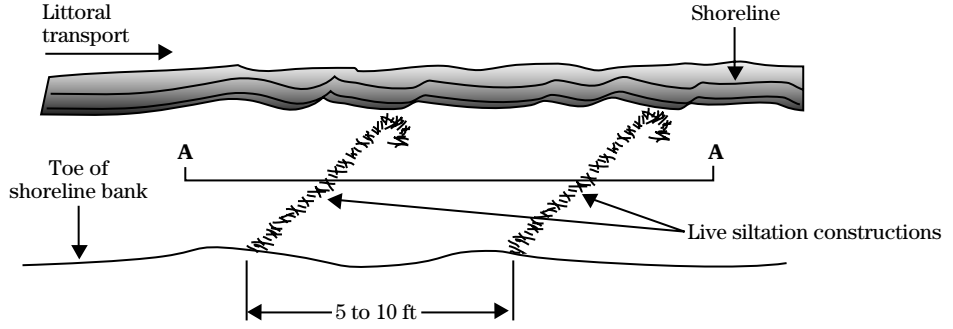
Live material—Live branch cuttings 0.5 to 1 inch in diameter and 4 to 5 feet long with side branches intact.

Installation

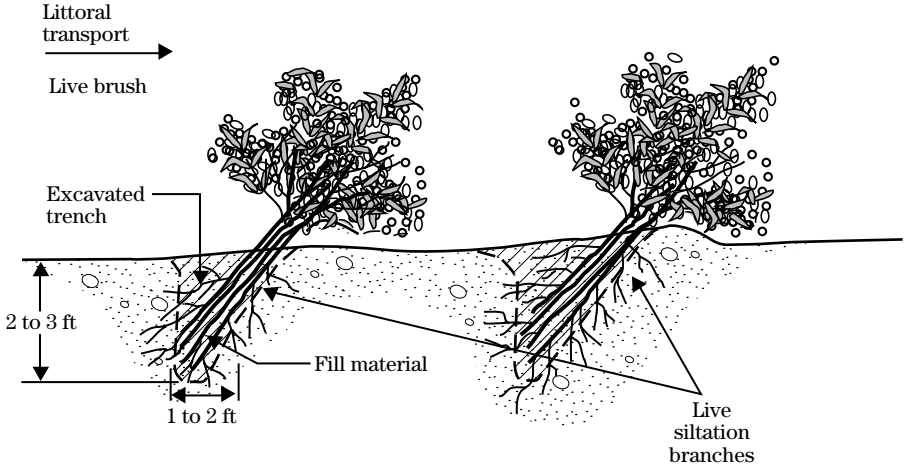
- Beginning at the toe of the shoreline bank to be treated, excavate a trench 2 to 3 feet deep and 1 to 2 feet wide, with one vertical side and the other angled toward the shoreline.
- Parallel live siltation rows should vary from 5 to 10 feet apart, depending upon shoreline conditions and stability required. Steep, unstable and high energy sites require closer spacing.

Figure 16–52 Live siltation construction details

Plan
Not to scale



Section A-A



Note: Rooted/leafed condition of the living plant material is not respresentative of the time of installation.

Figure 16–53 Live siltation construction system (Robbin B. Sotir & Associates photo)

(v) Reed clump—Reed clump installations consist of root divisions wrapped in natural geotextile fabric, placed in trenches, and staked down. The resulting root mat reinforces soil particles and extracts excess moisture through transpiration. Reed clump systems are typically installed at the water's edge or on shelves in the littoral zone (fig. 16–54 and 16–55).

Applications and effectiveness

- Reduces toe erosion and creates a dense energy-dissipating reed bank area.
- Offers relatively inexpensive and immediate protection from erosion.
- Useful on shore sites where rapid repair of spot damage is required.
- Retains soil and transported sediment at the shoreline.
- Reduces a long beach wash into a series of shorter sections capable of retaining surface soils.
- Enhances conditions for natural colonization and establishment of vegetation from the surrounding plant community.
- Grows in water and survives fluctuating water levels.

Construction guidelines

Live materials—The reed clumps should be 4 to 8 inches in diameter and taken from healthy water-dependent species, such as arrowhead, cattail, or water iris. They may be selectively harvested from existing natural sites or purchased from a nursery.

Wrap reed clumps in natural geotextile fabric and bind together with twine. These clumps can be fabricated several days before installation if they are kept moist and shaded.

Inert materials—Natural geotextile fabric, twine, and 3- to 3.5-foot-long dead stout stakes are required.

Installation

- Reed root clumps are either placed directly into fabric-lined trenches or prefabricated into rolls 5 to 30 feet long. With the growing tips pointing up, space clumps every 12 inches on a 2- to 3-foot-wide strip of geotextile fabric to fabricate the rolls. The growing buds should all be oriented in the same upright direction for correct placement into the trench.
- Wrap the fabric from both sides to overlap the top, leaving the reed clumps exposed and bound with twine between each plant.
- Beginning at and parallel to the water's edge, excavate a trench 2 inches wider and deeper than the size of the prefabricated reed roll or reed clumps.
- To place reed clumps directly into trenches, first line the trench with a 2- to 3-foot-wide strip of geotextile fabric before spreading a 1-inch layer of highly organic topsoil over it at the bottom of the trench. Next, center the reed clumps on 12-inch spacing in the bottom of the trench. Fill the remainder of the trench between and around reed clumps with highly organic topsoil, and compact. Wrap geotextile fabric from each side to overlap at the top and leave the reed clumps exposed before securing with dead stout stakes spaced between the clumps. Complete the installation by spreading previously excavated soil around the exposed reed clumps to cover this staked fabric.
- To use the prefabricated reed clump roll, place it in the excavated trench, secure it with dead stout stakes, and backfill as described above.
- Repeat the above procedure by excavating additional parallel trenches spaced 3 to 6 feet apart toward the shoreline. Place the reed clumps from one row to the next to produce a staggered spacing pattern.

Figure 16–54 Reed clump details

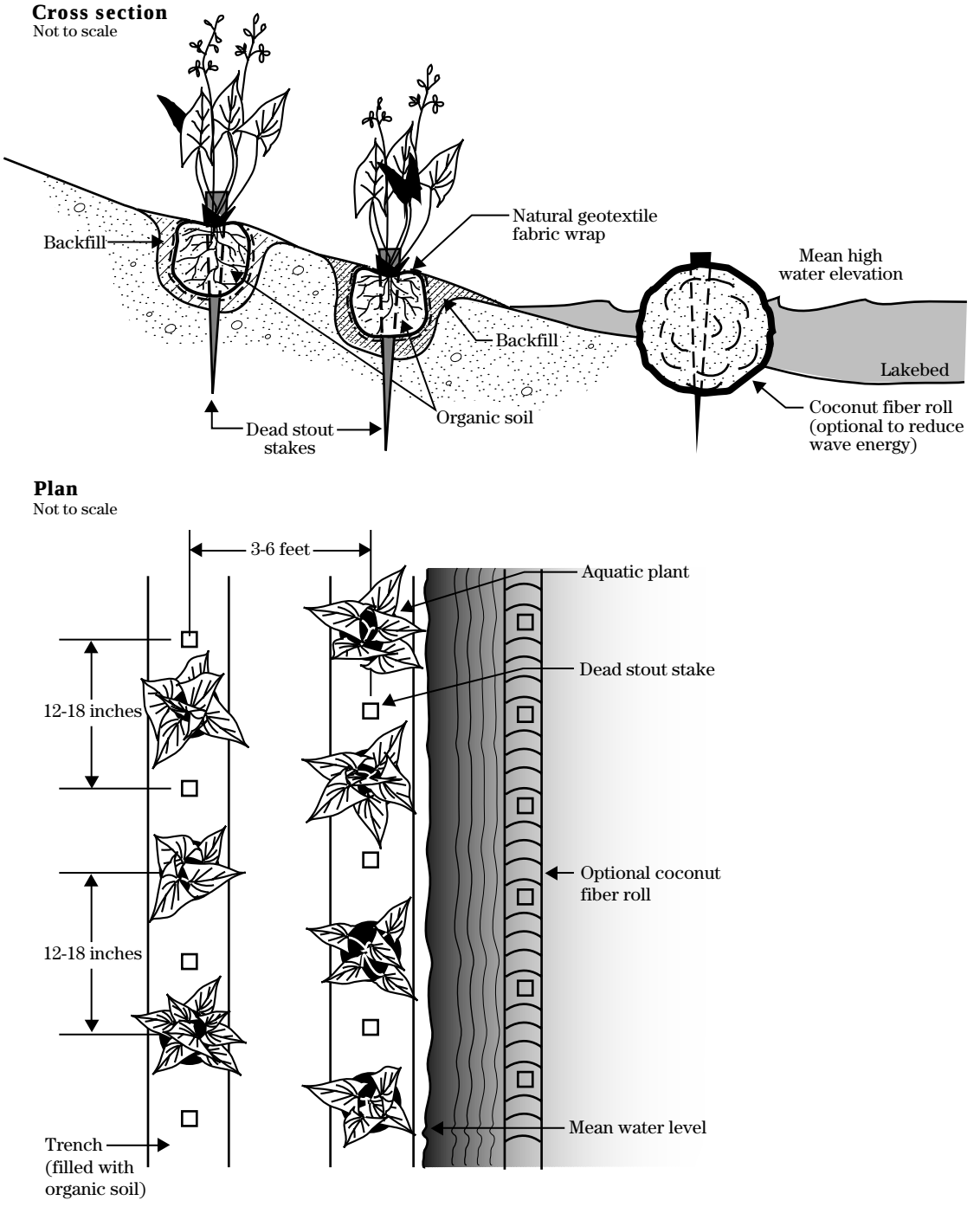


Figure 16–55a Installing dead stout stakes in reed clump system (Robbin B. Sotir & Associates photo)

Figure 16–55b Completing installation of reed clump system (Robbin B. Sotir & Associates photo)

Figure 16–55c Established reed clump system (Robbin B. Sotir & Associates photo)

Appendix 16B Plants for Soil Bioengineering and Associated Systems

The information in appendix 16B is from the Natural Resources Conservation Service's data base for Soil Bioengineering Plant Materials (biotype). The plants are listed in alphabetical order by scientific name. Further subdivision of the listing should be considered to account for local conditions and identify species suitable only for soil bioengineering systems.

Table header definitions (in the order they occur on the tables):

Scientific name—Genus and species name of the plant.

Common name—Common name of the plant.

Region of occurrence—Region(s) of occurrence using the regions of distribution in PLANTS (Plant List of Attributes, Nomenclature, Taxonomy, and Symbols, 1994). Region code number or letter:

1 Northeast—ME, NH, VT, MA, CT, RI, WV, KY, NY, PA, NJ, MD, DE, VA, OH
2 Southeast—NC, SC, GA, FL, TN, AL, MS, LA, AR
3 North Central—MO, IA, MN, MI, WI, IL, IN
4 North Plains—ND, SD, MT (eastern) WY (eastern)
5 Central Plains—NE, KS, CO (eastern)
6 South Plains—TX, OK
7 Southwest—AZ, NM
8 Intermountain—NV, UT, CO (western)
9 Northwest—WA, OR, ID, MT (western) WY (western)
0 California—Ca
A Alaska—AK
C Caribbean—PR, VI, CZ, SQ
H Hawaii—HI, AQ, GU, IQ, MQ, TQ, WQ, YQ

Commercial availability—Answers whether the plant is available from commercial plant vendors.

Plant type—Short description of the type of plant: tree, shrub, grass, forb, legume, etc.

Root type—Description of the root of the plant: tap, fibrous, suckering, etc.

Rooting ability from cutting—Subjective rating of cut stems of the plant to root without special hormone and/or environmental surroundings provided.

Growth rate—Subjective rating of the speed of growth of the plant: slow, medium, fast, etc.

Establishment speed—Subjective rating of the speed of establishment of the plant.

Spread potential—Subjective rating of the potential for the plant to spread: low, good, etc.

Plant materials—The type of vegetation plant parts that can be used to establish a new colony of the species.

Notes—Other important or interesting characteristics about the plant.

Soil preference—Indication of the type of soil the plant prefers: sand, loam, clay, etc.

pH preference—Lists the pH preference(s) of the plant.

Drought tolerance—Subjective rating of the ability of the plant to survive dry soil conditions.

Shade tolerance—Subjective rating of the ability of the plant to tolerate shaded sites.

Deposition tolerance—Subjective rating of the ability of the plant to tolerate deposition of soil or organic debris around or over the roots and stems.

Flood tolerance—Selective rating of the ability of the plant to tolerate flooding events.

Flood season—Time of the year that the plant can tolerate flooding events.

Minimum water depth—The minimum water depth required by the plant for optimal growth.

Maximum water depth—The maximum water depth the plant can tolerate and not succumb to drowning.

Wetland indicator—A national indicator from National List of Plant Species that Occur in Wetlands: 1988 National Summary.

Table 16B–1 Woody plants for soil bioengineering and associated systems

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Acer circinatum	vine maple	9,0	yes, but in limited quantities	shrub to small tree	fibrous, rooting at nodes	fair to good	slow	slow	good	plants	Branches often touch& root at ground level. Often occurs with conifer overstory. Occurs British Columbia to CA.
Acer glabrum	dwarf maple	4,5,7, 8,9,0, A	yes	small tree		poor				plants	usually dioecious, grows in poor soils.
Acer negundo	boxelder	1,2,3, 4,5,6, 7,8,9, 0	yes	small to medium tree	fibrous, moderately deep, spreading, suckering	poor	fast	fast	fair	plants, rooted cuttings	Use in sun & part shade. Survived deep flooding for one season in Pacific NW.
Acer rubrum	red maple	1,2,3, 6	yes	medium tree	shallow	poor	fast when young	medium	good	plants	Not tolerant of high pH sites. Occurs on and prefers sites with a high water table and/or an annual flooding event.
Acer saccharinum	silver maple	1,2,3, 4,5,6, 8	yes	medium tree	shallow, fibrous	poor	fast when young	medium	fair	plants	Plants occur mostly east of the 95th parallel. Survived 2 years of flooding in MS.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Alnus pacifica	pacific alder			tree		poor	most alders are fast			plants	A species for forested wetland sites in the Pacific northwest. Plant on 10- to 12-foot spacing.
Alnus rubra	red alder	9,0,A	yes	medium tree	shallow, spreading, suckering	poor to fair	fast	fast	good	plants	Usually grows west of the Cascade Mtns, within 125 milesof the ocean & below 2,400 feet elevation. A nitro-gen source. Short lived species. May be seedable. Sus-ceptible to caterpillers.
Alnus serrulata	smooth alder	1,2,3, 5,6	yes	large shrub	shallow, spreading	poor	slow	medium	fair	plants	Thicket forming. Survived 2 years of flooding in MS. Roots have relation with nitrogen-fixing actinomycetes, susceptible to ice damage, needs full sun.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Alnus viridis ssp.sinuata	sitka alder	9,0,A	yes, but very limited quantities	shrub to small tree	shallow	poor	rapid first year, moderate thereafter	medium	fair to good	plants	A nitrogen source. Occurs AK to CA.
Amelanchier alnifolia var cusickii	cusick's serviceberry	9	yes	shrub		poor	medium	medium	medium	plants	Usually seed propagated. Occurs in eastern WA, northern ID, & eastern OR. A different variety is Pacific serviceberry A. alnifolia var semiintegrifolia. Host to several insect & disease pests.
Amelanchier utahensis	utah serviceberry	9		small to large shrub						plants	Occurs in southeast OR, south ID, NV, & UT.
Amorpha fruitcosa	false indigo	1,2,3, 4,5,6, 7,8,0	yes	shrub		poor	medium	fast	poor	plants, seed	Supposedly root suckers. Has been seeded directly on roadside cut and fill sites in MD.
Aronia arbutifolia	red chokeberry	1,2,3, 6	yes	shrub		poor	fast	fast		plants, seed	Rhizomatous. May produce fruit in second year.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Asimina triloba	pawpaw	1,2,3,5,6	yes	small tree	tap and root suckers	poor to fair	fast		poor	root cuttings, plants	Does produce thickets where native & can be propagated by layering & root cuttings. Occurs NY to FL & TX.
Baccharis glutinosa	seepwillow	6,7,8,0	yes	medium shrub	deep & wide-spreading, fibrous	good				plants	Thicket forming.
Baccharis halimifolia	eastern baccharis	1,2,6	yes	medium shrub	fibrous	good	fair	fast	fair	fascines, cuttings, plants,	Resistant to salt spray; unisexual plants. Occurs MA to FL & TX.
Baccharis pilularis	coyotebush	9,0		medium evergreen shrub	fibrous	good			fair	fascines, stakes, brush mats, layering, cuttings	Pioneer in gullies, many forms prostrate & spreading. May be seedable. Colony-forming to 1 foot high in CA coastal bluffs.
Baccharis salicifolia	water wally	6,7,8,0		medium evergreen shrub	fibrous, deep, wide-spreading	good			fair	fascines, brush mats, stakes, layering, cuttings	Was B. glutinosa. Thicket forming, unisexual plants.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Baccharis viminea	mulefat baccharis	6,7,8,0		medium evergreen shrub	fibrous	good				fascines, stakes, brush mats, layering, cuttings	May be B. salicifolia.
Betula nigra	river birch	1,2,3,5,6	yes	medium to large tree		poor	fast when young	fast	poor	plants	Plants coppice when cut. Survived 1 year of flooding in MS. Hybridizes with B papyrifera.
Betula occidentalis	water birch	4,5,7,8,9,0,A	yes	medium tree	fibrous, spreading					plants	Occurs on the Pacific Coast to CO.
Betula papyrifera	paper birch	1,3,4,5,9,A	yes	medium tree	shallow, fibrous	poor	fast when young	fast	poor	plants	Not tolerant of more than a few days inundation in a New England trial. Short lived but the most resistant to borers of all birches.
Betula pumila	low birch	1,3,4,8,9		small to large shrub	fibrous	poor				plants	Occurs Newfoundland to NJ & MN.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Carpinis caroliniana	american hornbeam	1,2,3,6	yes, limited sources	small tree		poor	slow	slow	poor	plants	Not tolerant of flooding in TN Valley trial. Occurs MD to FL & west to southern IL & east TX. A northern form occurs from New England to NC & west to MN & AR.
Carya aquatica	water hickory	1,2,3,6	yes	tall tree	tap to shallow lateral	poor	slow	fast	poor	plants	A species for forested wetland sites.
Carya cordiformis	bitternut hickory	1,2,3,5,6	yes	tree	tap & dense laterals	poor	slow		poor	plants	Roots & stumps coppice. Not tolerate flooding in a MO trial. Occurs Quebec to FL & LA. Transplants with difficulty.
Carya ovata	shagbark hickory	1,2,3,4,5,6	yes	medium tree	tap	poor	slow	slow	poor	plants	Hard to transplant. Occurs Quebec to FL & TX.
Catalpa bignonioides	southern catalpa	1,2,3,5,6,7	yes	tree		poor	fair	fair	poor	plants	Occurs in SW GA to LA; naturalized in New England, OH, MI, & TX.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Celtis laevigata	sugarberry	1,2,3,5,6,7,9,0	yes	medium tree	relatively shallow	poor	medium	slow	low	plants	Very resistant to witches-broom. Occurs FL, west to TX & southern IN. Also in Mexico. Leaf fall allelopathic.
Celtis occidentalis	hackberry	1,2,3,4,5,6,8	yes	medium tree	medium to deep fibrous	poor	medium to fast	slow	low	plants	Survived 2 years of flooding in MS. Not tolerate more than a few days inundation in a MO trial. Susceptible to witches-broom. Occurs Quebec to NC & AL.
Cephalanthus occidentalis	buttonbush	1,2,3,5,6,7,8,0	yes	large shrub		fair to good	slow	medium	poor	brush mats, layering, plants	Survived 3 years of flooding in MS. Will grow in sun or shade.
Cercis canadensis	redbud	1,2,3,5,6,7,8	yes	small tree	tap	poor	slow	slow	poor	plants	Juvenile wood & roots will root.
Chilopsis linearis	desert willow	6,7,8,0	yes	shrub	fibrous		medium	medium	low	plants	Occurs TX to southern CA & into Mexico. 'Barranco,' 'Hope,' & 'Regal' cultivars were releasedin New Mexico.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Chionanthus virginicus	fringetree	1,2,3, 6	yes	small tree		poor	slow		poor	plants	Susceptible to severe browsing & scale. Occurs PA to FL & west to TX.
Clematis ligusticifolia	western clematis	1,2,4, 5,6,7, 8,9,0	yes	vine	shallow & fibrous	poor	fast	fast	good	plants	Produces new plants from layering in sandy soils at 7- to 8-inch precip & 1,000-foot elevation.
Clethera alnifolia	sweet pepperbush	1,2,6	yes	shrub		poor	slow			plants	Has rhizomes; salt tolerant on coastal sites. Occurs ME to FL.
Cornus amomum	silky dogwood	1,2,3, 4,5,6	yes	small shrub	shallow, fibrous	fair	fast	medium	poor	fascines, stakes, brush mats, layering, cuttings, plants	Pith brown, tolerates partial shade. 'Indigo' cultivar was released by MI PMC.
Cornus drummondii	roughleaf dogwood	1,2,3, 4,5,6	yes	large shrub	root suckering, spreading	fair			fair	fascines, stakes, layering, brush mats, cuttings, plants	Root suckers too. Pith usually brown. Occurs Saskatche-wan to KS & NE, south to MS, LA, & TX.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Cornus florida	flowering dogwood	1,2,3, 5,6	yes	small tree	shallow, fibrous	poor	fair	fair	poor	plants	Hard to transplant as bare root; coppices freely. Not tolerant of flooding in TN Valley trial.
Cornus foemina	stiff dogwood	1,2,3, 4,5,6		medium shrub		fair	fast			fascines, plants	Formerly C. racemosa Occurs VA to FL & west to TX. Pith white.
Cornus racemosa	gray dogwood	1,2,3, 4,5,6	yes	medium to small shrub	shallow, fibrous	fair	medium		fair	fascines, stakes, brush mats, layering, cuttings, plants	Forms dense thickets. Pith usually brown, tolerates city smoke. Occurs ME & MN to NC & OK.
Cornus rugosa	roundleaf dogwood	1,3		medium to small shrub	shallow, fibrous	fair to good				fascines, cuttings, plants	Pith white. Use in combination with species with root_abil = good to excellent. Occurs Nova Scotia to VA & ND.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Cornus sericea ssp sericea	red-osier dogwood	1,3,4, 5,7,8, 9,0,A	yes	medium shrub	shallow	good	fast	medium	fair	fascines, stakes, brush mats, layering, cuttings, plants	Forms thickets by rootstocks & rooting of branches. Survived 6 years of flooding in MS. Pith white, tolerates partial shade. Formerly C. stolonifera. 'Ruby' cultivar was released by NY PMC.
Cornus stricta	swamp dogwood			shrub		poor				plants	May be same as C. foemina.
Crataegus douglasii	douglas hawthorn	3,8,9, 0,A	yes	small tree	tap to fibrous	poor to fair	slow		poor	cuttings, plants	Forms dense thickets on moist sites. Grown from seed or grafted. Occurs British Columbia to CA & MN.
Crataegus mollis	downy hawthorn	1,2,3, 4,5,6	yes	tree	tap	poor to fair				plants	Occurs Ontario & MN to AL, AR & MS. 'Homestead' cultivar was released by ND PMC.
Cyrilla racemiflora	titi	1,2,6, C		small tree		poor				plants	Semievergreen, a good honey plant. Occurs VA to FL & on to South America. Prefers organic sites.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Diospyros virginiana	persimmon	1,2,3, 5,6	yes	medium tree	tap	poor	slow	fair	poor	plants	Forms dense thickets on dry sites. Stoloniferous & tap rooted. Occurs CT toFL & TX.
Elaeagnus commutata	silverberry	1,3,4, 8,9,A	yes	small tree	shallow, fibrous	poor to fair	fast	fast	fair	plants	Grows well in limestone & alkaline soils.
Forestiera acuminata	swamp privet	1,2,3, 6	yes	large shrub to small tree		fair	slow		poor	plants	Thicket forming. Survived 3 years of flooding in MS.
Fraxinus caroliniana	carolina ash	1,2,6		large tree	fibrous	poor	fast	fast		plants	Easily transplanted. Occurs in swamps VA to TX.
Fraxinus latifolia	oregon ash	9,0	yes	medium tree	moderately shallow, fibrous	poor	fast when young	medium	fair	plants	May be grown from seed but usually grafted. Usually occurs west of the Cascade Mtns.
Fraxinus pennsylvanica	green ash	1,2,3, 4,5,6, 8,9	yes	medium tree	shallow, fibrous	poor	fast	fast	good	plants	Survived 3 years of flooding in MS. 'Cardan' cultivar was released by ND PMC.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Gleditsia triacanthos	honeylocust	1,2,3, 4,5,6, 7,8,9	yes	medium tree	deep & widespread	poor to fair	fast	fast	medium	plants	Survived deep flooding for 100 days 3 consecutive years. Has been used in reg_occ 7,8,9. Native ecotypes have thorns!
Hibiscus aculeatus	hibiscus	2,6	yes	shrub		poor				plants	
Hibiscus laevis	halberd-leaf marshmallow		yes	shrub		poor				plants	Was H. militaris.
Hibiscus moscheutos	common rose mallow	1,2,3, 5,6,7, 0	yes	shrub		poor				plants	
Hibiscus moscheutos ssp.lasiocarpos	hibiscus		yes	shrub		poor				plants	
Holodiscus discolor	oceanspray	9,0	yes, from contract growers.	shrub		poor to fair	medium to rapid	fast	poor	plants	Often pioneers on burned areas. Occurs from British Columbia to CA to ID. Usually grown from seed or cuttings.
Ilex coriacea	sweet gallberry	1,2,6, C	yes	small to large shrub		poor				plants	Evergreen.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Ilex decidua	possomhaw	1,2,3,5,6	yes	large shrub to small tree		poor	slow			plants	Survived 3 years of flooding in MS.
Ilex glabra	bitter gallberrry	1,2,6	yes	small shrub		poor	slow			plants	Evergreen, sprouts after fire. Stoloniferous! Occurs eastern US & Canada.
Ilex opaca	american holly	1,2,3,6	yes	small tree	tap root & prolific laterals	poor	slow	medium	poor	plants	Easy to transplant when young.
Ilex verticillata	winterberry	1,2,3,6	yes	small to large shrub		poor	slow			plants	Prefers seasonally flooded sites. Plants dioecious.
Ilex vomitoria	yaupon	1,2,6	yes	large shrub		poor				plants	Root suckers.
Juglans nigra	black walnut	1,2,3,4,5,6	yes	medium tree	tap & deep & wide-spread laterals	poor	fair	fair	poor	plants	Though drought tolerant, will not grow on poor or dry soil sites. Not tolerate flooding in TN Valley trial.
Juniperus virginiana	eastern redcedar	1,2,3,4,5,6	yes	large tree	tap & dense fibrous laterals	poor	slow	medium	good	plants	Not tolerate flooding in TN Valley trial.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Leucothoe axillaris	leucothoe	1,2	yes	small to large shrub		poor	slow			plants	Evergreen.
Lindera benzoin	spicebush	1,2,3, 5,6	yes	shrub		poor	slow			plants	Prefers acid soils. Dioecious.
Liquidambar styraciflua	sweetgum	1,2,3, 6	yes	large tree	tap to fibrous	poor	slow		fair	plants	A species for forested wetland sites.
Liriodendron tulipifera	tulip poplar	1,2,3, 5,6	yes	large tree	deep & wide-spreading	poor	fast	fast		plants	Hard to transplant.
Lonicera involucrata	black twinberry	3,7,8, 9,0,A	yes	small to large shrub	fibrous & shallow	good	fast	fast	poor to fair	fascines, stakes, cuttings, plants	
Lyonia lucida	fetterbush	1,2		small to large shrub		poor				plants	Evergreen.
Magnolia virginiana	sweetbay	1,2,6	yes	small tree		poor	slow			plants	Occurs in swamps from MA to FL and west to east TX.
Myrica cerifera	southern waxmyrtle	1,2,6, c	yes	small shrub	fibrous	poor	medium	slow	slow	plants	Evergreen. Occurs east TX & OK, east to FL & north to NJ.
Nyssa aquatica	swamp tupelo	1,2,3, 6	yes	large tree	shallow, fibrous	poor		slow		plants	Trees from the wild do not transplant well.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Nyssa ogeeche	ogeeche lime	2		large shrub to small tree	sparse, fibrous	poor	slow	medium	poor	plants	Largest fruit of all Nyssa. Vegetative reproduction not noted. Only grows close to perennial wetland sites.
Nyssa sylvatica	blackgum	1,2,3, 6	yes	tall tree	sparse, fibrous, very long, decending	poor	medium	slow	fair	plants	A species for forested wetland sites. Difficult to transplant but plant in sun or shade on 10- to 12-foot spacing.
Ostrya virginiana	hophorn-beam	1,2,3, 4,5,6	yes	small tree		poor	slow	slow		plants	Difficult to transplant. Tolerated flooding for up to 30 days during 1 growing season.
Persea borbonia	redbay	1,2,6	yes	small to large evergreen tree		poor	slow	slow		plants	
Philadelphus lewesii	lewis mockorange	9,0	yes	large shrub	fibrous	poor	fast	medium to fast	medium	plants	Usually grown from seed.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Physocarpus capitatus	pacific ninebark	8,9,0, A	yes	large shrub	fibrous	good				fascines, brush mats, layering, cuttings, plants	Usually occurs west of the Cascade Mtns.
Physocarpus malvaceus	mallow ninebark	8,9	yes	small shrub	shallow but with rhizomes	fair				cuttings, plants	Propagated by seed or cuttings. Usually occurs east of the Cascade Mtns.
Physocarpus opulifolius	common ninebark	1,2,3, 4,5,6, 8,9	yes	medium shrub	shallow, lateral	fair	slow	slow	poor	fascines, brush mats, layering, cuttings, plants	Use in combination with other species with rooting ability good to excellent.
Pinus taeda	loblolly pine	1,2,3, 6	yes	medium tree	short tap changes to shallow spreading laterals	poor	fast	fast	poor	plants	
Planera aquatica	water elm	1,2,3, 5,6		small tree		poor	fairly fast			plants	Occurs KY to FL, west to IL & TX.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Platanus occidentalis	sycamore	1,2,3, 5,6	yes	large tree	fibrous, wide-spreading	poor	fast	fast	medium	plants	A species for forested wetland sites. Tolerates city smoke & alkali sites. Plant on 10- to12-foot spacing. Trans-plants well.
Platanus racemosa	California sycamore	0		tall tree						plants	A species for forested wetlands sites in CA.
Populus angustifolia	narrowleaf cottonwood	4,5,6, 7,8,9, 0		large tree	shallow	v good				fascines, stakes, poles, brush mats, layering, cuttings, plants	Under development in ID for riparian sites.
Populus balsamifera	balsam poplar	1,2,3, 4,5,8, 9,O,A	yes	tall tree	deep, fibrous	v good	fast	fast		fascines, stakes, poles, brush mats, layering, cuttings, plants	

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Populus deltoides	eastern cottonwood	1,2,3,4,5,6,7,8,9	yes	tall tree	shallow, fibrous, suckering	v good	fast	fast	poor	fascines, stakes, poles, brush mats, layering, cuttings, root suckers, plants	Short lived. Endures heat & sunny sites. Survived over 1 year of flooding in MS. Hybridizes with several other poplars. Plant roots may be invasive. May be sensitive to aluminum in the soil.
Populus fremontii	fremont cottonwood	6,7,8,0		tree	shallow, fibrous	v good	fast			fascines, stakes, poles, brush mats, layering, cuttings, plants	Tolerates saline soils. Dirty tree.
Populus tremuloides	quaking aspen	1,2,3,4,5,7,8,9,0,A	yes	medium tree	shallow, profuse suckers, vigorous underground runners	poor to fair	fast	fast	fair	layering, root cuttings, plants	Short lived. A pioneer species on sunny sites. Normal propagation is by root cuttings. Not tolerant of more than a few days inundation in a New England trial. Use rooted plant materials.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Populus trichocarpa	black cottonwood	4,7,8, 9,0,A	yes	large tree	deep & wide-spread, fibrous	v good	fast	fast	good	fascines, stakes, poles, brush mats, layering, cuttings, plants	A species for forested wetland sites. Was P. trichophora. Usually grown from cuttings. Under development in ID for riparian sites. Plant on 10- to 12-foot spacing. May be P. balsimifera
Prunus angustifolia	wild plum	1,2,3, 5,6	yes	small shrub	fibrous, spreading, suckering	poor	medium	fast	good	plants, root cuttings	Thicket forming. 'Rainbow' cultivar released by Knox City, TX, PMC.
Prunus virginiana	common chokecherry	1,2,3, 4,5,6, 7,8,9, 0,A	yes	large shrub	shallow, suckering	poor	medium	medium	fair	plants	A species for forested wetland sites. Has hydrocyanic acid in most parts, especially the seeds. Usually grown from seed. Thicket forming. Plant on 5- to 8-foot spacing. Reportedly poisonous to cattle.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Quercus alba	white oak	1,2,3,5,6	yes	large tree	tap to deep, well-developed fibrous	poor	slow	slow	slow	plants	Did not survive more than a few days flooding in a trial in New England. Difficult to transplant larger specimens.
Quercus bicolor	swamp white oak	1,2,3,5,6	yes	medium tree	somewhat shallow	poor	fast	medium	fair	plants	Survived 2 years of flooding in MS.
Quercus garryana	oregon white oak	9,0	yes	shrub to large tree	deep tap & well-developed laterals	poor	slow	slow	fair	plants	Usually grows west of the Cascade Mtns, in the Columbia River Gorge to the Dalles & to Yakima, WA. Propagated from seed sown in fall.
Quercus laurifolia	swamp laurel oak	1,2,6		tree	tap	poor	fast	fast		plants	Often used as a street tree in the southeast US.
Quercus lyrata	overcup oak	1,2,3,6	yes	medium tree	tap deteriorates to dense shallow laterals	poor	slow	slow	slow	plants	Often worthless as a lumber species.
Quercus macrocarpa	bur oak	1,2,3,4,5,6,9	yes	large tree	deep tap & well-developed laterals	poor	medium	fast	poor	plants	Survived 2 years of flooding in MS. 'Boomer' cultivar released by TX PMC.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Quercus michauxii	swamp chestnut oak	1,2,3, 6		medium tree	tap & deep laterals	poor	fair	fair	poor	plants	
Quercus nigra	water oak	1,2,3, 6		medium tree	shallow & spreading	poor	fast on good sites	slow	poor	plants	Easily transplanted.
Quercus pagoda	cherrybark oak			tree		poor				plants	
Quercus palustris	pin oak	1,2,3, 5,6	yes	large tree	well-developed fibrous laterals after taproot disintegrates	poor	fast	fast	fair	plants	A species for forested wetland sites. Survived 2 years of flooding in MS. Plant on 10- to 12-foot spacing.
Quercus phellos	willow oak	1,2,3, 6	yes	medium to large tree	shallow, fibrous	poor	fast	medium	fair	plants	Easily transplanted.
Quercus shumardii	shumard oak	1,2,3, 5,6	yes	large tree	shallow	poor	medium	slow	low	plants	
Rhododendron atlanticum	coast azalea	1,2		small shrub		poor	fast		good by stolons	plants	Mat forming from suckers & stolons. Occurs from DE to SC.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Rhododendron viscosum	swamp azalea	1,2		shrub		poor	slow			plants	Has stoloniferous forms. Occurs from ME to SC. Highly susceptible to insects & diseases.
Rhus copallina	flameleaf sumac	1,2,3,4,5,6	yes	medium shrub	fibrous, suckering	poor to fair	fast	fast	fair	root cuttings, root suckers, plants	Thicket forming.
Rhus glabra	smooth sumac	1,2,3,4,5,6,7,8,9	yes	large shrub	fibrous, suckering	poor to fair	fast	fast	fair to good	root cuttings, root suckers, plants	Thicket forming.
Robinia pseuodoacacia	black locust	1,2,3,4,5,6,7,8,9,0	yes	medium tree	shallow	poor	medium to fast	fast	good	root cuttings, plants	Normal propagation is by root cuttings or seed. Not tolerant of flooding in TN Valley trial. Escaped in regions 5,7,8,9,0. Reported toxic to livestock.
Rosa gymnocarpa	baldhip rose	9,0		shrub		fair to good				cuttings, plants	A browsed species.
Rosa nutkana	nootka rose	7,8,9,0,A		shrub		fair to good				cuttings, plants	A browsed species.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Rosa palustris	swamp rose	1,2,3,5		small shrub	shallow	good				fascines, plants	
Rosa virginiana	virginia rose	1,2,3	yes	small shrub	rhizomatous & fibrous	good	fair	fast	fair	plants	
Rosa woodsii	woods rose	3,4,5,6,7,8,9,0,A		shrub		fair to good				cuttings, plants	A browsed species.
Rubus allegheniensis	allegheny blackberry	1,2,3,5,6,0		small shrub	fibrous	good				plants	Normal propagation is by root cuttings.
Rubus idaeus ssp. strigosus	red raspberry	1,2,3,4,5,6,7,8,9,A		small shrub	fibrous	good				plants	Was R. strigosus. Normal propagation is by root cuttings.
Rubus spectabilis	salmonberry	9,0,A		small shrub	fibrous	good				plants	Normal propagation is by root cuttings. Use in combination with other species. Rooting ability is good to excellent.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Salix X cottetii	dwarf willow	not native	yes	small shrub	shallow	v good	medium	fast	poor	fascines, stakes, brush mats, layering, cuttings, plants	Not a native species. Plant plants on 2' to 6' spacing. 'Bankers' cultivar released by Kentucky PMC.
Salix amygdaloides	peachleaf willow	1,2,3, 4,5,6, 7,8,9	yes	large shrub to small tree	shallow to deep	v good	fast	fast		fascines, stakes, poles, brush mats, layering, cuttings, plants	Often roots only at callus cut. May be short-lived. Under development in ID for riparian sites. Not tolerant of shade. Hybridized with several other willow species.
Salix bebbiana	bebb's willow	1,3,4, 5,7,8, 9,A		small shrub to large tree	fibrous					cuttings, plants	Does not form suckers. Usually east of the Cascade Mtns & in ID & MT.
Salix bonplandiana	pussy willow	7	yes	medium shrub to large tree	fibrous	v good				fascines, stakes, poles, brush mats, layering, cuttings, plants	Eaten by livestock when young.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Salix boothii	booth willow	8,9		shrub							Under development in Idaho for riparian sites.
Salix discolor	pussy willow	1,2,3,4,9	yes	large shrub	shallow, fibrous, spreading	v good	rapid			fascines, stakes, poles, layering, cuttings, plants	Use on sunny to partial shade sites.
Salix drummondiana	drummond's willow	7,8,9,0	yes	shrub		good				fascines, cuttings, plants	Usually east of the Cascade Mtns. Under development in ID for riparian sites. 'Curlew' cultivar released by WA PMC.
Salix eriocephala	erect willow	7,8,9,0	yes	large shrub	fibrous	v good		fast		fascines, stakes, poles, layering, cuttings, plants	A botanic discrepancy in the name, it may be S. ligulifolia! 'Placer' cultivar released by OR PMC.
Salix exigua	coyote willow	1,2,3,4,5,6,7,8,9,0,A	yes	medium shrub	shallow, suckering, rhizomatous	good	fast			fascines, stakes, poles, brush mats, layering, cuttings, plants	Relished by livestock. Under development in ID for riparian sites. 'Silvar' cultivar released by WA PMC.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Salix geyeriana	geyer's willow	7,8,9, 0		small to large shrub						cuttings, plants	Occurs east of the Cascade Mtns at higher elevations. Relished by livestock. Under development in ID for riparian sites.
Salix gooddingii	goodding willow	6,7,8, 0		small shrub to large tree	shallow to deep	good to excel	fast	fast		fascines, stakes, poles, brush mats, layering, cuttings, plants	Not tolerate alkaline sites. Some say this is western black willow.
Salix hookeriana	hooker willow	9,0	yes	large shrub to small tree	fibrous, dense	v good	rapid when young, medium there-after	medium		fascines, stakes, poles, brush mats, layering, cuttings, plants	May have salt tolerance. Can compete well with grasses. 'Clatsop' cultivar was released by OR PMC.
Salix humilis	prairie willow	1,2,3, 4,5,6		medium shrub	fibrous, spreading	good		medium		fascines, stakes, poles, brush mats, layering, cuttings, plants	Thicket forming.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Salix interior	sandbar willow	1,3,4, 5,7,8, 9,A	yes	large shrub	shallow to deep	exce	medium	medium	fair	fascines, stakes, poles, brush mats, layering, cuttings, plants	Thicket forming. This species has been changed to S. exigua. Use in combination with species with rooting ability good to excellent.
Salix lasiolepis	arroyo willow	6,7,8, 9,0	yes	tall shrub to small tree	fibrous	v good	rapid when young, medium there-after	medium		fascines, stakes, poles, brush mats, layering, cuttings, plants	Roots only on lower 1/3 of cutting or at callus. 'Rogue' cultivar released by OR PMC.
Salix lemmonii	lemmon's willow	8,9,0	yes	medium shrub	fibrous	v good		fast		fascines, stakes, poles, brush mats, layering, cuttings, plants	Occurs at high elevations, east of the Cascade Mtns. Under development in ID for riparian sites. 'Palouse' cultivar released by WA PMC.
Salix lucida	shining willow	1,3,4, 5,7,8, 9,0		medium to tall shrub	fibrous, spreading	v good	rapid			fascines, stakes, poles, brush mats, layering, cuttings, plants	

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Salix lucida ssp. lasiandra	pacific willow	4,7,8, 9,0,A	yes	large shrub to small tree	fibrous	v good	medium to slow	medium to slow		fascines, stakes, poles, brush mats, layering, cuttings, plants	A species for forested wetlands sites. There are several subspecies of S. lucida. Under development in ID for riparian sites. Susceptible to several diseases and insects. Plant on 10- to 12-foot spacing. 'Nehalem' cultivar released by OR PMC.
Salix lutea	yellow willow	1,4,5, 7,8,9, 0		medium to tall shrub	fibrous	v good				fascines, stakes, poles, brush mats, layering, cuttings, plants	Usually browsed by livestock. Under development in ID for riparian sites.
Salix nigra	black willow	1,2,3, 5,6,7, 8	yes	small to large tree	dense, shallow, sprouts readily	good to excel	fast	fast	good	fascines, stakes, poles, brush mats, layering, cuttings, root cuttings, plants	May be short lived. Survived 3 years of flooding in MS. Needs full sun. Susceptible to several diseases & insects.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Salix pentandra	laural willow	not native	yes	large shrub to small tree	fibrous, spreading	good	fast	medium	poor	fascines, stakes, poles, brush mats, layering, cuttings, plants	From Europe, sparingly escaped in the East. Insects may defoliate it regularly.
Salix purpurea	purpleosier willow	1,2,3, 5	yes	medium tree	shallow	excel	fast	fast	poor	fascines, stakes, poles, brush mats, layering, cuttings, plants	Tolerates partial shade. 'Streamco' cultivar released by NY PMC.
Salix scouleriana	scouler's willow	4,7,8, 9,0,A		large shrub to small tree	shallow	v good	fast			fascines, stakes, poles, brush mats, layering, cuttings, plants	Pioneers on burned sites. Occurs on both sides of the Cascade Mtns in low to high elevations. Often roots only at callus.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Salix sitchensis	sitka willow	9,0,A	yes	very large shrub		v good	rapid when young, medium there-after	medium		fascines, stakes, poles, brush mats, layering, cuttings, plants	Occurs on both sides of the Cascade Mtns. Vigorous shoots branch freely; lends itself to bioengineering uses; excellent survival in trials. 'Plumas' cultivar released by OR PMC.
Sambucus canadensis	american elder	1,2,3, 4,5,6, 8,9	yes	medium shrub	fibrous & stolonif-erous	good	fast	fast	poor	fascines, cuttings, plants	Softwood cuttings root root easily in spring or summer. Pith white.
Sambucus cerulea	blue elderberry	6,7,8, 9,0	yes	large shrub	fibrous	poor	v fast	v fast	poor	plants	
Sambucus cerulea ssp. mexicana	mexican elder	6,7,8, 0,H		large shrub		good				fascines, plants	Was S. mexicana. Evergreen. Soft-wood cuttings root easily in spring or summer.
Sambucus racemosa	red elderberry	1,2,3, 4,7,8, 9,0,A	yes	medium shrub		good	medium	slow		fascines, brush mats, layering, cuttings, plants	Softwood cuttings root easily in spring or summer. Pith brown. This may be S. callicarpa.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Sambucus racemosa ssp. pubens	red elder	1,2,3,4,9,A		medium shrub	deep laterals	fair to good				fascines, plants	Occurs west of the Cascade Mtns, usually within 10 miles of the ocean & on the coastal bays & estuaries. Softwood cuttings root easily in spring or summer. Pith brown. Use in combination with species with rooting ability good to excellent.
Spiraea alba	meadowsweet spirea	1,2,3,4	yes	short dense tree	dense shallow, lateral	fair to good		medium		plants	Propagation by leafy softwood cuttings in midsummer under mist.
Spiraea betulifolia	shinyleaf spirea	1,2,4,9		shrub						plants	Usually grown from seed. Occurs east of the Cascade Mtns at medium to high elevations.
Spiraea douglasii	douglas spirea	2,3,9,0	yes	small dense shrub	fibrous, suckering	good	rapid	fast	excellent	fascines, brush mats, layering, cuttings, division of suckers, plants	Resists fire & prolific sprouter (forms thickets). Propagation by leafy softwood cuttings in midsummer under mist. 'Bashaw' cultivar released by WA PMC.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Spiraea tomentosa	hardhack spirea	1,2,3, 5		small shrub	dense, shallow	poor to fair				plants	Propagation by leafy softwood cuttings in mid-summer under mist. A weed in New England pastures. Use rooted materials.
Styrax japonica	Japanese snowbell	1,2,3, 5,6	yes	large shrub		poor				plants	
Symphoricarpos albus	snowberry	1,3,4, 5,7,8, 9,0,A	yes	small shrub, dense colony forming	shallow, fibrous, freely suckering	good	rapid	slow	fair	fascines, brush mats, layering, cuttings, plants	Plant in sun to part shade, especially on wet sites.
Taxodium distichum	baldcypress	1,2,3, 5,6	yes	medium tree	tap with laterals for knees for aeration	poor	medium	fast	poor	plants	Plant on 10- to 12-foot spacing. Tolerates upland sites in region 6 with 32" rainfall.
Tsuga canadensis	eastern hemlock	1,2,3	yes	large tree	shallow fibrous	poor	slow	slow	low	plants	

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

Scientific name	Common name	Region occurrence	Commercial availability	Plant type	Root type	Rooting ability from cutting	Growth rate	Establishment speed	Spread potential	Plant materials type	Notes
Ulmus americana	american elm	1,2,3,4,5,6,8	yes	large tree	tap on dry sites to shallow fibrous on moist sites	poor	medium	medium	poor	plants	A species for forested wetland sites. Survived near 2 years of flooding in MS. Plant on 10- to 12-foot spacing; tolerates full shade.
Viburnum dentatum	arrowwood	1,2,3,6	yes	medium to tall shrub	shallow, fibrous	good	fast	slow		layering, cuttings, plants	Thicket forming; tolerates city smoke. Use rooted plant materials.
Viburnum lantanoides	hubblebush viburnam	1,2,3		medium shrub	shallow, fibrous	good				fascines, stakes, brush mats, layering, cuttings, plants	Was V. alnifolium. Thicket forming. Branch tips root at soil.
Viburnum lentago	nannyberry	1,2,3,4,5,9	yes	large shrub	shallow	fair to good	fast	fast		fascines, cuttings, stakes, plants	Thicket forming; tolerates city smoke. Tolerates full shade. Older branches often root when they touch soil. Use in combination with species with rooting ability good to excellent.

Table 16B–1 Woody plants for soil bioengineering and associated systems—Continued

cientific name	Common name	Region occur-ence	Commer-cial avail-ability	Plant type	Root type	Rooting ability from cutting	Growth rate	Estab-lishment speed	Spread potential	Plant materials type	Notes
Viburnum nudum	swamp haw	1,2,6		large shrub		poor				plants	D. Wymann says it is more adapted to the South than V. cassinoides.
Viburnum trilobum	american cranberry-bush	1,3,4, 5,9	yes	medium shrub		poor	medium	slow		layering, plants	Use rooted plant materials. Fruits are edible.

Table 16B–2 Woody plants with fair to good or better rooting ability from unrooted cuttings

Scientific name	Common name	Scientific name	Common mame
Acer circinatum	vine maple	*Salix bonplandiana*	pussy willow
Baccharis glutinosa	seepwillow	*Salix discolor*	pussy willow
Baccharis halimifolia	eastern baccharis	*Salix drummondiana*	drummond's willow
Baccharis pilularis	coyotebush	*Salix eriocephala*	erect willow
Baccharis salicifolia	water wally	*Salix exigua*	coyote willow
Baccharis viminea	mulefat baccharis	*Salix gooddingii*	goodding willow
Cephalanthus occidentalis	buttonbush	*Salix hookeriana*	hooker willow
Cornus amomum	silky dogwood	*Salix humilis*	prairie willow
Cornus drummondii	roughleaf dogwood	*Salix interior*	sandbar willow
Cornus foemina	stiff dogwood	*Salix lasiolepis*	arroyo willow
Cornus racemosa	gray dogwood	*Salix lemmonii*	lemmon's willow
Cornus rugosa	roundleaf dogwood	*Salix lucida*	shining willow
Cornus sericea ssp sericea	red-osier dogwood	*Salix lucida ssp. lasiandra*	pacific willow
Lonicera involucrata	black twinberry	*Salix lutea*	yellow willow
Physocarpus capitatus	pacific ninebark	*Salix nigra*	black willow
Physocarpus opulifolius	common ninebark	*Salix pentandra*	laural willow
Populus angustifolia	narrowleaf cottonwood	*Salix purpurea*	purpleosier willow
Populus balsamifera	balsam poplar	*Salix scouleriana*	scouler's willow
Populus deltoides	eastern cottonwood	*Salix sitchensis*	sitka willow
Populus fremontii	fremont cottonwood	*Sambucus canadensis*	american elder
Populus trichocarpa	black cottonwood	*Sambucus cerulea ssp. mexicana*	mexican elder
Rosa gymnocarpa	baldhip rose	*Sambucus racemosa*	red elderberry
Rosa nutkana	nootka rose	*Sambucus racemosa ssp. pubens*	red elder
Rosa palustris	swamp rose	*Spiraea alba*	meadowsweet spirea
Rosa virginiana	virginia rose	*Spiraea douglasii*	douglas spirea
Rosa woodsii	woods rose	*Symphoricarpos albus*	snowberry
Rubus allegheniensis	allegheny blackberry	*Viburnum dentatum*	arrowwood
Rubus idaeus ssp.strigosus	red raspberry	*Viburnum lantanoides*	hubblebush viburnam
Rubus spectabilis	salmonberry	*Viburnum lentago*	nannyberry
Salix X cottetii	dwarf willow		
Salix amygdaloides	peachleaf willow		

Table 16B–3 Woody plants with poor or fair rooting ability from unrooted cuttings

Scientific name	Common name	Scientific name	Common mame
Acer glabrum	dwarf maple	*Fraxinus pennsylvanica*	green ash
Acer negundo	boxelder	*Gleditsia triacanthos*	honeylocust
Acer rubrum	red maple	*Hibiscus aculeatus*	hibiscus
Acer saccharinum	silver maple	*Hibiscus laevis*	halberd-leaf marshmallow
Alnus pacifica	pacific alder	*Hibiscus moscheutos*	common rose mallow
Alnus rubra	red alder	*Hibiscus moscheutos ssp. lasiocarpos*	hibiscus
Alnus serrulata	smooth alder	*Holodiscus discolor*	oceanspray
Alnus viridis ssp.sinuata	sitka alder	*Ilex coriacea*	sweet gallberry
Amelanchier alnifolia var cusickii	cusick's serviceberry	*Ilex decidua*	possomhaw
Amorpha fruitcosa	false indigo	*Ilex glabra*	bitter gallberrry
Aronia arbutifolia	red chokeberry	*Ilex opaca*	american holly
Asimina triloba	pawpaw	*Ilex verticillata*	winterberry
Betula nigra	river birch	*Ilex vomitoria*	yaupon
Betula papyrifera	paper birch	*Juglans nigra*	black walnut
Betula pumila	low birch	*Juniperus virginiana*	eastern redcedar
Carpinis caroliniana	american hornbeam	*Leucothoe axillaris*	leucothoe
Carya aquatica	water hickory	*Lindera benzoin*	spicebush
Carya cordiformis	bitternut hickory	*Liquidambar styraciflua*	sweetgum
Carya ovata	shagbark hickory	*Liriodendron tulipifera*	tulip poplar
Catalpa bignonioides	southern catalpa	*Lyonia lucida*	fetterbush
Celtis laevigata	sugarberry	*Magnolia virginiana*	sweetbay
Celtis occidentalis	hackberry	*Myrica cerifera*	southern waxmyrtle
Cercis canadensis	redbud	*Nyssa aquatica*	swamp tupelo
Chionanthus virginicus	fringetree	*Nyssa ogeeche*	ogeeche lime
Clematis ligusticifolia	western clematis	*Nyssa sylvatica*	blackgum
Clethera alnifolia	sweet pepperbush	*Ostrya virginiana*	hophornbeam
Cornus florida	flowering dogwood	*Persea borbonia*	redbay
Cornus stricta	swamp dogwood	*Philadelphus lewesii*	lewis mockorange
Crataegus douglasii	douglas' hawthorn	*Physocarpus malvaceus*	mallow ninebark
Crataegus mollis	downy hawthorn	*Physocarpus opulifolius*	common ninebark
Cyrilla racemiflora	titi	*Pinus taeda*	loblolly pine
Diospyros virginiana	persimmon	*Planera aquatica*	water elm
Dlaeagnus commutata	silverberry	*Platanus occidentalis*	sycamore
Forestiera acuminata	swamp privet	*Populus tremuloides*	quaking aspen
Fraxinus caroliniana	carolina ash	*Prunus angustifolia*	wild plum
Fraxinus latifolia	oregon ash		

Table 16B–3 Woody plants with poor or fair rooting ability from unrooted cuttings—Continued

Scientific name	Common name	Scientific name	Common mame
Prunus virginiana	common chokecherry	*Rhododendron atlanticum*	coast azalea
Quercus alba	white oak	*Rhododendron viscosum*	swamp azalea
Quercus bicolor	swamp white oak	*Rhus copallina*	flameleaf sumac
Quercus garryana	oregon white oak	*Rhus glabra*	smooth sumac
Quercus laurifolia	swamp laurel oak	*Robinia pseuodoacacia*	black locust
Quercus lyrata	overcup oak	*Sambucus cerulea*	blue elderberry
Quercus macrocarpa	bur oak	*Spiraea tomentosa*	hardhack spirea
Quercus michauxii	swamp chestnut oak	*Styrax americanus*	Japanese snowbell
Quercus nigra	water oak	*Taxodium distichum*	bald cypress
Quercus pagoda	cherrybark oak	*Tsuga canadensis*	eastern hemlock
Quercus palustris	pin oak	*Ulmus americana*	american elm
Quercus phellos	willow oak	*Viburnum nudum*	swamp haw
Quercus shumardii	shumard oak	*Viburnum trilobum*	american cranberrybush

Table 16B–4 Grasses and forbs useful in conjunction with soil bioengineering and associated systems

Scientific name	Common name	Warm season or non-competitive	Soil preference	pH preference	Drought tolerance	Shade tolerance	Deposition tolerance	Flood tolerance	Flood season	Min. h_2o	Max. h_2o	Wetland indicator 1/
Agrostis alba	redtop											
Ammophila breviligulata	American beachgrass		sands	5.5	fair	poor	good			0		1,facu- 2,upl 3,upl*
Andropogon gerardii	big bluestem	yes	loams	6.0	good	poor	poor	fair		0		1,fac 2,fac 3,fac- 4,facu 5,fac- 6,facu 7,fac- 8,facu 9facu
Arundo donax	giant reed		sandy	7.0	good	poor		poor		0	1"	1,facu- 2,facw 3,facw 6,fac+ 7,facw 8,facw 0,facw C,ni H,ni
Elymus virginicus	wildrye	yes noncompetitive	loams	6.0	fair	good	fair	good		0		1,facw-
Eragrostis trichodes	sand lovegrass	yes	sands	6.0	good	poor	poor	poor		0		
Festuca rubra	red fescue	noncompetitive	loams	6.5	good	good	poor	fair		0		1,facu

Table 16B–4 Grasses and forbs useful in conjunction with soil bioengineering and associated systems—Continued

Scientific name	Common name	Warm season or non-competitive	Soil preference	pH preference	Drought tolerance	Shade tolerance	Deposition tolerance	Flood tolerance	Flood season	Min. h_2o	Max. h_2o	Wetland indicator 1/
Hemarthria altissima	limpograss		sandy		poor	poor	poor	good		0	1'	1,facw 2,facw 6,facw
Panicum amarulum	coastal panicgrass	yes	sands to loams	5.5	good	poor	fair	good		0		1,facu- 2,fac 6,facu-
Panicum clandestinum	deertongue	yes										
Panicum virgatum	switchgrass	yes	loams to sands	6.0	good	poor	fair	good	all	0		1,fac 2,fac+ 3,fac+ 4,fac 5,fac 6,facw 7,fac+ 8,fac 9,fac+ H,ni
Paspalum vaginatum	seashore paspalum		sandy			poor		good		1/2'	1'	2,obl 6,facw* C,ni H,ni
Pennisetum purpureum	elephant-grass					poor				0	2'	2,facu+ C,ni H,ni

Table 16B–4 Grasses and forbs useful in conjunction with soil bioengineering and associated systems—Continued

Scientific name	Common name	Warm season or non-competitive	Soil preference	pH preference	Drought tolerance	Shade tolerance	Deposition tolerance	Flood tolerance	Flood season	Min. h_2o	Max. h_2o	Wetland indicator 1/
Poa pratensis	Kentucky bluegrass		loam	6.5	poor	poor	poor	fair		0		1,facu
Schizachyrium scoparium	little bluestem	yes	sands to loams	6.5	good	poor	poor	poor		0		1,facu
Sorghastrum nutans	Indiangrass	yes	sands to	6.5	fair	poor	poor	poor		0		1,upl
Spartina pectinata	prairie cordgrass	yes	sands to loams	6.0	good	fair	fair	fair		0	1"	1,obl 2,obl 3,facw+ 4,facw 5,facw 6,facw+ 7,facw 8,obl 9,obl
Zizaniopsis miliacea	giant cutgrass		loam	4.3-6.0	poor	poor		good	all	1/2'	2'	1,obl 2,obl 3,obl 6,obl

Table 16B–4 Grasses and forbs useful in conjunction with soil bioengineering and associated systems—Continued

Scientific name	Common name	Warm season or non-competitive	Soil preference	pH preference	Drought tolerance	Shade tolerance	Deposition tolerance	Flood tolerance	Flood season	Min. h_2o	Max. h_2o	Wetland indicator 1/

1/ Wetland indicator terms (from USDI Fish and Wildlife Service's National List of Plant Species That Occur in Wetlands, 1988):

Region code number or letter:

1 Northeast (ME, NH, VT, MA, CT, RI, WV, KY, NY, PA, NJ, MD, DE, VA, OH)
2 Southeast (NC, SC, GA, FL, TN, AL, MS, LA, AR)
3 North Central (MO, IA, MN, MI, WI, IL, IN)
4 North Plains (ND, SD, MT (eastern), WY (eastern))
5 Central Plains (NE, KS, CO (eastern))
6 South Plains (TX, OK)
7 Southwest (AZ, NM)
8 Intermountain (NV, UT, CO (western))
9 Northwest (WA, OR, ID, MT (western), WY (western))
0 California (Ca)
A Alaska (AK)
C Caribbean (PR, VI, CZ, SQ)
H Hawaii (HI, AQ, GU, IQ, MQ, TQ, WQ, YQ)

Indicator categories (estimated probability):

fac Facultative—Equally likely to occur in wetlands or nonwetlands (34-66%).
facu Facultative upland—Usually occur in nonwetlands (67-99%), but occasionally found in wetlands (1-33%)
facw Facultative wetland—Usually occur in wetlands (67-99%), but occasionally found in nonwetlands.
obl Obligate wetland—Occur almost always (99%) under naturl conditions in wetlands.
upl Obligate upland—Occur in wetlands in another region, but occur almost always (99%) under natural conditions in nonwetlands im¸QæB¸regioK¸QpC Ûh”DGed-¸'e¸` Qpec%Cs BMeQ nMt Mccur %n wetlands in any region, it is not on the National List.

Frequency of occurrence:

– (negative sign) indicates less frequently found in wetlands.
+ (positive sign) indicates more frequently found in wetlands.
***** (asterisk) indicates wetlands indicators were derived from limited ecological information.
ni (no indicator) indicates insufficient information was available to determine an indiator status.