# OPERATION AND MAINTENANCE PLAN

FOR

[Type the Landowner or Project Owner Name Here]

PREPARED BY

SAUK RIVER WATERSHED DISTRICT

[Date]

Dear Owner:

The design provided for your conservation practice on the best available technical knowledge, but it must be recognized that proper maintenance is also very important. As owner, you are responsible for the maintenance of these practices. Total benefits can only be realized if you maintain the practices to function for the designed purpose.

It is recommended that you inspect the practices annually or more if needed, particularly after major runoff events and during periods of drought.

The Sauk River Watershed District (SRWD) has prepared the enclosed guideline for maintaining your project.

The maintenance of structural practices (terraces, water and sediment basins, outlets, vegetated swales and drainage areas, diversions, retaining walls, rock blankets, etc.) are extremely dependent upon your management practices ( i.e. land use). If you have installed structural practices, your SRWD Technician has considered your planned use into the technical design in order to best meet your needs and conservation objectives. Therefore, it is recommended that you contact the SRWD to discuss the effects of changes you may be considering in your land use.

If you have questions about these guidelines or notice unusual circumstances occurring with a practice; contact your SRWD Technician for assistance.

District Technician

[Select the maintenance guidelines that correspond to this project and delete those that do not correspond to this project]

# Section 1: Shoreland Restoration

## 1.1 Natural Recovery (No-Mow) Shoreland:

Natural recovery or ñno-mowò zones are encouraged where feasible. Native vegetation will recover naturally when the site is protected from disturbance and where adequate seed and/or root sources and appropriate site conditions are present. Wet shoreline margins, where turf grasses are not well established, are particularly suited to natural recovery. *Results may be slower than for planted buffers, but there is virtually no cost, and the end result may appear more natural.*

*An area where a dense growth of turf grasses has been maintained for several years is usually not well suited to natural recovery.* Turf grasses frequently out-compete native vegetation, and the area may lack native seed sources. *Areas with extensive stands of invasive weeds should also not be left to recover naturally.*

### Maintenance

The most ideal maintenance is to simply leave the site alone. Do not fertilize, do not mow, do not rake, do not ñclean upò fallen limbs or trees. Allow native vegetation to regrow. Pulling invasive weeds around native shrubs, trees, and groundcovers the first year or two eliminates competition and will help natives fill in. Maintenance over the long-term must be in accordance with the local shoreland ordinance requirements.

The duff layer, made up of fallen leaves and pine needles, should be left intact. This layer covers the soil, thereby conserving moisture, preventing erosion, and allowing water to infiltrate into the soil.

### Protection Against Deer Browsing

Whitetail deer and other animals may damage vegetation, especially trees and shrubs. Protect against damage by physical or chemical means. Surround newly planted trees and shrubs with 4 ï 6 foot high, galvanized mesh fence supported with wooden stakes or fence posts, or cover plants with bird netting. Landscape products available to spray on plants deter browsing through strong tastes or odors. Red pepper spray is an example. Use of these products may need to be varied as deer become accustomed to their taste or smell. Protection against deer browsing is particularly important if deer are fed on the site or nearby. Deer feeding should be discouraged near restoration areas.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 1.2 Planted Buffer Zones

Accelerated recovery techniques are most appropriate where insufficient native vegetation is present for natural recovery techniques, or where quick results are desired. Accelerated recovery techniques can include planting trees and shrubs, planting native grass and wildflower seedlings, or seeding native grasses and wildflowers.

Exposed soil may be encountered because of erosion from runoff, bank instability, heavy use, or construction activities. Eliminate or minimize the cause of the bare soil and then stabilize the area following the guidelines below. Filter fabric fences may be necessary to capture sediment below exposed slopes.

Proper site preparation is one of the most important steps in establishing a native plant landscape. Reducing competition on the site by first removing the existing non-native vegetation is especially important. Turf grasses can quickly out-compete newly planted native plants if left in place.

Sometimes removing existing vegetation is not necessary, and it is possible to plant among existing scattered native plants or to leave zones of vegetation intact. The moist zone near the waterõs edge often consists mostly of native plants because turf grasses are flooded out. Seeds and underground stems may quickly revegetate the area if allowed to grow. Selected native flowers, grasses, and shrubs can usually be planted among existing native vegetation to fill in bare spots or to add color and variety. Plant flowers and grasses in a manner that will allow them to spread over the entire area. Stands of invasive plants like reed canary grass or purple loosestrife should be removed from wet areas.

Companion Seeding for Steep Slopes

When seeding on steep slopes, a companion seeding and/or other erosion control practices shall be used. See companion seeding rates table below.

**Slopes >12%**: Companion seeding of oats, side oats grama, or Canada wild rye. (E)

**Slopes >20%**: Companion seeding of oats, side oats grama, or Canada wild rye, and use either mulch and netting or an erosion control blanket.

| **Seeding Rates for Companion Crops** | |
|---|---|
| Oats | 0.5 lba/1000 sq. ft. |
| Canada Wildrye | 1.0 oz. / 1000 sq. ft. |
| Side Oats Grama | 1.0 oz. / 1000 sq. ft |

(E) *Oats are annuals that will temporarily stabilize an area and then be killed by a hard frost. Canada wild rye and side outs grama are short-lived native perennial grasses*

Temporary Cover Crop for Exposed Soil

A temporary cover crop should be planted only if soils have been exposed, and the restoration planting is delayed.

| **Seeding Rates for Cover Crop** | | |
|---|---|---|
| **RATE** | | **DATE** |
| Oats | 0.5 ï 1.0 lbs/1000 sq. ft. | 4/1 - 6/1 |
| Barley | 0.5 ï 1.0 lbs/1000 sq. ft. | 4/1 ï 6/1 |
| Annual Ryegrass | 0.5 ï 1.0 lbs/1000 sq. ft. | 8/1 ï 9/1 |
| Sideoats Grama | 0.5 ï 1.0 lbs/1000 sq. ft. | 5/1 ï 7/1 |

Species Selection

Plants shall be selected from species lists of plant communities that are native to the county. A list of these plants is available from the SRWD Technician, as well as through the MN DNR. Plants should further be chosen based on site soil, moisture, and light conditions.
In some cases, such as lack of plant or seed availability, substitutions may be allowed.

Seedlings

On nutrient poor soils, fertilizer may be required where mulches are used because they demand nitrogen as they decompose. Fertilizer should never be broadcast due to the potential for runoff into the lake. Instead, apply a very small amount of slow release phosphorous free fertilizer in each planting hole. Phosphorus levels are adequate in most soils, and phosphorus can increase algae growth in the lake. Phosphorus is the middle number of the three given on the fertilizer bag.

Application amounts will vary depending on nutrient concentration. For a 6-0-6 NPK ratio, use one teaspoon of organic fertilizer per grass or wildflower plant and ¼ cup per shrub or tree. Up to one cup can be added to larger shrub or tree planting holes.

Dead vegetation left in place after smothering or an herbicide application does not need to be removed. Leave the dead material to serve as a mulch to capture moisture, reduce weed growth, 10 and add organic material to the soil. Plant seedlings directly through the dead material. Roots must be buried in soil and not in the thatch of dead lawn, where the plant would quickly dry out and die.

Planting Densities

The table below describes planting standards for two major shoreland types: woodland, and barrens/dry prairie/wet prairie. The woodland has a nearly complete canopy of trees while the barrens/prairie and wetland are more open. Plant numbers are to be calculated based on the area in square feet to be reestablished and the appropriate density. The area to be reestablished shall be calculated for each layer.

| **Shoreland Habitat Planting Densities** | | | | |
|---|---|---|---|---|
| | **Woodland – Upland** | | **Wetland - Riparian** | |
| | **Minimum Number of Species** (A) | **Density** | **Minimum Number of Species** (A) | **Density** |
| **Trees** (B) | 2 | 0.5 ï 5 per 100 sq. ft. | 0 | 0 ï 0.2 per 100 sq. ft. |
| **Shrubs** | 3 | 1 ï 4 per 100 sq. ft. If clumped, maintain min. 2 foot spacing | 2 | 0.2 ï 0.5 per 100 sq. ft. If clumped, maintain min. 2 foot spacing |
| **Herbaceous Cover** (C) | | | | |
| **Plugs** | 3 | 25 ï 75 plants per 100 sq. ft. Soil must be mulched | 5 | 50 ï 100 plants per 100 sq. ft. Soil must be mulched |
| **Seeding** | 3 | Grass/Sedges: 4-8 oz. per 1000 sq. ft. Forbs: 2-4 oz. per 1000 sq. ft. | 5 (D) | Grass/Sedges: 4-8 oz. per 1000 sq. ft. Forbs: 2-4 oz. per 1000 sq. ft. |

(A) *Select species from established plant lists for shoreland habitat. Trees, shrubs, and groundcovers may be transplanted from adjacent woodland or open areas outside the restoration area.*
(B) *Trees must be at least 2 year old seedlings, 8 inches or taller.*
(C) *The herbaceous cover layer shall be comprised of a minimum of 30% grasses and/or sedges.*
(D) *Consider the use of plants rather than seeds in wet areas.*

Planting Dates

The table below provides approximate dates for planting. Weather and soil conditions, which vary year-to-year, determine the most appropriate planting time. Please note that adequate moisture levels are assumed due to required watering practices.

| **Recommended Planting Dates and Zones** | | |
|---|---|---|
| | **North** | **South** |
| **Seeded Herbaceous Covers** Seeding early favors cool season plants. Seeding after soil temperature increases above 50 degrees favors warm season plants. | Cool Season: April 1 ï June 15<br>July 15 ï Sept. 1<br><br>Warm Season: May 15-June 30 | Cool Season: April 1 ï June 1<br>August 1ï Sept. 10<br><br>Warm Season: May 15-June 30 |
| **Plugs (seedlings) and Potted Herbaceous Covers** Plant after danger of frost has passed, and up to first frost. Later plantings may require more frequent watering because of increased temperatures. | May 20 ï September 15 | May 1 ï October 31 |
| **Bare root Trees and Shrubs** | Any time soil is not frozen and before leaf out, or after leaves fall. | |
| **Potted Trees and Shrubs** | Any time soil is not frozen. | |

## Maintenance

The most ideal maintenance is to simply leave the site alone. Do not fertilize, do not mow, do not rake, do not ñclean upò fallen limbs or trees. Allow native vegetation to regrow. In accelerated recovery areas, some initial maintenance may be required. Pulling invasive weeds around native shrubs, trees, and groundcovers the first year or two eliminates competition and will help to give them a good start. Maintenance over the long-term must be in accordance with the local shoreland ordinance requirements.

The duff layer, made up of fallen leaves and pine needles, should be left intact. This layer covers the soil, thereby conserving moisture, preventing erosion, and allowing water to infiltrate into the soil.

- Leave trees shrubs, and groundcover in place, including leaves, pine needles and grass to provide constant ground cover (This minimizes the possibility of invasive and noxious weeds entering the area)
- Only remove vegetation if it is dead, poses a safety concern, or is invasive.
- Refrain from clearcuttin, filling grading or land disturbing activities.
- Exclude heavy wheeled or tracked equipment.

- Refrain from storage of vehicles, boats, docks or other equipment 9unless it occurs during the non-growing season AND vegetation in unaffected).
- Refrain from using fertilizer unless a soil test indicates it is necessary. MN law requires that any fertilizer used must be phosphorus-free.
- Refrain from using herbicides unless approved for controlling invasives.

# Year One

| | Description | Methods |
|---|---|---|
| Watering | Regular watering in the first two months of a spring or summer planting is one of the most important factors for success. Without supplemental watering, roots may not reach the soil moisture they need. | • Water 30 minutes per day or 1ò per week including rainfall (allows vigorous root growth for plants to become quickly established.)<br>• Consider Sprinkler timers<br>• Poor Drainage → Water early morning to reduce fungal disease.<br>• Use nutrient-rich lake water if feasible, since this water often is warmer and more nutrient-rich than well water. (May require DNR permit) |
| Grazing Protection from Waterfowl and Deer | Whitetail deer and other animals may damage plantings, especially trees and shrubs. Protect against damage by physical or chemical means. | • Surround newly planted trees and shrubs with 4 ï 6 foot high, galvanized mesh fence supported with wooden stakes or fence posts, or cover plants with bird netting.<br>• Use detterent sprays such as red pepper spray (Use of these products may need to be varied as deer become accustomed to their taste or smell).<br>• Deer feeding should be discouraged near restoration areas. |
| Weeding Planted Areas | Pull weeds out as early as possible being careful to not disturb the native plants. Be especially diligent in areas where non-native invasive species like purple loosestrife, mullein, lambôs quarter, quack grass, reed canary grass or bluegrass are known to be present. | |
| Weeding Seeded Areas | It can be difficult to tell weeds from the native plants in a seeded area. | • Sprouting a small sample of the native seeds in a plant tray will assist with their identification.<br>• Cut off flowering heads of weeds before they go to seed. |
| Fertilizing and Applying Insecticide | Fertilizers and insecticides should be avoided. Applying fertilizers may encourage weed growth. If native plants are selected appropriately, supplemental fertilization should not be required. Also avoid applying insecticides since so many are non-specific and can harm or even kill non-target species. | |

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|---|---|---|
| Vegetative Cover | At the end of the growing season, allow all dead vegetation to remain in place. It becomes a valuable seed source for next yearôs growth, provides food and cover for wildlife, and will help to cover the soil and slow spring runoff. The grass seed and dried flower heads add another level of appeal to the native landscape in the winter months. | |
| Replacement of Plants | Replant or anchor uprooted aquatic plants. Once established, aquatics require little or no long-term maintenance. | |
| Erosion Control Structure Repair | Inspect all erosion control blankets, inlet/outlets, silt fences, berms, etc. throughout the season | • Refer to Temporary Erosion control maintenance methods. |
| Wavebreak Removal and Repair | If wavebreaks were used to establish vegeatation, inspection is required. | • Inspect on a daily/weekly basis.<br>• Repair as necessary<br>• Remove breaks prior to freeze-up |

# Year Two

| | Description | Methods |
|---|---|---|
| Watering | Water only during periods of severe drought. | |
| Weeding | Thoroughly weed early in the summer. After this initial weeding, check for and remove weeds at least once a month. | |
| Plant Replacement | If there are areas that are bare or look as though they have frozen out, contact your SRWD Technician for a replanting strategy. | |
| Erosion Control Structure Repair | Inspect all erosion control blankets, inlet/outlets, silt fences, berms, etc. throughout the season | • Refer to Temporary Erosion control maintenance methods. |
| Wavebreak Removal and Repair | If wavebreaks were used to establish vegeatation, inspection is required. | • Install wavebreaks only if plants are not established<br>• Inspect on a daily/weekly basis.<br>• Repair as necessary |

# Year Three & Beyond

| | Description | Methods |
|---|---|---|
| Watering | No watering should be necessary except for extreme drought conditions. | |
| Weeding | Continue to do a thorough weeding in the early summer. If invasives are a problem, consider a weed management strategy provided by the SRWD Technician. Mowing and burning can occur every 3 to 5 years as recommended by your SRWD Technician. | |
| Vegetative Cover | Leave vegetation in place in the fall and through the extensive winter months. | • Approval from the zoning or land conservation office is required for extensive weed removal in the shoreland zone. |
| Fertilizing | Encourages invasives and noxious weeds. | None |
| Trimming and Burning | Prairie and savanna areas may be trimmed or burned only under an approved management plan.<br>Additional permits or approval may be necessary before trimming or burning. | • Trim groundcover in prairie areas no more than once every 3-5 years.<br>• Groundcover should be cut no less than 6-8 inches high.<br>• Cut vegetation in the late winter when the ground is still frozen, or in late spring, when the ground is dry enough to walk on without damaging new growth.<br>• Leave all dead plant clippings on-site. They will add to the shoreland soil structure.<br>• A controlled burn may be appropriate only in prairie and savanna areas. A burn should not be attempted until the prairie or savanna is well established ï usually after 5 or more years.<br>• To determine if a controlled burn is appropriate evaluate the site for safety considerations; threats to structures, shrubs, and trees; and weed species present.<br>• In addition to any required permits, DNR burning permits are required in intensive fire zones. Except in prairie areas that are identified in an approved management plan, any native trees, shrubs, and groundcover in the restoration area shall be left undisturbed. |

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|---|---|---|
| Erosion Control Structure Repair | Inspect all erosion control blankets, inlet/outlets, silt fences, berms, etc. throughout the season | • Refer to Temporary Erosion control maintenance methods. |
| Wavebreak Removal and Repair | If wavebreaks were used to establish vegeatation, inspection is required. | • Remove structures |

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 1.3 Fire Prevention

Areas with sandy soils are prone to forest fires. Conifer trees are especially susceptible to fire. To reduce fire danger, avoid planting conifers close to structures in those sandy areas of the state. Fire hazard is lower if conifers are planted on the waterward rather than the landward side of the house. Contact your local Department of Natural Resources for information about fire-prone areas.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 1.4 Plant and Seed Sources

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 1.5 Todd County Native Plant List

Native plant species are those which are native to a particular area. In this case, the SRWD recommends choosing plants which are native to the county where the project site is located.

**Todd County Native Wildflowers**

| Scientific Name | Common Name |
|---|---|
| *Acorus calamus* | Sweet flag |
| *Actaea rubra* | Red baneberry |
| *Agastache foeniculum* | Blue giant hyssop |
| *Alisma subcordatum* | Mud plantain |
| *Alisma triviale* | Water plantain |
| *Allium stellatum* | Prairie wild onion |
| *Allium tricoccum* | Wild leek |
| *Amphicarpaea bracteata* | Hog peanut |
| *Anemone canadensis* | Canada anemone |
| *Anemone cylindrica* | Thimbleweed |
| *Anemone quinquefolia* | Wood anemone |
| *Antennaria neglecta* | Narrow-leaved pussytoes |
| *Apocynum androsaemifolium* | Spreading dogbane |

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|---|---|
| *Apocynum sibiricum* | Indian hemp |
| *Aquilegia canadensis* | Columbine |
| *Aralia nudicaulis* | Wild sarsaparilla |
| *Aralia racemosa* | American spikenard |
| *Arisaema triphyllum* | Jack-in-the-pulpit |
| *Artemisia ludoviciana* | Prairie sage |
| *Asarum canadense* | Wild ginger |
| *Asclepias incarnata* | Swamp milkweed |
| *Aster ciliolatus* | Ciliate aster |
| *Aster ericoides* | Heath aster |
| *Aster laevis* | Smooth aster |
| *Aster lateriflorus* | Woodland (or Side-flowering) aster |
| *Aster macrophyllus* | Large-leaved aster |
| *Aster novae-angliae* | New England aster |
| *Aster oolentangiensis* | Sky-blue aster |
| *Aster puniceus* | Red-stemmed aster |
| *Aster sericeus* | Silky aster |
| *Aster lanceolatus (simplex)* | Panicled aster |
| *Aster umbellatus* | Flat-topped aster |
| *Astragalus canadensis* | Canada milk-vetch |
| *Athyrium angustum* | Lady fern |
| *Brasenia schreberi* | Water shield |
| *Caltha palustris* | Marsh marigold |
| *Campanula aparinoides* | Marsh bellflower |
| *Campanula rotundifolia* | Harebell |
| *Caulophyllum thalictroides* | Blue cohosh |
| *Cirsium muticum* | Swamp thistle |
| *Clintonia borealis* | Blue bead lily |
| *Comandra umbellata* | Star toadflax |
| *Coreopsis palmata* | Stiff tickseed |
| *Cornus canadensis* | Bunchberry |
| *Delphinium virescens* | Prairie larkspur |
| *Desmodium canadense* | Canada tick trefoil |
| *Dicentra cucullaria* | Dutchman's breeches |
| *Dryopteris carthusiana* | Wood fern |
| *Echinacea angustifolia* | Purple coneflower |
| *Epilobium angustifolium* | Fireweed |
| *Epilobium glandulosum* | Willow-herb |
| *Equisetum fluviatile* | Water horsetail |
| *Eupatorium maculatum* | Spotted Joe-Pye-weed |
| *Eupatorium perfoliatum* | Boneset |

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|---|---|
| *Eupatorium rugosum* | White snakeroot |
| *Euthamia graminifolia* | Grass-leaved goldenrod |
| *Fragaria virginiana* | Common strawberry |
| *Galium boreale* | Northern bedstraw |
| *Gentiana andrewsii* | Bottle gentian |
| *Geranium maculatum* | Wild geranium |
| *Geum aleppicum* | Yellow avens |
| *Geum triflorum* | Prairie-smoke |
| *Helenium autumnale* | Sneezeweed |
| *Helianthus giganteus* | Giant sunflower |
| *Helianthus grosseserratus* | Sawtooth sunflower |
| *Heliopsis helianthoides* | Ox-eye |
| *Helianthus hirsutus* | Hairy sunflower |
| *Helianthus maximiliani* | Maximilian sunflower |
| *Helianthus rigidus* | Stiff sunflower |
| *Helianthus strumosus* | Woodland sunflower |
| *Helianthus tuberosus* | Jerusalum artichoke |
| *Hepatica americana* | Round-lobed hepatica |
| *Heracleum lanatum* | Cow parsnip |
| *Heuchera richardsonii* | Alumroot |
| *Hieracium kalmii* | Canada hawkweed |
| *Hydrophyllum virginianum* | Virginia waterleaf |
| *Iris versicolor* | Blue flag iris |
| *Lathyrus ochroleucus* | White vetchling |
| *Lathyrus palustris* | Marsh vetchling |
| *Lathyrus venosus* | Veiny vetchling |
| *Liatris aspera* | Rough blazing star |
| *Liatris ligulistylis* | Meadow blazing star |
| *Liatris pycnostachya* | Prairie blazing star (Gay-feather) |
| *Lilium michiganense* | Michigan lily |
| *Lilium philadelphicum* | Wood lily |
| *Lobelia siphilitica* | Great blue lobelia |
| *Lobelia spicata* | Pale-spiked lobelia |
| *Lycopus americanus* | Water horehound (Cut-leaved bugleweed) |
| *Lycopus uniflorus* | Northern bugleweed |
| *Lysimachia ciliata* | Fringed loosestrife |
| *Lysimachia thyrsiflora* | Tufted loosestrife |
| *Maianthemum canadense* | Canada mayflower |
| *Matteuccia struthiopteris var. pensylvanica* | Ostrich fern |
| *Mentha arvensis* | Wild mint |

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|---|---|
| *Menyanthes trifoliata var. minor* | Buck-bean |
| *Mimulus ringens* | Monkeyflower |
| *Mirabilis nyctaginea* | Heart-leaved four-o'clock |
| *Mitella diphylla* | Miterwort |
| *Monarda fistulosa* | Wild bergamot |
| *Nuphar variegatum* | Yellow pond lily |
| *Nymphaea odorata* | White water lily |
| *Onoclea sensibilis* | Sensitive fern |
| *Osmorhiza claytonii* | Sweet cicely |
| *Osmunda cinnamomea* | Cinnamon fern |
| *Osmunda claytoniana* | Interrupted fern |
| *Penstemon gracilis* | Slender beard-tongue |
| *Penthorum sedoides* | Ditch stonecrop |
| *Dalea candidum* | White prairie clover |
| *Dalea purpurea* | Purple prairie clover |
| *Phlox pilosa* | Prairie phlox |
| *Physostegia virginiana* | Obedient plant |
| *Polygonum coccineum* | Swamp smartweed |
| *Polygonatum biflorum* | Giant Solomon's-seal |
| *Polygonum lapathifolium* | Dock-leaved smartweed |
| *Potentilla arguta* | Tall cinquefoil |
| *Potentilla palustris* | Marsh-cinquefoil |
| *Pteridium aquilinum* | Bracken fern |
| *Pulsatilla nuttalliana* | Pasque flower |
| *Pycnanthemum virginianum* | Virginia mountain mint |
| *Ranunculus hispidus* | Hairy crowfoot |
| *Rudbeckia hirta* | Black-eyed Susan |
| *Rudbeckia laciniata* | Green-headed (or tall) coneflower |
| *Rumex orbiculatus* | Water dock |
| *Sagittaria cristata* | Crested arrowhead |
| *Sagittaria cuneata* | Northern arrowhead |
| *Sagittaria latifolia* | Common arrowhead |
| *Sagittaria rigida* | Sessile-fruited arrowhead |
| *Sanguinaria canadensis* | Bloodroot |
| *Saxifraga pensylvanica* | Swamp saxifrage |
| *Scutellaria galericulata* | Marsh skullcap |
| *Scutellaria lateriflora* | Mad-dog skullcap |
| *Sisyrinchium campestre* | Blue-eyed grass |
| *Sium suave* | Water parsnip |
| *Smilacina racemosa* | False Solomon's seal |
| *Smilacina stellata* | Starry false Solomon's seal |

| | |
|---|---|
| *Solidago canadensis* | Canada goldenrod |
| *Solidago flexicaulis* | Zig-zag goldenrod |
| *Solidago gigantea* | Giant goldenrod |
| *Solidago nemoralis* | Gray goldenrod |
| *Solidago ptarmicoides* | White upland aster |
| *Solidago rigida* | Stiff goldenrod |
| *Solidago speciosa* | Showy goldenrod |
| *Solidago uliginosa* | Bog goldenrod |
| *Sparganium eurycarpum* | Giant bur-reed |
| *Stachys palustris* | Hedge nettle |
| *Streptopus roseus var. longipes* | Rose twisted-stalk |
| *Thalictrum dasycarpum* | Tall meadow rue |
| *Thalictrum dioicum* | Early meadow rue |
| *Thelypteris palustris* | Marsh fern |
| *Tradescantia bracteata* | Bracted spiderwort |
| *Triadenum fraseri* | Marsh St. John's-wort |
| *Trillium cernuum* | Nodding trillium |
| *Trillium grandiflorum* | Large-flowered trillium |
| *Typha latifolia* | Broad-leaved cattail |
| *Uvularia grandiflora* | Large-flowered bellwort |
| *Uvularia sessilifolia* | Pale bellwort (Wild oats) |
| *Verbena hastata* | Blue vervain |
| *Vernonia fasciculata* | Ironweed |
| *Veronica americana* | American brooklime |
| *Veronicastrum virginicum* | Culver's root |
| *Vicia americana* | American vetch |
| *Viola adunca* | Hooked violet |
| *Viola canadensis* | Canada violet |
| *Viola incognita* | Sweet white violet |
| *Viola macloskeyi* | Northern white violet |
| *Viola pedatifida* | Prairie bird-foot violet |
| *Viola pubescens* | Downy yellow violet |
| *Viola sororia* | Woolly blue violet |
| *Zizia aptera* | Heart-leaved alexanders |
| *Zizia aurea* | Golden alexanders |

# Todd County Native Grasses

| Scientific Name | Common Name |
|---|---|
| *Agropyron trachycaulum* | Slender wheatgrass |
| *Andropogon gerardii* | Big bluestem |
| *Beckmannia syzigachne* | Beckmannia |
| *Bouteloua curtipendula* | Side-oats grama |
| *Bouteloua gracilis* | Blue grama |
| *Bouteloua hirsuta* | Hairy grama |
| *Bromus ciliatus* | Fringed brome |
| *Bromus kalmii* | Kalm's brome |
| *Bromus latiglumis* | Tall brome |
| *Calamagrostis canadensis* | Bluejoint grass |
| *Calamovilfa longifolia* | Sand reedgrass |
| *Carex alopecoidea* | Foxtail sedge |
| *Carex aquatilis* | Water sedge |
| *Carex atherodes* | Slough sedge |
| *Carex bebbii* | Bebb's sedge |
| *Carex blanda* | Eastern woodland sedge |
| *Carex brevior* | Shortbeak sedge |
| *Carex comosa* | Bottlebrush sedge |
| *Carex radiata (convoluta)* | Eastern star sedge |
| *Carex cristatella* | Crested sedge |
| *Carex deweyana* | Dewey's sedge |
| *Carex gracillima* | Graceful sedge |
| *Carex hystericina* | Porcupine sedge |
| *Carex lacustris* | Lake sedge |
| *Carex lanuginosa* | Woolly sedge |
| *Carex lasiocarpa* | Wiregrass (Woolly needle sedge) |
| *Carex peckii* | Peck's sedge |
| *Carex prairea* | Prairie sedge |
| *Carex pseudocyperus* | Cyperus-like sedge |
| *Carex retrorsa* | Retrorse sedge |
| *Carex rostrata* | Beaked sedge |
| *Carex sartwellii* | Sartwell's sedge |
| *Carex scoparia* | Pointed broom sedge |
| *Carex sprengelii* | Sprengel's sedge |
| *Carex stipata* | Awl-fruited sedge |
| *Carex stricta* | Tussock sedge |
| *Carex vulpinoidea* | Fox sedge |
| *Dulichium arundinaceum* | Three-way sedge |

| | |
|---|---|
| *Eleocharis smallii (palustris)* | Creeping spikerush |
| *Elymus canadensis* | Canada wild rye |
| *Elymus hystrix* | Bottlebrush grass |
| *Elymus villosus* | Downy wild-rye |
| *Elymus virginicus* | Virginia wild-rye |
| *Eriophorum angustifolium* | Cotton grass |
| *Festuca obtusa* | Nodding fescue |
| *Glyceria borealis* | Northern manna grass |
| *Glyceria canadensis* | Rattlesnake manna grass |
| *Glyceria grandis* | Tall manna grass |
| *Glyceria striata* | Fowl manna grass |
| *Hierochloe odorata* | Sweet grass |
| *Juncus balticus var. littoralis* | Stiff rush |
| *Juncus effusus* | Soft rush |
| *Juncus nodosus* | Knotted rush |
| *Juncus tenuis* | Path rush |
| *Koeleria macrantha* | Junegrass |
| *Leersia oryzoides* | Rice cutgrass |
| *Luzula acuminata* | Woodrush |
| *Muhlenbergia glomerata* | Swamp satin grass |
| *Muhlenbergia mexicana* | Mexican satin grass |
| *Oryzopsis asperifolia* | Mountain rice-grass |
| *Panicum leibergii* | Leiberg's panic grass |
| *Panicum virgatum* | Switchgrass |
| *Poa palustris* | Fowl meadow grass |
| *Schizachne purpurescens* | False melic grass |
| *Schizachyrium scoparium* | Little bluestem |
| *Scirpus acutus* | Hardstem bulrush |
| *Scirpus atrovirens* | Dark green bulrush |
| *Scirpus cyperinus* | Woolgrass |
| *Scirpus fluviatilis* | River bulrush |
| *Scirpus pungens* | Three-square bulrush |
| *Scirpus validus* | Softstem bulrush |
| *Sorghastrum nutans* | Indian grass |
| *Spartina pectinata* | Prairie cordgrass |
| *Sporobolus cryptandrus* | Sand dropseed |
| *Sporobolus heterolepis* | Prairie dropseed |
| *Stipa spartea* | Porcupine grass |

## Todd County Native Shrubs and Trees

| *Scientific Name* | Common Name |
|---|---|

| | |
|---|---|
| *Acer negundo* | Box elder |
| *Acer rubrum* | Red maple |
| *Acer saccharinum* | Silver maple |
| *Acer saccharum* | Sugar maple |
| *Alnus incana ssp. rugosa* | Speckled alder |
| *Amelanchier interior* | Inland juneberry |
| *Amelanchier laevis* | Smooth juneberry |
| *Amorpha canescens* | Leadplant |
| *Amorpha fruticosa* | False indigo |
| *Aronia melanocarpa* | Black chokeberry |
| *Betula alleghaniensis* | Yellow birch |
| *Betula pumila* | Bog birch |
| *Betula papyrifera* | Paper birch |
| *Carpinus caroliniana ssp. virginiana* | American hornbeam (Musclewood) |
| *Ceanothus americanus* | New Jersey tea |
| *Celtis occidentalis* | Hackberry |
| *Cornus alternifolia* | Pagoda dogwood |
| *Cornus amomum* | Silky dogwood |
| *Cornus racemosa* | Gray dogwood |
| *Cornus sericea (stolonifera)* | Red-osier dogwood |
| *Corylus americana* | American hazel |
| *Corylus cornuta* | Beaked hazel |
| *Crataegus chrysocarpa* | Fireberry hawthorn |
| *Crataegus punctata* | White hawthorn |
| *Diervilla lonicera* | Bush honeysuckle |
| *Dirca palustris* | Leatherwood |
| *Fraxinus nigra* | Black ash |
| *Fraxinus pennsylvanica* | Green ash |
| *Juniperus communis var. depressa* | Bush juniper |
| *Juniperus virginiana* | Red cedar |
| *Larix laricina* | Tamarack |
| *Ostrya virginiana* | Ironwood |
| *Pinus banksiana* | Jack pine |
| *Pinus resinosa* | Red pine |
| *Pinus strobus* | White pine |
| *Populus balsamifera* | Balsam poplar |
| *Populus deltoides* | Cottonwood |
| *Populus grandidentata* | Big-tooth aspen |
| *Populus tremuloides* | Quaking aspen |

| | |
|---|---|
| *Prunus americana* | Wild plum |
| *Prunus pensylvanica* | Pin cherry |
| *Prunus serotina* | Black cherry |
| *Prunus virginiana* | Chokecherry |
| *Quercus alba* | White oak |
| *Quercus ellipsoidalis* | Northern pin oak |
| *Quercus macrocarpa* | Bur oak |
| *Quercus rubra* | Red oak |
| *Rhus glabra* | Smooth sumac |
| *Ribes americanum* | Wild black currant |
| *Rosa arkansana* | Prairie rose |
| *Rosa blanda* | Smooth wild rose |
| *Rubus allegheniensis* | Common blackberry |
| *Rubus occidentalis* | Black raspberry |
| *Rubus idaeus subsp. strigosus* | Red raspberry |
| *Salix amygdaloides* | Peach-leaved willow |
| *Salix bebbiana* | Bebb's willow |
| *Salix discolor* | Pussy willow |
| *Salix eriocephala* | Heart-leaved willow |
| *Salix exigua* | Sandbar willow |
| *Salix humilis* | Prairie willow |
| *Salix lucida* | Shining willow |
| *Salix nigra* | Black willow |
| *Salix serissima* | Autumn willow |
| *Sambucus canadensis* | Common elderberry |
| *Sambucus racemosa* | Red-berried elder |
| *Spiraea alba* | Meadowsweet |
| *Symphoricarpos albus* | Snowberry |
| *Symphoricarpos occidentalis* | Wolfberry (Western snowberry) |
| *Tilia americana* | Basswood |
| *Vaccinium angustifolium* | Common low blueberry |
| *Viburnum lentago* | Nannyberry |
| *Viburnum rafinesquianum* | Downy arrowwood |
| *Viburnum trilobum* | High-bush cranberry |

## 1.6 Soil Amendments

In most cases soil amendments are not required to plant native plants. Adding black dirt or manure can be detrimental to lakeshore plantings. These soil amendments will favor weed growth, and the native plants may grow more quickly and be less sturdy.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 1.7 Plant Installation

1. *Lay mulch down prior to planting.* Spread 2 to 3 inches of straw, wood chips, leaves, or pine needles to conserve moisture and reduce weed growth. Avoid using field hay because it generally contains weed seeds. Do not use marsh hay, which is reed canary grass, and is an invasive species.

2. *Be ready to water.* Watering plant plugs is critical to their success. Be ready with hoses and sprinklers before planting. Water seedlings immediately after they are planted.

3. *Dig holes for plants.* A bulb planter or bulb auger drill bit attached to an electric drill will work well to speed up planting. Be sure the holes for the plants penetrate the dead grass.

4. *Fertilize.* A small amount of slow release, phosphorus-free fertilizer is recommended. The second number on the fertilizer label represents phosphorus. To fertilize, place a small amount in each plant hole. Excess fertilizer will encourage weed growth.

5. *Place live plants in the ground soon after they are brought to the site.* To store plants for a few days before planting, keep them in an area with partial sun such as on the east side of a building or under a deciduous tree. Do not leave them in a dark area for long periods; this will weaken plants. Water to keep packs moist once or twice a day.

6. *Plant in the cool hours of the day.* Plants will have a greater survival rate if planted on a cool day or during the morning or evening hours. To plant, separate the mulch, dig a hole, sprinkle organic fertilizer, place the plug in the hole, press the soil gently around the plug, and replace the mulch, being careful to keep mulch 1/2ò from stem of plants.

7. *Water.* Water immediately after planting. Plan to water at least daily for the first few weeks or until plants are well established. If plants wilt or droop, a repeated watering may be necessary during the day. Once plants are established, water only if prolonged dry periods occur.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 1.8 Seed Installation

1. *Rake or till only enough to expose soil for planting seed,* no more than 1ï 2 inches deep.

2. *Select seed.* Refer to Table 1 for seeding densities. Greater amounts of seed will result in denser growth and better chances for success. Include 1 ounce of Canada wild rye per 1,000 square feet if desired. This seed will germinate readily to indicate areas where seeding is successful and help to hold the soil in place. Canada wild rye is a short-lived native perennial grass.

3. *Mix seeds with slightly moist sand or sawdust.* Fill an ice cream pail or similar one gallon bucket 2/3 full with moist, but not wet, sand or sawdust. Add up to 4 ounces of seed and mix well. The seeds will adhere to the sand or sawdust, so they can be spread more thinly and evenly.

4. *Broadcast the seed/sand mixture.* Use half of the seed/sand mixture to cover the entire area. Sow the remaining half while walking perpendicular to the line of the first pass to assure good seed distribution. The sand or sawdust will make it easier to see places that have not been seeded.

5. *Press seed in by tamping down the soil* with a rake or lightly raking the seeds in. The site may be rolled with a water-filled roller to insure good soil/seed contact. Do not roll when soil is wet, this will compact the soil, decrease levels of oxygen in the soil, and reduce seed germination.

6. *Mulch lightly with 1/2 inch of weed free straw.* Soil must be visible between the straw stems, or the mulch is too thick to allow seedlings to grow. If mulch is used on steep slopes, hold it in place with jute or biodegradable net. A biodegradable erosion control blanket up to ½ inch thick may be used as an alternative to mulch.

7. *Water.* Water immediately following seeding. Watering seeds and small seedlings after sprouting is critical for sandy soils. Plan to water daily, preferably in the morning, for the first few weeks or until plants are well established. Check to see that soil is moist beneath the mulch. Very sandy sites may require watering more than once daily for the first few weeks. Once plants are established, water only if prolonged dry periods occur.
Note: Watering may not be necessary for spring plantings in areas with loamy or clay soils as long as regular (weekly) rainfall of ½ inch or more occurs.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 1.9 Shrubs and Tree Installation

1. *Keep bare-root stock moist and cool before planting*. Dormant bare-root shrubs can be ordered in fall or winter for delivery in the spring. Plant bare-root stock as soon as it arrives if possible. If necessary, store bare-root stock close to 34 degrees Fahrenheit, to avoid breaking dormancy. Keep tree roots moist by periodically sprinkling with water. Do not soak roots in water because this will deprive them of oxygen.

2. *Dig the hole deeply enough so that the roots won't curl or bunch up.* The trees and shrubs should be planted with the root collar at the soil line or no more than ½ò deep. Paler colored bark and a slight swelling on the stem show where the old soil line was. Bare rootstock may need to be root pruned.

3. *Pack soil firmly around the roots.* Air pockets left around the roots will dry them out. Press soil around the roots with your foot, but do not stomp on them.

4. *Water regularly* to keep soil moist but not saturated.

5. *Mulch* a two-foot diameter circle around each plant 4 to 5 inches deep with wood chips, straw, or leaves. Keep mulch away from the bark. This will reduce competition with other plants. Keep this area free of other growth by weed whacking or hand-pulling weeds for the first couple of years. Avoid mulching where there are steep slopes. In this case, reduce competition by weed whacking.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

Operation and Maintenance

- Access by vehicles or equipment during or after tree/shrub establishment shall be controlled to protect new plants and minimize erosion, compaction and other site impacts.
- The trees and shrubs will be inspected periodically and protected from adverse impacts including insects, diseases or competing vegetation, fire and damage from livestock or wildlife.
- If needed, competing vegetation will be controlled until the woody plants are established. Noxious weeds will be controlled.
- Replanting will be required when survival is inadequate.
- Supplemental water will be provided as needed.
- Periodic applications of nutrients may be needed to maintain plant vigor.

## 1.10 Transplanting Trees and Shrubs

It is best to transplant when trees and shrubs are dormant in the early spring or late fall. Identify and label trees and shrubs when leaves are on the plant. Obtain permission from the landowner before removing plant material. Dig up as much of the root as possible. Replace the duff layer of leaves and stems to reduce erosion at the site. Only dig up trees and shrubs if they are part of a large stand or if the seedlings are numerous. If the tree or shrub is uncommon or rare, do not move it. Only remove a small percentage of any one type of plant. Leave behind a large enough population to allow further reproduction of the native population.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

**Chemicals:**

Selected herbicides can be used to effectively manipulate plant succession, control bush, reduce plant competition, control exotic weeds, and improve habitat diversity.

- Careful planning and care in application are required in the use of chemicals to improve existing habitat. Selection of a product shall be based on several factors, including: (a) product effectiveness, (b) non-target species impacts, (c) toxicological risks, and d) offsite movements of chemicals.
- Chemicals are to be applied only for the uses listed on the container label. Follow all directions and precautions.

[Source: NRCS Biology Job Sheet #3. Grassland Management for Wildlife Habitat. 647]

Operation and Maintenance

- Access by vehicles or equipment during or after tree/shrub establishment shall be controlled to protect new plants and minimize erosion, compaction and other site impacts.
- The trees and shrubs will be inspected periodically and protected from adverse impacts including insects, diseases or competing vegetation, fire and damage from livestock or wildlife.

- If needed, competing vegetation will be controlled until the woody plants are established. Noxious weeds will be controlled.
- Replanting will be required when survival is inadequate.
- Supplemental water will be provided as needed.
- Periodic applications of nutrients may be needed to maintain plant vigor.

## 1.11 Stearns County Native Vegetation

Native plant species are those which are native to a particular area. In this case, the SRWD recommends choosing plants which are native to the county where the project site is located.

**Stearns County Native Wildflowers**

| *Scientific Name* | Common Name |
|---|---|
| Acorus calamus | Sweet flag |
| Actaea rubra | Red baneberry |
| Adiantum pedatum | Maidenhair fern |
| Agastache foeniculum | Blue giant hyssop |
| Alisma subcordatum | Mud plantain |
| Alisma triviale | Water plantain |
| Allium stellatum | Prairie wild onion |
| Allium tricoccum | Wild leek |
| Amphicarpaea bracteata | Hog peanut |
| Anemone canadensis | Canada anemone |
| Anemone cylindrica | Thimbleweed |
| Anemone quinquefolia | Wood anemone |
| Anemonella thalictroides | Rue-anemone |
| Angelica atropurpurea | Angelica |
| Antennaria neglecta | Narrow-leaved pussytoes |
| Apocynum androsaemifolium | Spreading dogbane |
| Apocynum sibiricum | Indian hemp |
| Aquilegia canadensis | Columbine |
| Aralia nudicaulis | Wild sarsaparilla |
| Aralia racemosa | American spikenard |
| Arisaema triphyllum | Jack-in-the-pulpit |
| Artemisia ludoviciana | Prairie sage |
| Artemisia serrata | Saw-toothed sage |
| Asarum canadense | Wild ginger |
| Asclepias incarnata | Swamp milkweed |
| Asclepias tuberosa | Butterfly weed |
| Asclepias verticillata | Whorled milkweed |
| Aster ciliolatus | Ciliate aster |

| | |
|---|---|
| Aster ericoides | Heath aster |
| Aster laevis | Smooth aster |
| Aster lateriflorus | Woodland (or Side-flowering) aster |
| Aster macrophyllus | Large-leaved aster |
| Aster novae-angliae | New England aster |
| Aster oolentangiensis | Sky-blue aster |
| Aster puniceus | Red-stemmed aster |
| Aster sericeus | Silky aster |
| Aster lanceolatus (simplex) | Panicled aster |
| Aster umbellatus | Flat-topped aster |
| Astragalus canadensis | Canada milk-vetch |
| Astragalus crassicarpus | Buffalo-bean (Ground plum) |
| Athyrium angustum | Lady fern |
| Boltonia asteroides | Boltonia |
| Brasenia schreberi | Water shield |
| Calla palustris | Wild calla |
| Caltha palustris | Marsh marigold |
| Campanula aparinoides | Marsh bellflower |
| Campanula rotundifolia | Harebell |
| Caulophyllum thalictroides | Blue cohosh |
| Chelone glabra | Turtlehead |
| Cirsium muticum | Swamp thistle |
| Clintonia borealis | Blue bead lily |
| Comandra umbellata | Star toadflax |
| Coreopsis palmata | Stiff tickseed |
| Cornus canadensis | Bunchberry |
| Delphinium virescens | Prairie larkspur |
| Dentaria laciniata | Cut-leaved toothwort |
| Desmodium canadense | Canada tick trefoil |
| Dicentra cucullaria | Dutchman's breeches |
| Dryopteris carthusiana | Wood fern |
| Echinacea angustifolia | Purple coneflower |
| Epilobium angustifolium | Fireweed |
| Epilobium glandulosum | Willow-herb |
| Equisetum fluviatile | Water horsetail |
| Erythronium albidum | White trout lily |
| Eupatorium maculatum | Spotted Joe-Pye-weed |
| Eupatorium perfoliatum | Boneset |
| Eupatorium rugosum | White snakeroot |
| Euthamia graminifolia | Grass-leaved goldenrod |
| Fragaria virginiana | Common strawberry |

| | |
|---|---|
| Galium boreale | Northern bedstraw |
| Gentiana andrewsii | Bottle gentian |
| Geranium maculatum | Wild geranium |
| Geum aleppicum | Yellow avens |
| Geum triflorum | Prairie-smoke |
| Helenium autumnale | Sneezeweed |
| Helianthus giganteus | Giant sunflower |
| Helianthus grosseserratus | Sawtooth sunflower |
| Heliopsis helianthoides | Ox-eye |
| Helianthus hirsutus | Hairy sunflower |
| Helianthus maximiliani | Maximilian sunflower |
| Helianthus rigidus | Stiff sunflower |
| Helianthus strumosus | Woodland sunflower |
| Helianthus tuberosus | Jerusalum artichoke |
| Hepatica acutiloba | Sharp-lobed hepatica |
| Hepatica americana | Round-lobed hepatica |
| Heracleum lanatum | Cow parsnip |
| Heuchera richardsonii | Alumroot |
| Hieracium kalmii | Canada hawkweed |
| Hydrophyllum virginianum | Virginia waterleaf |
| Hypericum pyramidatum | Great St. John's-wort |
| Hypoxis hirsuta | Yellow stargrass |
| Iris versicolor | Blue flag iris |
| Lathyrus ochroleucus | White vetchling |
| Lathyrus palustris | Marsh vetchling |
| Lathyrus venosus | Veiny vetchling |
| Lespedeza capitata | Round-headed bush clover |
| Liatris aspera | Rough blazing star |
| Liatris ligulistylis | Meadow blazing star |
| Liatris punctata | Dotted blazing star |
| Liatris pycnostachya | Prairie blazing star (Gay-feather) |
| Lilium michiganense | Michigan lily |
| Lilium philadelphicum | Wood lily |
| Lobelia siphilitica | Great blue lobelia |
| Lobelia spicata | Pale-spiked lobelia |
| Lycopus americanus | Water horehound (Cut-leaved bugleweed) |
| Lycopus uniflorus | Northern bugleweed |
| Lysimachia ciliata | Fringed loosestrife |
| Lysimachia quadriflora | Prairie loosestrife |
| Lysimachia terrestris | Swamp candles |
| Lysimachia thyrsiflora | Tufted loosestrife |

| | |
|---|---|
| Maianthemum canadense | Canada mayflower |
| Matteuccia struthiopteris var. pensylvanica | Ostrich fern |
| Mentha arvensis | Wild mint |
| Menyanthes trifoliata var. minor | Buck-bean |
| Mimulus ringens | Monkeyflower |
| Mirabilis nyctaginea | Heart-leaved four-o'clock |
| Mitella diphylla | Miterwort |
| Monarda fistulosa | Wild bergamot |
| Nuphar variegatum | Yellow pond lily |
| Nymphaea odorata | White water lily |
| Onoclea sensibilis | Sensitive fern |
| Osmorhiza claytonii | Sweet cicely |
| Osmunda cinnamomea | Cinnamon fern |
| Osmunda claytoniana | Interrupted fern |
| Osmunda regalis | Royal fern |
| Penstemon gracilis | Slender beard-tongue |
| Penstemon grandiflorus | Large-flowered beard-tongue |
| Penthorum sedoides | Ditch stonecrop |
| Dalea candidum | White prairie clover |
| Dalea purpurea | Purple prairie clover |
| Phlox divaricata | Blue phlox |
| Phlox pilosa | Prairie phlox |
| Physostegia virginiana | Obedient plant |
| Polygonum coccineum | Swamp smartweed |
| Polygonatum biflorum | Giant Solomon's-seal |
| Polygonum lapathifolium | Dock-leaved smartweed |
| Polygonum pensylvanicum | Pennsylvania smartweed |
| Pontederia cordata | Pickerel weed |
| Potentilla arguta | Tall cinquefoil |
| Potentilla palustris | Marsh-cinquefoil |
| Psoralea esculenta | Prairie turnip |
| Pteridium aquilinum | Bracken fern |
| Pulsatilla nuttalliana | Pasque flower |
| Pycnanthemum virginianum | Virginia mountain mint |
| Ranunculus hispidus | Hairy crowfoot |
| Ratibida columnifera | Columnar coneflower |
| Rudbeckia hirta | Black-eyed Susan |
| Rudbeckia laciniata | Green-headed (or tall) coneflower |
| Rumex orbiculatus | Water dock |
| Sagittaria cristata | Crested arrowhead |

| | |
|---|---|
| Sagittaria cuneata | Northern arrowhead |
| Sagittaria latifolia | Common arrowhead |
| Sagittaria rigida | Sessile-fruited arrowhead |
| Sanguinaria canadensis | Bloodroot |
| Saxifraga pensylvanica | Swamp saxifrage |
| Scutellaria galericulata | Marsh skullcap |
| Scutellaria lateriflora | Mad-dog skullcap |
| Sisyrinchium campestre | Blue-eyed grass |
| Sium suave | Water parsnip |
| Smilacina racemosa | False Solomon's seal |
| Smilacina stellata | Starry false Solomon's seal |
| Solidago canadensis | Canada goldenrod |
| Solidago flexicaulis | Zig-zag goldenrod |
| Solidago gigantea | Giant goldenrod |
| Solidago nemoralis | Gray goldenrod |
| Solidago ptarmicoides | White upland aster |
| Solidago riddellii | Riddell's goldenrod |
| Solidago rigida | Stiff goldenrod |
| Solidago speciosa | Showy goldenrod |
| Solidago uliginosa | Bog goldenrod |
| Sparganium chlorocarpum | Bur-reed |
| Sparganium eurycarpum | Giant bur-reed |
| Stachys palustris | Hedge nettle |
| Streptopus roseus var. longipes | Rose twisted-stalk |
| Teucrium canadense | Germander |
| Thalictrum dasycarpum | Tall meadow rue |
| Thalictrum dioicum | Early meadow rue |
| Thelypteris palustris | Marsh fern |
| Tradescantia bracteata | Bracted spiderwort |
| Triadenum fraseri | Marsh St. John's-wort |
| Trillium cernuum | Nodding trillium |
| Trillium grandiflorum | Large-flowered trillium |
| Typha latifolia | Broad-leaved cattail |
| Uvularia grandiflora | Large-flowered bellwort |
| Uvularia sessilifolia | Pale bellwort (Wild oats) |
| Verbena hastata | Blue vervain |
| Verbena stricta | Hoary vervain |
| Vernonia fasciculata | Ironweed |
| Veronica americana | American brooklime |
| Veronicastrum virginicum | Culver's root |
| Vicia americana | American vetch |

| | |
|---|---|
| Viola adunca | Hooked violet |
| Viola canadensis | Canada violet |
| Viola incognita | Sweet white violet |
| Viola macloskeyi | Northern white violet |
| Viola pedatifida | Prairie bird-foot violet |
| Viola pubescens | Downy yellow violet |
| Viola sororia | Woolly blue violet |
| Zizia aptera | Heart-leaved alexanders |
| Zizia aurea | Golden alexanders |

## Stearns County Native Grasses

| *Scientific Name* | Common Name |
|---|---|
| *Agropyron trachycaulum* | Slender wheatgrass |
| *Andropogon gerardii* | Big bluestem |
| *Beckmannia syzigachne* | Beckmannia |
| *Bouteloua curtipendula* | Side-oats grama |
| *Bouteloua gracilis* | Blue grama |
| *Bouteloua hirsuta* | Hairy grama |
| *Bromus ciliatus* | Fringed brome |
| *Bromus kalmii* | Kalm's brome |
| *Bromus latiglumis* | Tall brome |
| *Calamagrostis canadensis* | Bluejoint grass |
| *Calamovilfa longifolia* | Sand reedgrass |
| *Carex alopecoidea* | Foxtail sedge |
| *Carex aquatilis* | Water sedge |
| *Carex arctata* | Drooping woodland sedge |
| *Carex atherodes* | Slough sedge |
| *Carex bebbii* | Bebb's sedge |
| *Carex blanda* | Eastern woodland sedge |
| *Carex brevior* | Shortbeak sedge |
| *Carex comosa* | Bottlebrush sedge |
| *Carex radiata (convoluta)* | Eastern star sedge |
| *Carex cristatella* | Crested sedge |
| *Carex deweyana* | Dewey's sedge |
| *Carex gracillima* | Graceful sedge |
| *Carex hystericina* | Porcupine sedge |
| *Carex lacustris* | Lake sedge |
| *Carex lanuginosa* | Woolly sedge |
| *Carex lasiocarpa* | Wiregrass (Woolly needle sedge) |
| *Carex peckii* | Peck's sedge |

| | |
|---|---|
| *Carex prairea* | Prairie sedge |
| *Carex pseudocyperus* | Cyperus-like sedge |
| *Carex retrorsa* | Retrorse sedge |
| *Carex rostrata* | Beaked sedge |
| *Carex sartwellii* | Sartwell's sedge |
| *Carex scoparia* | Pointed broom sedge |
| *Carex sprengelii* | Sprengel's sedge |
| *Carex stipata* | Awl-fruited sedge |
| *Carex stricta* | Tussock sedge |
| *Carex vulpinoidea* | Fox sedge |
| *Dulichium arundinaceum* | Three-way sedge |
| *Eleocharis smallii (palustris)* | Creeping spikerush |
| *Elymus canadensis* | Canada wild rye |
| *Elymus hystrix* | Bottlebrush grass |
| *Elymus villosus* | Downy wild-rye |
| *Elymus virginicus* | Virginia wild-rye |
| *Eriophorum angustifolium* | Cotton grass |
| *Festuca obtusa* | Nodding fescue |
| *Glyceria borealis* | Northern manna grass |
| *Glyceria canadensis* | Rattlesnake manna grass |
| *Glyceria grandis* | Tall manna grass |
| *Glyceria striata* | Fowl manna grass |
| *Hierochloe odorata* | Sweet grass |
| *Juncus balticus var. littoralis* | Stiff rush |
| *Juncus nodosus* | Knotted rush |
| *Juncus tenuis* | Path rush |
| *Koeleria macrantha* | Junegrass |
| *Leersia oryzoides* | Rice cutgrass |
| *Luzula acuminata* | Woodrush |
| *Muhlenbergia glomerata* | Swamp satin grass |
| *Muhlenbergia mexicana* | Mexican satin grass |
| *Oryzopsis asperifolia* | Mountain rice-grass |
| *Panicum leibergii* | Leiberg's panic grass |
| *Panicum virgatum* | Switchgrass |
| *Poa palustris* | Fowl meadow grass |
| *Schizachne purpurescens* | False melic grass |
| *Schizachyrium scoparium* | Little bluestem |
| *Scirpus acutus* | Hardstem bulrush |
| *Scirpus atrovirens* | Dark green bulrush |
| *Scirpus fluviatilis* | River bulrush |
| *Scirpus pungens* | Three-square bulrush |

| | |
|---|---|
| Scirpus validus | Softstem bulrush |
| Sorghastrum nutans | Indian grass |
| Spartina pectinata | Prairie cordgrass |
| Sporobolus cryptandrus | Sand dropseed |
| Sporobolus heterolepis | Prairie dropseed |
| Stipa spartea | Porcupine grass |
| Stipa viridula | Green needle grass |

## Stearns County Native Shrubs & Trees

| *Scientific Name* | Common Name |
|---|---|
| *Acer negundo* | Box elder |
| *Acer rubrum* | Red maple |
| *Acer saccharinum* | Silver maple |
| *Acer saccharum* | Sugar maple |
| *Alnus incana ssp. rugosa* | Speckled alder |
| *Amelanchier interior* | Inland juneberry |
| *Amorpha canescens* | Leadplant |
| *Amorpha fruticosa* | False indigo |
| *Betula alleghaniensis* | Yellow birch |
| *Betula pumila* | Bog birch |
| *Betula papyrifera* | Paper birch |
| *Carpinus caroliniana ssp. virginiana* | American hornbeam (Musclewood) |
| *Carya cordiformis* | Bitternut hickory |
| *Ceanothus americanus* | New Jersey tea |
| *Celtis occidentalis* | Hackberry |
| *Cornus alternifolia* | Pagoda dogwood |
| *Cornus amomum* | Silky dogwood |
| *Cornus racemosa* | Gray dogwood |
| *Cornus sericea (stolonifera)* | Red-osier dogwood |
| *Corylus americana* | American hazel |
| *Corylus cornuta* | Beaked hazel |
| *Crataegus chrysocarpa* | Fireberry hawthorn |
| *Crataegus punctata* | White hawthorn |
| *Diervilla lonicera* | Bush honeysuckle |
| *Dirca palustris* | Leatherwood |
| *Euonymus atropurpureus* | Wahoo |
| *Fraxinus nigra* | Black ash |
| *Fraxinus pennsylvanica* | Green ash |
| *Ilex verticillata* | Winterberry |

| | |
|---|---|
| *Juniperus communis var. depressa* | Bush juniper |
| *Juniperus virginiana* | Red cedar |
| *Larix laricina* | Tamarack |
| *Mitchella repens* | Partridge-berry |
| *Ostrya virginiana* | Ironwood |
| *Pinus banksiana* | Jack pine |
| *Populus balsamifera* | Balsam poplar |
| *Populus deltoides* | Cottonwood |
| *Populus grandidentata* | Big-tooth aspen |
| *Populus tremuloides* | Quaking aspen |
| *Prunus americana* | Wild plum |
| *Prunus pensylvanica* | Pin cherry |
| *Prunus serotina* | Black cherry |
| *Prunus virginiana* | Chokecherry |
| *Quercus alba* | White oak |
| *Quercus ellipsoidalis* | Northern pin oak |
| *Quercus macrocarpa* | Bur oak |
| *Quercus rubra* | Red oak |
| *Rhus glabra* | Smooth sumac |
| *Rhus hirta* | Staghorn sumac |
| *Ribes americanum* | Wild black currant |
| *Rosa arkansana* | Prairie rose |
| *Rosa blanda* | Smooth wild rose |
| *Rubus allegheniensis* | Common blackberry |
| *Rubus occidentalis* | Black raspberry |
| *Rubus idaeus subsp. strigosus* | Red raspberry |
| *Salix amygdaloides* | Peach-leaved willow |
| *Salix bebbiana* | Bebb's willow |
| *Salix discolor* | Pussy willow |
| *Salix eriocephala* | Heart-leaved willow |
| *Salix exigua* | Sandbar willow |
| *Salix humilis* | Prairie willow |
| *Salix lucida* | Shining willow |
| *Salix nigra* | Black willow |
| *Salix serissima* | Autumn willow |
| *Sambucus canadensis* | Common elderberry |
| *Sambucus racemosa* | Red-berried elder |
| *Spiraea alba* | Meadowsweet |
| *Spiraea tomentosa var. rosea* | Steeplebush |
| *Symphoricarpos occidentalis* | Wolfberry (Western snowberry) |

| | |
|---|---|
| *Tilia americana* | Basswood |
| *Vaccinium angustifolium* | Common low blueberry |
| *Viburnum lentago* | Nannyberry |
| *Viburnum rafinesquianum* | Downy arrowwood |
| *Viburnum trilobum* | High-bush cranberry |

## 1.12 Douglas County Native Plants

### Douglas County Native Wildflowers

| *Scientific Name* | Common Name |
|---|---|
| *Actaea rubra* | Red baneberry |
| *Agastache foeniculum* | Blue giant hyssop |
| *Alisma subcordatum* | Mud plantain |
| *Alisma triviale* | Water plantain |
| *Allium stellatum* | Prairie wild onion |
| *Allium tricoccum* | Wild leek |
| *Amphicarpaea bracteata* | Hog peanut |
| *Anemone canadensis* | Canada anemone |
| *Anemone cylindrica* | Thimbleweed |
| *Anemone quinquefolia* | Wood anemone |
| *Antennaria neglecta* | Narrow-leaved pussytoes |
| *Apocynum androsaemifolium* | Spreading dogbane |
| *Apocynum sibiricum* | Indian hemp |
| *Aquilegia canadensis* | Columbine |
| *Aralia nudicaulis* | Wild sarsaparilla |
| *Aralia racemosa* | American spikenard |
| *Arisaema triphyllum* | Jack-in-the-pulpit |
| *Artemisia ludoviciana* | Prairie sage |
| *Artemisia serrata* | Saw-toothed sage |
| *Asarum canadense* | Wild ginger |
| *Asclepias incarnata* | Swamp milkweed |
| *Asclepias verticillata* | Whorled milkweed |
| *Aster ciliolatus* | Ciliate aster |
| *Aster ericoides* | Heath aster |
| *Aster laevis* | Smooth aster |
| *Aster lateriflorus* | Woodland (or Side-flowering) aster |
| *Aster novae-angliae* | New England aster |
| *Aster oblongifolius* | Aromatic aster |
| *Aster oolentangiensis* | Sky-blue aster |
| *Aster puniceus* | Red-stemmed aster |
| *Aster sericeus* | Silky aster |

| | |
|---|---|
| *Aster lanceolatus (simplex)* | Panicled aster |
| *Aster umbellatus* | Flat-topped aster |
| *Astragalus canadensis* | Canada milk-vetch |
| *Astragalus crassicarpus* | Buffalo-bean (Ground plum) |
| *Athyrium angustum* | Lady fern |
| *Boltonia asteroides* | Boltonia |
| *Caltha palustris* | Marsh marigold |
| *Campanula aparinoides* | Marsh bellflower |
| *Campanula rotundifolia* | Harebell |
| *Caulophyllum thalictroides* | Blue cohosh |
| *Cirsium muticum* | Swamp thistle |
| *Comandra umbellata* | Star toadflax |
| *Coreopsis palmata* | Stiff tickseed |
| *Delphinium virescens* | Prairie larkspur |
| *Desmodium canadense* | Canada tick trefoil |
| *Dicentra cucullaria* | Dutchman's breeches |
| *Dryopteris carthusiana* | Wood fern |
| *Echinacea angustifolia* | Purple coneflower |
| *Epilobium glandulosum* | Willow-herb |
| *Equisetum fluviatile* | Water horsetail |
| *Eupatorium maculatum* | Spotted Joe-Pye-weed |
| *Eupatorium perfoliatum* | Boneset |
| *Eupatorium rugosum* | White snakeroot |
| *Euthamia graminifolia* | Grass-leaved goldenrod |
| *Fragaria virginiana* | Common strawberry |
| *Galium boreale* | Northern bedstraw |
| *Gentiana andrewsii* | Bottle gentian |
| *Geranium maculatum* | Wild geranium |
| *Geum aleppicum* | Yellow avens |
| *Geum triflorum* | Prairie-smoke |
| *Helenium autumnale* | Sneezeweed |
| *Helianthus giganteus* | Giant sunflower |
| *Helianthus grosseserratus* | Sawtooth sunflower |
| *Heliopsis helianthoides* | Ox-eye |
| *Helianthus maximiliani* | Maximilian sunflower |
| *Helianthus rigidus* | Stiff sunflower |
| *Helianthus strumosus* | Woodland sunflower |
| *Helianthus tuberosus* | Jerusalum artichoke |
| *Hepatica americana* | Round-lobed hepatica |
| *Heracleum lanatum* | Cow parsnip |
| *Heuchera richardsonii* | Alumroot |

| | |
|---|---|
| *Hydrophyllum virginianum* | Virginia waterleaf |
| *Hypoxis hirsuta* | Yellow stargrass |
| *Iris versicolor* | Blue flag iris |
| *Lathyrus ochroleucus* | White vetchling |
| *Lathyrus palustris* | Marsh vetchling |
| *Lathyrus venosus* | Veiny vetchling |
| *Liatris aspera* | Rough blazing star |
| *Liatris ligulistylis* | Meadow blazing star |
| *Liatris punctata* | Dotted blazing star |
| *Liatris pycnostachya* | Prairie blazing star (Gay-feather) |
| *Lilium philadelphicum* | Wood lily |
| *Lobelia siphilitica* | Great blue lobelia |
| *Lobelia spicata* | Pale-spiked lobelia |
| *Lycopus americanus* | Water horehound (Cut-leaved bugleweed) |
| *Lycopus uniflorus* | Northern bugleweed |
| *Lysimachia ciliata* | Fringed loosestrife |
| *Lysimachia quadriflora* | Prairie loosestrife |
| *Lysimachia thyrsiflora* | Tufted loosestrife |
| *Maianthemum canadense* | Canada mayflower |
| *Matteuccia struthiopteris var. pensylvanica* | Ostrich fern |
| *Mentha arvensis* | Wild mint |
| *Menyanthes trifoliata var. minor* | Buck-bean |
| *Mimulus ringens* | Monkeyflower |
| *Mirabilis nyctaginea* | Heart-leaved four-o'clock |
| *Monarda fistulosa* | Wild bergamot |
| *Nuphar variegatum* | Yellow pond lily |
| *Onoclea sensibilis* | Sensitive fern |
| *Osmorhiza claytonii* | Sweet cicely |
| *Penstemon gracilis* | Slender beard-tongue |
| *Penstemon grandiflorus* | Large-flowered beard-tongue |
| *Penthorum sedoides* | Ditch stonecrop |
| *Dalea candidum* | White prairie clover |
| *Dalea purpurea* | Purple prairie clover |
| *Phlox pilosa* | Prairie phlox |
| *Physostegia virginiana* | Obedient plant |
| *Polygonum coccineum* | Swamp smartweed |
| *Polygonatum biflorum* | Giant Solomon's-seal |
| *Polygonum lapathifolium* | Dock-leaved smartweed |
| *Polygonum pensylvanicum* | Pennsylvania smartweed |
| *Potentilla arguta* | Tall cinquefoil |

| | |
|---|---|
| *Potentilla palustris* | Marsh-cinquefoil |
| *Psoralea esculenta* | Prairie turnip |
| *Pteridium aquilinum* | Bracken fern |
| *Pulsatilla nuttalliana* | Pasque flower |
| *Pycnanthemum virginianum* | Virginia mountain mint |
| *Ranunculus hispidus* | Hairy crowfoot |
| *Ratibida columnifera* | Columnar coneflower |
| *Rudbeckia hirta* | Black-eyed Susan |
| *Rudbeckia laciniata* | Green-headed (or tall) coneflower |
| *Rumex orbiculatus* | Water dock |
| *Sagittaria cristata* | Crested arrowhead |
| *Sagittaria cuneata* | Northern arrowhead |
| *Sagittaria latifolia* | Common arrowhead |
| *Sanguinaria canadensis* | Bloodroot |
| *Saxifraga pensylvanica* | Swamp saxifrage |
| *Scutellaria galericulata* | Marsh skullcap |
| *Scutellaria lateriflora* | Mad-dog skullcap |
| *Sisyrinchium campestre* | Blue-eyed grass |
| *Sium suave* | Water parsnip |
| *Smilacina racemosa* | False Solomon's seal |
| *Smilacina stellata* | Starry false Solomon's seal |
| *Solidago canadensis* | Canada goldenrod |
| *Solidago flexicaulis* | Zig-zag goldenrod |
| *Solidago gigantea* | Giant goldenrod |
| *Solidago nemoralis* | Gray goldenrod |
| *Solidago ptarmicoides* | White upland aster |
| *Solidago riddellii* | Riddell's goldenrod |
| *Solidago rigida* | Stiff goldenrod |
| *Solidago speciosa* | Showy goldenrod |
| *Sparganium eurycarpum* | Giant bur-reed |
| *Stachys palustris* | Hedge nettle |
| *Streptopus roseus var. longipes* | Rose twisted-stalk |
| *Teucrium canadense* | Germander |
| *Thalictrum dasycarpum* | Tall meadow rue |
| *Thalictrum dioicum* | Early meadow rue |
| *Thelypteris palustris* | Marsh fern |
| *Tradescantia bracteata* | Bracted spiderwort |
| *Trillium cernuum* | Nodding trillium |
| *Trillium grandiflorum* | Large-flowered trillium |
| *Typha latifolia* | Broad-leaved cattail |
| *Uvularia grandiflora* | Large-flowered bellwort |

| | |
|---|---|
| *Uvularia sessilifolia* | Pale bellwort (Wild oats) |
| *Verbena hastata* | Blue vervain |
| *Vernonia fasciculata* | Ironweed |
| *Veronica americana* | American brooklime |
| *Veronicastrum virginicum* | Culver's root |
| *Vicia americana* | American vetch |
| *Viola canadensis* | Canada violet |
| *Viola incognita* | Sweet white violet |
| *Viola pedatifida* | Prairie bird-foot violet |
| *Viola pubescens* | Downy yellow violet |
| *Viola sororia* | Woolly blue violet |
| *Zizia aptera* | Heart-leaved alexanders |
| *Zizia aurea* | Golden alexanders |

## Douglas County Native Grasses

| *Scientific Name* | Common Name |
|---|---|
| *Agropyron trachycaulum* | Slender wheatgrass |
| *Andropogon gerardii* | Big bluestem |
| *Beckmannia syzigachne* | Beckmannia |
| *Bouteloua curtipendula* | Side-oats grama |
| *Bouteloua gracilis* | Blue grama |
| *Bouteloua hirsuta* | Hairy grama |
| *Bromus ciliatus* | Fringed brome |
| *Bromus kalmii* | Kalm's brome |
| *Bromus latiglumis* | Tall brome |
| *Calamagrostis canadensis* | Bluejoint grass |
| *Calamovilfa longifolia* | Sand reedgrass |
| *Carex alopecoidea* | Foxtail sedge |
| *Carex aquatilis* | Water sedge |
| *Carex atherodes* | Slough sedge |
| *Carex bebbii* | Bebb's sedge |
| *Carex blanda* | Eastern woodland sedge |
| *Carex brevior* | Shortbeak sedge |
| *Carex comosa* | Bottlebrush sedge |
| *Carex radiata (convoluta)* | Eastern star sedge |
| *Carex cristatella* | Crested sedge |
| *Carex deweyana* | Dewey's sedge |
| *Carex gracillima* | Graceful sedge |
| *Carex hystericina* | Porcupine sedge |
| *Carex lacustris* | Lake sedge |
| *Carex lanuginosa* | Woolly sedge |

| | |
|---|---|
| *Carex lasiocarpa* | Wiregrass (Woolly needle sedge) |
| *Carex peckii* | Peck's sedge |
| *Carex prairea* | Prairie sedge |
| *Carex retrorsa* | Retrorse sedge |
| *Carex rostrata* | Beaked sedge |
| *Carex sartwellii* | Sartwell's sedge |
| *Carex scoparia* | Pointed broom sedge |
| *Carex sprengelii* | Sprengel's sedge |
| *Carex stipata* | Awl-fruited sedge |
| *Carex stricta* | Tussock sedge |
| *Carex vulpinoidea* | Fox sedge |
| *Eleocharis smallii (palustris)* | Creeping spikerush |
| *Elymus canadensis* | Canada wild rye |
| *Elymus hystrix* | Bottlebrush grass |
| *Elymus villosus* | Downy wild-rye |
| *Elymus virginicus* | Virginia wild-rye |
| *Eriophorum angustifolium* | Cotton grass |
| *Festuca obtusa* | Nodding fescue |
| *Glyceria grandis* | Tall manna grass |
| *Glyceria striata* | Fowl manna grass |
| *Hierochloe odorata* | Sweet grass |
| *Juncus balticus var. littoralis* | Stiff rush |
| *Juncus nodosus* | Knotted rush |
| *Juncus tenuis* | Path rush |
| *Koeleria macrantha* | Junegrass |
| *Leersia oryzoides* | Rice cutgrass |
| *Muhlenbergia glomerata* | Swamp satin grass |
| *Muhlenbergia mexicana* | Mexican satin grass |
| *Oryzopsis asperifolia* | Mountain rice-grass |
| *Panicum leibergii* | Leiberg's panic grass |
| *Panicum virgatum* | Switchgrass |
| *Poa palustris* | Fowl meadow grass |
| *Schizachyrium scoparium* | Little bluestem |
| *Scirpus acutus* | Hardstem bulrush |
| *Scirpus fluviatilis* | River bulrush |
| *Scirpus pungens* | Three-square bulrush |
| *Scirpus validus* | Softstem bulrush |
| *Sorghastrum nutans* | Indian grass |
| *Spartina pectinata* | Prairie cordgrass |
| *Sporobolus cryptandrus* | Sand dropseed |
| *Sporobolus heterolepis* | Prairie dropseed |

| | |
|---|---|
| *Stipa spartea* | Porcupine grass |
| *Stipa viridula* | Green needle grass |

## Douglas County Native Woody Vegetation

| *Scientific Name* | Common Name |
|---|---|
| *Acer negundo* | Box elder |
| *Acer saccharinum* | Silver maple |
| *Acer saccharum* | Sugar maple |
| *Alnus incana ssp. rugosa* | Speckled alder |
| *Amorpha canescens* | Leadplant |
| *Amorpha fruticosa* | False indigo |
| *Betula pumila* | Bog birch |
| *Betula papyrifera* | Paper birch |
| *Celtis occidentalis* | Hackberry |
| *Cornus alternifolia* | Pagoda dogwood |
| *Cornus racemosa* | Gray dogwood |
| *Cornus sericea (stolonifera)* | Red-osier dogwood |
| *Corylus americana* | American hazel |
| *Crataegus chrysocarpa* | Fireberry hawthorn |
| *Diervilla lonicera* | Bush honeysuckle |
| *Dirca palustris* | Leatherwood |
| *Fraxinus nigra* | Black ash |
| *Fraxinus pennsylvanica* | Green ash |
| *Juniperus virginiana* | Red cedar |
| *Larix laricina* | Tamarack |
| *Ostrya virginiana* | Ironwood |
| *Populus balsamifera* | Balsam poplar |
| *Populus deltoides* | Cottonwood |
| *Populus grandidentata* | Big-tooth aspen |
| *Populus tremuloides* | Quaking aspen |
| *Prunus americana* | Wild plum |
| *Prunus pensylvanica* | Pin cherry |
| *Prunus serotina* | Black cherry |
| *Prunus virginiana* | Chokecherry |
| *Quercus macrocarpa* | Bur oak |
| *Quercus rubra* | Red oak |
| *Rhus glabra* | Smooth sumac |
| *Ribes americanum* | Wild black currant |
| *Rosa arkansana* | Prairie rose |
| *Rosa blanda* | Smooth wild rose |
| *Rubus allegheniensis* | Common blackberry |

| | |
|---|---|
| *Rubus occidentalis* | Black raspberry |
| *Rubus idaeus subsp. strigosus* | Red raspberry |
| *Salix amygdaloides* | Peach-leaved willow |
| *Salix bebbiana* | Bebb's willow |
| *Salix discolor* | Pussy willow |
| *Salix eriocephala* | Heart-leaved willow |
| *Salix exigua* | Sandbar willow |
| *Salix humilis* | Prairie willow |
| *Salix serissima* | Autumn willow |
| *Sambucus canadensis* | Common elderberry |
| *Sambucus racemosa* | Red-berried elder |
| *Spiraea alba* | Meadowsweet |
| *Symphoricarpos occidentalis* | Wolfberry (Western snowberry) |
| *Tilia americana* | Basswood |
| *Viburnum lentago* | Nannyberry |
| *Viburnum rafinesquianum* | Downy arrowwood |
| *Viburnum trilobum* | High-bush cranberry |

# Section 2: Shoreline & Streambank Bioengineering

## 2.1 Branch Packing

Branch packing is used to repair small, localized slumps and holes in streambanks. It consists of alternating layers of live branches and compacted backfill. Branches trap sediment that refills the localized slump or hole, while roots spread throughout the backfill and into the surrounding earth to form a unified mass.

*Live material*

Live branches should be from 0.5 to 2 in. in diameter, and long enough to touch the undisturbed soil of the back of the slump and extend slightly from the rebuilt streambank.

*Inert material*

Wooden stakes should be 5 to 8 ft. long, depending on the depth of the particular slump or hole being repaired, and made from poles that are either 3 to 4 in. in diameter or 2- by 4-ft. lumber. Live posts can be substituted.

Installation

- Dig out the bottom at or below the stream or lake bed. Place a layer of rock and/or root wad in combination on the bottom. Cover with 2 to 4 in. of soil.

- Start at the lowest point of the slump or hole, drive the poles vertically 3 to 4 ft. into the ground. Set them 1 to 1.5 ft. apart.
- Place an initial layer of living branches 4- to 6-in. thick in the bottom of the hole between the vertical stakes and perpendicular to the slope face (see illustration). Place them in a crisscross configuration with the growing tips oriented toward the slope face. The basal ends of the branches should touch the undisturbed soil at the back of the hole.
- Follow each layer of branches with a layer of compacted soil to ensure soil contact with the branches. Wet the soil.
- Install subsequent layers of branches with the basal ends lower than the growing tips of the branches.
- Conform to the existing slope. At final installation branches should protrude only slightly.
- Key in this technique to the bank or end at an existing tree or rock outcrop.
- Control or divert water if the original stream bank damage was caused by water flowing over the bank. If this is not done, it is likely that erosion will occur on either or both sides of the new branch packing installation.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.2 Brush Layering: Fill Method

Brush layering is the technique of laying cuttings on horizontal benches that follow the contour of either an existing or filled bank (slope). Branches serve as tensile inclusions or earth-reinforcing units to provide shallow stability of slopes.

The cuttings are oriented more or less perpendicular to the slope face. The portion of the brush that protrudes from the slope face assists in retarding runoff and reducing surface erosion. When used on a fill slope, this technique is similar to vegetated geogrids without the geotextile fabric.

Applications and Effectiveness

- Breaks up the slope length into a series of shorter slopes separated by rows of brush layer.
- Dries excessively wet sites.
- Works where the toe is not disturbed.
- Works on a slump and as a patch.
- Reinforces the soil with the unrooted branch stems
- Reinforces the soil as roots develop, adding significant resistance to sliding or shear displacement.
- Traps debris on the slope.
- Aids infiltration on dry sites.
- Adjusts the siteôs microclimate, aiding seed germination and natural regeneration.

- May cause flow to wash soil from between layers.
- Does not work on outside bends.

Construction Guidelines

Brush layering can be installed on an existing or filled slope. On an existing slope, a bench is cut 2- to 3-ft. deep and angled slightly down into the slope. On a fill slope, brush layers are laid into the bank as it is filled.

*Live material*

- Branch cuttings should be 0.5 to 2 in. in diameter and long enough to reach the back of the bench and still protrude from the bank.
- Side branches should remain intact.
- Mix easy-to-root species such as willow, dogwood, and poplar.

Installation

- Begin above the ordinary high-water mark or bankfull level.
- Begin at the bottom of the slope and work up the bank.

*On a cut bank:*

- Excavate 2- to 3-ft. wide horizontal benches on the contour.
- Slope the bench so that the outside edge is higher than the inside.
- Arrange live branch cuttings on the bench in a crisscross or overlapping configuration.
- Arrange 20 to 25 branches per yard.
- Extend 1/4 of the cuttingôs length beyond the slope face.
- Compact 2 to 4 in. of soil around the cuttings, then fill the remainder of the trench.
- Backfill each lower bench with the soil obtained from excavating the bench above.
- Place long straw or similar mulching material with seeding between rows on 3:1 or flatter slopes, while placing mulch or an erosion control fabric on slopes steeper than 3:1 (Gray 1996). (This is optional.)
- Control or divert water to prevent exposed soil from being washed away if the original streambank damage was caused by water flowing over the bank. Otherwise, erosion is likely to occur on the slope before vegetation can protect it.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.3 Brush Mattress

A brush mattress is a layer of dormant branches laid on and secured to a bank surface. It offers immediate bank coverage. This technique is also effective on lakeshores. Typically, it is combined with a toe stabilizing technique such as rock, root

wads, live siltation, fascines, coconut fiber logs, or tree revetments. In this example, a fascine will be used with the mattress.

Applications and Effectiveness

- Works well on steep fast-flowing streams.
- Restores riparian vegetation and streamside habitat rapidly.
- Requires good soil to stem contact. It will not grow if all of its branches are exposed.
- Allows installation in combination with live stakes and rooted stock on the bank.
- Forms an immediate, protective cover over the streambank.
- Captures sediment during flood conditions.
- Enhances conditions for colonization of native vegetation.

Construction guidelines

*Live materials*

- Use branches that are 6- to 9-ft. long (the height of the bank to be covered), with 8 to 12 in. to be anchored at the toe, and approximately 1in. in diameter. Multiple species can be used.
- Use cuttings that are flexible enough to conform to variations in the slope face.

*Inert materials*

- Use jute twine for bundling the live fascines and tying down the branch mattress.
- Use dead stout stakes to secure the live fascines and brush mattress in place. Make dead stout stakes from 2.5- to 4-ft. long, untreated, 2-ft. by 4-in. sound lumber. Cut each length diagonally across the 4-in face to make two stakes. Use only new, sound lumber. Discard any stakes that shatter upon installation.

Installation

- Grade the unstable area of the streambank to its angle of repose, and decompact the slope, if necessary.
- Prepare live stakes and live fascines immediately beforeinstallation.
- Apply just above ordinary high-water mark or bankfull level.
- Excavate a trench on the contour large enough to accommodate a live fascine and the basal ends of the mattress cuttings. (Typically, a shovel deep and a shovel wide.)
- Ensure that basal (cut) ends are in soil that will retain moisture throughout the growing season.
- Install an even mix of live and dead stout stakes at a 1-ft. depth over the face of the slope using 2-ft. square spacing. Live stakes need to be installed deeply enough to reach the dry season water table (see Live Stakes).

- Place branches slightly crisscrossed in a layer 4- to 6-in. thick on the slope with basal ends located in the trench. Stretch twine diagonally from one dead stout stake to another by tightly wrapping twine around each stake no closer than 6 in from its top.
- Tamp and drive the live and dead stout stakes into the ground until branches are tightly secured to the slope. Use a dead blow hammer on the live stakes.
- Place a live fascine in the trench over the basal ends of the mattress branches.
- Drive dead stout stakes directly into the live fascine every 2 ft. along its length.
- Fill voids between branches with a layer of soil to promote rooting.Wet the surface to wash soil down in between the branches. Leave the top surface of the brush mattress and live fascine slightly exposed.
- Add a live fascine just above the mattress to help break up sheet runoff that may undermine the bank. (This is optional.)

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.4 Coconut Fiber Rolls / Coir Logs: Non-Lakeshore

A coconut fiber roll (CoirÊ log) is used to protect a bankôs toe and to define an edge. It is a cylindrical structure composed of coconut husk fibers bound together with twine woven from coconut fiber. This product is most commonly manufactured in 12 in. diameters and lengths of 20 ft. However, purchases of prefabricated rolls can be expensive. Use stakes or duckbills to anchor it in place at the toe of the slope, generally at the ordinary high-water mark or bankfull level.

Applications and Effectiveness

- Protects slopes from shallow slides or undermining.
- Molds to existing curvature of the streambank.
- Traps sediment in and behind the roll.
- Produces a well-reinforced toe without much site disturbance.
- Lasts an estimated 6 to 10 years, according to manufacturerôs claims.

Construction Guidelines

*Inert materials*

- Coconut logs (CoirÊ ).
- Untreated twine.
- Cable and duckbill anchors.
- 5/16 in cable and cable clips.
- Dead stout stakes. Make dead stout stakes from 2.5- to 4-ft. long, sound, untreated 2- by 4-in. lumber. Cut each length diagonally

across the 4-in. face to make two stakes. Use only sound lumber. Discard any stakes that shatter upon installation.

Installation

- Excavate a shallow trench at the toe of the slope to a depth slightly below channel grade.
- Place the coconut fiber roll in the trench.
- Drive dead stout stakes between the binding twine and coconut fiber. Stakes should be placed on both sides of the roll on 2- to 4-ft. centers depending upon anticipated velocities. Tops of stakes should not extend above the top of the fiber roll.
- Notch the outside of stakes on either side of the fiber roll and secure with 16-gauge wire in areas that experience ice or wave action. Cable with duckbill anchors may also be used in these situations.
- Backfill soil behind the fiber roll.
- Install rooted herbaceous plants in the coconut fiber if conditions permit (plants will not easily wash away).
- Install additional bioengineering techniques upslope of the fiber roll.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.5 Coconut Fiber Roll: Lakeshore

A coconut fiber roll can function as a breakwater along a calm shallow lakeshore. In addition to reducing wave energy, this product can help contain substrate and encourage development of wetland communities.

Applications and Effectiveness

- Protects the shoreline and encourages new vegetation. Effective in lake areas where the water level fluctuates.
- Molds to the curvature of the shoreline.
- Lasts an estimated 6 to 10 years, according to manufacturerôs claims.

Installation

- Install the fiber roll offshore at a distance where the top of the fiber roll is exposed at low tide. In nontidal areas, the fiber roll should be placed where it will not be overtopped by wave action.
- Drive dead stout stakes between the binding twine and the coconut fiber. Stakes should be placed on 4-ft. centers and should not extend above the fiber roll.
- Secure with steel cable and duckbill anchors in areas that experience ice or wave action.
- Install rooted cuttings between the coconut fiber roll and the shoreline, if desired.
- Backfill soil behind the fiber roll if placed against the bank.
- Install rooted herbaceous plants in the coconut fiber if the roll is moist.

- Install appropriate bioengineering techniques upslope from the fiber roll.

[Source: United States Department of Agriculture. October 2002. FS-683]

Maintenance

- Maintain the coconut fiber rolls by checking for displacement from wave and ice action. If the rolls have become displaced, return them to their original location as best as possible and stake them in according to the above installation instructions.
- Check to see that the stakes are still securely in the soil. Pound in any stakes that have become loose over time.
- If herbaceous or woody plants have been installed, maintain the plants according to the guidelines for Planted buffers.
- Check for invasive and noxious plants which may be growing in or around the rolls. Hand weed these plants out of the area. Do not use herbicides, as these may enter the lake (Excessive vegetation of aquatic plants may require a permit from the MN DNR)

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.6 HayBale Breakwater

Cylindrical hay bales, lined up parallel to the shore, are used in reservoirs and lakes to break wave action and to promote vegetative recovery of the shoreline. These cultivated or native hay bales weigh 1,800 lb when dry and approximately 2,500 lb when wet. They are 5-ft. in diameter and 7-ft. long. Do not use straw.

Applications and Effectiveness

Applications

- Used where the fetch is greater than 2 mi. long.
- Used parallel to shorelines to break up fetch-caused waves. Up to 1,000 ft. of shoreline can be protected with one long row of hay bales.
- Used in combination with bioengineering techniques on shore.

Effectiveness

- Breaks waves before they reach the shoreline.
- Breaks the fetch. Do not use where ice scour is a known problem.
- Lasts at least 5 years.
- Forms a natural seedbed as sediment settles between the breakwater and the shore.
- Provides an inexpensive method if hay is locally grown.

Construction Guidelines

*Inert material*

- Use cylindrical cultivated or native hay bales, 5-ft. in diameter and 7-ft. long. Do not use straw bales.

- Wrap bales with hemp netting.
- Lift the bales with a crane or use an excavator to push them into the water.

Installation

- Wrap the bales in hemp netting. This extends their useful lives.
- Lift bales into place with a crane or excavator. Be sure conditions are safe for use of specific machinery.
- Deliver by using a barge and place with a winch ifdesired.
- Place parallel to the shore.
- Place in water at a depth where half the bale, 2.5 ft., is below the waterline, between 5- to 25-ft. from shore.
- Place bales end to end so they touch.
- Leave the ends of the breakwater open so water canwash in and deposit sediment and silt. (See detail.)
- Decompact the soil where heavy equipment was used.
- Use two parallel rows in rough areas. The one closest to the shore becomes silted in and is the new shoreline. The other continues to act as a breakwater.
- Install soil bioengineering techniques on the shore and in the water.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.7 Joint Planting

Joint planting disguises riprap and may provide habitat. The plant roots help hold soil together under the rocks. It involves tamping live stakes into joints or open spaces between existing rocks or when rock is being placed on the slope face.

Applications and Effectiveness

- Useful where rock riprap is required or already in place.
- Successful 30 to 50 percent of the time. First year irrigation improves survival rates.
- Improves drainage by removing soil moisture.
- Creates, over time, a living root mat in the soil base upon which the rock has been placed. These root systems bind or reinforce the soil and prevent washout of fines between and below the rock.
- Provides immediate protection and is effective in reducing erosion on actively eroding banks.
- Dissipates some of the energy during a flood stage.

Construction Guidelines

*Live material*

The live stakes must have side branches removed and bark intact. They should be 1.5 in. or larger in diameter and long enough to extend well into the soil, reaching into the dry season water level.

Installation

- Tamp live stakes into the openings between the rocks during or after placement of riprap. The basal (cut) ends of the cuttings must extend into the backfill or undisturbed soil behind the riprap.
- Prepare a hole through the riprap using a steel rod or waterjet stinger (Hoag, et al. 2001).
- Allow growing tips to protrude slightly above the rock.
- Place the stakes in a random configuration.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.8 Jute-mat Log

Make your own coconut fiber log. This log can reinforce a streambank without much site disturbance. Each log is 1 to 2 ft. in diameter and made out of coconut fiber mat or jute, straw, and lengths of branch cuttings. Logs are placed along the banks to provide armoring. They can vary in length from a few feet up to 100 ft.

Applications and Effectiveness

Applications

- Make in the field to meet on-site needs.
- Apply at ordinary high-water mark or bankfull level.
- Stack to cover more bank; on smaller streams a single strand may suffice.
- String together along the banks, overlapping the logs and molding them to the existing curvature of the streambank.
- Plant with rooted stock, sedges, and so on between the log and the bank.

Effectiveness

- Armors bank toe effectively while plants take root.
- Protects slopes from shallow slides or undermining while trapping sediment that encourages plant growth within and behind the log.
- Retains moisture in log, which aids vegetative growth.
- Provides an inexpensive method.

Construction Guidelines

*Live materials*

- Collect straight branch cuttings, 0.5 to 1 in. in diameter and 4- to 7-ft. long, from deciduous species, such as willow, dogwood, and cottonwood, which easily root from cuttings.
- Use live stakes.

*Inert materials*

- Straw.
- Untreated twine to tie the logs as they are made.
- Cable and duckbill anchors.

- 5/16 in. cable and cable clips.
- Coconut/jute-mat to make the log is sold by the square foot in rolls 8-ft. wide by up to 1,000-ft. long. The 3/8- to 1/2-in. mesh has been used successfully (that is the opening between strands).
- Use dead stout stakes to secure the log. Make dead stout logs from 2.5- to 4-ft. long, sound, untreated, 2- by 4-in. lumber. Cut each length diagonally across the 4-in. face to make two stakes. Use only new, sound lumber.
- Discard any stakes that shatter upon installation.

Installation

- Cut the mat to the length required for each segment plus 2 ft. It will be 8 ft. wide.
- Lay the mat flat and cover with a layer of straw, leaving 1 ft. of mat at each end (along the 8-ft. edge) uncovered.
- Place the cuttings lengthwise along one long edge, three to four stems together.
- Fold the empty edges inward, along the 8-ft. border, over onto the straw.
- Roll up the mat starting at the edge opposite the cuttings.
- Tie the rolls in several places to secure their shape. Use loose coconut strands from the matting as ties or twine.
- Place the log in position on the streambank at average water height with the cuttings against the bank.
- Start at the downstream end of the section, place the first log and overlap the next one by 18 in. Overlap the next log so that it is on the stream side of the original log. One long log section (70- to 100-ft.) is stronger than several shorter logs.
- Secure the log with cable spaced every 2 to 2.5 ft.Wrap the cable around the log and secure it by driving a duckbill into the bank. Be sure the anchor is in firm soil.
- Drive live stakes through the log to help anchor it and to add more plant material.
- Use dead stout stakes, if desired, to anchor the log in placid settings.
- Key in upstream and downstream ends.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.9 Live Cribwall

A live cribwall is used to rebuild a bank in a nearly vertical setting. It consists of a boxlike interlocking arrangement of untreated log or timber members. The structure is filled with rock at the bottom and soil beginning at the ordinary high-water mark or bankfull level. Layers of live branch cuttings root inside the crib structure and extend into the slope. Once the live cuttings root and become established, vegetation gradually takes over the structural functions of the wood members.

## Applications and Effectiveness

### Applications

- Appropriate at the base of a slope where a low wall may be required to stabilize the toe of the slope and to reduce its steepness.
- Appropriate above and below the water level where stable streambeds exist.
- Useful where space is limited and requires a more vertical structure.
- Useful in maintaining a natural streambank appearance.
- Useful for effective bank erosion control on fast flowing streams.
- Tilt back.

### Effectiveness

- Complex and expensive.
- Effective on outside bends of streams where strong currents are present.
- Effective in locations where an eroding bank may eventually form a split channel.
- Excellent habitat provider.
- Provides immediate protection from erosion and long-term stability.

### Construction Guidelines

*Live materials*

Live branch cuttings should be 0.5 to 2.5 in. in diameter and long enough to reach the back of the wooden crib structure.

*Inert materials*

- Logs or untreated timbers should range from 4 to 6 in. in diameter. Lengths will vary with the size of the crib structure.
- Large nails or reinforcement bars are required to secure the logs or timbers together.
- Fill rock should be 6 in. in diameter.

### Installation

- Excavate, starting at the base of the streambank to be treated, 2- to 3-ft. below the existing streambed until a stable foundation 5- to 6-ft. wide is reached.
- Excavate the back of the stable foundation closest to the slope 6- to 12-in. lower than the front to add stability to the structure.
- Place the first course of logs or timbers at the front and back of the excavated foundation, approximately 4- to 5-ft. apart and parallel to the slope contour.
- Place the next course of logs or timbers at right angles (perpendicular to the slope) on top of the previous course to overhang the front and back of

the previous course by 3 to 6 in. Each course of the live cribwall is placed in the same manner and secured to the preceding course with nails or reinforcement bars.

- Place rock fill in the openings in the bottom of the crib structure until it reaches the approximate existing elevation of the streambed. In some cases, it is necessary to place rocks in front of the structure for added toe support, especially in outside stream meanders. An alternative to a rock toe may be a log revetment.
- Place the first layer of cuttings on top of the rock material at the base flow water level. Change the rock fill to soil fill at this point. Ensure that the basal ends of some of the cuttings contact undisturbed soil at the back of the cribwall.
- Place live branch cuttings at each course to the top of the cribwall structure with buds oriented toward the stream. Place the basal ends of the live branch cuttings so that they reach undisturbed soil at the back of the cribwall with growing tips protruding slightly beyond the front. Cover the cuttings with backfill (soil) and compact. Wet each soil layer.
- Use an engineering analysis to determine appropriate dimensions for the system. The live cribwall structure, including the section below the streambed, should not exceed 7 ft. in ht.
- Do not exceed 20 ft. in length for any single constructed unit.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.10 Live Fascines

A live fascine helps control surface erosion and roots from the sprouted fascine help stabilize the bank. A fascine is a long bundle of branch cuttings bound together in a cylindrical structure. It should be placed in a shallow contour trench on a dry slope and at an angle on a wet slope to reduce erosion and shallow sliding.

Install live stakes on the down slope side of the fascine. Tamp the live stake below and against the fascine between the previously installed dead stout stakes, leaving 3 in. to protrude above the top of the ground. A fascine that fails to sprout will slow the raveling of a bank and catch sediment. This sediment rebuilds the bank and forms a natural seedbed. Sometimes a ñsacrificialò fascine is installed in the water, knowing that it wonôt grow, but that it will lessen erosion and promote bank stability.

### Applications and Effectiveness

#### Applications

- Apply above ordinary high-water mark or bankfull level except on very small drainage area sites.
- Use between the high- and low-water marks on the bank in arid climates.

#### Effectiveness

- Traps and holds soil on a streambank, reducing the slope length to a series of shorter slopes by creating small dam-like structures.
- Protects slopes from shallow slides (1- to 2-ft. depth).
- Requires soil moisture or regular precipitation during the growing season to grow.
- Causes minimal site disturbance when properly installed.
- Offers immediate protection from surface erosion.
- Enhances conditions for colonization of native vegetation by creating surface stabilization and a microclimate conducive to plant growth.
- Serves to facilitate drainage when installed at an angle.

Construction Guidelines

*Live materials*

Cuttings must be from species, such as young willows or shrub dogwoods, that root easily and have long straight branches.

*Live material sizes and preparation*

- Tie cuttings, 0.5 to 1.5 in. in diameter, together to form live fascine bundles that vary in length from 5 to 10 ft. or longer, depending on site conditions and handling limitations.
- Stagger the cuttings in the bundles so that tops are evenly distributed throughout the length of the uniformly sized live fascine. The completed bundles should be 6- to 8-in. in diameter.
- Ensure that live stakes are at least 2.5-ft. long.

**Live Fascine Spacing**

| | **Soils** | | |
|---|---|---|---|
| **Slope Steepness** | **Fill (ft)** | **Erosive (ft)** | **Non-erosive (ft)** |
| 3:1 or flatter | 3 - 5 | 5 - 7 | 3 ï 5[*1] |
| Steeper than 3:1 (up to 1:1) | 3[*1] | 3 - 5 | [*2] |

[*1] Not Recommended alone

[*2] Not a recommended system

*Inert materials*

- Use untreated twine for bundling fascines.
- Use dead stout stakes. Make dead stout stakes from 2.5- to 4-ft. long, sound, untreated, 2- by 4-in. lumber.
- Cut each length diagonally across the 4-in. face to make two stakes. Use only sound lumber. Discard any stakes that shatter upon installation

Installation

- Prepare the live fascine bundle and live stakes immediately before installation. If possible, have a fascine-tying team, a digging team, and a fascine-laying team. Team members can do double duty; everyone must know his role ahead of time.
- Jam the ends together, for longer fascines, before placing them into the trench.
- Begin at the base of the slope, marking contours before digging.
- Excavate a trench on the contour approximately 10-in. wide and 10-in. deep.
- Excavate trenches up the slope at 3- to 5-ft. intervals. Where possible, place one or two rows over the top of the slope to break up sheet runoff.
- Place the live fascine into the trench.
- Dig the next trench as the fascine is placed in the one below and use the excavated soil to partially cover the fascine.
- Place moist soil along the sides and top of the fascines. The top of the fascines should be slightly visible when the installation is completed.
- Place long straw and annual grasses or install erosion control fabric between the rows if the soil is loose. Secure the fabric.
- Drive dead stout stakes directly through the live fascine. Extra stakes should be used at fascine overlaps. Leave the top of the dead stout stakes flush with the installed fascine.

[Source: United States Department of Agriculture. October 2002. FS-683]

Maintenance

1.

## 2.11 Live Posts

Live posts form a permeable revetment. They reduce stream velocities and cause sediment deposition in the treated area. The roots help to stabilize a bank. Dormant posts are made of large cuttings installed in streambanks in square or triangular patterns. Unsuccessfully rooted posts at spacings of about 4 ft. can also provide some benefits by deflecting higher stream flows and trapping sediment.

Applications and Effectiveness

Applications

- Well-suited to smaller nongravel streams. If high flows and ice are a problem, they can be cut low to the ground.
- Used in combination with other soil bioengineering techniques.
- Installed by a variety of methods including water jetting or mechanized stringers (Hoag, et al. 2001) to form planting holes or by driving the posts directly with machine-mounted rams. Place a metal cap atop the post when it is necessary to pound it into the ground.

Effectiveness

- Quickly reestablishes riparian vegetation.
- Enhances conditions for colonization of native species.
- Repairs itself. For example, posts damaged by beavers often develop multiple stems.

Construction Guidelines

*Live materials*

Live posts 7- to 20-ft. long and 3 to 5 in. in diameter. Avoid over-harvesting from one plant or area to maintain healthy, attractive stock. Select a plant species appropriate to the site conditions that will root readily. Willows and poplars have demonstrated high success rates.

Installation

- Taper the basal end of the post for easier insertion into the ground.
- Trim off all side branches and the apical bud (top).
- Dip the apical end into a mixture of equal parts water and latex white paint. This will mark which end goes up and will help retain moisture in the post after installation.
- Install posts into the eroding bank at or just above the normal waterline. Make sure posts are installed with buds pointing up.
- Insert one-half to two-thirds of the length of the post below the ground line .Several inches of the post should be set into the dry season water level.
- Extend posts 6 to 12 in above estimated water height if the area is prone to seasonal standing water (30 days or longer).
- Avoid excessive damage to the bark of the posts.
- Place two or more rows of posts spaced 2- to 4-ft. apart using square or triangular spacing.
- Add compost to each hole before the post is installed.
- Apply on slopes of 1:1 or less.
- Supplement the installation with other bioengineering techniques.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.12 Live Siltation

Live siltation is used to armor and revegetate the toe of a bank. It can be used on streams and lakeshores to combat wind and wave erosion. Plant live siltation perpendicular to the wind and waves.

Dead and live branch cuttings are used to provide immediate and long-term stability, cover, and fish habitat. Live siltation is similar to trench packing with the addition of rock and requires a v-shaped trench. Cuttings are laid against the streamside edge of the trench. A layer of soil is packed around the cuttings. A layer of gravel, small rock, and soil fill the trench to hold the cuttings in place.

Applications and Effectiveness

- Stabilizes the toe and provides good fish habitat after applying at the ordinary high-water mark or bankfull level.
- Follows the contour of the bank.
- Traps sediment first in bare branches, then in leafed out branches.
- Provides a good barrier for rooted stock and other techniques used on the bank.
- Reduces velocities of wind and water.
- Reinforces the soil as deep, strong roots develop and adds resistance to sliding and shear displacement.
- Enhances conditions for colonization of native vegetation by creating surface stabilization and a microclimate conducive to plant growth.
- Install in multiple rows if desired.

**Construction Guidelines**

*Live materials*

- Collect live deciduous material known for its good rooting structure, 1 to 2 in. in diameter and a minimum of 3-ft. long, with side branches attached.
- Use species that can tolerate having their feet wet, such as willows.

Installation

- Dig (by hand or machine) a v-shaped trench approximately 2-ft. deep, of any length. Be sure the ends of the trench are tied into something solid or keyed into the bank.
- Layer deciduous cuttings, a minimum of 40 branches per yd, in the trench leaning towards the stream.
- Place branches, bud ends up, in the trench.
- Expose one-third the length of each branch.
- Tamp native soil around cuttings so that they are in contact with the soil. This should not fill the entire trench.
- Backfill the trench with gravel and small rock. Safeguard against washout by topping the surface with larger rocks, coconut log, or a fascine.
- Wet the surface to wash soil down into the trench. Add more soil if necessary.
- Install a sacrificial row below the ordinary high-water mark or bankfull level, if necessary.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.13 Live Stakes

Live stakes create a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. Most willow species root rapidly and begin to dry out an excessively wet bank soon after installation.

Live, rootable vegetative cuttings are inserted or tamped into the ground. If correctly prepared, handled, and placed the live stake will root and grow.

**Lakeshore** live stakes offer no stability until they root into the shoreline area; however, over time they provide excellent soil reinforcement. To reduce failure until the roots establish themselves, installations may be enhanced with a layer of long straw mulch covered with jute mesh or, in more critical areas, a geotextile fabric.

## Applications and Effectiveness

### Application

Use stakes in the wetted zone of banks or where precipitation is likely to keep the soil moist during growing seasons.

### Effectiveness

- Provides a technique where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed.
- Repairs small earth slips and slumps that frequently are wet.
- Enhances the performance of geotextile fabric by serving as pegs to hold fabric down.
- Enhances conditions for natural colonization of vegetation from the surrounding plant community.
- Produces streamside habitat.
- Stabilizes areas among other bioengineering techniques, such as live fascines.

### Construction Guidelines

*Live material sizes*

The stakes generally are 1 to 2 in. in diameter and 2- to 3-ft. long. The specific site requirements and available cutting source determine size.

*Live material preparation*

- Remove side branches, leaving the bark intact.
- Cut the basal ends at an angle or point for easy insertion into the soil. The top should be cut square.
- Install materials the same day that they are prepared.
- Place according to species. For example, along many western streams tree-type willow species are placed on the inside curves of point bars where more inundation occurs, while shrub willow species are planted on outside curves where the inundation period is minimal.

### Installation

- Orient buds up.
- Install a live stake 2- to 3-ft. apart using triangular spacing. The density of the installation will range from two to four stakes per square yard. Site variations may require slightly different spacing. A spacing pattern should

allow for the variables of a fluctuating water level. The installation may be started at any point on the slope face.

- Install 4/5 of the length of the live stake into the ground and firmly pack the soil around it after installation.
- Remove and replace any stakes that split during installation.
- Use an iron bar to make a pilot hole in firm soil or waterjet stinger (Hoag, et al. 2001).
- Dig in live stakes unless the soil is fine and loose. Too many tamped-in stakes split or have their bark damaged by hammering and by hard rocky soils.
- Install the live stake slightly angled downstream.
- Tamp the stake into the ground with a dead blow hammer (hammer head filled with shot or sand).
- Install geotextile fabric (optional) on slopes subject to erosive inundation. Install the stakes through the fabric.
- Plant on banks that will be moist during growing seasons or install longer stakes that reach the dry season water level.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.14 Log Breakwater

The log breakwater is used on lakes and reservoirs to reduce waves, deflect debris and ice, and trap sediment. It is 5- to 6-ft. wide. A breakwater is effective floating or tied to the lakebed. If tied to the bed, it will trap sediment more rapidly. In this case, the top of the logs should be at ordinary pool height. The installation technique is the same in either case. The breakwater is built with a series of log rafts. Stagger the logs in each raft. Then, when the rafts are strung end to end, the ends will mesh.

### Applications and Effectiveness

#### Applications

- Use where the fetch is greater than 2 mi.
- Use logs gathered on site whenever possible.
- Use in combination with soil bioengineering techniques
- on shore.

#### Effectiveness

- Breaks waves. Do not use where ice scour is a known problem.
- Accumulates sediment between the breakwater and the shoreline.
- Is labor intensive to install.
- Requires monitoring, especially after storm events.

### Construction Guidelines

*Inert materials*
Logs that are 2 to 3 ft. or greater in diameter.

*Tools*

- Steel cable.
- Steel cable clamps to match the size of cable.
- Duckbill, screw-type earth anchors, or plate anchors. The type of anchor used depends upon the shear strength of the soil under the lakebed. The most secure anchor will be set in dry material under the lakebed. If that is not possible, use anchor plates.
- Hydraulic jet pump for setting anchors.

Installation
Duckbills will be used as anchors in this example.

- String the logs together to form a chain long enough to protect the shoreline. Overlap each log by several feet and wrap the cable around the ends to hold the logs together. Clamp the cable together.
- Run one long stringer cable the length of the log breakwater. Thread the cable between the log and the cable wrap.
- Locate the breakwater in 3 to 4 ft. of water. Install the duckbills into the substrate using the hydraulic jet pump at 8- to 10-ft. intervals.
- Use a cable clamp to form a small loop at the end of the duckbill cable.
- Thread a length of cable through the loop. Use this t tie the logs to the duckbills. (Cable needs to be long enough to accomodate changes in water levels.)
- Thread this cable over the stringer cable.
- Use a cable clamp to secure the stringer cable to the threaded cable.
- Use a cable clamp on the threaded cable to form a loop.
- Float logs at the normal pool elevation of a lake or reservoir or tie to the bed.
- Install soil bioengineering techniques on the shore.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.15 Pre-vegetated Mat

A plant mat provides an instant swath of herbaceous ground cover in much the same way that unrolling sod does. Use this technique on lakeshores and on quiet stretches of streams. The mats are 2- to 3-in.-thick nonwoven coconut fiber that are held together with organic latex and secured with a high tensile strength net backing. Herbaceous plants, such as sedges, and/or emergent aquatic plants are grown on a mat in a hydroponic setting, and then transported to the project site. A dry mat weighs approximately 45 lb. Hollow stemmed or woody plants can be started on smaller mats called pallets. Some companies will collect wild seed, germinate the mat, and transport it to the site.

Applications and Effectiveness

- Requires many hours to collect and germinate seeds.
- Protects toe of slope. Place behind a revetment if protection from strong currents is needed.
- Transports easily; lightweight.
- Improves habitat instantly.
- Traps sediment and prevents surface erosion.
- Provides a good success rate for plant survival.
- Enhances conditions for colonization of native plants by providing protection and a culture conducive to seed germination.

Construction Guidelines

- Inert materials
- 2- by 4-in. lumber and nails for building frame.
- Waterproof liner.
- Dead stout stakes to secure the live fascines. Make dead stout stakes from 2.5- to 4-ft. long, sound, untreated, 2- by 4-in. lumber. Cut each length diagonally across the 4-in. face to make two stakes. Use only sound lumber.
- Discard any stakes that shatter upon installation.

*Live materials*

- Rushes, sedges, or flood-tolerant grasses are grown in 1- to 2-in. containers, and then plugged into a plant mat.
- Seed.

*Preparation*

- Grow native stock in 1- to 2-in. containers or use seed.
- Build a tray to hold the mat and water; size varies according to need. Build the frame of 2- by 4-in. lumber set on edge and line with a waterproof liner. Plant mats are 3- by 15-ft. and 2-in. thick, although they can be cut easily to a desired size.
- Plug plants into the mat at 10- to 20-in. apart or in a 12-in. grid, depending on the type and amount of plant material available. Seed may be used also. Evenly cover the mat with seed. Quantities of seed will vary by species.
- Fill the tray with water and, if desired, add nutrients.
- Grow plants for 4 to 6 weeks; stop adding nutrients 2 to 3 weeks before moving the mat.
- Change the neutral water to saltwater, gradually, 2 weeks before planting, if plants will be installed in saltwater.

Installation

- A finished mat weighs approximately 90 lb with the water drained out. If necessary, after the plants grow, the mat can be cut into manageable pieces using a tile knife or sharp hedge cutter.
- Roll the mat up if you are using herbaceous plants and turn the mat on edge to drain.
- Wrap the roll in plastic and transport it to the site. A roll can live for 3 days this way, a shorter time if the temperature is hot and dry or freezing.
- Loosen compacted soils on site.
- Unroll the mat at the site and stake the corners and middle with dead stout stakes.
- Cinch the mat down with twine. Wrap the twine around the stakes and pull.
- Wet the newly unfurled mat.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.16 Wrapped Plant Roll

This technique introduces herbaceous vegetation to streambank and lakeshore sites while providing structural stability. Clumps of plants in sod are placed tightly in a sausage-like roll held together with burlap and twine. They are approximately 9- to 10-in. in diameter and can be 2- to 15-ft. long. They can be used alone or with other techniques, for example, at the base of a brush mattress instead of a live fascine.

### Applications and Effectiveness

#### Applications

- Constructed on site.
- Applied to banks that support mostly grasses and sedges and where seeding is impractical because of fluctuating water levels and other factors.
- Useful on shore sites where rapid repair of spot damage is required.

#### Effectiveness

- Grows in water and survives fluctuating water levels.
- Establishes sod, sedges, and reeds.
- Provides a microclimate conducive to plant growth and seed germination.
- Offers relatively inexpensive and immediate protection from erosion.
- 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.
- Reduces toe erosion and creates a dense energy dissipating reed bank area.

### Construction Guidelines

*Live materials*

Cut and dig clumps of native sedges and grasses from nearby stable bank sites or grow in a nursery from native seeds. Take some soil with the plants, but not enough to cause instability to the area.

*Inert materials*

- Burlap, 5-ft. wide by the length of the roll.
- Untreated twine and/or hog rings.
- Dead stout stakes to secure the rolls. Make dead stout stakes from 2.5- to 4-ft. long, untreated, 2- by 4-in. lumber. Cut each length diagonally across the 4-in. face to make two stakes. Use only sound lumber. Discard any stakes that shatter upon installation.

Installation

- Excavate a trench 2-in. wider and deeper than the size of the roll (5- to 30-ft. long) beginning at and parallel to the waterôs edge.
- Line the trench with a 2- to 3-ft.-wide strip of geotextile fabric before spreading a 1-in. layer of highly organic topsoil over the bottom of the trench.
- Center the plant clumps at 12-in. intervals along the bottom of the trench.
- Orient the growing buds in the same upright direction for correct placement into the trench.
- Fill in and around the plant clumps with highly organic topsoil and compact.
- Wrap the ends with geotextile fabric and tie them to keep soil from washing out.
- Wrap the geotextile fabric from each side, overlapping at the top. Cut slits in the fabric to expose the plants.
- Anchor the roll every 2 ft. with dead stout stakes. Drive stakes through the roll and into solid ground or wedge them above and below the roll.
- Pack excavated soil around the rolls to cover the fabric.
- Place the prefabricated plant roll in the excavated trench, secure it with dead stout stakes, and backfill as described above.
- Wet the surface.
- Tie or key the upstream and downstream ends to the bank, a rock outcrop, or large stable tree.
- Repeat the above procedure on lakeshores by excavating additional parallel trenches, spaced 3 to 6 ft. apart, toward the shoreline to produce a staggered spacing pattern. Rolls can also be fabricated on the bank and rolled into the trench.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.17 Rooted Stock

Rooted stock provides instant leaf cover and habitat improvement. Rooted stock is a transplanted tree, woody shrub, or herbaceous plant with an established root system. It can be rooted cuttings balled with a burlap wrap, bare root, containerized plants, or sod or sedge harvested near the site and transplanted.

### Applications and Effectiveness

#### Applications

- Use for plants that will not grow from cuttings, such as conifers, and for planting an understory in shaded habitat.
- Planning is crucial. Plan time for harvesting seeds and slips, potting, and growing.
- Use containerized plants in sandy soils.
- Use in conjunction with other bioengineering techniques.
- Use wild, transplanted stock or nursery-raised stock. Wild, transplanted stock establishes at a lower rate.
- Start plants from cuttings, such as live stakes, posts, and so on, if possible; nursery stock is more expensive.
- Use at stream level when flow is less than 3 cubic feet per second (cfs), and behind or in a coconut log revetment when flow is 5 cfs.
- Use on mid-bank to upper-bank and on the floodplain where natural precipitation is adequate for specific plants or where irrigation is available.
- Use where plants are not likely to be pulled out by grazing or recreation activities, frost heaving, erosion, or washout.

#### Effectiveness

- Offers immediate bank protection. The root system will invade the bank within weeks, as opposed to the months a cutting takes to establish a significant root system.
- May not reach the water table during the dry season because of short roots.
- Causes minimal site disturbance.
- Enhances conditions for natural colonization of surrounding plants.

### Construction Guidelines

Plants should be from an adjacent site. If this is not possible, they should be indigenous to the area, from the same ecotone, watershed, or climate zone, from the same or nearly the same elevation, and from within 100 mi. of the site.

*Native plants*

- Select a random pattern for digging up native plants or for cutting slips.
- Collect individual plants, clumps, and cuttings away from public view take only healthy plants and only one-third of the ñmother plantò for cuttings. Remove any weeds.

- Dig no deeper than 6 in. when harvesting plants to allow roots in the ground to grow back. Transplant the same day or keep roots wet for next-day planting.
- Split clumps of sedges into individual plants. Be sure the stems have roots attached.
- Use cuttings and seeds to grow nursery stock.
- Cut several inches off the tip of the cuttings before planting. The bud end draws too much energy away from stored reserves, reducing the chance of survival. Trim off any side branches.

*Nursery stock*

- Use willows, other woody species, and herbaceous plants that can be propagated and grown by nurseries.
- Allow 2 years or more for plants to produce enough woody growth to survive in the wild.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.18 Root Wad with Footer

Root wads armor a bank by keeping the current off the bank. They should be used in combination with other soil bioengineering techniques to stabilize a bank. Use them on lakeshores to combat wind- and wave-erosion.

There are a number of ways to install root wads. The bole (trunk) can be driven into the bank, laid in a deep trench, or installed as part of a log and boulder revetment. Two methods are illustrated here.

Log, root wad, and boulder revetments are systems selectively placed in and on streambanks. These revetments can provide excellent overhead cover, resting areas, and shelters for insects and fish. Several of these combinations are described in Flosi and Reynolds (1991), Rosgen (1992), and Berger (1991).

Use tree wads that have a brushy top and durable wood, such as Douglas fir, oak, hard maple, juniper, spruce, cedar, red pine, white pine, larch, or beech. Caution: Ponderosa pine and aspen are too inflexible and alder decomposes rapidly.

Applications and Effectiveness

Applications

- Used for stabilization and to create and improve fish-rearing and spawning habitat.
- Used on meandering streams with out-of-bank flow conditions.
- Suited to streams where fish habitat deficiencies exist.

Effectiveness

- Tolerates high boundary shear stress when logs and root wads are well anchored.
- Enhances the diversity of the riparian corridor when used in combination with bioengineering techniques.

- Has a limited lifespan and may require periodic maintenance or replacement, depending on the climate and durability of the species used. If natural vegetation does not take hold, revetments may need eventual replacement.
- Creates a lot of bank disturbance because of the machinery used to dig the trenches for the boles.

Construction Guidelines

*Inert materials*

- Trees that were downed with the roots intact. Root wad span should be approximately 5 ft. with numerous root protrusions. The bole (trunk) should be at least 8- to 12 ft. long.
- Boulders should be as large as possible, but a minimum one- and one-half times the logôs diameter. They should have an irregular surface.
- Logs are to be used as footers or revetments. Use logs over 16-in. in diameter.

Installation

- Install a footer log, 12- to 18-ft. long at the toe of the eroding bank, by excavating trenches or driving it into the bank to provide a stable foundation for the root wad.
- Place the footer log to the expected scour depth at a slight angle away from the direction of the stream flow.
- Use boulders to anchor the footer log against flotation. If boulders are not available, logs can be pinned into gravel and rubble substrate using a 3/4-in. rebar, 54 in. or longer. Anchor the rebar to provide maximum pullout resistance. Cable and anchors (duckbills) may also be used in conjunction with boulders and rebars.
- Drive or trench and place the bole of root wads into the streambank so that the treeôs primary brace roots are flush with the streambank and at a 30 to 45 percent angle to the bank, facing upstream, and slightly down towards the streambed. The wad should be below the ordinary high-water mark or bankfull level with some of the roots extending into the streambed, if possible.
- Backfill and use soil bioengineering techniques behind the root wad and on the bank. Live stakes and live posts can be installed in the openings of the revetment below the ordinary high-water mark or bankfull level.
- Install root wads perpendicular to the waves. Use a line of overlapping root wad to impede erosion and trap littoral drift, where wave action is a problem on a stream or lakeshore.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.19 Terraced Crib

This type of crib can be used to provide public access while stabilizing a bank. It stabilizes without laying the bank back or losing riparian habitat.

Applications and Effectiveness

- Provides planned access points.
- Is inexpensive.
- Requires monitoring and maintenance on the tread as use wears it down.
- Provides an aesthetically pleasing access route

.

Construction Guidelines

*Inert material*

- Logs range from 15- to 40-ft. long, 6 to 8 in. in diameter. The quantity and length of logs necessary is determined according to the size of the installation.
- Treated 6 by 6 in. timber can also be used. See http://www.treatedwood.com/news/transition_details. html
- Cobble stone for the toe or other stabilization method.
- 5/8-in. reinforcement bar for joining logs or timbers.
- Drill and 1/2-in. bit.

Installation

- Dig a trench; begin at the mean water level, or ordinary pool elevation in the lake, 2- to 3-ft. deep and 3 ft. back into the bank.
- Fill the trench with cobble 2 to 3 in. in diameter. An alternative to cobble would be a log revetment. The log should be set deep enough into the shore to avoid undercutting by waves. This log should be larger in diameter than the others.
- Place log or timber on top of the cobble or revetment parallel to the bank. All logs should be small in diameter, 6 to 7 in., because they form steps. Two logs can be placed one behind the other for greater stability or a wider tread.
- Place the next course of logs or timbers at right angles (perpendicular to the slope) on top of the previous course.
- Anchor the logs to each other and to the ground with a reinforcement bar. Drive a 5/8-in. rebar through predrilled 1/2-in. holes a minimum of 3 ft into the ground. Place anchors at all corners. Add additional anchors every 4 ft. on long spans. For distances shorter than 7 ft., split the difference.
- Countersink all exposed rebar.
- Place the next parallel log one to several feet behind the previous log depending on the steepness of the access.
- Build each course of the terraced crib in the same manner and secure it to the preceding course with reinforcement bars.

- Fill the rectangular space between the logs with cobble or gravel, then top with soil to form a walkway.
- Fill pockets outside the tread with soil bioengineering techniques.
- Live stakes and posts need to reach the dry season water level.
- Stabilize and revegetate the outer edges of the terrace. The resulting vegetation provides stability and habitat, and helps keep people on the access route.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.20 Tree Revetment

A tree revetment creates an armored bank. It is constructed from whole trees (minus the root wad), cabled together and anchored to the bank.

Log revetments are tree revetments with the branches removed. In certain instances, it may be necessary to remove some or all of the branches. This facilitates stacking the logs. It is always beneficial to leave the branches intact. Branches slow the rate of flow, catch sediment, and provide fish habitat.

Christmas tree revetments are those made of smaller trees and are generally anchored into the bank using duckbill anchors.

### Applications and Effectiveness

#### Applications

- *Do not use upstream of nearby bridges or other structures where there is high potential for downstream damage if the revetment dislodges during flood events.*
- Use in conjunction with live soil bioengineering techniques to establish a riparian plant community.

#### Effectiveness

- Secures the toe.
- Allows trees to be stacked.
- May be damaged in streams where heavy ice flows occur.
- Uses inexpensive, readily available materials to form semi-permanent protection.
- Has a limited lifespan and may require periodic maintenance or replacement depending on the climate and durability of tree species used. Replace damaged or deteriorating trees. Ideally, by the time the trees have deteriorated, native vegetation will have taken over and no revetment will be needed.

#### Construction Guidelines

*Inert materials*

- Steel cable to wrap trunks together and lead from trees to earth anchors.

- Steel cable clamps.
- Duckbill anchors, deadman anchors, or 7-1/2-ft. metal T-posts for anchoring trees.
- Rope.
- Trees that have a trunk diameter of 12 in. or larger.

Smaller diameter trees can work in a small stream. Select trees that have a brushy top and durable wood, such as Douglas fir, oak, hard maple, juniper, spruce, cedar, red pine, white pine, larch, or beech. Some species, such as cottonwood, often sprout and accelerate natural colonization.

*Caution:* Ponderosa pine and aspen are too inflexible, and alder decomposes rapidly.

Installation

- Determine what type of anchor is needed. A large tree or log may need a deadman anchor buried deep into the bank, while smaller trees, or revetments placed in less turbulent water,may need a duckbill or some other type of earth anchor.
- Use a wood or steel deadman. Both are 6- to 8-ft. long. Steel pipe is 4- to 6-in. I diameter, logs are 8- to 10-in. in diameter, and timbers are 6- by 6-in. or greater.
- Lay the trees along the bank with treetops pointing downstream.
- Overlap the trees by one-third to one-half their lengths to ensure continuous bank protection.
- Extend installation of trees, one to three tree lengths upstream and downstream beyond the eroded bank. Upstream and downstream ends must be keyed into the bank.

A revetment may be installed in two ways. Weather, such as extreme temperature; size of trees; steepness and height of the bank; or the number of persons available to work may dictate which of the two techniques to use.

1. Put the trees at the bottom of the streambank, move them into place, cable them together, wrap the cable around them, run the cable ends through the clamp, cinch the cable down, and tighten the clamp.

2. Arrange the trees on the bank, wrap the cable around them, run the cable ends through the clamp, cinch the cable down, and tighten the clamp. Install t-posts on the upland side of these trees. Tie rope around the trees and to the t-posts. Lower them as a chain into the water and move them into place. The rope will help to keep the trees in place.

- Clip the anchor cable to the log cable or wrap it around the logs and through the clamp. The required cable size and anchor design are dependent upon many variables, including tree size, water force, and soil type, and should be customized to fit specific site conditions.

- Cinch trees as close to the soil as possible.

For large trees use the recommendations for deadman size.

On a Christmas tree revetment:

- Insert the duckbill at a 45° angle into the bank to help assuage pull from rising, dropping, and rushing water. Hammer the duckbill into the soil as deeply as possible.
- Use inexpensive t-posts with smaller trees, 4 to 6 in. in diameter, to supplement duckbill anchors. They must be driven into the bed, on the streamside of the trees, well below the point of maximum bed scour.

If replacement becomes necessary:

- Cable the new tree directly over the original tree.
- Use soil bioengineering techniques within and behind revetments to restore stability and establish a riparian community.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.21 Log Revetment

A log revetment is similar to a tree revetment. Generally, the branches are removed, and the logs are larger in diameter. Root wads and boulders can be incorporated into the design. The log revetments can be installed as previously described using a deadman and cables. The following six steps illustrate another way to assemble a log revetment.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.22 Trench Pack

Trench packs act to break the force of moving water, and trap sediment. They are deciduous branch cuttings placed vertically in trenches or holes. Plant cuttings should be selected from the same zone in which they will be planted, such as at streamôs edge, on the bank, or on the floodplain.

Applications and Effectiveness

Applications

- Install at ordinary high-water mark or bankfull level to stabilize the toe and to provide good fish habitat (follow the contour of the bank), on floodplains perpendicular to or in the direction of the flood flow.
- Use on lakeshores to combat wind and waves.
- Pack into gullies to catch sediment.

Effectiveness

- Traps sediment.

- Reduces velocities of wind and water.
- Provides a good barrier for rooted stock.
- Dries excessively wet sites through evapotranspiration.
- Reinforces soil with unrooted branch cuttings and with deep roots, adding resistance to sliding and shear displacement.
- Enhances conditions for colonization of native vegetation by creating surface stabilization and a microclimate conducive to plant growth.

*Construction Guidelines*

*Live materials*

- Use live deciduous material known for its good rooting structure.
- 1 to 1.5 in. in diameter, with side branches attached. Mix species if appropriate.
- Use cuttings long enough to reach the dry-season water level.

*Fall planting:* Branches should extend 2- to 3-ft. above ground to provide immediate bank protection. In spring, trim the branches back to two bud above ground to stimulate root growth.

*Spring planting:* Plant with branches extending no more than 12 in. above ground or branches with at least two buds.

*Inert material*

- Augment the pack with dead material, such as conifer branches, if live plant materials are unavailable to provide structural stability while the live material roots.
- Plant branches 3- to 4-ft. deep if the planting is subjected to moving, erosive water. In other situations, at least one-half the length of the cutting should be in the ground.

Installation

- Dig, by hand or machine, a hole or trench 12- to 24-in. wide to dry-season water level of the stream or lake. The trench can be any length, however, the ends of the trench must be tied into something solid or keyed into the bank.
- Place the branches in the trench, bud ends up. Pack branches to a 4-in. thickness.
- Tamp native soil around packed branches to ensure that they are in contact with the soil and not the air; air contact will stop growth.
- Construct a 2- to 4-in. water retention berm or basin on either side of the trench.
- Wet the surface to wash soil down into the trench. Add more soil, if necessary, so that there is good soil-to-stem contact throughout.

[Source: United States Department of Agriculture. October 2002. FS-683]

## 2.23 Vegetated Geogrid

Vegetated geogrids are used to rebuild a bank. They are similar to the brush layering fill technique except that an erosion control fabric (geotextile) is wrapped around each soil lift. Live branch cuttings are laid between the layers.

### Applications and Effectiveness

#### Applications

- Benefits are similar to those of brush layering. Place a vegetated geogrid on a 1:1 or steeper streambank or lakeshore.
- Use above and below the ordinary high-water mark or bankfull level.
- Build only during low flow conditions.
- Use in restoring outside bends where erosion is a problem.

#### Effectiveness

- Produces a newly constructed, well-reinforced streambank.
- Captures sediment to further stabilize the streambank.
- Enhances conditions for colonization of native vegetation.
- Produces rapid vegetative growth.
- Can be complex and expensive.
- Functions immediately.

### Construction Guidelines

*Live materials*

- Use live branch cuttings that are brushy and root readily.
- Use cuttings 0.5 to 2 in. in diameter and 4- to 6-ft. long.

*Inert material*

- Biodegradable erosion control fabric is required.
- Soil suitable for plant growth.
- Batter board (4 by 12), the length of the geogrid, optional. This helps define the front edge of the lift during construction.
- Dead stout stakes to secure the live fascines. Make dead stout stakes from 2.5- to 4-ft. long, untreated, 2- by 4-ft. lumber. Cut each length diagonally across the 4-in. face to make two stakes. Use only sound lumber. Discard any stakes that shatter upon installation.

### Installation

Rock Toe

- Dig a trench that is 2- to 3-ft. below streambank elevation and 3- to 4-ft. wide.

- Measure the width and length of the trench (layer), double the width, and add 12 in. (height of the layer) to the width. Cut a length of cloth. Install one layer before cutting all the pieces to be sure the lengths are correct.
- Fill the trench area 12 in. high with 2- to 3-in. diameter rocks.
- Fold the fabric over the rock and stake every 2 ft. along the length of the layer.

Branch cuttings

- Place, at the ordinary high-water mark or bankfull level, a 6- to 8-in. layer of live branch cuttings on top of the rock-filled geogrid with the growing tips at right angles to the streamflow. The basal ends of branch cuttings should touch the back of the excavated slope.
- Cover the branches with a layer of soil. Wet the surface to wash soil down in between the branches. Add more soil until the majority of stems are covered.
- Lay a batter board on edge at the front edge of a new lift. This is optional.
- Cover this layer of cuttings with cloth, leaving an overhang. Place a 12-in. layer of soil suitable for plant growth on top of the cloth before compacting it to ensure good soil contact with the branches.Wrap the overhanging portion of the cloth over the compacted soil to form the completed cloth wrap. Once the cloth is pulled up over the soil, adjust the cloth to ensure that it forms the desired contour without overhanging the layer below. Stake down the cloth. Remove the batter board. After each layer is formed, place cuttings.
- Continue this process of rebuilding the bank with lifts, alternating layers of cuttings and cloth wraps until the bank is restored to its original height.
- Limit this system to a maximum of 8 ft. in total height, including the 2- to 3-ft. below the bed. An engineering analysis should determine appropriate dimensions of the system.
- Match the final installation to the existing slope. Branch cuttings protrude only slightly from the lifts.

[Source: United States Department of Agriculture. October 2002. FS-683]

Maintenance

The geogrid should be regularly monitored and repaired as necessary.

- Inspect for gully formation beneath the mattress prior to the establishment of the root systems in years 1-3.
- Control invasive and noxious weeds within the geogrid.
- Add additional native vegetation to any areas that are lacking vegetation establishment.

## 2.24 Terrace

An earth embankment, or a combination ridge and channel, constructed across the field slope. This practice is applied as part of a resource management system for one

or more of the following purposes to reduce erosion by reducing slope length and to retain runoff for moisture conservation.

Operation and Maintenance

1. Prepare an operation and maintenance plan for the operator. The minimum requirements to be addressed in a written operation and maintenance plan are:
2. Periodic inspections, especially immediately following significant runoff events.
3. Prompt repair or replacement of damaged components.
4. Maintenance of terrace ridge height, channel profile, terrace cross-sections and outlet elevations.
5. Removal of sediment that has accumulated in the terrace channel to maintain capacity and grade.
6. Regular cleaning of inlets for underground outlets. Repair or replacement of inlets damaged by farm equipment. Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the terrace channel.
7. Where vegetation is specified, seasonal mowing and control of trees and brush.
8. Notification of hazards about steep slopes on the terrace.

[Source: NRCS Conservation Practice Standard Code 600. 2008]

# Section 3: Temporary Erosion Control and Establishment Measures

## 3.1 Snow Fence Wave Break

A wooden snow fence can trap sediment and help restore natural stability to the shore. A fence is not soil bioengineering. It is suggested here as a temporary barrier to be used while soil bioengineering installations take hold.

Applications and Effectiveness

- Use where the fetch is 1/2 mi. or less.
- Limit use to lakes and reservoirs with very gentle slopes, 10:1.
- Use to break waves and trap sediment between the shore and the fence.
- Use only wooden snow fences.
- Apply soil bioengineering techniques on the shore.

Construction Guidelines

*Inert materials*

- Wooden snow fence.

- Steel fence posts.

Installation

- Ensure that the lake bottom is as gradual as is the shore.
- Install in knee-deep water parallel to the wave action.
- Space steel posts every 10 ft.
- Attach reflective buoys to the fence posts if the fence is submerged for part of the year.

## 3.2 Runoff Control

Runoff from impervious surfaces and roof gutter downspouts should be directed to maximize infiltration. Runoff should be maintained in sheet flow (not channels) to the greatest extent possible. In soils where adequate infiltration cannot be achieved, outletting through a tile may be an option.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 3.3 Wave Control

In areas where waves may influence the establishment of native vegetation products such as coconut fiber logs may be staked along the edge of open water to decrease wave energy. More elaborate wave break structures may be needed in some situations.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 3.4 Silt Fence

A silt fence is a temporary barrier designed to retain sediment on the construction site. It consists of a geotextile attached to supporting posts that are trenched into the ground. The fence retains sediment primarily by retarding flow and promoting deposition on the uphill side of the fence. Runoff is also filtered as it passes through the geotextile.

Applications and Effectiveness

- Easy installation
- Cost-effective
- Materials readily available
- Widely accepted practis
- Effectiveness is superior to straw bales

Limitations

- Not effective for concentrated flows less than 1.0 cfs.
- Proper installation is critical for effective performance.

Construction

- Silt fence that is inadequately embedded in the ground will blow out, release in water and sediment under the fence. Failure to properly install, inspect and maintain tare the primary causes of this failure.
- Silt fence is not meant to be places in concentrated flow areas.
- Silt fences are not terraces; they cannot be put in sequence to extend the slope length allowable.
- Improperly designed and installed silt fences are often eroded around the ends. The fence must be tied into the slope so that the base of the fence is above the designed storage depth.
- Construct from a continuous role of geotextile if possible.
- Never attach to trees.

*Heavy Duty Silt Fence*

- Posts should be spaced max of 8 feet apart.
- Geotextile should be attached to the upstream side of the post and backing. The bottom edge of the geotextile should be buried at least 6 inches deep in a vertical slot or trench, with the soil pressed firmly against the embedded geotextile.
- When wire mesh is used, wire fasteners shall fasten the geotextile of the top mesh along the upper edge oat a max spacing of 1 foot. A min of 3 metal U-shaped clips or wire shall fasten the wire mesh and two layers of geotextile to the post.
- When plastic mesh is used, the mesh backing should be joined to the geotextile at the top with two rows of stitching. Geotextile should protrude below the bottom edge of the plastic mesh to allow embedment. A minimum of 3 metal U-shaped clips or wire shall fasten the plastic mesh and geotextiles to the metal posts.

*Machine-sliced Silt Fence*

- Posts should be a max of 6 ft apart.
- A geotextile fabric should be inserted in a slit in the soil (6-12 inches deep). The slit should be created such that a horizontal chisel point, at the base of a soil-slicing blasde, slightly disrupts soil upward as the blade slices through the soil. This upward disruption minimizes horizontal compaction and creates an optimal soil condition for mechanical compaction against the geotextile. The geotextile should be mechanically inserted directly behind the soil-slicing blade ina simultaneous operation, achieving consistant placement and depth. No truing over (plowing) of soil is allowed for slicing method.

*Preassambled Silt Fence*

- Posts should be spaced a maximum of 6 feet apart.
- The bottom edge of the geotextile is to be buried a minimum of 6 in a vertical trench with the soil pressed firmly against the embedded geotextile.

Maintenance

1. Inspect wilt fences at least once a week and after each rainfall, or as required by applicable permits. Make any require repairs immediately. Repair scoured areas on the back of fence at this time to prevent future problems.
2. Should the fabric of silt fence collapse, tear, decompose, or otherwise become ineffective, replace it within 24 hours of discovery.
3. Remove silt deposits once they reach 1/3 the height of the fence to provide adequate storage volume for the next rain fall and to reduce pressure on the fence. Take care to avoid undermining the fence during cleanout.
4. It may be easier and more effective to remove and replace the silt fence when removing silt deposits for large projects.
5. Silt fences are to be removed upon stabilization of the contributing drainage area. Accumulated sediment may be spread to form a surface for turf or other vegetation establishment, or disposed of elsewhere. The area should be reshaped to permit natural drainage.

[U.S. Department of Transoprattion. 1195. Best management Practices for Erosion and Sediment control. Eastern Federal Lands Highway Division, Washington D.C.]

## 3.5 Mulching

Applying plant residues or other suitable materials produced off site, to the land surface, the purpose of which is to; conserve soil moisture, moderate soil temperature, provide erosion control, suppress weed growth, facilitate the establishment of vegetative cover, improve soil condition, and to reduce airborne particulates. This practice applies to all lands where mulches are needed. This practice may be used alone or in combination with other practices.

Applications and Materials

- The selection of mulching materials will depend primarily on site conditions and the materialôs availability. Mulch materials shall consist of natural and/or artificial materials that are environmentally safe such as plant residue, wood bark or chips, gravel, plastic, fabric, rice hulls, or other equivalent materials of sufficient dimension (depth or thickness) and durability to achieve the intended purpose for the required time period.
- Prior to mulching, the soil surface shall be prepared in order to achieve the desired purpose.
- The mulch material shall be evenly applied and, if necessary, anchored to the soil. Tackifiers, emulsions, pinning, netting, crimping or other acceptable methods of anchoring will be used if needed to hold the mulch in place for specified periods.
- As a minimum, manufactured mulches shall be applied according to the manufacturerôs specifications.

- Mulching operations shall comply with federal, state and/or local laws and regulations during the installation, operation and maintenance of this practice.
- Mulch material shall be relatively free of disease, pesticides, chemicals, noxious weed seeds, and other pests and pathogens.

*Additional Criteria to Conserve Soil Moisture*
Mulch materials applied to the soil surface shall provide at least 60 percent surface cover to reduce potential evaporation.

*Additional Criteria to Moderate Soil Temperature*
Mulch materials shall be selected and applied to obtain 100 percent coverage over the area treated. The material shall be of a significant thickness to persist for the period required for the temperature modification.

*Additional Criteria to Provide Erosion Control*
When mulching with cereal grain straw or grass hay, apply at a rate to achieve a minimum 70 percent ground cover. Mulch rate shall be determined using current erosion prediction technology to reach the soil erosion objective. When mulching with wood products such as wood chips, bark, or shavings or other wood materials, apply a minimum 2-inch thickness. When mulching with gravel or other inorganic material apply a minimum 2 inch thickness and shall consist of pieces 0.75 to 2 inches in diameter.

*Additional Criteria to Suppress Weed Growth*
The thickness of mulch will be determined by the size of the plant being mulched. Mulches shall be kept clear of the stems of plants where disease is likely to occur. Mulches applied around growing plants or prior to weed seedling development shall have 100 percent ground cover. Thickness of the mulch shall be adequate to prevent emergence of targeted weeds. Plastic mulches may be used.

*Additional Criteria to Establish Vegetative Cover*
Mulch shall be applied at a rate that achieves a minimum of 70 percent ground cover to provide protection from erosion and runoff and yet allow adequate light and air penetration to the seedbed to ensure proper germination and emergence.

*Additional Criteria to Improve Soil Condition*
Apply mulch materials with a carbon to nitrogen ratio (C:N) less than 30 to 1 so that soil nitrogen is not immobilized by soil biota. Do not apply mulch with C:N less than 20:1 to an area of designed flow in watercourses.
Use the Soil Conditioning Index to assess soil quality impact and to determine the type and rate of the mulching material.

*Additional Criteria to Reduce Airborne Particulate Matter from Wind Erosion*
Mulch rate shall be determined using current wind erosion prediction technology to reach the soil erosion (movement of particulates offsite) objective.

Installation

- Evaluate the effects of mulching on evaporation, infiltration and runoff. Mulch material may affect microbial activity in the soil surface, increase infiltration, and decrease runoff, erosion and evaporation. The temperature of the surface runoff may also be lowered.
- Mulch material used to conserve soil moisture should be applied prior to moisture loss. Prior to mulching, ensure soil under shallow rooted crops is moist, as these crops require a constant supply of moisture.
- Mulch materials with a high water holding capacity and/or high impermeability to water droplets may adversely affect the water needs of plants.
- Fine textured mulches (e.g. rice hulls) which allow less oxygen penetration than coarser materials should be no thicker than 1 or 2 inches.
- Organic materials with C:N ratios of less than 20:1 will release nitrate-nitrogen which could cause water quality impairments.
- Mulching may also provide habitat for beneficial insect and provide pest suppression.
- Clear and infra-red transmissible (IRT) plastics have the greatest warming potential. They are transparent to incoming radiation and trap the longer wavelengths radiating from the soil. Black mulches are limited to warming soils by conduction only and are less effective.
- Clear mulches allow profuse weed growth and may negate the benefits of soil warming. Black mulches provide effective weed control. Wavelength selective (IRT) plastic provides the soil warming characteristics of clear mulch with the weed control ability of black mulch.
- Low permeability mulches (e.g. Plastic) may increase concentrated flow and erosion on un-mulched areas.
- Consider potential toxic alleleopathic effects that mulch material may have on other organisms. Animal and plant pest species may be incompatible with the site.
- Consider the potential for increased pathogenic activity within the applied mulch material.
- Keep mulch 3 to 6 inches away from plant stems and crowns to prevent disease and pest problems. Additional weed control may be needed around the plant base area.
- Deep mulch provides nesting habitat for ground-burrowing rodents that can chew extensively on tree trunks and/or tree roots. Light mulch applied after the first cold weather may prevent rodents from nesting.
- Some mulch material may adversely affect aquatic environments through changes in water chemistry or as waterborne debris. Consider placing mulch in locations that minimizes these risks.

Operation and Maintenance

- Mulched areas will be periodically inspected, and mulch shall be reinstalled or repaired as needed to accomplish the intended purpose.
- Removal or incorporation of mulch materials shall be consistent with the intended purpose and site conditions.
- Operation of equipment near and on the site shall not compromise the intended purpose of the mulch.
- Prevent or repair any fire damage to the mulch material.
- Properly collect and dispose of artificial mulch material after intended use.
- Monitor and control undesirable weeds in mulched areas.

[Source: NRCS Conservation Practices Standard Code 484. 2008]

## 3.6 Floating Silt Curtain

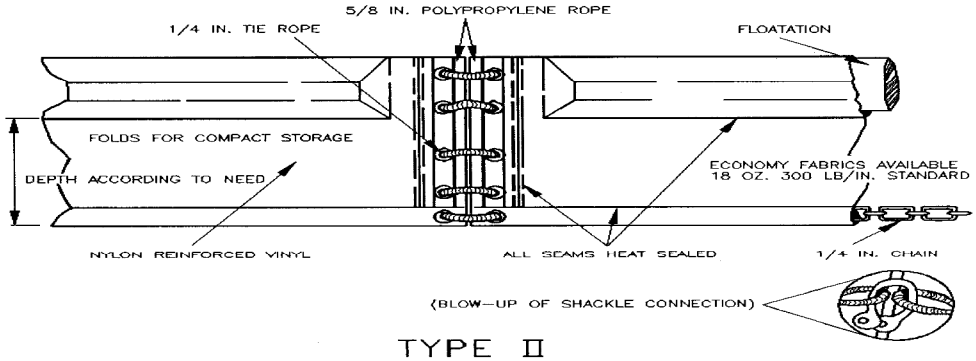
Floating silt curtain is defined as a floating geotextile material which minimizes sediment transport from a disturbed area adjacent to or within a body of water, to provide sedimentation protection for a watercourse from up-slope land disturbance or from dredging or filling within the watercourse.

**Design Criteria**

1. Type I configuration (see Plate 3.27-1) should be used in protected areas where there is no current and the area is sheltered from wind and waves.
2. Type II configuration (see Plate 3.27-1) should be used in areas where there may be small to moderate current running (up to 2 knots or 3.5 feet per second) and/or wind and wave action can effect the curtain.
3. Type III configuration (see Plate 3.27-2) should be used in areas where considerable current (up to 3 knots or 5 feet per second) may be present, where tidal action may be present and/or where the curtain is potentially subject to wind and wave action.
4. Turbidity curtains should extend the entire depth of the watercourse whenever the watercourse in question is not subject to tidal action and/or significant wind and wave forces.
5. In tidal and/or wind and wave action situations, the curtain should never be so long as to touch the bottom. A minimum 1-foot "gap" should exist between the weighted lower end of the skirt and the bottom at "mean" low water. Movement of the lower skirt over the bottom due to tidal reverses or wind and wave action on the flotation system may fan and stir sediments already settled out.
6. In tidal and/or wind and wave action situations, it is seldom practical to extend a turbidity curtain depth lower than 10 to 12 feet below the surface, even in deep water. Curtains which are installed deeper than this will be subject to very large loads with consequent strain on curtain materials and the mooring system. In addition, a curtain installed in such a manner can "billow up" towards the surface under the pressure of the moving water, which will result in an effective depth which is significantly less than the skirt depth.
7. Turbidity curtains should be located parallel to the direction of flow of a moving body of water. Turbidity Curtain should not be placed across the main flow of a significant body of moving water.
8. When sizing the length of the floating curtain, allow an additional 10-20% variance in the straight line measurements. This will allow for measuring errors, make installing easier and reduce stress from potential wave action during high winds.
9. An attempt should be made to avoid an excessive amount of joints in the curtain; a minimum continuous span of 50 feet between joints is a good "rule of thumb."
10. For stability reasons, a maximum span of 100 feet between joints (anchor or stake locations) is also a good rule to follow.

# *TURBIDITY CURTAIN*

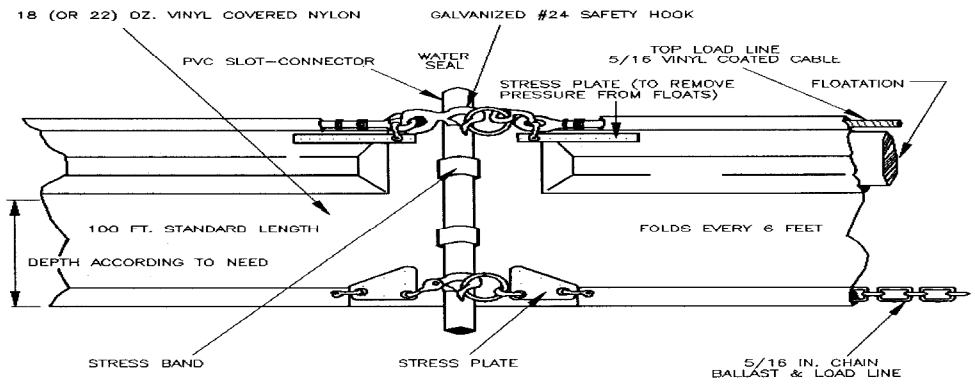
## TYPE I

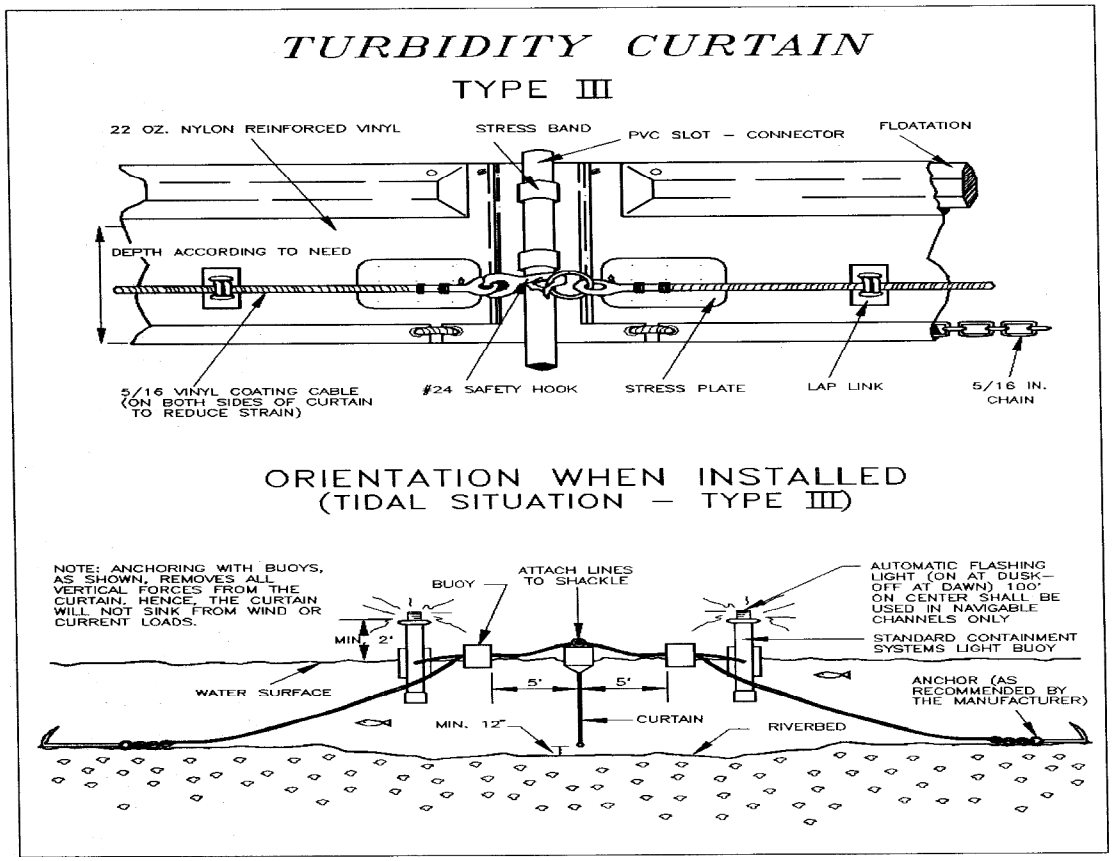



(BLOW–UP OF SHACKLE CONNECTION)



## TYPE II






11. The ends of the curtain, both floating upper and weighted lower, should extend well up into the shoreline, especially if high water conditions are expected. The ends should be secured firmly to the shoreline (preferably to rigid bodies such as trees or piles) to fully enclose the area where sediment may enter the water.

12. When there is a specific need to extend the curtain to the bottom of the watercourse in tidal or moving water conditions, a heavy woven pervious filter fabric may be substituted for the normally recommended impervious geotextile. This creates a "flow-through" medium which significantly reduces the pressure on the curtain and will help to keep it in the same relative location and shape during the rise and fall of tidal waters.

13. Typical alignments of turbidity curtains can be seen in Plate 3.27-3. The number and spacing of external anchors may vary depending on current velocities and potential wind and wave action; manufacturer's recommendations should be followed.

## Construction Specifications

### Materials

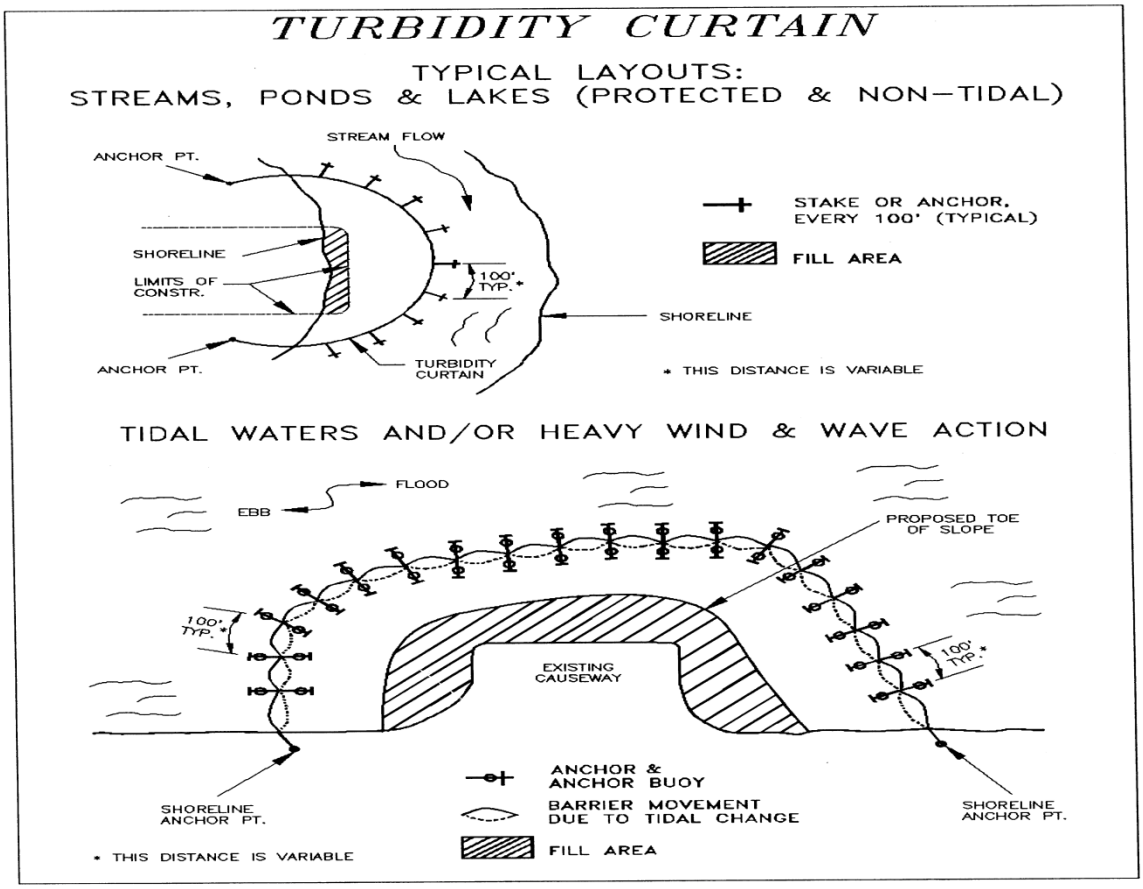
1. Barriers should be a bright color (yellow or "international" orange are recommended) that will attract the attention of nearby boaters.

2. The curtain fabric must meet the minimum requirements noted in Table 3.27-A.

3. Seams in the fabric shall be either vulcanized welded or sewn, and shall develop the full strength of the fabric.

4. Floatation devices shall be flexible, buoyant units contained in an individual floatation sleeve or collar attached to the curtain. Buoyancy provided by the floatation units shall be sufficient to support the weight of the curtain and maintain a freeboard of at least 3 inches above the water surface level (see Plate 3.27-2).

5. Load lines must be fabricated into the bottom of all floating turbidity curtains. Type II and Type III must have load lines also fabricated into the top of the fabric. The top load line shall consist of woven webbing or vinyl-sheathed steel cable and shall have a break strength in excess of 10,000 pounds. The supplemental (bottom) load-line shall consist of a chain incorporated into the bottom hem of the curtain of sufficient weight to serve as ballast to hold the curtain in a vertical position. Additional anchorage shall be provided as necessary. The load lines shall have suitable connecting devices which develop the full breaking strength for connecting to load lines in adjacent sections (see Plates 3.27-1 and 3.27-2 which portray this orientation).




6. External anchors may consist of wooden or metal stakes (2- x 4-inch or 2⅓-inch minimum diameter wood or 1.33 pounds/linear foot steel) when Type I installation is used; when Type II or Type III installations are used, bottom anchors should be used.

7. Bottom anchors must be sufficient to hold the curtain in the same position relative to the bottom of the watercourse without interfering with the action of the curtain. The anchor may dig into the bottom (grappling hook, plow or fluke-type) or may be weighted (mushroom type) and should be attached to a floating anchor buoy via an anchor line. The anchor line would then run from the buoy to the top load line of the curtain. When used with Type III installations, these lines must contain enough slack to allow the buoy and curtain to float freely with tidal changes without pulling the buoy or curtain down and must be checked regularly to make sure they do not become entangled with debris. As previously noted, anchor spacing will vary with current velocity and potential wind and wave action; manufacturer's recommendations should be followed. See orientation of external anchors and anchor buoys for tidal installation in Plate 3.27-2.

Installation

1. In the calm water of lakes or ponds (Type I installation) it is usually sufficient to merely set the curtain end stakes or anchor points (using anchor buoys if bottom anchors are employed), then tow the curtain in the furled condition out and attach it to these stakes or anchor points. Following this, any additional stakes or buoyed anchors required to maintain the desired location of the curtain may be set and these anchor points made fast to the curtain. Only then, the furling lines should be cut to let the curtain skirt drop.

2. In rivers or in other moving water (Type II and Type III installations) it is important to set all the curtain anchor points. Care must be taken to ensure that anchor points are of sufficient holding power to retain the curtain under the existing current conditions, prior to putting the furled curtain into the water. Again, anchor buoys should be employed on all anchors to prevent the current from submerging the flotation at the anchor points. If the moving water into which the curtain is being installed is tidal and will subject the curtain to currents in both directions as the tide changes, it is important to provide anchors on both sides of the curtain for two reasons:

   a) Curtain movement will be minimized during tidal current reversals.

   b) The curtain will not overrun the anchors and pull them out when the tide reverses.

   When the anchors are secure, the furled curtain should be secured to the upstream anchor point and then sequentially attached to each next downstream anchor point until the entire curtain is in position. At this point, and before unfurling, the "lay" of the curtain should be assessed and any necessary adjustments made to the anchors. Finally, when the location is ascertained to be as desired, the furling lines should be cut to allow the skirt to drop.

3. Always attach anchor lines to the flotation device, not to the bottom of the curtain. The anchoring line attached to the floatation device on the downstream side will provide support for the curtain. Attaching the anchors to the bottom of the curtain could cause premature failure of the curtain due to the stresses imparted on the middle section of the curtain.

4. There is an exception to the rule that turbidity curtains should not be installed across channel flows; it occurs when there is a danger of creating a silt build-up in the middle of a watercourse, thereby blocking access or creating a sand bar. Curtains have been used effectively in large areas of moving water by forming a very long-sided, sharp "V" to deflect clean water around a work site, confine a large part of the silt-laden water to the work area inside the "V" and direct much of the silt toward the shoreline. Care must be taken, however, not to install the curtain perpendicular to the water current.

Removal

1. Care should be taken to protect the skirt from damage as the turbidity curtain is dragged from the water.

2. The site selected to bring the curtain ashore should be free of sharp rocks, broken cement, debris, etc. so as to minimize damage when hauling the curtain over the area.

3. If the curtain has a deep skirt, it can be further protected by running a small boat along its length with a crew installing furling lines before attempting to remove the curtain from the water.

Maintenance

1. The developer/owner shall be responsible for maintenance of the filter curtain for the duration of the project in order to ensure the continuous protection of the watercourse.

2. Should repairs to the geotextile fabric become necessary, there are normally repair kits available from the manufacturers; manufacturer's instructions must be followed to ensure the adequacy of the repair.

3. When the curtain is no longer required as determined by the inspector, the curtain and related components shall be removed in such a manner as to minimize turbidity. Remaining sediment shall be sufficiently settled before removing the curtain. Sediment may be removed and the original depth (or plan elevation) restored. Any spoils must be taken to upland area and be stabilized.

# Section 4: Vegetation Management

## 4.1 Grassland Management

Grassland management is used to develop and maintain grassland habitats in prairie, transition and forested regions of Minnesota. This practice improves habitat for certain species such as greater prairie chicken, sharp-tailed grouse, waterfowl and grassland dependent songbirds.

Management

Grasslands may be managed by one, or a combination of the following methods. No more than 1/3-1/2 of a field should be disturbed at any given management period.

**Mechanical**: includes mowing or light disking. Mechanical disturbance should be done prior to the primary nesting season (May 1) or between August 1 - September 1 to protect ground nesting wildlife.

*Mowing*

- Where possible, manage no more than 50% of the stand in any given year in 4-5 year increments, or in strips to maintain cover.
- Rotate mowed strips across the field. Mow cool season grasses no shorter than 6ò. Native warm season grasses should be mowed no shorter than 10ò.
- Strip mowing can be applied in the spring prior to the nesting season to encourage vegetative diversity without greatly impacting ground nesting activities or loss of fall food plants.
- Minimum standing strip width shall be 100ô.

*Light Disking*

- Light disking (2-4ò deep) of existing stands, typically greater than 4 years old, may be necessary to increase the amount of open ground and encourage a diverse plant community of annuals and perennials.
- Alternate disked strips of <75ô in width, with standing buffer strips a minimum 2 times the disked width, across the field on the contour or across slope.
- Rotate the disked strips across the field.

**Prescribed Burning**:
If the area is not mowed or grazed, grass stands may need periodic renovation to remove excess litter which may reduce the quality of wildlife habitat.

Controlled fire can allow germination of seed bearing annuals, increase plant species diversity, control unwanted woody vegetation, and open up the stand for movement of small animals and birds.

- Frequency of burning should generally not exceed once every 4-5 years.
- Fall burns and early spring burns tend to favor wildflowers. Late spring burns provide maximum stimulus to warm season plants and work well to control cool season grasses and brush.

- Burning can only be done under an approved burn plan prepared by qualified personnel.
- Check with your local MDNR wildlife manager or forester about required permits.
- See NRCS practice standard PRESCRIBED BURNING (338) for additional recommendations.

**Prescribed Grazing:**
Domestic livestock may be used to manipulate plant succession. This manipulation may be beneficial to maintaining the quality of herbaceous cover, and controlling brush when done in accordance with a prescribed grazing plan with wildlife as the primary objective.

- This technique requires very careful management to assure the site is not over grazed.
- Do not recommend this technique unless assured that the land user fully understands the grazing system, and is capable of managing the system.
- A grazing plan should be developed at a ñlight grazing intensityò.

Maintenance

- Control undesired weed species, especially state-listed noxious weeds, and other pests that could inhibit proper functioning of the grassland area.
- Inspect and repair treatment areas after storm events to fill in gullies, remove flow disrupting sediment accumulation, re-seed disturbed areas, and take other measures to prevent concentrated flow.
- Apply supplemental nutrients and soil amendments as needed to maintain the desired species composition and stand density of herbaceous vegetation
- Maintain or restore the treatment area as necessary by periodically grading when deposition jeopardizes its function, and then reestablishing to herbaceous vegetation
- Routinely de-thatch and/or aerate treatment areas used for treating runoff from livestock holding areas (if applicable) in order to promote infiltration.
- Conduct maintenance activities only when the surface layer of the grassland area is dry enough to prohibit compaction.
- Treatment areas in arid or semiarid regions that potentially could be affected by high salinity and/or sodium content should be monitored for excessive salt and sodium buildup. If excessive salt or sodium is found, an appropriate corrective action shall be taken.

[NRCS Conservation Practice Standard Code 635. 2008]

## 4.2 Removing Undesirable Vegetation

Techniques to remove existing vegetation by smothering and/or applying herbicide are described below.

Smothering ï Use Black Plastic

Black plastic spread over vegetation eliminates light and creates heat that kills existing plants. This method is suitable for almost any site. In areas with high exposure to wind, extra care must be taken to anchor the plastic in place.

1. You will need
   - Å3.5 mil or thicker black plastic to adequately cover the area, plus extra to overlap sheets at least 6 inches.
   - Å4 inch or longer, 11 gauge or heavier U-shaped metal staples (enough to space 1 foot apart where plastic overlaps and at the edges).
   - ÅHeavy objects like logs, cement blocks, boards, or tires to hold the plastic in place.

2. Prepare the site by mowing, weed whacking, or trimming vegetation to be removed.

3. If soil is dry, water thoroughly. This will increase the weed killing effectiveness.

4. Lay down the plastic. Overlap the plastic at least 6 inches if using more than one piece. Staple in place at one-foot intervals as it is laid down.

5. Place heavy objects over plastic. All seams and edges must be firmly anchored to exclude light. Edges can also be buried in a shallow trench to help hold them in place.

6. Leave the plastic in place for 4-6 weeks during spring or summer. Make certain there is no sign of living vegetation before removing it.

7. Remove plastic, but leave dead vegetation in place. If using plant mulch over the dead vegetation, plant directly through the mulch.

Applying Herbicide

A glyphosate herbicide like Roundup® is recommended. Avoid drift of herbicide to water. If herbicide is to be applied in or over the water, an aquatic glyphosate formulation such as Rodeo® must be used, and a Department of Natural Resources permit is required. Always follow label instructions carefully.

Timing of herbicide applications is crucial. Do not apply when rain is forecast in the next 24 hours. Do not apply on windy days, since vegetation you wish to preserve may be damaged by herbicide drift. Vegetation must be actively growing for glyphosate herbicides to be effective. To encourage growth, mow grass and allow it to regrow several inches. Air temperature must be between 50 and 75 degrees Fahrenheit for cool season plants like quack grass and brome grass to be actively growing, and therefore effectively killed by the herbicide.

Be certain that vegetation is dead before planting. If turf is still green or yellow-green after 7 ï 10 days, a repeated herbicide application is recommended.

[Source: MN Biology Technical Note. NRCS. Shoreland Habitat Restoration. ]

## 4.3 Common Invasive Plants

| List of Common Invasive Plants |
|---|

| Latin Name | Common Name |
|---|---|
| *Bidnes spp.* | *Beggar Ticks* |
| *Polygonum convolvulus* | *Bindweed (Black)* |
| *Lotus corniculata* | *Bird's Foot Trefoil* |
| *Medicago lupilina* | *Black Medick* |
| *Arctium minus* | *Burdock (Common)* |
| *Linaria vulgaris* | *Butter and Eggs* |
| *Potntilla norvegica* | *Cinquefoil (Rough)* |
| *Trifolium pretense, T. hybridum, T. repens* | *Clover (Red, Alsike & White)* |
| *Rumex crispus* | *Curly Dock* |
| *Taraxacum officinale* | *Dandelion (Common)* |
| *Tragopogon spp.* | *Goat's Beard* |
| *Berteroa incana* | *Hoar-alyssum* |
| *Chenopodium album* | *Lamb's Quarters* |
| *Conzya canadensis* | *Horseweed (Canadian)* |
| *Brassica spp.* | *Mustards* |
| *Solanum nigrum* | *Nightshade (Black)* |
| *Amaranthus spp.* | *Pigweeds* |
| *Plantago major & P. ruglii* | *Plantain (Common & American)* |
| *Lythrum salicaria* | *Purple Loosestrife* |
| *Portulaca oleracea* | *Purslane* |
| *Ambrosia artemisiifolia & A. trifida* | *Ragweed (Common & Giant)* |
| *Sonchus spp.* | *Sowthistles* |
| *Centaurea maculosa* | *Spotted Knapweed* |
| *Urtica dioica* | *Stinging Nettle* |
| *Melilotus officinalis & M. alba* | *Sweet clover (Yellow & White)* |
| *Tanacetum vulgare* | *Tansy (Common)* |
| *Cardus nutans & C. acanthus* | *Thistle (Musk & Plumeless)* |
| *Vicia cracca* | *Vetch (Cow)* |
| *Cirsium vulgare, C. discolor, & C. muticum* | *Thistle (Bull, Field & Swamp)* |
| *Cirsium arvense* | *Thistle (Canada)* |
| *Silene latifolia* | *White Cockle* |
| *Echinochloa crus-gali* | *Barnyard Grass* |
| *Setaria sp.* | *Foxtail Grasses* |
| *Elytigia repens* | *Quackgrass* |
| *Phalaris arundinacea* | *Reed Canary Grass* |
| *Bromus inermis* | *Smooth Brome Grass* |

## Section 5: Commercial Erosion Control Operation and Maintenance Specifications

## 5.1 Agrecol's Envirolok™ Vegetated Retaining Wall and Steepened Slope System™

This special provision describes furnishing and installing all materials required to construct and establish Agrecolôs Envirolok Vegetated Retaining Wall and Steepened Slope System. The work includes furnishing and installing Envirolok Engineered Soil BagÊ , Envirolok SpikeÊ , Envirolok Bag StabilizerÊ , geotextile fabric, erosion mat, foundation material, soil, live plants, and hydroseeding mix. The work also includes submitting retaining wall design calculations, soil testing reports, plant and seed lists proof of install qualifications, ongoing maintenance schedule and warranty commitments to the engineer for approval.

Construction Guidelines

*Inert materials*

- Furnish Envirolok Engineered Soil Bags consisting of a staple fiber, needle-punched, non-woven polypropylene geotextile meeting the following specifications:

  Grab Tensile Strength ï 115 pounds - *ASTM Test Method D4632*
  Fabric Weight - 3.5 ounces per square yard - *ASTM Test Method D5261*
  Mullen Burst Strength - 210 pounds per square inch - *ASTM Test Method D3786*
  UV resistance @ 500 hours - greater than 70%- *ASTM Test Method D4355*
  Water Flow ï 140 gallons per minute per square foot

- Unfilled bags shall be nominally 18 inches x 36 inches, including seams. Stitch all seams with polyester thread. Bags (including bag fill) shall have a nominal weight of 80 pounds each. Bags shall be sound and free of defects that would interfere with the proper placing of the unit or impair the strength or permanence of the structure.
- Bag fill shall consist of 80% (by volume) clean sandy and granular material and 20% (by volume) fine grade compost.
- Engineered Soil Bag fill shall be free of sharp material that could damage or puncture the geotextile fabric. Soil must be free of harmful chemical contaminants.
- Furnish Spikes made of polypropylene. The Spike shall be a 4-inch diameter disc with 1/2-inch diameter spikes protruding 90 degrees from the center of each side of the disc, 2 inches in length. Spike must be capable of allowing root growth while retaining structural shear strength.
- Furnish Bag Stabilizer consisting of a 4-inch wide uniaxial network of integrally connected tensile elements with aperture geometry sufficient to permit significant mechanical interlock with

surrounding soil, aggregate or other material. Bag Stabilizer shall be high density polyethylene (HDPE) with a nominal tensile strength of 3,000 pounds per square foot.

- Furnish material for the Engineered Soil Bag wall foundation consisting of compacted sand, gravel, or combination thereof (USCS soil types GP, GW, SP, and SW). Aggregate shall be pea gravel, clean stone or granular type fill (no sharp angled stones that puncture bags).

*Live Materials*

- Furnish live plants for installation per the plans and details.
- Submit a complete list of all live herbaceous plants, tubers, bulbs, and dormant root stocks to the ownerôs representative prior to delivery of any materials to the site. Include complete data on source, quantity, and quality.
- All material shall be true to genus and species. Cultivars and hybrids are not recommended. Species substitutions must be approved by the SRWD. Plugs shall have well developed root systems filling the soil. Plant tops shall be well developed, healthy, viable, and adequately hardened off for outdoor planting. Deliver plugs to the planting site with adequate soil moisture, free of disease, mold, insect infestation, or other defects. Plants used shall be grown from seed origins within the project eco-region.
- Vegetation must cover the wall and also help lock system to the parent material on site.
- Genus and species must be native to the county where the project is located.

<u>Installation</u>

- Fill bags with a homogenous mix of sand and compost as described in section B of this special provision. Seal each bag with a plastic zip tie. Install bags at locations as per the details and as shown in the plans. Follow Agrecolôs Envirolok Installation Guide for detailed construction or as directed by the engineer.
- Place bags in a staggered fashion, overlapping half of the bag below. Tamp each bag firmly in place, with seams exposed to wall face.
- Insert two spikes per bag, between each course of bags, so each bag is pinned to adjacent bags above and below.
- Install stabilizer in an over-under weaving fashion along each course of bags. Splice stabilizer with a minimum overlap of 2 bags or tie together using a square knot. Install stabilizer parallel to the bag wall ensuring that the fabricôs strength axis is aligned in the same manner.
- Foundation material: Place fill of bags in 6-inch lifts and compact.
- Backfill: Backfill in a manner that prevents damage or misalignment of facing wall unit.

- Install plants in the correct zone as shown on the detail, per manufactures guidelines and as follows:

  Emergent Zone Plantings: Install one to three plants per bag in a random assortment, between layers of bags during wall construction. Do not puncture the bags during installation.

  Wetland Zone Plantings: Install one to three plants per bag in a random assortment, between layers of bags during wall construction. Do not puncture the bags during installation.

  Riparian Buffer Zone Plantings: Install plants in a random assortment, with a minimum of one plant per square foot.

- Hydrate bags to saturation.
- If hydroseeding, sow or spread native seed upon the installed bags 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 contents stirred or agitated to provide uniform distribution. Spread the tank contents within 1 hour after adding the seed to the tank. The engineer will reject seed that remains mixed with the water for longer than one hour.
- Apply fiber mulch and bonding agent to installed bags using a stream or spray of water under pressure and operated from an engineer-approved machine designed for that purpose. Place the material and water into a tank provided within the machine, in sufficient quantities that when spraying the material on a given area it is uniformly spread at the required application rate. During this process, keep the contents stirred or agitated to provide uniform distribution.

Maintenance

- Ensure the plants are growing for two (2) months following live plant installation and seed germination. Replace all dead plants with live plants of same species, if required during this period.
- Maintain plants by watering, weeding, hand pulling and/or herbicide applications, and resetting plants, as required to establish healthy, viable plantings for three (3) years following live plant installation and seed germination.
- Remove noxious and invasive plants of your eco-region from the project area.

| Latin Name | Common Name |
|---|---|
| *Bidnes spp.* | *Beggar Ticks* |

| | |
|---|---|
| *Polygonum convolvulus* | *Bindweed (Black)* |
| *Lotus corniculata* | *Bird's Foot Trefoil* |
| *Medicago lupilina* | *Black Medick* |
| *Arctium minus* | *Burdock (Common)* |
| *Linaria vulgaris* | *Butter and Eggs* |
| *Potntilla norvegica* | *Cinquefoil (Rough)* |
| *Trifolium pretense, T. hybridum, T. repens* | *Clover (Red, Alsike & White)* |
| *Rumex crispus* | *Curly Dock* |
| *Taraxacum officinale* | *Dandelion (Common)* |
| *Tragopogon spp.* | *Goat's Beard* |
| *Berteroa incana* | *Hoar-alyssum* |
| *Chenopodium album* | *Lamb's Quarters* |
| *Conzya canadensis* | *Horseweed (Canadian)* |
| *Brassica spp.* | *Mustards* |
| *Solanum nigrum* | *Nightshade (Black)* |
| *Amaranthus spp.* | *Pigweeds* |
| *Plantago major & P. ruglii* | *Plantain (Common & American)* |
| *Lythrum salicaria* | *Purple Loosestrife* |
| *Portulaca oleracea* | *Purslane* |
| *Ambrosia artemisiifolia & A. trifida* | *Ragweed (Common & Giant)* |
| *Sonchus spp.* | *Sowthistles* |
| *Centaurea maculosa* | *Spotted Knapweed* |
| *Urtica dioica* | *Stinging Nettle* |
| *Melilotus officinalis & M. alba* | *Sweet clover (Yellow & White)* |
| *Tanacetum vulgare* | *Tansy (Common)* |
| *Cardus nutans & C. acanthus* | *Thistle (Musk & Plumeless)* |
| *Vicia cracca* | *Vetch (Cow)* |
| *Cirsium vulgare, C. discolor, & C. muticum* | *Thistle (Bull, Field & Swamp)* |
| *Cirsium arvense* | *Thistle (Canada)* |
| *Silene latifolia* | *White Cockle* |
| *Echinochloa crus-gali* | *Barnyard Grass* |
| *Setaria sp.* | *Foxtail Grasses* |
| *Elytigia repens* | *Quackgrass* |
| *Phalaris arundinacea* | *Reed Canary Grass* |
| *Bromus inermis* | *Smooth Brome Grass* |

* For more information regarding plant identification contact the SRWD for assistance and guidance.

- Herbicide treatments shall be performed by licensed applicators who are experienced with native and non-native plant identification. Used herbicides in full conformance with label requirements and application techniques and approved by local ordinances. Take care to limit overspray and damage to off-target species. Manage pests to maintain plants in a

healthy and aesthetically pleasing condition for the long term. Maintain all plants through the establishment period.

- Establish a semi-monthly maintenance cycle and provide written documentation of tasks performed to the owner after each cycle.

## Section 6: Residential Rain Garden Operation and Maintenance

### Year One

| | Description | Methods |
|---|---|---|
| Watering | During the first year, supplemental watering is important for plant root establishment. | • Make sure to water the plants thoroughly after planting.<br>• Water once a week for the first growing season for 30 minutes to ensure plant survival during times of dryness, similar to other gardens you may have on your property |
| Grazing Protection from Waterfowl and Deer | Whitetail deer and other animals may damage plantings, especially trees and shrubs. Protect against damage by physical or chemical means. | • Surround newly planted trees and shrubs with 4 ï 6 foot high, galvanized mesh fence supported with wooden stakes or fence posts, or cover plants with bird netting.<br>• Use detterent sprays such as red pepper spray (Use of these products may need to be varied as deer become accustomed to their taste or smell).<br>• Deer feeding should be discouraged near restoration areas. |
| Weeding Planted Areas | Pull weeds out as early as possible being careful to not disturb the native plants. Be especially diligent in areas where non-native invasive are known to be present. | |

| | | |
|---|---|---|
| Weeding Seeded Areas | It can be difficult to tell weeds from the native plants in a seeded area. | • Sprouting a small sample of the native seeds in a plant tray will assist with their identification.<br>• Cut off flowering heads of weeds before they go to seed. |
| Fertilizing and Applying Insecticide | Fertilizers and insecticides should be avoided. Applying fertilizers may encourage weed growth. If native plants are selected appropriately, supplemental fertilization should not be required. Also avoid applying insecticides since so many are non-specific and can harm or even kill non-target species. | |
| Vegetative Cover | At the end of the growing season, allow all dead vegetation to remain in place. It becomes a valuable seed source for next yearôs growth, provides food and cover for wildlife, and will help to cover the soil and slow spring runoff. The grass seed and dried flower heads add another level of appeal to the native landscape in the winter months.<br><br>If you want a manicured look, be sure to prune back vegetation as desired to maintain the desired aesthetic. | |
| Replacement of Plants | Replant or anchor uprooted aquatic plants. Once established, aquatics require little or no long-term maintenance. | |
| Mulching | Mulching minimizes weeds from getting into the garden, retains moisture, soak up chemical pollutants from runoff, etc. | • Refer to Mulching maintenance methods. |
| Maintain Inlet and Outlets | Areas where water comes to the raingarden should be carefully cleaned out to remove sediment that has collected. | |

# Year Two

| | Description | Methods |
|---|---|---|
| Watering | Water only during periods of severe drought. | |
| Weeding | Thoroughly weed early in the summer. After this initial weeding, check for and remove weeds at least once a month. | |

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| Plant Replacement | If there are areas that are bare or look as though they have frozen out, contact your SRWD Technician for a replanting strategy. | |
| Erosion Control Structure Repair | Inspect all erosion control blankets, inlet/outlets, silt fences, berms, etc. throughout the season | • Refer to Temporary Erosion control maintenance methods. |
| Mulching | Mulching minimizes weeds from getting into the garden, retains moisture, soak up chemical pollutants from runoff, etc. | • Refer to Mulching maintenance methods. |
| Maintain Inlet and Outlets | Areas where water comes to the raingarden should be carefully cleaned out to remove sediment that has collected. | |

# Year Three & Beyond

| | Description | Methods |
|---|---|---|
| Watering | No watering should be necessary except for extreme drought conditions. | |
| Weeding | Continue to do a thorough weeding in the early summer. If invasives are a problem, consider a weed management strategy provided by the SRWD Technician. Mowing and burning can occur every 3 to 5 years as recommended by your SRWD Technician. | |
| Vegetative Cover | Leave vegetation in place in the fall and through the extensive winter months. | • Approval from the zoning or land conservation office is required for extensive weed removal in the shoreland zone. |
| Fertilizing | Encourages invasives and noxious weeds. | None |
| Trimming and Burning | Prairie and savanna areas may be trimmed or burned only under an approved management plan.<br>Additional permits or approval may be necessary before trimming or burning. | • Trim groundcover in prairie areas no more than once every 3-5 years.<br>• Groundcover should be cut no less than 6-8 inches high.<br>• Cut vegetation in the late winter when the ground is still frozen, or in late spring, when the ground is dry enough to walk on without damaging new growth.<br>• Leave all dead plant clippings on-site. They will add to the shoreland soil structure.<br>• A controlled burn may be appropriate only in prairie and savanna areas. A burn should not be attempted until the prairie or |

| | | |
|---|---|---|
| | | savanna is well established ï usually after 5 or more years.<br>• To determine if a controlled burn is appropriate evaluate the site for safety considerations; threats to structures, shrubs, and trees; and weed species present.<br>• In addition to any required permits, DNR burning permits are required in intensive fire zones. Except in prairie areas that are identified in an approved management plan, any native trees, shrubs, and groundcover in the restoration area shall be left undisturbed. |
| Mulching | Mulching minimizes weeds from getting into the garden, retains moisture, soak up chemical pollutants from runoff, etc. | • Refer to Mulching maintenance methods. |
| Maintain Inlet and Outlets | Areas where water comes to the raingarden should be carefully cleaned out to remove sediment that has collected. | |

# Section 7: Miscellaneous Practices

## 7.1 Irrigation System, Sprinkler

An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure.

This practice may be applied as part of a conservation management system to achieve one or more of the following:

- Efficiently and uniformly apply irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment.
- Climate control and/or modification.
- Applying chemicals, nutrients, and/or waste water.
- Leaching for control or reclamation of saline or sodic soils.
- Reduction in particulate matter emission to improve air quality.

Operation and Maintenance

- An operation and maintenance plan must provide specific instructions for operating and maintaining the system to insure that it functions properly. It should also provide information regarding periodic inspections and prompt

repair or replacement of damaged components. The plan, at minimum, shall include provisions to address the following:

- Periodic checks and removal of debris and sediment as necessary from nozzles to assure proper operation.
- Inspection or testing of all pipeline and pumping plant components and appurtenances, as applicable.
- Regular testing of pressures and flow rates to assure proper operation.
- Periodic checks of all nozzles and spray heads for proper operation and wear.
- Routine maintenance of all mechanical components in accordance with the manufacturerôs recommendations.
- Prior to retrofitting any electrically powered irrigation equipment, electrical service must be disconnected and the absence of stray electrical current verified.

# Section 8: Rip Rap Standards

## 8.1 Rock Rip Rap Installation

A layer of stone designed to protect and stabilize areas subject to erosion to protect the soil surface from erosive forces and/or improve the stability of soil slopes that are subject to seepage or have poor soil structure. Riprap is used for cut and fill slopes subject to seepage, erosion, or weathering, particularly where conditions prohibit the establishment of vegetation. Riprap is also used for channel side slopes and bottoms, streambanks, grade sills, on shorelines subject to erosion, and at inlets and outlets to culverts, bridges, slope drains, grade stabilization structures, and storm drains.

### Design Criteria

- **Gradation** ï Riprap should be a well-graded mixture with 50% by weight larger than the specified design size. The diameter of the largest stone size in such a mixture should be 1.5 times the d50 size with smaller sizes grading down to 1 inch. The designer should select the size or sizes that equal or exceed that minimum size based on riprap gradations commercially available in the area.
- **Thickness** ï The minimum layer thickness should be 1.5 times the maximum stone diameter, but in no case less than 6 inches.

- **Quality** ï Stone for riprap should be hard, durable field or quarry materials. They should be angular and not subject to breaking down when exposed to water or weathering. The specific gravity should be at least 2.5.

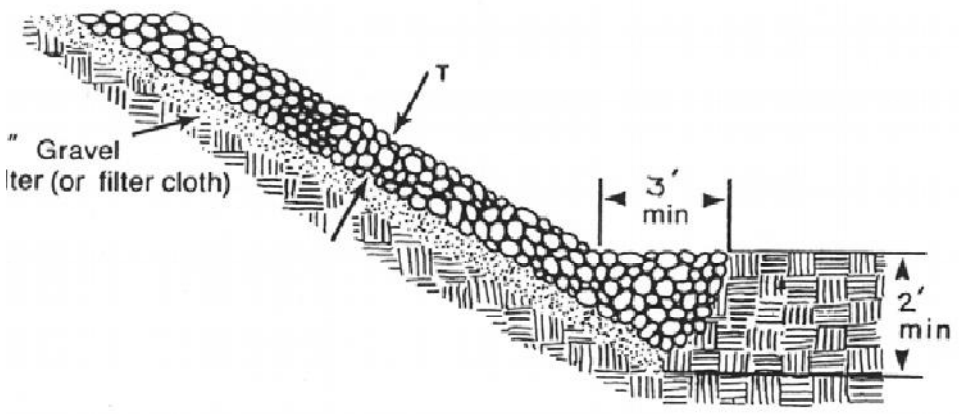
- **Size** ï The sizes of stones used for riprap protection are determined by purpose and specific site conditions:

    - Slope Stabilization ï Riprap stone for slope stabilization not subject to flowing water or wave action should be sized for the

proposed grade. The gradient of the slope to be stabilized should be less than the natural angle of repose of the stone selected. Angles of repose of riprap stones may be estimated from Figure 5B.26. Riprap used for surface stabilization of slopes does not add significant resistance to sliding or slope failure and should not be considered a retaining wall. Slopes approaching 1.5:1 may require special stability analysis. The inherent stability of the soil must be satisfactory before riprap is used for surface stabilization.

- **Filter Blanket** ï A filter blanket is a layer of material placed between the riprap and the underlying soil to prevent soil movement into or through the riprap. A suitable filter may consist of a well-graded gravel or sand-gravel layer or a synthetic filter fabric manufactured for this purpose. The design of a gravel filter blanket is based on the ratio of particle size in the overlying filter material to that of the base material in accordance with the criteria below. Multiple layers may be designed to affect a proper filter if necessary.

- **Stone placement** ï Placement of the riprap should follow immediately after placement of the filter. Place riprap so that it forms dense, well-graded mass of stone with a minimum of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry and controlled dumping during final placement. Place riprap to its full thickness in one operation. Do not place riprap by dumping through chutes or other methods that cause segregation of stone sizes. Be careful not to dislodge the underlying base or filter when placing the stones. The toe of the riprap should be keyed into a stable foundation at its base. The toe should be excavated to a depth of 2.0 feet. The design thickness of the riprap should extend a minimum of 3 feet horizontally from the slope. The finished slope should be free of pockets of small stone or clusters of large stones. Hand placing may be necessary to achieve proper distribution of stone sizes to produce a relatively smooth, uniform surface. The finished grade of the riprap should blend with the surrounding area.



[Source: MN Department of Transportation. 2005 ]

## Maintenance

Riprap should be inspected periodically for scour or dislodged stones. Control weed and brush growth as needed.

The most unpredictable maintenance issues in shoreline stabilization projects result from ice action or extreme weather events. Freeze and thaw cycles or heavy winds during ice break-up can exert an amazing amount of pressure against the shores of a lake. Rock treatments are generally designed to withstand the forces of wave action, but cannot always withstand the forces of moving ice. Problems at the interaction between ice and shoreline can include both plucking of the rock by rising and falling of ice sheets as the water level of the lake changes, and shoving action by ice sheet movement.

- If the rock is moved out of place, it can expose areas of the protective geotextile. Undermining or damage to the protective geotextile will result in loss of its effectiveness. Any exposed geotextile needs to be covered to prevent breakdown from ultraviolet rays.
- The sites need to be inspected each spring following breakup of the ice or following extreme wind events.
- Any displaced or dislodged rock should be put back in place according to site specific guidelines.

As stated in General Recitals, Paragraph 3, of the SRWD best Management Practice Financial Assistance Agreement:

> Owner will, at Owner's expense, be responsible for the operation and maintenance of the Project during its minimum effective life of 20 years from the date of implementation described in paragraph 3, below. If Owner fails to operate and maintain the Project or removes or modifies any Project component during the Projectôs effective life, without written consent and approval from the Watershed District, the Watershed District may require Owner to repay to the Watershed District the amount of financial assistance provided pursuant to this Agreement. Owner agrees to allow representatives of the State and Watershed District to inspect the Projectôs implementation, operation and maintenance.

The SRWD and I, _____ have discussed the guidelines for operation and maintenance contained herein.

_____ _____

Owner Signature Date

| | |
|---|---|
| Received by SRWD Staff | Date |