Appendix C - Stormwater Plant Materials

This section includes information that can aid in the selection of plant materials for vegetated stormwater Best Management Practices (BMPs). This information was developed by Daniel G. Ogle, Plant Materials Specialist, and J. Chris Hoag, Wetland Plant Ecologist, of the USDA Natural Resources Conservation Service.

Selecting the proper plant materials for these BMPs is essential because many of these BMPs rely on the plants to perform important functions. Plants can purify the water by removing suspended solids (sediment) and a wide variety of nutrients and minerals such as nitrate, phosphorus, heavy metals, and fecal coliform bacteria. The plants also provide bank protection by reducing the wave energy before it hits the bank. By reducing the wave energy, the plants will cause the water to drop sediment around the base of the plants thereby cleaning the water by removing suspended solids. The above ground plant biomass provides sites for algae and other microorganisms to live and multiply. The root systems provide colony sites for microbes that break down nutrients into usable proteins and amino acids in addition to basic elements and nitrogen gas.

If the wrong plants are selected, they may not tolerate site conditions and either become weak or die. Weakened or dead plants will need to be replaced so that the BMP will work properly. Continual plant replacement increases project costs and reduces BMP effectiveness. Similarly, other plants may require significant short-term and long-term maintenance. Consequently, the designer should choose plants wisely.

1.1 Vegetative BMPs

Vegetative stormwater BMPs provide a variety of uses, depending on the objective. BMPs such as biofiltration swales and grass buffer strips are primarily pretreatment systems that are used in conjunction with other stormwater facilities for on-site disposal. Infiltration swales and ponds are systems that could be used alone or with some type of pretreatment. Detention ponds are designed exclusively for flood control and may be either wet or dry. Plant materials used in detention ponds are primarily for stabilization and aesthetics. Extended detention ponds are multifunctional; with a longer detention time in order to provide both water quality treatment and flood control. Table 1 shows the different uses of vegetative stormwater BMPs.

Table 1. Vegetative BMPs and their uses

Facility Type	Maximum Period of Standing Water	Comments
Detention pond	24-48 hours	Water quantity control
Extended detention pond	48-72 hours	Water quality control
Evaporation pond	Varies	Water quantity/quality control
Infiltration basin	48-72 hours	On-site disposal; requires pretreatment
Biofiltration swale	No standing water	Used for pretreatment only
Grass buffer strip	No standing water	Used for pretreatment only
Grass channel	Duration of storm	Used for conveyance only

Another type of vegetative BMP is bioretention. Bioretention is a method to manage stormwater runoff using native plants and soil conditioning. Bioretention areas capture sheet flow from impervious surfaces. The captured water usually flows through a grass buffer strip and then is infiltrated into a filtration bed. Bioretention capitalizes on the biological abilities and physical attributes of specific plants and native grasses.

1.2 Understanding Your Site

Understanding the site's characteristics will help determine which plant materials and planting methods the designer should select. Selecting the appropriate plant materials and planting methods will improve plant establishment. This section will discuss the soil properties that are integral to successful plant establishment: soil characteristics, soil fertility, and topsoil.

Soil characteristics

Plant growth can be limited by certain soil characteristics. Species must be able tolerate the soil's limitations in order to successfully establish on a site. Soil limitations can include the following:

- fine or coarse textures
- impermeable soil layers
- extended periods of wetness or high ground water
- salinity or alkalinity
- acidity
- shallow depth
- toxicity

- severe nutrient imbalance

The designer should consider other soil characteristics that may or may not be a limitation to the plant. For example, the soil's water-holding capacity affects the composition of natural vegetation and selection of species. In addition, slope is also important in each plant's ability to adapt within the climatic range.

Soil fertility

Disturbed areas can be extremely deficient in available nitrogen and phosphorus. Consequently, unless topsoil is applied, soil material can be nearly devoid of organic matter. To remedy this problem, the use of compost or annual applications of nitrogen fertilizer may be needed to sustain a plant community until the plants can establish their own nutrient cycle.

Disturbed areas can also be phosphorus deficient because the pH is at or above 8.3 and abundant calcium carbonate keeps the phosphorus largely unavailable. Phosphate fertilizer increases the plant-available supply for only a few years. Applying topsoil to the site greatly increases the available phosphorus levels on disturbed areas.

Prior to amending the soil, the soil should be analyzed to determine nutrient content. Additional fertilizer may be unnecessary or even harmful.

A general guideline to increasing soil fertility is to apply fertilizer to the site. Apply a minimum of 30 pounds of nitrogen and 40 pounds of phosphate (P_20_5) per acre to disturbed areas. Subsequent soil tests will determine if fertilizer rates will need to be adjusted.

Topsoil

All topsoil and soil-like material should be saved and redistributed on the reclaimed area. Direct placement of topsoil (moved and replaced) provides a source of viable native plant seeds and vegetative structures, which volunteer into the reclaimed plant community. If topsoils are not available, subsoils should be amended with compost and other organic amendments that will ensure better soil tilth, improved infiltration characteristics, and improved soil biologic activity.

1.3 Plant Material Selection

Selecting plants requires more than understanding the soils on the site. It requires selecting the appropriate plants that will work for the BMP. Section 3 contains plant tables that list information on grass and grass-like plants, riparian trees and shrubs, and upland trees and shrubs that are suitable for vegetative stormwater BMPs.

Species selection

As previously mentioned, vegetative stormwater BMPs provide a variety of uses, depending on the stormwater objective. To meet that objective, the designer must select the plants that will meet the system requirements of the BMP.

For example, detention ponds are designed to collect and temporarily hold surface and stormwater runoff. They are specifically used for flood control. System components of a wet detention pond include using plant materials to stabilize pond slopes (for dust control) and to improve pond aesthetics. Therefore, if a designer wanted to construct a wet detention pond on the site, the combination of plants selected for the pond should meet the criteria of soil stabilization and pond aesthetics.

In addition, the designer should consider the environmental factors of a site to determine which plants are appropriate for the BMP. Expected precipitation, irrigation supply, site exposure, elevation, temperature, and soil type and properties all play a role in selecting the appropriate plants. If the designer chose plants that are good soil stabilizers, but do not tolerate acidic soils then the plants will have limited establishment and will not meet the system requirements of the BMP.

Also, the designer must consider the location of the BMP in relation to land use activities. For example, if a vegetated BMP is going to be located next to a roadway, the plants should have high salt tolerance in case excessive amounts of de-icing salts run off the pavement into the BMP.

Finally, the designer must consider the extreme conditions under which the plant must survive. For example, plants have an extremely difficult time establishing in the Intermountain West because of the severe conditions. Plants must withstand long periods of drought and low temperatures without snow cover. Some wetland plants, however, can tolerate a variety of growing conditions. These wetland plants are rushes and sedges. Rushes can withstand up to six months of drought without supplemental irrigation and up to two months of total inundation. Rushes have extensive root systems and when the plant becomes inundated with sediment, they continue to grow. Also, the larger root systems allow the plant to take up and transpire a larger volume of water.

Rushes are also used in constructed wetlands to remove heavy metals from mine tailings, nutrients from domestic wastewater, and petrochemicals from urban runoff. The extensive root system allows the plant to survive even when pollutants have damaged a portion of the plant.

Rushes require little maintenance. They have hollow-stemmed blades that produce less residue and because of the small plant size, do not require mowing. However, mowing will not harm the plant.

Other considerations for vegetative BMPs

A designer should consider four planning-related issues when selecting plants for vegetative BMPs: use or function, plant characteristics, availability and cost, and long-term maintenance. Each consideration will be briefly discussed.

- Use or function **-** In selecting plants; consider their desired function in the landscape. Is the plant needed as ground cover, soil stabilizer, water quality treatment, or a shade source? Will the plant be placed to frame a view, create focus, or provide an accent? Nearly every plant and plant location should serve some function in addition to adding aesthetic appeal.

- Plant characteristics - Plant characteristics should also be considered when selecting plants for vegetative BMPs. Consider the following example of how the plant characteristics can affect the landscape and the function of vegetative BMPs. Catalpa sop. produce large seed pods in the autumn that ultimately fall off the tree and onto the ground. As the tree matures, it produces more seedpods. Designers should consider where they plant this type of tree in relation to a vegetative BMP so that seed pods (and other tree matter) do not land in the BMP and either increase maintenance costs (i.e., requiring unclogging of system pipes) or reduce BMP treatment effectiveness.

  In addition, the designer should determine how the plant would fit in the landscape today as well as years to come. Growth rate, color, seasonal interest, and texture all play a role in the characteristics of a plant and its relationship to the landscape and vegetative BMPs.

- Water availability - Most stormwater systems located in urban areas are located on sites where supplemental irrigation is provided. Supplemental irrigation allows for a wider diversity of plant materials. Supplemental irrigation also makes the season of seeding less critical than if the area had no additional irrigation.

- Availability and cost - These two factors can ultimately determine if the plants you have selected will be used in the vegetative BMP. As a result, the designer may have to check different plant suppliers for best price and selection. Also, choosing native plants over exotic or ornamental plants increases the chance that the plants will perform better than those species accustomed to more temperate zones.

Local suppliers should be contacted first, since local suppliers stock plants and seeds adapted to this area. Successful plantings are directly related to the source of the plant materials and the conditions under which they were propagated.

- Long-term maintenance - Like structural BMPs, vegetative BMPs require long-term maintenance. As previously mentioned, the designer should determine how the plant will fit in the landscape today as well as in the future. Will the plant sustain growth in the same location for several years or will it aggressively take over the site? Does the plant, over time, produce large amounts of litter that form a mat over the soil reducing seedling growth? Will irrigation be required? If the designer has carefully considered the plant characteristics, then the plants will continue to serve their function and will not require substantial maintenance.

1.4 Plant Establishment

To ensure that plant establishment is successful, the designer should consider the following planting guidelines. The guidelines discuss the importance of proper seed bed preparation, seeding rates, seasons and methods of seeding, mulching, and herbicide use.

Seedbed preparation

Good seedbed preparation is essential in revegetating disturbed land, such as those found on construction sites. Often, this is the most important stage in revegetation because, in many cases, subsurface layers have been compacted during construction operations. Compaction hinders root penetration and water infiltration.

Good seedbed preparation scarifies and loosens the soil surface creating a favorable environment for seed planting and subsequent seedling emergence. Generally, the seedbed is properly prepared if a person walking across the area does not sink more than1/8”into the soil. Scrapers should be used to apply subsoil and topsoil over the construction site. These machines compact the soil as it is applied, therefore, the subsoil and topsoil must be treated for compaction. Ripping with a bulldozer with ripper tooth is the first step to good seedbed preparation. After ripping the subsoil, topsoil can be applied to the desired thickness. Usually the topsoil is shallow enough that ripping is unnecessary. Poorly prepared seedbeds require higher than normal seeding rates; however, increased seeding rates will not compensate for poor seedbed preparation.

Seeding rate

Seeding rate computations are based on pure live seed (PLS) per square foot. Pure live seed (PLS), expressed as a percentage, designates the calculated quantity of viable seed to plant. The percent PLS of a lot of seed is obtained by multiplying the percent purity times the percent germination and dividing the product by 100. PLS is important in determining the amount of material needed for planting and in determining the quality of the seed to be purchased. It is the best way to determine the actual cost of the seed.

In most cases, individual plant materials are used to vegetate a stormwater BMP. The BMP is generally small so the cost of using plants in comparison to direct seeding is not prohibitive. Seeding can be used when the area to be vegetated is large or plants are not available.

A seeding rate from 30 to 40 seeds per square foot is generally adequate. Seeding rates should provide adequate seed for a good stand and limit the reduction of future stands because of too much competition among seedlings. Increased seeding rates may increase initial plant densities, but there is usually an inverse relationship between initial high density and survivability the first year after the stand is established. Seed mixes should include about 25 to 50 pure live seeds per square foot when drilled and 50 to 100 pure live seeds per square foot when broadcast. Dry areas need less seed and critical areas need more seed.

Season of seeding

A late fall or dormant seeding prior to winter is the most common seeding period in the Intermountain West. The timing of seeding is important on disturbed lands. Plant late enough in the fall so seed does not germinate or emerge before winter weather sets in. The closer to winter the planting can be made, the more successful the seeding will usually be. Overwintering helps break seed dormancy in some species and cool season grasses germinate readily under the snow when temperatures are slightly above freezing. Seedlings are protected from rodents by the snow pack and emerge quickly with early spring moisture.

Most legumes and grasses are seeded in the spring to allow the seedling to become well established before being subjected to freezing temperatures. The designer should schedule spring plantings as early in the spring as possible to provide for optimum germination temperatures and to allow seedling to get a jump on the weeds. A few species, such as cider milk vetch and other legumes, require warmer soil temperatures and should not be planted until mid spring. Ideally, the site should be prepared the previous fall if a spring seeding is desired. Usually spring seedings are planted between periods of wet and dry weather. If spring seedings are to be effective, they should be made prior to spring rains. There may be a problem of I getting heavy equipment onto the site to prepare a seedbed in the spring following a wet winter that has saturated the soil profile. In addition, flows should be diverted away from the seedbed until the area is stabilized.

Method of seeding

Direct seeding can be accomplished by any of the following methods: broadcast seeding, drill seeding, or hydroseeding. Each of these methods will be discussed in some detail.

- Broadcast seeding is recommended in small areas or in seedbeds that are relatively uniform and rough. Dry method - hand cyclone seeders, air guns, or blowers are good inexpensive means for broadcast seeding of grass and legume seeds. There should be an even distribution of light and heavy seeds over the area. When using the broadcast seeding method, the designer should double the seeding rates normally used for drilled planting.

  One advantage of broadcast seeding is that all seed types can be contained in the seeding mixture. Using a seed mixture is recommended on highly disturbed construction sites because it increases the chance that the plants will successfully establish and improve vegetation diversity.

  Heavy, awned or fuzzy seed are suited for the broadcast seeding method because they can clog a drill, making drill seeding a tedious process.

  One requirement for using the broadcast planting method is that the seed should be adequately covered by the soil following sowing. Using a heavy sheepsfoot roller is an acceptable method to cover seed. It compresses some seed to approximately 1” depth while others are only slightly covered.

- Drill seeding is most effective when only a few species are included in the mixture and larger sites are involved. Large and small seeded species can be placed in separate boxes and depth bands can be set to plant the seed at a specific depth. Seed spacing is also more controlled with a drill. Row widths of 6-14 inches produces good stand establishment. A sound practice, although not commonly used, is alternate row seeding. Seeding grass, legumes, and shrubs into alternate rows increases the survivability of the slower developing legumes and shrubs by reducing competition during the establishment year(s).

  Sometimes a slope is too steep to use tillage equipment to prepare a seedbed. On some sites, ripping can be completed across the contour and then seeding with equipment is completed on the contour. When this is not possible and the slopes are accessible from a level area, hydroseeding may be an acceptable planting technique.

- Hydroseeding is commonly used for planting road cuts and embankments.

Ideally, the seed and fertilizer are applied first then the site is mulched with hydromulch. A small amount of green dye and hydromulch (100 - 200 lbs/ acre) is included in the seed and fertilizer slurry to provide a tracer for judging seed distribution. The wood fiber, straw, or paper mix is then placed into the water vat and is applied as a cover for seed in a second operation.

The hydroseeding method is recommended over the more common method of applying seed, fertilizer, and mulch in one operation because when seed is suspended in the mulch, the seed may not come in contact with the soil and poor stand establishment may result. The seed may dry out and die after germination unless the relative humidity is constantly high enough to maintain high moisture levels when the seed is suspended in the mulch.

Disadvantages of hydroseeding include: damage to some of the seed as it goes through the pump and operations require large crews, water tankers, supply trucks, adequate water supplies and relatively smooth, flat areas from which to operate the equipment.

To reduce damage to the seed, apply the seed and fertilizer from separate bins. Avoid mixing the seed and fertilizer for more than a few hours or seed germination may be adversely affected.

Other seeding methods

Most shrubs are difficult to establish using direct seeding methods. Transplanting bare rootstock or tubed plants improves establishment success. Bare rootstock or tubed plants are planted into previously dug holes. Plant bareroot stock and tubed plants about 1 inch lower than the soil surface, cover with soil and compact the soil firmly around the roots. Plants should be thoroughly watered following planting. Tree spades can be used to transplant larger dormant shrubs and small trees onto disturbed sites or road cuts.

If a sod-forming plant species is desired for quick vegetative cover, a sprig digger or modified potato harvester can be used to gather vegetative sprigs. Plant sprigs using a manure spreader or a specially designed sprig planter. If a manure spreader is used, sprigs must be lightly disked into the soil so that the sprigs are in contact with moist soil at all times. Another alternative would be to place sod.

Mulching

Mulching is the most common and widely used method of rapidly stabilizing soils on moderate to steep slopes. Mulching materials such as straw, hay, jute and other appropriate materials should also be used to protect the new seeding (especially late summer and fall seedings). Mulches increase water infiltration of water and provide a microclimate for establishment of vegetative cover.

Wood fiber, erosion control blankets, hay and straw are the most commonly used commercial mulches. Net or blanket type mulches include straw or other fibers secured with jute or polypropylene netting and wire staples. Net mulches can be utilized on either slopes or flat surfaces, provided the net is attached securely to the ground. Straw or native grass hay is perhaps the most commonly used mulch because it is available, inexpensive, and easy to apply, and gives reasonably good results.

Straw or hay must be crimped by disking into the soil surface from 2 to 3 inches deep to prevent the mulch from being blown from the site by high winds. Because of this incorporation requirement, it is not a viable technique on steep slopes unless a tackifiers or polypropylene netting anchors the mulch.

Straw is generally more weed-free than grass hay, but good native grass hay can also provide a source of adapted seed. These mulches can be spread by hand or with mechanical blowers.

Straw mulch can be used on high, steep slopes along roads to help hold the seed and fertilizer in place. Organic tackifiers and netting can be used to hold the straw in place. Wind, water and gravity should be evaluated to determine the amount and method used to hold the mulch in place. Anchor mulch 2 -4 inches deep with no more than two passes of the anchoring equipment.

For mulching with straw, a minimum of 4,000 pounds per acre to a maximum of 6,000 pounds per acre of clean small grain straw is recommended. Additional nitrogen needs to be applied when mulching with organic materials because nitrogen will be tied up in the process of breaking down the mulch. The following amounts should be applied for straw:

Mulch	Nitrogen
4,000 pounds/acre	15 pounds/acre
5,000 pounds/acre	20 pounds/acre
6,000 pounds/acre	25 pounds/acre

1.5 Herbicides

Restrictions and limitations

Herbicides are chemicals formulated to control broadleaf and grass weeds. All have limitations as to type and degree of control. Many have restrictions on their use. The label for each herbicide should be read thoroughly and mixing and application directions followed carefully.

When choosing an herbicide, the applicator must consider its effectiveness in controlling specific weeds. Will it injure other plants? What effect will it have on beneficial organisms within the treated area? Will it have any ill effects on nontarget areas?

Label information indicates product restrictions and limitations when applied to certain plants and in various habitats. These restrictions and limitations should be understood before an herbicide is selected to control a certain weed(s) in a specific planting. The limitations will help determine which herbicide(s) to purchase.

Herbicides and the environment

Weed control practices and environment protection require time-consuming precautions. The designer must select herbicides that will kill the weeds without damaging other plants. They must restrict the drift to nearby sensitive vegetation. Succeeding plant damage from herbicidal residues in the soil must be avoided. When weeds are treated in or near irrigation ditches or streams, special precaution must be taken to avoid contamination of water and injury to fish or other beneficial forms of life. The use of herbicides in and around stormwater systems should be restricted and avoided, when possible, because of the potential to contaminate surface and ground water.

Section 2 – Specific Guidance for Stormwater BMPs

This section discusses specific guidance for vegetative BMPs. The BMPs included in this section are ponds, biofiltration systems, and infiltration systems.

2.1 Ponds

General information

The guidelines below are primarily for ponds that exhibit hydrologic zones.

Hydrologic zones

The depth of the water and the period of standing water define hydrologic zones. Knowing what hydrologic zones are present in a BMP will help the designer determine where plants can be successfully planted based on the water levels that are expected with each BMP. The hydrologic zones would include the following:

Zone #	Zone Description	Hydrologic Conditions
Zone 1	Deep-water pool	3-6+ feet deep, permanent pool
Zone 2	Shallow water bench	2-18 inches deep, fluctuating water
Zone 3	Shallow water fringe	0-2 inches deep, fluctuating water, regularly inundated
Zone 4	Shoreline fringe	Permanent moisture zone, periodically inundated
Zone 5	Terrace	Rarely inundated
Zone 6	Upland	Seldom or never inundated

Zone 1: Deep Water Pool (3—6+ feet)

Ponds and wetlands generally have deep pools that are a minimum of 3 feet deep. Emergent wetland vegetation generally will not grow in permanent water depths that are deeper than 3 feet.

Many species can withstand deeper water for short periods of time. However, they will tend to die out in these water depths over time. Most plants that are found in water with these depths are called submergent species. Submergent species root in the pool bottom and extend their stems up toward the water surface. Occasionally, they will emerge out of the water. These plant species can provide excellent fish and aquatic invertebrate habitat. They can also provide water cleaning functions, such as removal of nitrates and phosphorous. Submergent plant materials are not readily available on the retail market at the present time. However, plant parts and seeds are mobile and will come in from other wetland areas, so planting may not be necessary.

Zone 2: Shallow Water Bench (2- 18 inches), fluctuating water

Zone 2 is a bench that is added to wetlands and ponds specifically to allow plants to become established and grow. Emergent wetland plants grow in this zone and are generally limited to long-term permanent water depths of less than 3 feet and more often, 18 inches and less. Species such as Hardstem bulrush can withstand water depths of 8 feet for short periods of time. However, they typically prefer water depths of 10-18 inches. Fluctuating water levels are important for maintaining wetland plant populations, keeping plant vigor high, and allowing for the rapid spread of the plants after planting.

Establishing wetland plants in this zone can provide additional benefits. First, the plants contribute extensive wildlife and fish habitat to the wetland areas. Second, the plants provide resident sites for phytoplankton: a microscopic aquatic plant that significantly reduces nutrients in the water. Third, the plants can also soften the engineered contours of wetlands or ponds and conceal lower water levels caused by water drawdown.

Zone 3: Shallow Water Fringe (0-2 inches), fluctuating water, regularly inundated

Zone 3 is the fringe around the edge of the water in the wetland or pond area. This area is regularly inundated, but will dry out frequently as the water level fluctuates. Although fluctuating water levels makes it difficult to establish plants in this zone, it is critical to have good plant cover so that soil erosion and wave motion are reduced. Wetland plant plugs (as opposed to seed) should be used in this zone. The seed of wetland plants require light to germinate and cannot be covered by soil. If water is introduced into the systems prior to seed germination and rooting, the seed may float and form a ring of plants at water level. Designers should consider diverting water flow until the plants become established.

This zone will support wetland plants and water-tolerant shrubs such as willows, birch, dogwood, and other shrubs. The shrubs provide wildlife habitat and water quality improvement through shade, nutrient uptake and breakdown, and sediment deposition.

Zone 4: Shoreline Fringe, permanent moisture zone, periodically inundated

This zone extends about 1-4 feet horizontally (-2 feet vertically) above the normal pool level. It can be periodically inundated after significant storms or high water events. Water will typically move off of this zone fairly rapidly, so designers should consider this zone characteristic when evaluating design storm frequency. Plants in this zone typically like ”wet feet” and do well under fluctuating water conditions. This zone is saturated for a majority of the growing season except when droughty conditions cause the water level in the wetland or pond to drop below normal levels for an extended period of time. Herbaceous plants should be planted to protect the ground from overland drainage flows moving into the wetland or pond.

Zone 5: Terrace, infrequently inundated

Zone 5 is normally dry but can be inundated by floodwaters that normally drop in one day or less. In general, zone 5 extends from the maximum 2-year water surface elevation to the 10- or 100-year maximum water surface elevation. Plants in this zone should be capable of withstanding occasional inundation and common drought conditions. Supplemental irrigation may be needed to maintain this zone during the hot summer months. The designer should carefully select the herbaceous plants that will grow in this zone because it may be difficult to mow the area because of steep slopes. Woody plants may be used in this zone to discourage waterfowl use.

Zone 6: Upland, seldom or never inundated

This zone is usually above the 100-year water surface elevation and generally does not extend down into the design area. The variety of plants established in this zone can also be used for foothills revegetation and site stabilization. The plants should be selected based on the soil conditions, water schedule potential, and function within the landscape.

Section 3 contains plant tables that list information on grass and grass-like plants, riparian trees and shrubs, and upland trees and shrubs that are suitable for vegetative stormwater BMPs.

Establishment year

Wetland plants can survive in anaerobic soils (soil without oxygen) because they have spongy plant tissue that acts like a straw to bring oxygen from the atmosphere to the root system. The establishment year is the most critical for young pond plants because they need to grow and develop the spongy plant tissue. A mature pond plant can withstand months of total inundation, but young plants will die under the same conditions. Refer to the plant tables in the Section 3 for more information on appropriate plant species for ponds.

Fluctuating water levels for at least the first year are extremely important to successfully establishing a wetland plant community. Fluctuating water levels allow the plants to spread more quickly than if the water level is kept constant. Water levels must be maintained at a maximum of 1-2 inches for the first two months. After that time, 1-2 inches can be added over the next few months. Fluctuating the water level from 2 inches of standing water down to saturated soils will allow the root system to spread and increase chances of plant survival.

Plants

When purchasing plants, always obtain plant plugs that are a minimum of 12- 21 cubic inches. These plants have a much bigger root system and more developed spongy plant tissue. As a result, the plants will withstand wider variations in water depth than small plugs.

Pay particular attention to the wetland plant species when designing the landscape plan. Some species such as sedges and rushes cannot survive in deep water (more than 1-2 inches). Hardstem bulrush can withstand water depths of up to 8 feet for short periods of time, but normal water levels are about 10-18 inches.

2.2 Evaporation Ponds

Selection factors

Evaporation ponds should be stabilized to with vegetation, rock, or other acceptable material to prevent erosion and provide dust control. If vegetation is chosen, use a deep-rooted grass that can withstand extreme water level changes (i.e., long periods of drought and of total inundation). Barrier shrubs, such as barberry, planted around the facility should be considered when there is a possibility that the public could damage the facility or hinder its function. Trees and shrubs should be planted high on the side slopes or above the design stormwater line elevation. Plant trees and shrubs at least 15 feet away from the toe of the slope.

Operation and Maintenance

Grass should be mowed to maintain an average grass height between 3” and 9” depending on site characteristics, Grass clippings should be removed and disposed of properly. Sediment deposition at the head should be removed if grass growth is being inhibited or if the sediment is blocking the entry of water. Annual sediment removal and spot reseeding should be anticipated.

2.3 Vegetative Buffers

Vegetative buffer strips are required around the pond perimeter. Buffer strips will reduce erosion and provide additional sediment and nutrient removal. Native plants should be used instead of introduced plants. Native plants require less maintenance and replacement than plants that are introduced to a region because the native plants have adapted to the climatic conditions. As a result, maintenance costs will be lower with native plants than with introduced plants.

Operation and Maintenance

As the plants become established in the pond, they will need to be inspected periodically to ensure they are thriving. Seeding failures are common during the establishment year, so it is critical that the pond is inspected regularly. Generally, if plants are uniformly distributed, with a minimum amount of weeds or undesirable vegetation, the seeding is establishing properly. Non-native plant species should be monitored carefully since they can quickly invade the area. Seasonal weather conditions will determine the frequency of subsequent inspections.

In addition, ponds will need to be maintained to work properly. Over time, problems such as compaction, overgrown vegetation, and weed infestations will occur and must be corrected. Also, the owner or operator will be required to identify how these problems will be corrected in an Operation and Maintenance (O&M) Plan.

2.4 Biofiltration Systems

Definition

Biofiltration systems include grass buffer strips and swales. Grass buffer strips are uniformly graded and densely vegetated areas of grass or grass-like plants. Swales are a natural or constructed channel that is shaped or graded to specified dimensions and established in suitable vegetation for the stable conveyance and treatment of runoff. Biofiltration systems rely on the use of vegetation to slow runoff velocities, filter sediment and other pollutants, and to improve or maintain water quality.

Design

Flow must be evenly distributed across the entire strip to be most effective. Once flow concentrates to form a channel, the filtering effectiveness is significantly reduced. Select grass or grass mixtures that have stiff upright stems (even after mowing) to promote filtering of sheet flows. Native woody plants may be desirable on channel back slopes and top of bank to improve screening, erosion control, wildlife habitat, space definition, and climate control. Avoid planting woody species in the filtration area. See Table 2 for plant characteristics of common cover types.

Table 2. Vegetal Retardance – Cover type – Biofiltration Swales

n Value Range[1]	Cover	Average Expected Height[2]	Preferred Slope
0.17 – 0.37	Reed canarygrass Creeping Foxtail	20-36”	5-10%
0.1 – 0.31	Smooth bromegrass Reed canarygrass Tall Fescue Grass/legume/forb mix[3]	12 – 20”	<5%
0.06 – 0.27	Redtop Smooth bromegrass Streambank wheatgrass Intermediate wheatgrass Pubescent wheatgrass Western wheatgrass Grass/legume/forb mix[3]	6 - 15”	< 5%
0.05 – 0.2	Kentucky bluegrass Red fescue Intermediate wheatgrass Grass/legume/forb mix[3]	2 – 6”	<5%

[1] n values vary according to product velocity and hydraulic radius (low velocity and shallow flows result in higher Mannings “n”; high velocity and deep flows result in lower Mannings “n”). Refer to SCS-TP-61 “Handbook of Channel Design for Soil and Water Conservation” for experimental results of Vegetal Retardance/VR/Mannings “n” relationships.
[2] During normal critical flow periods, if vegetation has been mowed or flattened due to snow cover, the appropriate n value should be used.
[3] These are bunchgrasses or bunch type legumes and should be used only in seed mixtures and on slopes less than or equal to 5%.

Selection factors

The vegetation selected for a biofiltration swale must have characteristics that provide vegetal retardance of water or a Mannings “n” of between 0.20 and 0.24. For grass bufferstrips, the Mannings “n” must be 0.40. Mannings equation of open channel flow is used to obtain the width of a facility for a given flow, slope, and selected water depth.

Species should be selected on the basis of filtering abilities, inundation tolerance, and soil protection qualities. Local factors that will influence the plant selection are:

- Discharge to be handled - In general, the greater the discharge the more root mass, ground cover, and stiffness of above ground vegetal lining required.

- Gradient - As gradient increases, channeling of the flow is more likely to occur. For this reason, bunchgrasses should not be used on slopes steeper than 5 percent. For slopes above 5 percent, only sod-forming covers should be used on the portion of channel where the main flow occurs.

- Establishment - Ease of establishment and time required to develop a protective cover are extremely important considerations in selecting species. Generally, any type of temporary cover during establishment of permanent cover is better than none at all. Use of temporary cover plantings and geotextile products should be considered. Refer to slope protection and stabilization BMPs (BMP 15 – BMP 27) in Volume 2 of the BMP Catalog.

  If a sod cover is required, as determined by discharge and slope, but is objectionable to the user because of likely spreading, a combination of species may be selected. This type of planting may have, for example, Kentucky bluegrass on the bottom and partially up the sides of biofiltration system and a mix of sod wheatgrass, bunch wheatgrass, and alfalfa or forbs on the upper sides and top of bank.

- Deposition - Deposition may be controlled to some extent by the selection of vegetation. Low, shallow flows encounter very high retardance when flowing through dense sod covers such as reed canarygrass. Dense sod covers keep the flows from channeling and result in low velocities conducive to deposition. Only when the vegetation bends and submerges will high, non-depositional velocities develop. Low growing sod species, bunchgrasses and open covers like alfalfa offer less resistance to shallow flows than dense sod-forming covers, therefore, velocities are higher, owing primarily to development of channeled flow with less deposition. These covers offer less erosion protection than dense sod covers and are limited to flatter slopes.

Operation and Maintenance

As with vegetated buffers, as the plants become established in the biofiltration system, they will need to be inspected periodically to ensure they are thriving. Seeding failures are common during the establishment year, so it is critical that the system is inspected regularly. Generally, if plants are uniformly distributed, with a minimum amount of weeds or undesirable vegetation, the seeding is establishing properly. Seasonal weather conditions and land use activity will determine the frequency of subsequent inspections.

Biofiltration systems will need to be maintained to work properly. Over time, problems such as overgrown vegetation and weed infestations will occur and must be corrected. In addition, the owner or operator will be required to identify how these problems will be corrected in an Operation and Maintenance (O&M) Plan.

2.5 Infiltration systems

General information

Infiltration systems that require incorporation of plant materials include infiltration basins and infiltration swales. An infiltration basin impounds water in a surface pond until it infiltrates the soil. Infiltration basins do not maintain a permanent pool between storm events and should drain within 48-72 hours after a design event. Infiltration swales are vegetated channels designed to retain, treat, and infiltrate stormwater runoff.

Design

The side slopes above infiltration basins and swales should be vegetated to prevent erosion. Additional grass or nonaggressive ground covers are appropriate. Other types of plants materials can also be used. If infiltration swales are to be constructed the following standards apply:

- Up to 15% of the total area of the swale designated for stormwater infiltration may be covered with ground cover plants.
- Up to 10% of the total area of the swale designated for stormwater infiltration may be elevated above the bottom of the swale to allow the planting of trees and shrubs.

If trees and shrubs will be used, plant them on the top perimeter of the side slopes. A spacing of at least 20’ is appropriate for trees planted close to a swale.

Selection factors

Infiltration basins should be stabilized to prevent erosion, minimize sediment transport and plugging, and provide dust control. Vegetating the basin with a deep-rooted grass will provide erosion control and promote infiltration.

Infiltration swales must be grass-covered. Uniformly fine, close-growing, water-tolerant grasses should be used. If sod is chosen to vegetate the basin, select sod that has been grown in permeable soils. Sod grown in clay soils will not be effective because the clay soil can restrict water infiltration reducing the expected infiltration rate of the system. If sod grown in clay soils is the only sod available, ask the grower to wash off the soil from the sod to remove all clay material.

Barrier shrubs, such as barberry, planted around the facility should be considered when there is a possibility that the public could damage the facility or hinder its function. Trees and shrubs should be planted high on the side slopes or above the water line elevation for the design storm. Trees and shrubs should be planted at least 15 feet away from perforated pipes and 25 feet away from a riser structure.

Operation and maintenance

Grass should be mowed to maintain an average grass height between 3” and 9” depending on site characteristics, Grass clippings should be removed and disposed of properly. Sediment deposition at the head should be removed if grass growth is being inhibited or if the sediment is blocking the entry of water. Annual sediment removal and spot reseeding should be anticipated.

Section 3 - Stormwater Plant Materials Tables

The following tables contain information on grass and grass-like plants, riparian trees and shrubs and upland trees and shrubs that are suitable for stormwater management facilities. The tables are to be used as a guide for general planning and planting purposes. Landscape architects and nursery suppliers may be able to provide more information about specific site conditions that are necessary for successfully establishing plants within different hydrologic zones.

Below is a list of some of the information provided in the tables:

- Scientific name – arranged alphabetically; common name is also provided
- Hydrology zones (as described in Section 2.1 above) – indicates the most suitable planting location for successful plant establishment
- Plant indicator status – shows the estimated probability of a species occurring in wetlands or non-wetland areas
- Flood tolerance – used in conjunction with plant indicator status; provides additional information on the plant's ability to withstand the depth or duration of flooding

To access each table, click on the link below.

Table 1. Native Shrubs and Trees
Table 2. Willows for Riparian Areas and Biofiltration Systems
Table 3. Herbaceous Grass and Grass-Like Plants
Table 4. Upland Shrubs and Trees