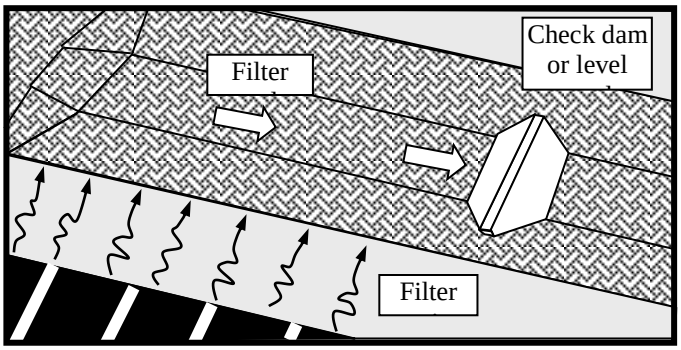
ACTIVITY: Filter Strips and Swales | ST – 05



CITY OF KNOXVILLE

Targeted Constituents				
● Significant Benefit	◗ Partial Benefit	○ Low or Unknown Benefit		
◗ Sediment	◗ Heavy Metals	○ Floatable Materials	◗ Oxygen Demanding Substances	
◗ Nutrients	◗ Toxic Materials	◗ Oil & Grease	○ Bacteria & Viruses	○ Construction Wastes

Description

Filter strips and swales are able to remove some sediments and pollutants from stormwater runoff if correctly designed and constructed. Low velocities, combined with healthy stands of grass vegetation, allow particles to settle out from stormwater runoff. Filter strips can be composed of grass or forest buffer zones, provided that efforts are made to ensure sheet flow to the buffer zone. Generally, a maintained grass filter strip is used to treat sheet flow, and a maintained grass filter swale is used to treat channel flow. This practice will provide a partial reduction in most types of pollutants.

Suitable Applications

- Filter strips and swales are often used in conjunction with other stormwater management practices to treat runoff from paved streets and parking lots.
- Filter strips and swales can also be used to reduce the amount of directly connected impervious area (DCIA) that drains into the storm drainage system, thus reducing peak flows. In addition to pavement areas, this typically can be used for rooftops.

Approach

A filter strip is a relatively flat area of healthy grass vegetation adjacent to or downstream from an impervious surface that may contain pollutants. Or alternatively, a wildgrass or forest buffer zone may function as a filter strip. A filter strip is usually intended for sheet flow from parking lots or streets, unless a level spreader (see ES-26) is used to convert concentrated channel flow into sheet flow. A filter swale is a vegetated channel which is wide and flat, used to slow runoff velocities from impervious surfaces that may contain pollutants. A filter swale is wider than necessary to convey the design storm; it is designed to have much lower velocities than a normal channel or ditch but still drain adequately.

Filter strips and swales perform well for small light-intensity rainfalls, but typically have no effect on the large design rainfalls used for stormwater detention. Since most precipitation occurs during light-intensity rainfalls, filter strips and swales are a major component in improving water quality. Detention basins and constructed wetlands provide water quality treatment both during and between storms for the large design rainfalls. Filter strips and swales should generally be used in combination with other stormwater treatment BMPs whenever possible.

See Figure ST-05-2 for examples of how filter strips and swales can be used in parking lots and residential properties. Since thick and healthy grass vegetation is a part of every landscaped property, filter strips and swales are easy to incorporate into most BMP

strategies. Filter strips and swales have removed as much as 80% of total suspended sediments and 50% of soluble zinc in the metropolitan Washington D.C. area if properly constructed, but have not shown any removal for dissolved phosphorous or copper (reference 77). Other studies have also shown little or no removal for heavy metals, and also generally poor performance due to incorrect construction. California guidelines include a typical size for filter strips equal to 1000 square feet per impervious acre, with a minimum width of 10 feet (reference 32).

The upper layout (Figure 2A - parking lot) shows sheet flow entering a wide swale rather than a gutter or curb inlet. Design considerations include width of swale, the anticipated overhang of vehicles, whether to use wheel stops, and spacing of grate inlets. In general, the grate inlets should flow to a detention basin or other stormwater treatment BMP prior to being discharged to a storm drainage system or natural stream.

The lower layout (Figure 2B – residential property) shows impervious area from rooftops and driveways. Rooftop drainage typically reach ground level via gutters and downspouts, and it is understood that this stormwater should be conveyed at least 5 to 10 feet from the building to avoid wet basements or saturated foundations. However, downspouts should be turned into sheet flow through filter strips whenever possible.

Filter strips and swales may also be used as a temporary erosion control strategy, in conjunction with other erosion control measures. Filter strips and swales are used downstream from erosion control measures that remove most coarse sediment and silts from the stormwater. Also, sod (if properly pegged and stabilized) may be used as part of temporary inlet protection in conjunction with silt fence or straw bale barriers.

Sod Placement

Sodded grass (see ES-09) is preferable to seeded grass vegetation (see ES-08), but either method may be used to establish grass filter strips and swales. Sod has the advantages of immediate erosion control and stormwater treatment, healthier stands of vegetation, aesthetics, less maintenance and less inspection, and increased property values. Refer to Figure ST-05-3 for a relative comparison of various types of turfgrass; information is also available from the UT Agricultural Extension website and office (5th floor of City County Building).

Sod guidelines are explained more fully in ES-09. Protect sod with tarps or other covers during delivery so that it does not dry out between harvesting and placement. Prepare subgrade by removing all weeds and debris, then add fertilizer, lime and water as needed. Place sod in staggered fashion so that there are no long seams. After placing sod, lightly roll to eliminate air pockets and ensure close contact with the soil. After rolling, the sodded areas shall be watered so that the soil is moistened to a minimum depth of 4 inches. Sod should not be planted during very hot or wet weather. Do not place sod on slopes that are greater than 3:1 (H:V) if they are to be mowed.

Filter Strips

A minimum width of 10 feet is recommended for vegetated filter strips at a slope of 1%. Widths of 20 to 30 feet are highly recommended, particularly if the slope is more than 1%. The length of a filter strip is typically the entire length of the adjacent parking lot, street, or building. The use of sod is very beneficial in establishing a filter strip, particularly for small widths such as 10 feet. Limit the width of pavement that drains to a filter strip; typical values should be 50 to 100 feet whenever possible.

Curbs and curb cuts will concentrate flows, so that generally curbs and gutters are not desirable for paved areas with filter strips. Avoid concentrating stormwater runoff on

pavements by ensuring that the pavement slopes and vegetated surface slopes are level or change very gradually. In busy parking lots, even vehicle wheels or parking curb stops may channelize flow in some instances. and can only be overcome by a level spreader. Channelization will reduce the effective treatment area of the filter strip and may erode grass because of excessive velocities. A level speader, check dam or energy dissipator may assist in returning channelized flow back into sheet flow, if designed and constructed properly.

Protect grass filter strips from vehicle traffic; this is typically done with wheel stops made of precast concrete, iron or landscaping timbers. Even heavy foot traffic can compact the topsoil and trample the grass, affecting performance of a filter strip. Design and analyze probably areas of foot traffic, and provide paths and sidewalks that are compatible with the need for grass filter strips. If irregular or uneven areas appear while the vegetation is being established, repair and restore to a smooth and even appearance to prevent concentrating stormwater sheet flows.

Filter Swales

Filter swales are generally grass-lined channels which are wider than necessary for conveyance. Other materials may be incorporated into grass-lined channels, such as a gabion wall along one side of the channel or a concrete swale crossing, provided that overall flow velocities are below 1 foot per second. Typical slopes are generally 1 percent to ensure positive drainage. The average flow depth should not be more than 1 inch, and the maximum flow depth at any point should not be more than 3 inches.

Filter swales are often constructed around parking lots and commercial centers as recessed planters for landscaping. Filter swales in these areas may also incorporate inlets raised 4 to 6 inches above the swale, which may function as first-flush retention volume for pretreatment if infiltration rates are sufficient (typically 0.2 inches per hour observed field rate). Raised inlets should be constructed in a way that appears different and purposeful, so that the flooded median will not appear to be a case of bad drainage design. For instance, the inlets in Figure ST-05-2 may be raised if there is sufficient storage in the median areas to prevent flooding the parking lot. A raised inlet may also be indicated by wetland-type vegetation such as bulrushes, cattails, or sedges.

Filter swales may have level spreaders at the beginning of the swale (see ES-26) or landscape timbers spaced at regular intervals throughout the swale. Landscape timbers can be used to reduce the channel slope and increase residence time within the filter swale. Landscape timbers can also be used as bookends to enclose a "gravel filter", typically 5 to 10 feet long, in the end reach of a swale to trap sediment and pollutants.

The typical channel shape for a filter swale is trapezoidal or parabolic, with side slopes as flat as possible. The swale velocity and flow depth should be determined using Manning's equation and the design parameters included in ES-22, Channel Linings. Typically the velocity is checked for the mowed condition, while the flow depth and capacity are checked for the unmowed condition. Manning's roughness coefficient n depends heavily on the height of grass, so that the mowed and unmowed conditions will yield significantly different velocities and flow depths.

Pollutant Removal Efficiency

Grass swales and ditches should generally be designed for a minimum 10-year storm in order to verify adequate capacity. However, the average mean rainfall is generally used to analyze the total suspended sediment (TSS) removal efficiency, which is shown in Figure ST-05-1 and comes from reference 40. Compute the average flow depth: divide

the cross-sectional flow area by the top width of the water surface. The following three heavy metals can also be estimated based upon the TSS removal efficiency from Figure 4-3:

Copper (Cu) - 60 percent of TSS removal efficiency
Lead (Pb) - 90 percent of TSS removal efficiency
Zinc (Zn) - 50 percent of TSS removal efficiency

In addition, removal efficiencies for grass filter strips and grass buffers can be estimated using Figure ST-05-1. Compute travel time using typical NRCS methods such as the kinematic equation for time of concentration. Then enter the graph with an assumed depth of 0.02 feet (or about 0.25 inches). The effectiveness of a grass filter strip depends heavily upon sheet flow being maintained across the grass surface. This is accomplished by level spreaders and by careful maintenance of the grass surface.

Check dams generally increase the travel time within a swale and remove trash/debris.

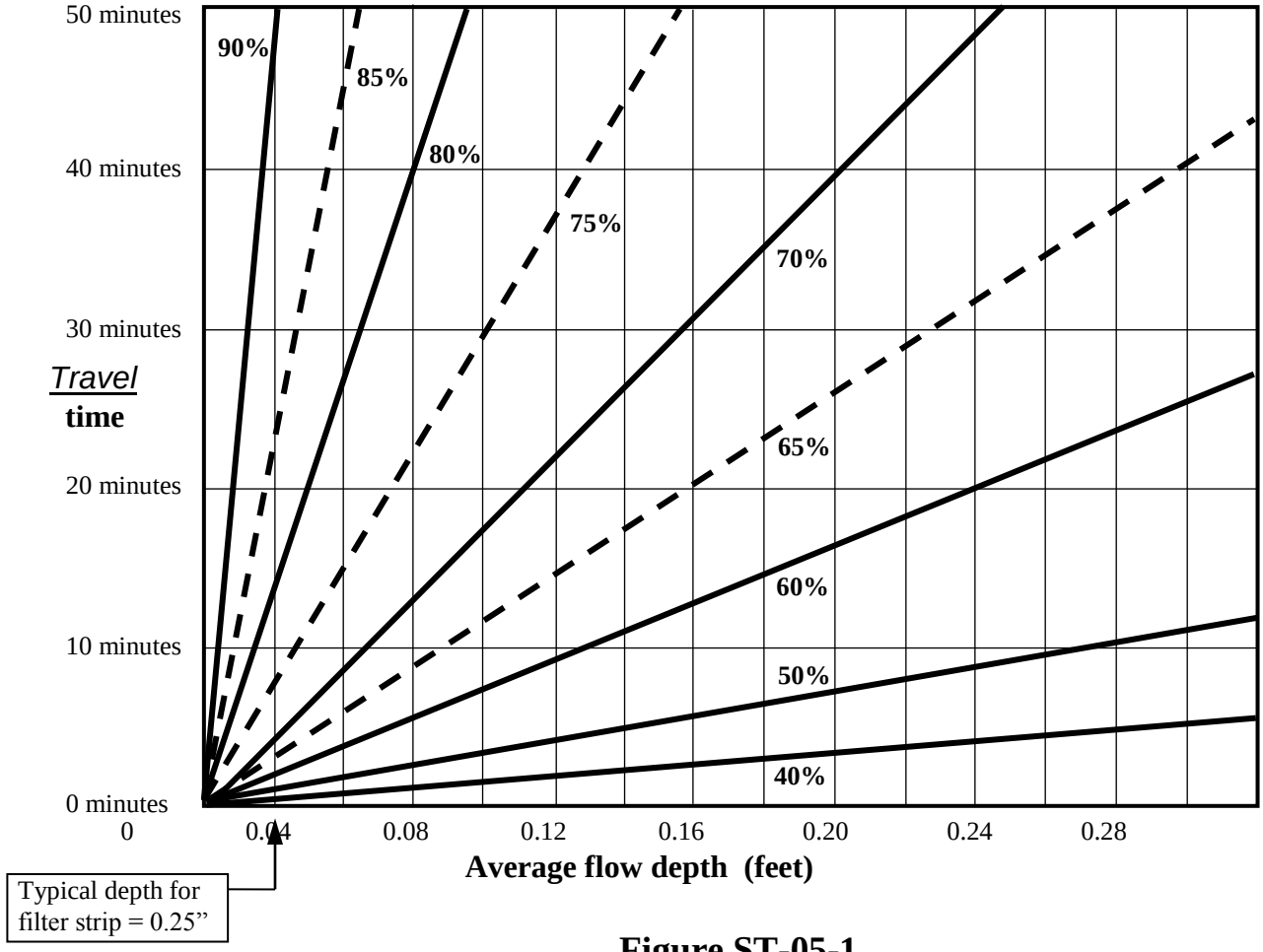


Figure ST-05-1
TSS Removal Efficiency for Grass Swales and Filters

Maintenance

Filter strips and swales should be inspected regularly during the establishment of vegetation. Repair or replace any damage to the sod, vegetation, or evenness of grade as needed. Look for signs of erosion, distressed vegetation or channelization of sheet flow.

- In general, grass vegetation should not be mowed shorter than 3 inches. Maximum recommended length of grass is 6 to 8 inches. Allowing the grass to grow taller may

cause it to thin and become less effective. The clippings should be bagged and removed. Mowing grass regularly promotes growth and pollutant uptake.

- Keep all level spreaders or check dams even and free of debris. Remove sediment by hand with a flat-bottomed shovel during dry periods, leaving as much of the vegetation in place as possible. Reseed or plug any damaged turf or vegetation.

Sediment Removal

- The sediment accumulation rate is dependent on a number of factors such as land use, watershed size, types of industry, nearby construction, etc. The sediment composition should be identified before being removed and disposed.
- Some sediment may contain contaminants for which the Tennessee Department of Environment and Conservation (TDEC) requires special disposal procedures. Consult TDEC - Division of Water Pollution Control (594-6035) if there is any uncertainty about what the sediment contains or if it is known to contain contaminants. Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants are suspected to accumulate.
- Clean sediment can be used as fill material, hole filling, or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm runoff.

Limitations

- Grass filter strips can only treat sheet flow. Curb cuts have the effect of channelizing sheet flow and are not useful in establishing grass filter strips as a stormwater treatment BMP.
- Grass filter strips and swales are effective only on gentle slopes, typically less than 1 or 2 percent. Steeper slopes generally will not receive credit as being a stormwater treatment BMP. Site topography may not allow the use of grass filter strips or swales. Grass swales typically must be very long to accomplish stormwater flow reduction and stormwater quality equal to a detention basin.
- Grass filter strips and swales are useful primarily for small areas only, typically 1 acre or less. Larger project sites or properties can also make effective use of filter strips and swales for smaller subbasins.
- Proper maintenance is required to maintain the health and density of grass vegetation, such as irrigation during summer droughts and adding small amounts of fertilizer or lime as needed.

References

15, 16, 17, 28, 31, 32, 33, 40, 59, 60, 66, 77, 88, 91, 102, 116, 118, 144, 146
(see BMP Manual Chapter 10 for list)

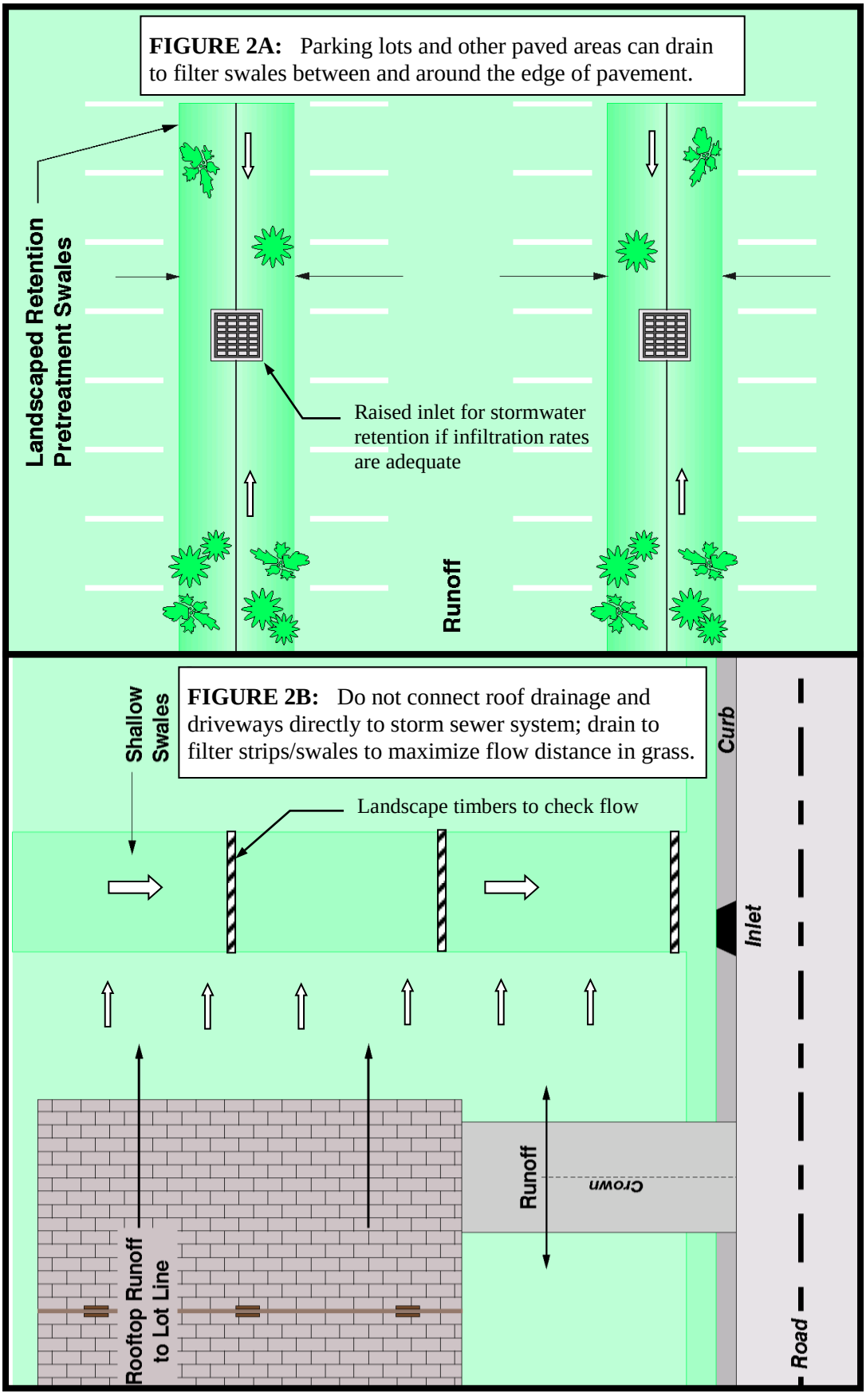
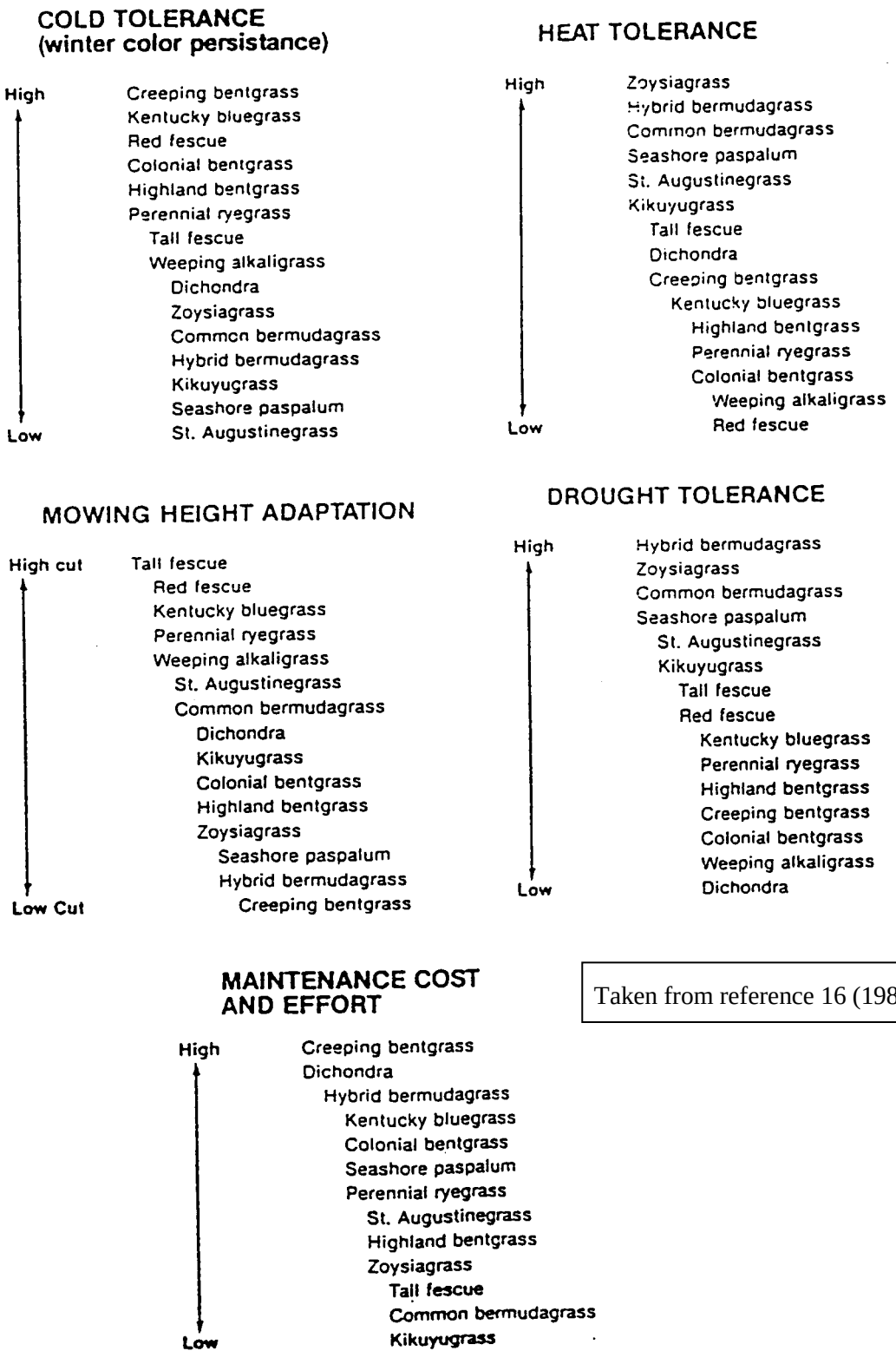


Figure ST-05-2
Examples of Filter Strips and Swales



Taken from reference 16 (1984)

Figure ST-05-3
Characteristics of Various Types of Grass