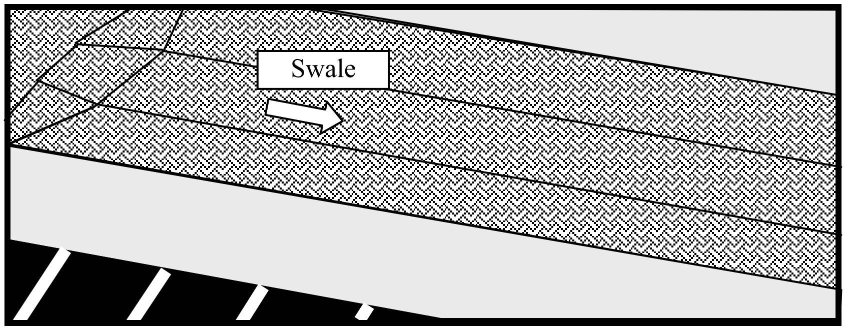
ACTIVITY: Swales

O – 01



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	
Implementation Requirements					
● High		◗ Medium		○ Low	
◗ Capital Costs	◗ O & M Costs	◗ Maintenance		○ Training	

Description

Swales, one type of open channel, are able to remove some sediments and pollutants from stormwater runoff if correctly designed and constructed. They are capable of controlling peak runoff for small design storms and can enhance the water quality of stormwater runoff by infiltration through the subsoil and filtration through the grass. Low velocities, combined with healthy stands of grass vegetation, allow particles to settle and filter out from stormwater runoff. 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.

Selection Criteria

- Swales are often used in conjunction with other stormwater management practices to treat runoff from paved streets and parking lots.
- Grass swales are generally used in low-density residential, commercial, or industrial areas and along roadways to replace curb and gutter installation. Because grass swales are not capable of handling large amounts of runoff, they are not useful in highly urbanized areas.
- 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 applications, swales can be used to drain stormwater from rooftops. Swales reduce runoff volume through increased infiltration potential.

Design and Sizing Considerations

A filter swale is a vegetated open channel which is relatively wide and situated on a mild slope. They are used to slow runoff velocities originating from impervious surfaces that may contain pollutants. A filter swale is designed to have much lower velocities than a normal channel or ditch but still drain adequately. The reader is referred to the theory and practice of design of grass- and vegetation-lined channels by n-VR "retardance method" discussed in Chow (Chow, 1959).

Swales perform well for small light-intensity rainfalls, but typically have little effect on the large design rainfalls used for stormwater detention. Swales help to decrease the velocity of stormwater runoff, which increases its travel time, and thus, its peak flow rate for short, intense storms. Swales can also be used as a component for enhancing stormwater quality, through filtration and directing runoff flows to detention basins and constructed wetlands, which provide water quality treatment both during and between storms for the large design rainfalls. Swales should generally be used in combination with other stormwater treatment BMPs whenever possible.

Figures O-01-2 illustrates 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 most landscaped properties, swales are easy to incorporate into most BMP strategies. 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 (Metropolitan Washington Council of Governments, 1992). Other studies have also shown little or no removal for heavy metals, and also generally poor performance due to incorrect construction.

The upper layout (Figure O-01-2A - 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 O-01-2B – residential property) shows impervious area from rooftops and driveways. Rooftop drainage typically reaches 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.

Swales may be used as a temporary erosion control strategy, in conjunction with other erosion control measures. 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.

Filter swales are generally grass-lined channels wider than that which is 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.

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 O-01-2 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 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. Typically the eroding velocity is checked for the mowed condition, while the flow depth and capacity are checked for the unmowed, higher retardance condition (i.e., SCS n-VR “retardance method”). Channel roughness characteristics depend heavily on the height of grass, so that the mowed and unmowed conditions will yield significantly different velocities and flow depths.

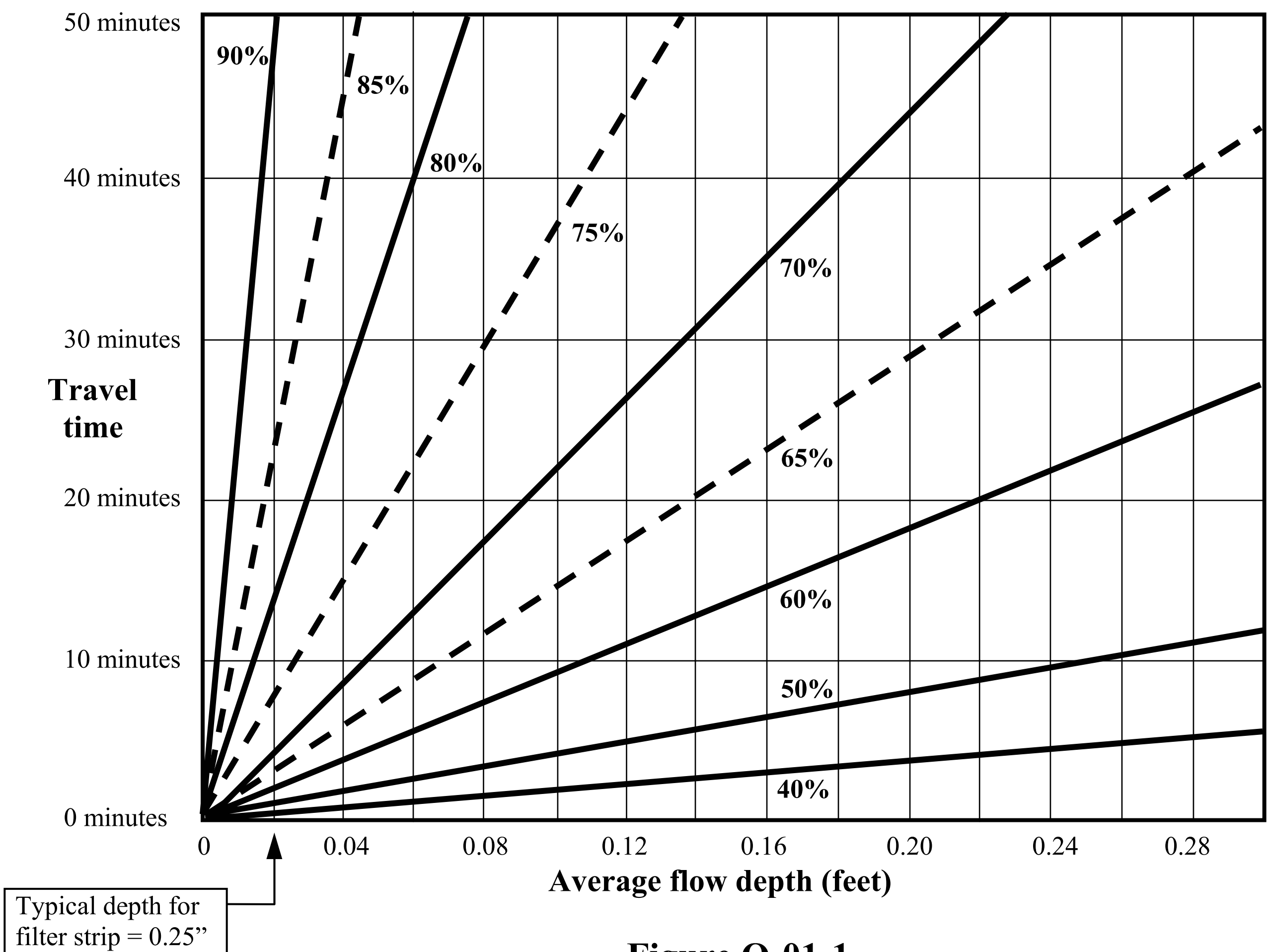


Figure O-01-1
TSS Removal Efficiency for Grass Swales and Filters

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 above in Figure O-01-1 and comes from the Federal Highway Administration.

Other design factors are as follows:

- Check dams can be installed to slow down the flow of runoff, to increase the time for infiltration, and to allow for slightly steeper slopes.

- Long channels (> 200 feet) maximize pollutant removal and increase runoff contact time. The minimum swale length should be 100 feet.
- Channel slopes greater then two percent prevent ponding, and slopes less then five percent help maintain slow velocities within the swale and increase pollution settlement.
- Highly permeable subsoils are beneficial for maximizing infiltration.
- Dense grass in the swale promotes filtration of runoff and pollutant removal.
- Designing for small storms with a peak discharge less than 5 cubic feet per second maximizes performance of the swale and allows for drying between storms.
- Whenever possible, it is good practice to remove high concentrations of oil and grease before entrance into the swale.
- Grass swales function best on highly permeable soils. Infiltration rates of 0.5 inches per hour or more are recommended.
- The bottom width should be between two and ten feet.
- The depth of flow within a grass swale should not exceed the height of the grass, which averages around four inches.
- The bottom of a grass swale should be at least two feet above the water table.
- The longer stormwater runoff is in contact with the grass swale, the greater its pollutant removal capability. Using the appropriate grass cover along with the proper slope, width, and length of swale can greatly increase contact time and pollutant removal. Installing check dams within the grass swale can increase contact time by allowing runoff to pond behind them.
- Grass swales are very susceptible to erosion in highly urbanized areas because of the amount of impervious surfaces.
- Many existing low-density residential, industrial, and commercial areas already have existing grass channels. Retrofitting is possible; however, if the appropriate land area is available. Adding check dams is a good way of improving upon existing grass swales.

Construction/ Inspection Considerations

Swales should not normally be used to carry runoff during construction, since grass swales do not function properly when clogged with sediment.

Sod Placement

Sodded grass is preferable to seeded grass vegetation, but either method may be used to establish grass 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 O-01-3 for a relative comparison of various types of turf grass; information is also available from the UT Agricultural Extension website.

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, and 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 3H:1V if they are to be mowed.

Maintenance

- 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 and debris by hand and 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.
- As with most BMPs, the burden of maintenance falls on the homeowner. Thus, a crucial factor in maintenance is educating the owner on the necessary conditions of a functioning grass swale. They require periodic mowing (again, never mowing too close to the ground), occasional reseeding, watering during drought periods, and sediment removal.
- Minimizing pesticide use on adjacent lawns is important in reducing the chemical pollutants to the water.

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 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.

Cost Considerations

Although grass swales may require more land then curb and gutter installations, they are cheaper to construct. Estimates for cost range between $5 and $15 per linear foot, depending on dimensions, and labor and materials costs.

Limitations

- Swales are effective only on gentle slopes, typically less than 1 or 2 percent. Swales located on steeper slopes generally will not receive credit as being a stormwater treatment BMP. Site topography may not allow the use of swales. Grass swales typically must be very long to accomplish stormwater flow reduction and stormwater quality equal to a detention basin.
- Swales are useful primarily for small areas only, typically 1 acre or less. Larger project sites or properties can also make effective use of swales for smaller subbasins.
- Grass swales are often ineffective in areas with a peak discharge greater than 5 cubic feet per second because water quantity and quality benefits are drastically reduced.
- The groundwater quality could be affected by infiltration through the grass swale. Trace metals and nutrients in the runoff could be increased if leaching from culverts and fertilized lawns occurred.
- Standing water in a grass swale could pose neighborhood safety concerns as well as potential odors and mosquito problems.
- 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.
- If the side slopes of a grass swale are too steep and the flow velocity becomes too great, erosion of the swale can become a problem by adding sediment to the runoff water, reducing infiltration rate, and not providing intended filtration.

  Likewise, if substantial runoff enters a swale during the dry season, inappropriate grass cover could hinder infiltration rates and reduce the effectiveness of the swale.
- Runoff from fertilized lawns into the swale system could increase the pollutant load.

Additional Information

Examples illustrating swale applications are shown in the following figures.

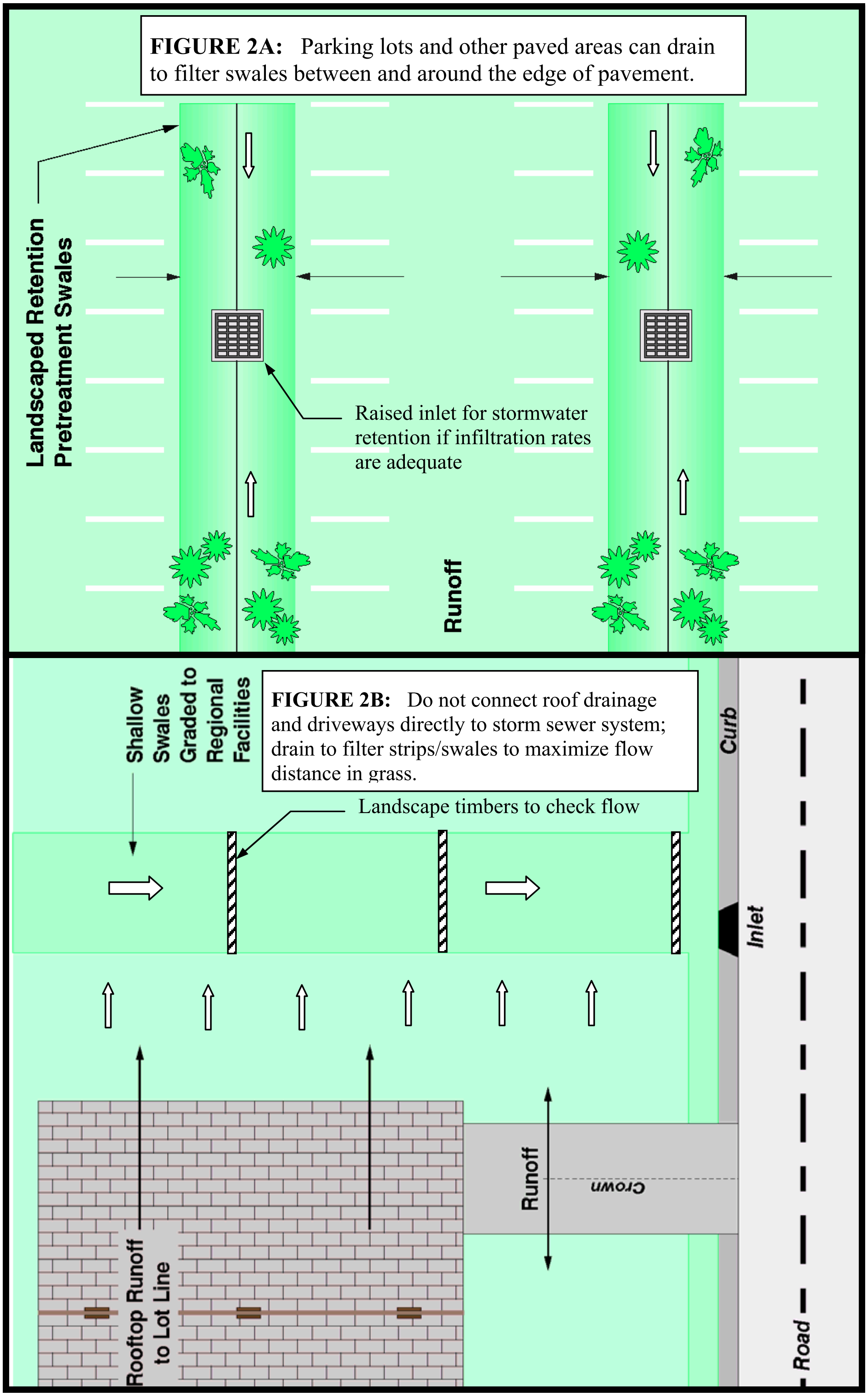


Figure O-01-2
Examples of Filter Strips and Swales

COLD TOLERANCE (winter color persistance)

High
- Creeping bentgrass
- Kentucky bluegrass
- Red fescue
- Colonial bentgrass
- Highland bentgrass
- Perennial ryegrass
- Tall fescue
- Weeping alkaligrass
- Dichondra
- Zoysiagrass
- Common bermudagrass
- Hybrid bermudagrass
- Kikuyugrass
- Seashore paspalum
- St. Augustinegrass

Low

HEAT TOLERANCE

High
- Zoysiagrass
- Hybrid bermudagrass
- Common bermudagrass
- Seashore paspalum
- St. Augustinegrass
- Kikuyugrass
- Tall fescue
- Dichondra
- Creeping bentgrass
- Kentucky bluegrass
- Highland bentgrass
- Perennial ryegrass
- Colonial bentgrass
- Weeping alkaligrass
- Red fescue

Low

MOWING HEIGHT ADAPTATION

High cut
- Tall fescue
- Red fescue
- Kentucky bluegrass
- Perennial ryegrass
- Weeping alkaligrass
- St. Augustinegrass
- Common bermudagrass
- Dichondra
- Kikuyugrass
- Colonial bentgrass
- Highland bentgrass
- Zoysiagrass
- Seashore paspalum
- Hybrid bermudagrass
- Creeping bentgrass

Low Cut

DROUGHT TOLERANCE

High
- Hybrid bermudagrass
- Zoysiagrass
- Common bermudagrass
- Seashore paspalum
- St. Augustinegrass
- Kikuyugrass
- Tall fescue
- Red fescue
- Kentucky bluegrass
- Perennial ryegrass
- Highland bentgrass
- Creeping bentgrass
- Colonial bentgrass
- Weeping alkaligrass
- Dichondra

Low

MAINTENANCE COST AND EFFORT

High
- Creeping bentgrass
- Dichondra
- Hybrid bermudagrass
- Kentucky bluegrass
- Colonial bentgrass
- Seashore paspalum
- Perennial ryegrass
- St. Augustinegrass
- Highland bentgrass
- Zoysiagrass
- Tall fescue
- Common bermudagrass
- Kikuyugrass

Low

Taken from California Cooperative Agricultural Extension (1984)

Figure O-01-3
Characteristics of Various Types of Grass

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