



March 15, 2024

Mr. Bobby Weidmann  
City of Lone Tree, Planning Department  
9220 Kimmer Drive  
Lone Tree, Colorado 80124

Re: SIP Drainage Conformance Letter  
Jack's Restaurant  
9155 Park Meadows Drive  
DEC No. 105616

Dear Bobby:

The referenced site was formerly a Mimi's Café but that building has now been demolished. The proposed building will be a fine-dining restaurant with approximately 15,000 square feet divided between two stories. The parking and drives are expected to remain without modification. Pavement and grading for the parking area has no significant changes from a runoff perspective. Rainfall will continue to sheet flow across pavement areas to a flume near the northwest corner of the property. Time of concentration and runoff coefficient will remain unchanged. Flows will continue to drain into a shared detention pond that serves the shopping center.

Based on the plans for the commercial center of which this site is a part, the design runoff coefficient was 0.76 for a 5 year event and 0.82 for a 100 year event. The proposed impervious area of the site is 72.9% which is a slight reduction in runoff quantity and larger area for potential infiltration and quality improvement.

The site has generally two discharge points which is an underground conduit connection to the city system, which then drains to an existing off-site pond, and a surface flow condition to an open-air pond within the commercial center development surrounding the site. It is understood that the off-site pond does not currently have a quality treatment component; however, the runoff to this location is restricted to roof drainage only. The proposed roofing material is metal and a synthetic membrane which provide a stable, non-erodible surface. The two-story structure with gabled roofing will also minimize, if not eliminate, any capture of organics that may fall from trees. It is therefore requested that this runoff be allowed to release directly into the conveyance system without further treatment.

The remainder of the site will surface flow to the adjacent pond. Because almost all of the pavement areas are being retained and minimal landscape grading is available due to preservation of the existing trees, treatment options are limited. New sidewalk areas are being graded to slope toward landscape areas that will be graded with a gradual slope to promote infiltration similar to the effect of a grass swale. It is assumed that an underdrain will not be required or effective; however, plant selections will be made with

March 15, 2024  
Jacks Restaurant SIP Project Narrative  
DEC Job No. 105616



the intention of slowing conveyance and promoting solids removal. Additional measures will be provided where plausible during final design calculations.

Overall the proposed project will not increase any water quality conditions or create any new concerns. Detailed area and flow calculations can be provided with technical review but please consider the design elements above for approval of this SIP package.

Sincerely,

A handwritten signature in blue ink that reads 'Daniel Stewart'. The signature is written in a cursive, flowing style.

Daniel Stewart, P.E.  
Project Engineer  
Development Engineering Consultants, LLC

## Description

Grass swales are densely vegetated trapezoidal or triangular channels with low-pitched side slopes designed to convey runoff slowly. Grass swales have low longitudinal slopes and broad cross-sections that convey flow in a slow and shallow manner, thereby facilitating sedimentation and filtering (straining) while limiting erosion. Berms or check dams may be incorporated into grass swales to reduce velocities and encourage settling and infiltration. When using berms, an underdrain system should be provided. Grass swales are an integral part of the Low Impact Development (LID) concept and may be used as an alternative to a curb and gutter system.



**Photograph GS-1.** This grass swale provides treatment of roadway runoff in a residential area. Photo courtesy of Bill Ruzzo.

## Site Selection

Grass swales are well suited for sites with low to moderate slopes. Drop structures or other features designed to provide the same function as a drop structures (e.g., a driveway with a stabilized grade differential at the downstream end) can be integrated into the design to enable use of this BMP at a broader range of site conditions. Grass swales provide conveyance so they can also be used to replace curb and gutter systems making them well suited for roadway projects.

## Designing for Maintenance

Recommended ongoing maintenance practices for all BMPs are provided in Chapter 6 of this manual. During design, the following should be considered to ensure ease of maintenance over the long-term:

- Consider the use and function of other site features so that the swale fits into the landscape in a natural way. This can encourage upkeep of the area, which is particularly important in residential areas where a loss of aesthetics and/or function can lead to homeowners filling in and/or piping reaches of this BMP.

Grass Swale	
<b>Functions</b>	
LID/Volume Red.	Yes
WQCV Capture	No
WQCV+Flood Control	No
Fact Sheet Includes EURV Guidance	No
<b>Typical Effectiveness for Targeted Pollutants<sup>3</sup></b>	
Sediment/Solids	Good
Nutrients	Moderate
Total Metals	Good
Bacteria	Poor
<b>Other Considerations</b>	
Life-cycle Costs	Low
<sup>3</sup> Based primarily on data from the International Stormwater BMP Database ( <a href="http://www.bmpdatabase.org">www.bmpdatabase.org</a> ).	

- Provide access to the swale for mowing equipment and design sideslopes flat enough for the safe operation of equipment.
- Design and adjust the irrigation system (temporary or permanent) to provide appropriate water for the selected vegetation.
- An underdrain system will reduce excessively wet areas, which can cause rutting and damage to the vegetation during mowing operations.
- When using an underdrain, do not put a filter sock on the pipe. This is unnecessary and can cause the slots or perforations in the pipe to clog.

## Design Procedure and Criteria

The following steps outline the design procedure and criteria for stormwater treatment in a grass swale. Figure GS-1 shows trapezoidal and triangular swale configurations.

1. **Design Discharge:** Determine the 2-year flow rate to be conveyed in the grass swale under fully developed conditions. Use the hydrologic procedures described in the *Runoff* Chapter in Volume 1.
2. **Hydraulic Residence Time:** Increased hydraulic residence time in a grass swale improves water quality treatment. Maximize the length of the swale when possible. If the length of the swale is limited due to site constraints, the slope can also be decreased or the cross-sectional area increased to increase hydraulic residence time.
3. **Longitudinal Slope:** Establish a longitudinal slope that will meet Froude number, velocity, and depth criteria while ensuring that the grass swale maintains positive drainage. Positive drainage can be achieved with a minimum 2% longitudinal slope or by including an underdrain system (see step 8). Use drop structures as needed to accommodate site constraints. Provide for energy dissipation downstream of each drop when using drop structures.
4. **Swale Geometry:** Select geometry for the grass swale. The cross section should be either trapezoidal or triangular with side slopes not exceeding 4:1 (horizontal: vertical), preferably flatter. Increase the wetted area of the swale to reduce velocity. Lower velocities result in improved pollutant removal efficiency and greater volume reduction. If one or both sides of the grass swale are also to be used as a grass buffer, follow grass buffer criteria.

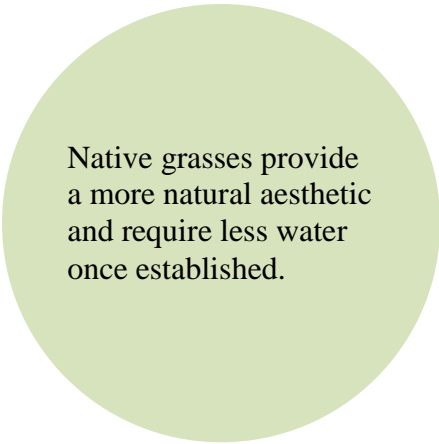
## Benefits

- Removal of sediment and associated constituents through filtering (straining)
- Reduces length of storm sewer systems in the upper portions of a watershed
- Provides a less expensive and more attractive conveyance element
- Reduces directly connected impervious area and can help reduce runoff volumes.

## Limitations

- Requires more area than traditional storm sewers.
- Underdrains are recommended for slopes under 2%.
- Erosion problems may occur if not designed and constructed properly.

5. **Vegetation:** Select durable, dense, and drought tolerant grasses. Turf grasses, such as Kentucky bluegrass, are often selected due to these qualities<sup>1</sup>. Native turf grasses may also be selected where a more natural look is desirable. This will also provide the benefit of lower irrigation requirements, once established. Turf grass is a general term for any grasses that will form a turf or mat as opposed to bunch grass, which will grow in clumplike fashion. Grass selection should consider both short-term (for establishment) and long-term maintenance requirements, given that some varieties have higher maintenance requirements than others. Follow criteria in the *Revegetation* Chapter of Volume 2, with regard to seed mix selection, planting, and ground preparation.
6. **Design Velocity:** Maximum flow velocity in the swale should not exceed one foot per second. Use the Soil Conservation Service (now the NRCS) vegetal retardance curves for the Manning coefficient (Chow 1959). Determining the retardance coefficient is an iterative process that the UD-BMP workbook automates. When starting the swale vegetation from sod, curve "D" (low retardance) should be used. When starting vegetation from seed, use the "E" curve (very low vegetal retardance).
7. **Design Flow Depth:** Maximum flow depth should not exceed one foot at the 2-year peak flow rate. Check the conditions for the 100-year flow to ensure that drainage is being handled without flooding critical areas, structures, or adjacent streets.



**Table GS-1. Grass Swale Design Summary for Water Quality**

Design Flow	Maximum Froude Number	Maximum Velocity	Maximum Flow Depth
2-year event	0.5	1 ft/s	1 ft

### Use of Grass Swales

Vegetated conveyance elements provide some benefit in pollutant removal and volume reduction even when the geometry of the BMP does not meet the criteria provided in this Fact Sheet. These criteria provide a design procedure that should be used when possible; however, when site constraints are limiting, vegetated conveyance elements designed for stability are still encouraged.

<sup>1</sup> Although Kentucky bluegrass has relatively high irrigation requirements to maintain a lush, green aesthetic, it also withstands drought conditions by going dormant. Over-irrigation of Kentucky bluegrass is a common problem along the Colorado Front Range. It can be healthy, although less lush, with much less irrigation than is typically applied.

8. **Underdrain:** An underdrain is necessary for swales with longitudinal slopes less than 2.0%. The underdrain can drain directly into an inlet box at the downstream end of the swale, daylight through the face of a grade control structure or continue below grade through several grade control structures as shown in Figure GS-1.

The underdrain system should be placed within an aggregate layer. If no underdrain is required, this layer is not required. The aggregate layer should consist of an 8-inch thick layer of CDOT Class C filter material meeting the gradation in Table GS-2. Use of CDOT Class C Filter material with a slotted pipe that meets the slot dimensions provided in Table GS-3 will eliminate the need for geotextile fabrics. Previous versions of this manual detailed an underdrain system that consisted of a 3- to 4-inch perforated HDPE pipe in a one-foot trench section of AASHTO #67 coarse aggregate surrounded by geotextile fabric. If desired, this system continues to provide an acceptable alternative for use in grass swales. Selection of the pipe size may be a function of capacity or of maintenance equipment. Provide cleanouts at approximately 150 feet on center.

**Table GS-2. Gradation Specifications for Class C Filter Material**  
(Source: CDOT Table 703-7)

Sieve Size	Mass Percent Passing Square Mesh Sieves
19.0 mm (3/4")	100
4.75 mm (No. 4)	60 – 100
300 μm (No. 50)	10 – 30
150 μm (No. 100)	0 – 10
75 μm (No. 200)	0 - 3

**Table GS-3. Dimensions for Slotted Pipe**

Pipe Diameter	Slot Length <sup>1</sup>	Maximum Slot Width	Slot Centers <sup>1</sup>	Open Area <sup>1</sup> (per foot)
4"	1-1/16"	0.032"	0.413"	1.90 in <sup>2</sup>
6"	1-3/8"	0.032"	0.516"	1.98 in <sup>2</sup>

<sup>1</sup> Some variation in these values is acceptable and is expected from various pipe manufacturers. Be aware that both increased slot length and decreased slot centers will be beneficial to hydraulics but detrimental to the structure of the pipe.

9. **Soil preparation:** Poor soil conditions often exist following site grading. When the section includes an underdrain, provide 4 inches of sandy loam at the invert of the swale extending up to the 2-year water surface elevation. This will improve infiltration and reduce ponding. For all sections, encourage establishment and long-term health of the bottom and side slope vegetation by properly preparing the soil. If the existing site provides a good layer of topsoil, this should be striped, stockpiled, and then replaced just prior to seeding or placing sod. If not available at the site, topsoil can be imported or the existing soil may be amended. Inexpensive soil tests can be performed following rough grading, to determine required soil amendments. Typically, 3 to 5 cubic yards of soil amendment per 1,000 square feet, tilled 4 to 6 inches into the soil is required in order for vegetation to thrive, as well as to enable infiltration of runoff.
10. **Irrigation:** Grass swales should be equipped with irrigation systems to promote establishment and survival in Colorado's semi-arid environment. Systems may be temporary or permanent, depending on the type of grass selected. Irrigation practices have a significant effect on the function of the grass swale. Overwatering decreases the permeability of the soil, reducing the infiltration capacity of the soil and contributing to nuisance baseflows. Conversely, under watering may result in delays in establishment of the vegetation in the short term and unhealthy vegetation that provides less filtering (straining) and increased susceptibility to erosion and riling over the long term.

## Construction Considerations

Success of grass swales depends not only on a good design and maintenance, but also on construction practices that enable the BMP to function as designed. Construction considerations include:

- Perform fine grading, soil amendment, and seeding only after upgradient surfaces have been stabilized and utility work crossing the swale has been completed.
- Avoid compaction of soils to preserve infiltration capacities.
- Provide irrigation appropriate to the grass type.
- Weed the area during the establishment of vegetation by hand or mowing. Mechanical weed control is preferred over chemical weed killer.
- Protect the swale from other construction activities.
- When using an underdrain, ensure no filter sock is placed on the pipe. This is unnecessary and can cause the slots or perforations in the pipe to clog.



**Photograph GS-2.** This community used signage to mitigate compaction of soils post-construction. Photo courtesy of Nancy Styles.

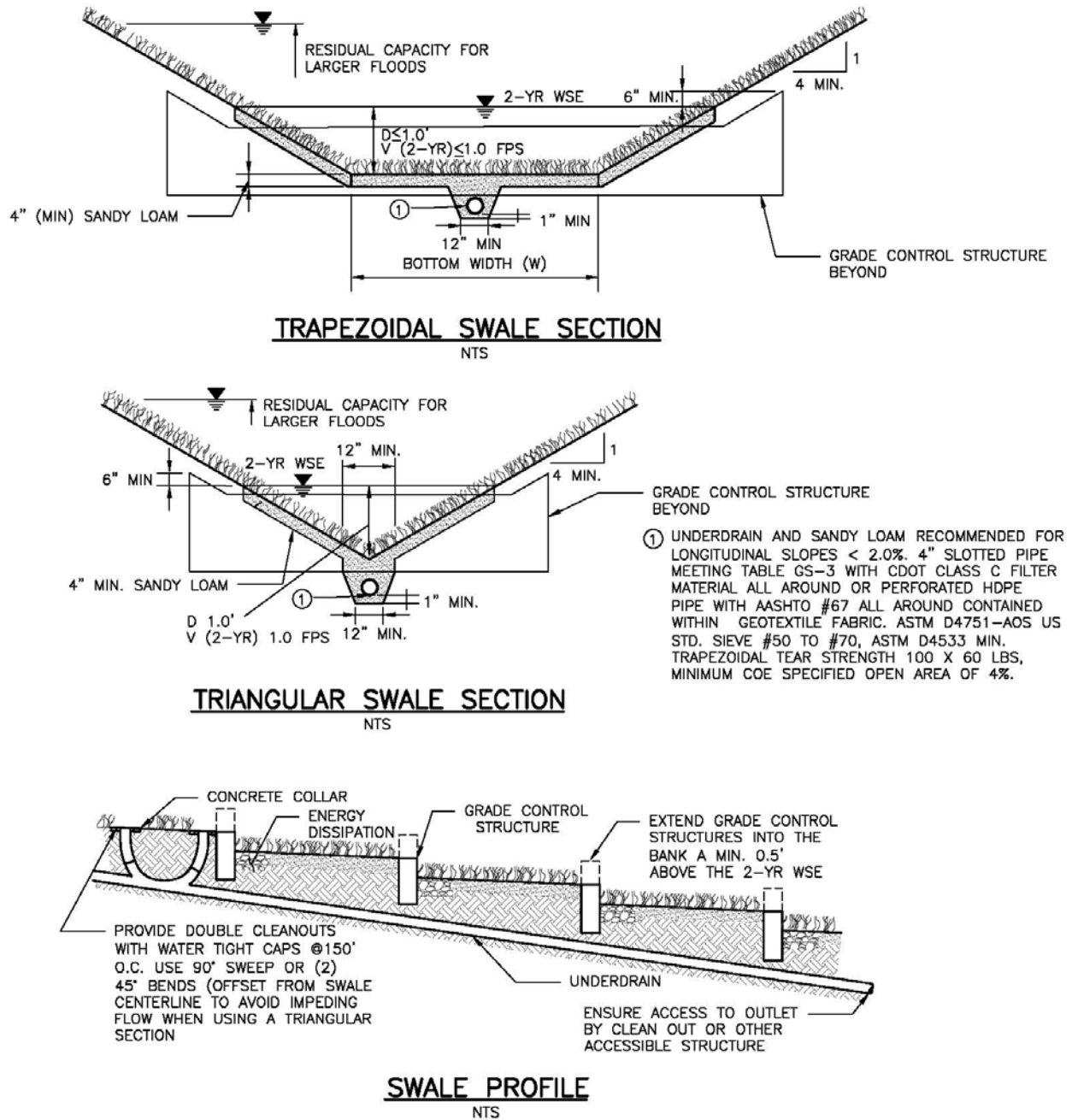


Figure GS-1. Grass Swale Profile and Sections

## Design Example

The *UD-BMP* workbook, designed as a tool for both designer and reviewing agency is available at [www.udfcd.org](http://www.udfcd.org). This section provides a completed design form from this workbook as an example.



**Design Procedure Form: Grass Swale (GS)**

Sheet 1 of 1

**Designer:** M. Levine  
**Company:** BMP Inc.  
**Date:** November 24, 2010  
**Project:** Filing 30  
**Location:** Swale between north property line and 52nd Ave.

1. Design Discharge for 2-Year Return Period	$Q_2 = \underline{4.00} \text{ cfs}$
2. Hydraulic Residence Time A) : Length of Grass Swale B) Calculated Residence Time (based on design velocity below)	$L_S = \underline{400.0} \text{ ft}$ $T_{HR} = \underline{6.7} \text{ minutes}$
3. Longitudinal Slope (vertical distance per unit horizontal) A) Available Slope (based on site constraints) B) Design Slope	$S_{avail} = \underline{0.020} \text{ ft / ft}$ $S_D = \underline{0.010} \text{ ft / ft}$
4. Swale Geometry A) Channel Side Slopes (Z = 4 min., horiz. distance per unit vertical) B) Bottom Width of Swale (enter 0 for triangular section)	$Z = \underline{4.00} \text{ ft / ft}$ $W_B = \underline{4.00} \text{ ft}$
5. Vegetation A) Type of Planting (seed vs. sod, affects vegetal retardance factor)	Choose One _____ <input type="radio"/> Grass From Seed <input checked="" type="radio"/> Grass From Sod
6. Design Velocity (1 ft / s maximum)	$V_2 = \underline{1.00} \text{ ft / s}$
7. Design Flow Depth (1 foot maximum) A) Flow Area B) Top Width of Swale C) Froude Number (0.50 maximum) D) Hydraulic Radius E) Velocity-Hydraulic Radius Product for Vegetal Retardance F) Manning's n (based on SCS vegetal retardance curve D for sodded grass) G) Cumulative Height of Grade Control Structures Required	$D_2 = \underline{0.62} \text{ ft}$ $A_2 = \underline{4.0} \text{ sq ft}$ $W_T = \underline{9.0} \text{ ft}$ $F = \underline{0.26}$ $R_H = \underline{0.44}$ $VR = \underline{0.44}$ $n = \underline{0.088}$ $H_D = \underline{4.00} \text{ ft}$
8. Underdrain (Is an underdrain necessary?)	Choose One _____ <input checked="" type="radio"/> YES <input type="radio"/> NO <span style="color: blue; font-weight: bold; font-size: small;">AN UNDERDRAIN IS REQUIRED IF THE DESIGN SLOPE &lt; 2.0%</span>
9. Soil Preparation (Describe soil amendment)	Till 5 CY of compost per 1000 SF to a depth of 6 inches.
10. Irrigation	Choose One _____ <input checked="" type="radio"/> Temporary <input type="radio"/> Permanent

Notes: \_\_\_\_\_

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**References**

Chow, Ven Te. 1959. *Open Channel Flow*. McGraw Hill: New York, NY.