MIDS Credits: Swales

MIDS Work Group
March 15, 2013
Outline

• Review:
  – Credit Process
  – Calculator
  – Draft Drawings
Swale Credit Process

• Step 1: Break swales into components
  – Side slope
  – Main channel
    • Dry swale
    • Dry swale with an under drain
    • Wet swale
Swale Credit Process
Treat side slopes as individual BMP and route to 1 of the 3 main channel configurations

- Watershed Area
- Swale Side Slope
  - Bioretention Basin outflow
  - Dry Swale - Main Channel
  - Dry Swale w/ underdrain - Main Channel
  - Wet Swale - Main Channel
Swale Credit Process

• Step 2: Use modeling to determine annual volume reductions
Swale Credit Process
Side Slope annual modeling

- Use P8
- Run 58 years of Twin Cities precipitation
- Parameters (384 model runs)
  - Slope (Side Slope): 3H:1V, 4H:1V, 5H:1V
  - Flow path length: 10, 20, 30, 50 ft
  - Infiltration rate: 0.2, 0.6, 1.0, 1.6 in/hr
  - Impervious area/side slope area: 1, 3, 7
  - Manning’s n: 0.25 (short grass), 0.35 (high grass)
Swale Credit Process
Main channel annual modeling

• Use P8
• Run 58 years of Twin Cities precipitation
• Parameters (total of 432 model runs)
  – Channel slope: 1%, 2%, 3%, 4%
  – Infiltration rate: 0.2, 0.6, 1.0, 1.6 in/hr
  – Impervious Area/Channel Area: 5, 20, 40
  – Manning's n: 0.25 (short grass), 0.35 (high grass)
  – Bottom Width: 4, 8 ft
  – Channel Length: 150, 300, 700 ft
Swale Credit Process

Modeling Procedure

• Run model simulations
• Develop relationship between volume reduction and design parameters using multivariate regression analysis
• Use relationship to calculate annual volume reduction percentage in calculator
Swale Credit Process
Modeling Process Results
Side Slope Annual Volume Reduction by Parameter

\[
y = -4.6481x^2 + 22.687x - 0.0635 \\
R^2 = 0.4358
\]

\[
y = -0.2139x + 20.203 \\
R^2 = 0.011
\]

\[
y = 0.4475x + 2.3124 \\
R^2 = 0.3472
\]

\[
y = -0.2139x + 20.203 \\
R^2 = 0.011
\]

\[
y = 38.214x + 3.1547 \\
R^2 = 0.0289
\]

\[
y = -3.496\ln(x) + 19.254 \\
R^2 = 0.099
\]
Swale Credit Process

• Step 3: Annual volume reduction are converted to event reductions using performance curves
Swale Credit Process

Use performance goal curves to calculate Performance Goal reductions

Note: Performance curve is for a 10 acre site, 30% impervious
Calculator Overview
Calculator Parameters

- Side Slope (3:1, 4:1, 5:1, 6:1 ....)
- Flow Path Length (ft)
- Side Slope Length (ft)
- Soil Type
- Manning’s n of vegetation (0.25 – mowed turf, 0.35 - native grass)
Calculator Overview
Side Slope

• Use parameters to calculate % annual volume reduction based on modeling relationship

• Use performance goal curve to convert % annual volume reduction to event volume reduction

• Route remaining runoff to one of three main channel configurations

• Pollutant removal will be applied based on main channel configuration

• Restriction: Watershed flow must be routed as sheet flow over side slope to obtain credit
Calculator Overview
Dry Swale - Main Channel

- Volume reduction calculated using 3 components
  - Grass Channel
  - Check Dam
  - Bioretention Base

Top width at check dam ($W_T$)
Depth at check dam ($D_{CD}$)
Depth of Bioretention Base ($D_{BB}$)
Bottom width ($W_B$)
Channel Length ($L_C$)
Slope ($S$)
Grass Channel Volume Reduction

• Calculator Parameters
  – Channel Length ($L_C$)
  – Bottom width ($W_B$)
  – Channel Slope ($S$)
  – Soil type
  – Manning’s $n$ of vegetation
    (0.25: mowed turf, 0.35: native grass)
• Use parameters to calculate % annual volume reduction based on modeling relationship

• Use performance goal (PG) curves to convert % annual volume reduction to event volume reduction
Calculator Overview

Check Dam Volume Reduction

• Calculate volume of water held behind check dam

• Parameters:
  – Channel width ($W_B$)
  – Top width of check dam ($W_T$)
  – Depth of check dam ($D_{CD}$)
  – Channel slope (%)
Calculator

Bioretention Base Volume Reduction

• Calculate the volume of water that can be held in the pore spaces of the bioretention base

Parameters

– Depth of bioretention base ($D_{BB}$)
– Channel length ($L_C$)
– Channel width ($W_B$)
– Porosity ($n$)
Final Credit Calculation: Dry Swale – Main Channel

- **Grass Channel**
  - Calculate PG volume reduction from modeling

- **Grass Channel with check dam**
  - Calculate PG volume reduction from modeling
  - Add water volume stored behind check dam

- **Dry Swale with bioretention base**
  - Calculate water stored in pore space of bioretention base

- **Dry Swale with bioretention base and check dam**
  - Calculate water stored in pore space of bioretention base
  - Add water volume stored behind check dam
Dry Swale – Main Channel with an Underdrain

- No volume reduction
- With or without a check dam
- 36% Particulate P reduction\(^1\)
- 68% TSS reduction\(^1\)
- 0% Dissolved P reduction unless iron enhanced

Wet Swale – Main Channel

• No Volume Reduction

• 0% Particulate P reduction\(^1\)

• 68% TSS reduction\(^1\)

• 0% dissolved P reduction unless iron enhanced

Credit Example 1a: Road Side/Highway Grass Channel

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious Area</td>
<td>2 acres</td>
</tr>
<tr>
<td>Channel length</td>
<td>1320 ft</td>
</tr>
<tr>
<td>Side slope flow path</td>
<td>10 ft</td>
</tr>
<tr>
<td>Side slope</td>
<td>4:1 (25%)</td>
</tr>
<tr>
<td>Swale bottom width</td>
<td>5 ft</td>
</tr>
<tr>
<td>Channel slope</td>
<td>2 %</td>
</tr>
<tr>
<td>Manning’s n</td>
<td>0.35 (long grass)</td>
</tr>
</tbody>
</table>

MIDS Performance Goal Credit:
Type A soils (1.6 in/hr) = 34%
Type B soils (0.6 in/hr) = 23%
Type C soils (0.2 in/hr) = 17%
Credit Example 1a: Road Side/Highway Grass Channel

<table>
<thead>
<tr>
<th>Soils &amp; Infiltration Rate</th>
<th>MIDS Performance Goal Credit</th>
<th>Annual Volume Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1.6 in/hr)</td>
<td>34%</td>
<td>77%</td>
</tr>
<tr>
<td>B (0.6 in/hr)</td>
<td>23%</td>
<td>51%</td>
</tr>
<tr>
<td>C (0.2 in/hr)</td>
<td>17%</td>
<td>35%</td>
</tr>
</tbody>
</table>
Credit Example 1b: Road Side/Highway Dry Swale (Bioretention Base)

Instead of grass channel add bioretention base to previous example

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of bioretention base</td>
<td>2 ft</td>
</tr>
<tr>
<td>Porosity of media</td>
<td>0.4</td>
</tr>
</tbody>
</table>

MIDS Performance Goal Credit = 68%
Credit Example 1b: Road Side/Highway Dry Swale (Bioretention Base)

<table>
<thead>
<tr>
<th>Soil &amp; Infiltration rate</th>
<th>MIDS Performance Goal Credit</th>
<th>Annual Volume Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1.6 in/hr)</td>
<td>68%</td>
<td>93%</td>
</tr>
<tr>
<td>B (0.6 in/hr)</td>
<td>67%</td>
<td>85%</td>
</tr>
<tr>
<td>C (0.2 in/hr)</td>
<td>66%</td>
<td>81%</td>
</tr>
</tbody>
</table>
Credit Example 2a: Parking Lot Grass Channel

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impervious Area</td>
<td>2 acres</td>
</tr>
<tr>
<td>Channel length</td>
<td>363 ft</td>
</tr>
<tr>
<td>Side slope flow path</td>
<td>10 ft</td>
</tr>
<tr>
<td>Side slope</td>
<td>4:1 (25%)</td>
</tr>
<tr>
<td>Swale bottom width</td>
<td>5 ft</td>
</tr>
<tr>
<td>Channel slope</td>
<td>2 %</td>
</tr>
<tr>
<td>Manning’s n</td>
<td>0.35 (long grass)</td>
</tr>
</tbody>
</table>

MIDS Performance Goal Credit:
Type A soils (1.6 in/hr) = 11%
Type B soils (0.6 in/hr) = 6%
Type C soils (0.2 in/hr) = <1%
Credit Example 2a: Parking Lot Grass Channel

<table>
<thead>
<tr>
<th>Soils &amp; Infiltration Rate</th>
<th>MIDS Performance Goal Credit</th>
<th>Annual Volume Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1.6 in/hr)</td>
<td>11%</td>
<td>44%</td>
</tr>
<tr>
<td>B (0.6 in/hr)</td>
<td>6%</td>
<td>16%</td>
</tr>
<tr>
<td>C (0.2 in/hr)</td>
<td>&lt;1%</td>
<td>1%</td>
</tr>
</tbody>
</table>
Credit Example 2b: Parking Lot Dry Swale (Bioretention Base)

Instead of grass channel add bioretention base to previous example

Parameter | Value
--- | ---
Depth of bioretention base | 2 ft
Porosity of media | 0.4

MIDS Performance Goal Credit = 20%
Credit Example 2b: Parking Lot Dry Swale (Bioretention Base)

<table>
<thead>
<tr>
<th>Soil &amp; Infiltration rate</th>
<th>MIDS Performance Goal Credit</th>
<th>Annual Volume Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (1.6 in/hr)</td>
<td>20%</td>
<td>60%</td>
</tr>
<tr>
<td>B (0.6 in/hr)</td>
<td>18%</td>
<td>44%</td>
</tr>
<tr>
<td>C (0.2 in/hr)</td>
<td>18%</td>
<td>37%</td>
</tr>
</tbody>
</table>
### Table D-4. Dry Swale Design Guidance

<table>
<thead>
<tr>
<th>Level 1 Design (RR:40; TP:20; TN:25)</th>
<th>Level 2 Design (RR:60; TP:40; TN: 35)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV = (1.0)(Rv)(A)</td>
<td>TV = (1.1)(Rv)(A)</td>
</tr>
<tr>
<td>Swale slopes from &lt;0.5% or &gt;2.0%</td>
<td>Swale slopes from 0.5% to 2.0%</td>
</tr>
<tr>
<td>Soil infiltration rates less than 0.5 in</td>
<td>Soil infiltration rates exceed one inch</td>
</tr>
<tr>
<td>Swale served by underdrain</td>
<td>Lacks underdrain or uses underground stone sump</td>
</tr>
<tr>
<td>On-line design</td>
<td>Off-line or multiple treatment cells</td>
</tr>
<tr>
<td>Media depth less than 18 inches</td>
<td>Media depth more than 24 inches</td>
</tr>
<tr>
<td>Turf cover</td>
<td>Turf cover, with trees, shrubs, or herbaceous plantings</td>
</tr>
</tbody>
</table>

**All Designs:** acceptable media mix tested for phosphorus index

- Grass Channel A/B soils = 20% annual reduction
- Grass Channel C/D soils = 10% annual reduction
Swale Credits
Conversion of Virginia Annual Credits to MIDS Performance Goal credits

Level 2 design 60% annual reduction = ~20% of Performance Goal

Grass channel A/B soils 20% annual reduction = ~5% of performance goal

Note: Performance curve is for a 50% impervious site
<table>
<thead>
<tr>
<th></th>
<th>Virginia</th>
<th>MIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td>Fixed</td>
<td>Flexible</td>
</tr>
<tr>
<td><strong>Annual Volume Reductions</strong></td>
<td>40% or 60% for dry swales</td>
<td>0-100%, depending on design, soils, and imperviousness</td>
</tr>
<tr>
<td></td>
<td>10% or 20% for grass channels</td>
<td></td>
</tr>
<tr>
<td><strong>MIDS Performance Goal %</strong></td>
<td>&gt;0-100%, depending on soils and imperviousness</td>
<td>0-100%, depending on design, soils, and imperviousness</td>
</tr>
</tbody>
</table>
Drawings
See Anne for copies
TABLE 1: MIDS GRASS CHANNEL SOIL AMENDMENT MATRIX

<table>
<thead>
<tr>
<th>Operation Type</th>
<th>In Situ Soil Type</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>BORROW TURF SWALE</td>
<td>Place 0’ MWD’ topsoil borrow, mix imported soil into subsoil by loosing subsoil to maximum depth of 12”</td>
<td>Loose subsoil to a minimum depth of 12”</td>
<td>Place 12” filtration soil*</td>
<td>Mix imported soil into subsoil by loosing subsoil to maximum depth of 12”</td>
<td></td>
</tr>
<tr>
<td>NATIVE GRASS SWALE</td>
<td>Place 0’ MWD’ topsoil borrow, mix imported soil into subsoil by loosing subsoil to maximum depth of 12”</td>
<td>Loose subsoil to a minimum depth of 12”</td>
<td>Place 12” filtration soil*</td>
<td>Mix imported soil into subsoil by loosing subsoil to maximum depth of 12”</td>
<td></td>
</tr>
</tbody>
</table>

*Filtration soil is defined as 80% clay soil treated with 10% organic matter by volume.

TYPICAL CONSTRUCTION SEQUENCES (GRADED CHANNEL)

1. Complete channel to subgrade elevations per the plans.
2. Construct erosion control blanket at locations and in the elevations shown on the plans.
3. Construct erosion control blanket at locations and in the elevations shown on the plans.
4. Construct erosion control blanket at locations and in the elevations shown on the plans.
5. Construct erosion control blanket at locations and in the elevations shown on the plans.
6. Construct erosion control blanket at locations and in the elevations shown on the plans.
7. Construct erosion control blanket at locations and in the elevations shown on the plans.
8. Construct erosion control blanket at locations and in the elevations shown on the plans.
9. Construct erosion control blanket at locations and in the elevations shown on the plans.
10. Construct erosion control blanket at locations and in the elevations shown on the plans.

GENERAL NOTES: GRASS SWALE AND EROSION CONTROL

1. All projects will be required to have erosion control measures installed in accordance with the SWMP. Project plans and specifications will be required in order to effectively reduce the volume and velocity of overland erosion from surface areas and to control sediment transport on site during the construction period.
2. All erosion control measures will be installed during the duration of the project.
3. Screen and trap any erosion control measures during the duration of the project.
4. Erosion control techniques shall be selected in accordance with project specifications and the specific site conditions. The minimum erosion control blanket required on slopes shall be based upon sediment yield, channel length, and channel depth.
5. Erosion control blankets shall be installed in accordance with project specifications and the specific site conditions. The minimum recommended erosion control blanket shall be installed in accordance with the specific design, flow velocity, and erosion depth.
6. Erosion control blankets installation shall be in accordance with project specifications and manufacturer's recommendations for anchoring, check dams, and installation of erosion control blankets.
7. AVOID COMPLIANCE AT ALL TIMES AND REPORT ANY VIOLATIONS TO THE AUTHORITIES. DO NOT DISCARD SOIL UNDER CHECK DAMS.
NOT FOR CONSTRUCTION PURPOSES
MIDS Credits: Swales

MIDS Work Group
March 15, 2013
• The ET calculations are not included. We need to review all the BMPs and figure out which ones should get ET credit, etc. We’ll develop a list and recommendations to review with the MPCA. For swales, this will affect the swales with a bioretention base and underdrain only.

• Currently in the calculator ET is not included with any of the BMPs.
Next slides are old slides that we might or might not need—depending on the discussion.
## Volume Reduction Summary

<table>
<thead>
<tr>
<th>Reference</th>
<th>Grass Channel</th>
<th>Dry Swale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virginia Design specifications (Grass Channels)</td>
<td>10% - HSG Soils C and D</td>
<td>40% - Level Design 1</td>
</tr>
<tr>
<td></td>
<td>20% - HSG Soils A and B</td>
<td>60% - Level Design 2</td>
</tr>
<tr>
<td></td>
<td>30% - with Compost Amended Soils</td>
<td></td>
</tr>
<tr>
<td>Virginia Design specifications (Dry Swales)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weiss, Gulliver and Erickson (2010).</td>
<td>50% (Barrett 2008, semiarid regions)</td>
<td></td>
</tr>
<tr>
<td>CSN (2009) Virginia Calculator</td>
<td>0% (Schueler 1983, VA)</td>
<td>98% (Horner et al. 2003, WA)</td>
</tr>
<tr>
<td></td>
<td>40% (Strecker et al. 2004, USA)</td>
<td>46 to 54% (Stagge 2006, MD)</td>
</tr>
<tr>
<td></td>
<td>0% (UNHSC 2007, NH)</td>
<td>90%? (Barrett et al, 1998, TX)</td>
</tr>
<tr>
<td>Rossman (2009) SWMM model (Ksat 1.0 in/hr, slope 1.3%, 1 inch precip)</td>
<td>27% (Liptan and Murase 2000, OR)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>International Stormwater Database (2011)</td>
<td>48% = Average (13 studies, 84 events)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>41%, 85% (Yu et al. 1993, VA)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19%, 27%, 35%, 42%, 65% (City of Portland 1999, OR)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60% (Wa State 1999, WA)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27%, 41%, 46%, 65%, 76% (CA DOT, 2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U of MN/LRRB</td>
<td>Barr/MIDS</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Infiltration Modeling Process</td>
<td>Green Ampt method</td>
<td>Constant infiltration rate</td>
</tr>
<tr>
<td>Infiltration Rate</td>
<td>Initially faster infiltration rate (some cells in grid &gt;39 in/hr) and mean final rates of 1.3-0.4 in/hr, depending on measured rate at cells</td>
<td>Rates in MN Stormwater Manual: 1.63 - &lt;0.2 in/hr, depending on soil</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Various rainfall intensities, including a 1-inch 24-hour event</td>
<td>58 continuous years of real storms at 1-hour time increments</td>
</tr>
<tr>
<td></td>
<td>Unclear if intense events were analyzed</td>
<td>1.1 inches in 15 minutes (~10 year event) and 1.1 inches in 30 minutes (~2 year event)</td>
</tr>
<tr>
<td>Real Life Volume Reduction Monitoring</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
What about storm events (e.g., 1.1-inch 15-minute, 1.1-inch 30-minute, and 1.1-inch 6 hour)?
What about events?

<table>
<thead>
<tr>
<th>Storm</th>
<th>Probability</th>
<th>Return Frequency “Year”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1-inch 15-minute</td>
<td>20%</td>
<td>5</td>
</tr>
<tr>
<td>1.1-inch 30-minute</td>
<td>50%</td>
<td>2</td>
</tr>
<tr>
<td>1.1-inch 6-hour</td>
<td>&gt;99%</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Source:  
NOAA Technical Memorandum NWS Hydro-35 for 15-minute and 30-minute durations  
NWS Technical Paper 40 for 6-hour duration  
Minneapolis-St. Paul Airport area