We will cover . . .

- References
- Processes
- Entering Grass Swale Data into the Model
References

- HEC-15, Design of Roadside Channels with Flexible Linings, 2005
- Results of Tests on Vegetated Waterways (Cox and Palmer, 1948)
- Treatment of Contaminated Roadway Runoff Using Vegetated Filter Strips (Ebihara, 2009)
Pollutant Control in Grass Swales and Filter Strips

- Runoff from Pervious/impervious area
- Reducing runoff velocity
- Trapping sediments and associated pollutants
- Infiltration
- Reduced volume and treated runoff

Dynamic Wetted Width Calculation

- Calculate event volume
- Convert volume to flow with:
  - Runoff duration = 1.2 times rainfall duration
  - Complex triangular hydrograph peak to average ratio = 3.8
- Flow rate calculated for each time interval set by user
- Calculate the wetted width from the flow rate and swale geometry using Manning’s open channel flow equation for each time step

- Width
- Side slope
- Slope
- Manning’s n from Retardance Factor
Particulate Removal Calculations

For each time step -

- Calculate flow velocity, settling velocity and flow depth
- Determine flow depth to grass height, for particulate reduction for each particle size increment using Nara & Pitt reference
- Check particle size group limits
  - Not exceed irreducible concentration value
  - No filtering for particles less than 50 microns
- Scour adjustment by
  - Flow velocity
  - Impervious area

Modeling Grass Swales
Five Components to Modeling Grass Swales

- Swale Density
- Swale Infiltration Rate
- Swale Geometry
- Grass Characteristics
- Runoff Particle Size Distribution

![Swale Density Diagram]

Drainage Areas

Select infiltration rate by soil type
- Sand - 4 in/hr
- Loamy sand - 1.25 in/hr
- Sandy loam - 0.75 in/hr
- Loam - 0.25 in/hr
- Silt loam - 0.15 in/hr
- Sandy clay loam - 0.11 in/hr
- Silt clay loam - 0.025 in/hr
- Silty clay - 0.02 in/hr
- Clay - 0.01 in/hr

Select Swale Density by Land Use
- Low density residential - 240 ft/ac
- Medium density residential - 350 ft/ac
- High density residential - 375 ft/ac
- Strip commercial - 410 ft/ac
- Shopping center - 59 ft/ac
- Industrial - 360 ft/ac
- Freeways (shoulder only) - 430 ft/ac
- Freeways (center and shoulder) - 540 ft/ac
Swale Density

Swale Geometry

Swale Geometry
Average Swale Length
= \text{AVG}(\sum(\text{Segment Length}/2))

...or

Use the Default:
1.5 \times \text{SQRoot of the Drainage Area}
Infiltration Rate

Swale Retardance Factor

Table 4.1. Retardance Classification of Vegetal Covers

<table>
<thead>
<tr>
<th>Retardance Class</th>
<th>Cover</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Weeping Love Grass</td>
<td>Excellent stand, tall, average 750 mm (30 in)</td>
</tr>
<tr>
<td></td>
<td>Yellow Starwheather</td>
<td>Excellent stand, tall, average 800 mm (32 in)</td>
</tr>
<tr>
<td></td>
<td>Kentucky Bluegrass</td>
<td>Good stand, tall, average 700 mm (28 in)</td>
</tr>
<tr>
<td></td>
<td>Bermudagrass</td>
<td>Good stand, average 300 mm (12 in)</td>
</tr>
<tr>
<td></td>
<td>Blue Grama</td>
<td>Good stand, average 400 mm (16 in)</td>
</tr>
<tr>
<td>B</td>
<td>Arid Bluegrass</td>
<td>Good stand, average 300 mm (12 in)</td>
</tr>
<tr>
<td></td>
<td>Redtop</td>
<td>Good stand, average 500 mm (20 in)</td>
</tr>
<tr>
<td></td>
<td>Kentucky Bluegrass</td>
<td>Good stand, average 500 mm (20 in)</td>
</tr>
<tr>
<td></td>
<td>Perennial Ryegrass</td>
<td>Good stand, average 500 mm (20 in)</td>
</tr>
<tr>
<td></td>
<td>Chinese Fescue</td>
<td>Good stand, average 500 mm (20 in)</td>
</tr>
<tr>
<td></td>
<td>Buffalo Grass</td>
<td>Good stand, average 500 mm (20 in)</td>
</tr>
<tr>
<td></td>
<td>Blue Grama</td>
<td>Good stand, average 500 mm (20 in)</td>
</tr>
<tr>
<td></td>
<td>Bermudagrass</td>
<td>Good stand, average 500 mm (20 in)</td>
</tr>
<tr>
<td></td>
<td>Bermudagrass</td>
<td>Bermudagrass</td>
</tr>
</tbody>
</table>

Covers classified have been tested in experimental channels. Covers were green and generally uniform.

Swale Retardance Classification System is from HEC-15, Classification of Vegetal Covers

Mannings n = f(velocity, hydraulic radius, retardance)

Swale Dynamic Infiltration Rate

Values listed in WinSLAMM are about ½ of the static infiltration rate for a given soil
Particle Size File

Enter Grass Height and Particle Size Distribution to Determine Particle Size Filtering

Particle Size Distribution File not accessible if Flows and Particle Sizes transferred through the drainage system

Infiltration Rate Adjustment

This is what you start with

Static Infiltration Rate

Dynamic Infiltration Rate
### Additional Output

<table>
<thead>
<tr>
<th>Rain No.</th>
<th>Rainfall Depth (in)</th>
<th>Step Count</th>
<th>Qn</th>
<th>QCc</th>
<th>Diff</th>
<th>h</th>
<th>Wetted Perimeter</th>
<th>Swale Q Reduction</th>
<th>Runoff Vol Before Swales</th>
<th>Runoff Vol After Swales</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>0.21</td>
<td>1</td>
<td>0.056658 15.08515 15.22568 0.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>0.21</td>
<td>2</td>
<td>0.056658 3.333224 2.672468 0.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Iterative calculation to determine swale height and wetted perimeter for each runoff event**

### Detailed Hydraulics By Time Step

### Hydraulics And Concentration By Event

### Incremental Performance

### Irreducible Concentration

### Particulate Reduction by Particle Size

| SwaleQ = 1.486 / n * (h * BottomWidth + SideSlope * h ^ 2) ^ (5 / 3) / (BottomWidth + h * Sqr(SideSlope * SideSlope + 1) * 2) ^ (2 / 3) * Sqr(LongSlope) |
|---|---|---|---|---|---|---|
| 40 | 0.3 | 1 | 0.43074 | 0.481597 | 5.060E-02 | 0.186889 |
| 40 | 0.3 | 2 | 0.43074 | 3.333224 | 2.001284 | 0.26 |
| 40 | 0.3 | 3 | 0.43074 | 0.796487 | 0.367127 | 0.125 |

### Questions?

| 2.525232 | 0.673294 | 10497.38 | 3429.661 |
| 4116 | 14116 | 2.153859 | 0.781577 | 16996.33 | 3813.94 |