Brief Summary of WinSLAMM Features and Uses

Robert Pitt
Dept. of Civil, Construction, and Environmental Engineering
University of Alabama
Tuscaloosa, AL 35487

John Voorhees
PV and Associates
Madison, WI

What WinSLAMM is:
• Urban stormwater model (does not address agricultural areas, etc.)
• Designed as multi-scale model (individual lots to whole communities)
• Annual or seasonal pollutant loads and event pollutant probability distributions using long-term rainfall records
• Evaluates individual or multiple stormwater control scenarios (source area, land use, drainage, outfalls), such as:

<table>
<thead>
<tr>
<th>WinSLAMM Weaknesses:</th>
<th>Applications of WinSLAMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Not used for peak flow predictions or flood analyses.</td>
<td>• Permit Compliance – Municipal Pollutant Loadings and Discharge Reductions</td>
</tr>
<tr>
<td>• Can be integrated with other models and tools to address fate and transport in receiving waters (such as QUAL2E, HSPF)</td>
<td>• Evaluate Alternative Stormwater Controls:</td>
</tr>
<tr>
<td>• Doesn’t calculate construction erosion, but does calculate rainfall energy for post processing</td>
<td>– City-wide</td>
</tr>
<tr>
<td>• Doesn’t include snowmelt</td>
<td>– Watershed</td>
</tr>
<tr>
<td>• Can be used with SWMM to evaluate combined sewer</td>
<td>– Site Development</td>
</tr>
<tr>
<td>• Is not a lifestyle, but can be integrated with models that are connected to Youtube, etc.</td>
<td>• Identify critical drainage areas</td>
</tr>
<tr>
<td></td>
<td>– ID critical land uses</td>
</tr>
<tr>
<td></td>
<td>– ID critical source areas</td>
</tr>
<tr>
<td></td>
<td>– Assist with cost-sharing</td>
</tr>
<tr>
<td></td>
<td>– Identify the most cost-effective stormwater control and development scenarios</td>
</tr>
</tbody>
</table>
Background & History

- Development Began in mid-1970’s
  - Early EPA street cleaning and receiving water projects
  - San Jose and Coyote Creek (CA)

- Primary Purpose:
  - Identify Sources of Urban Stormwater Pollutants
  - Evaluate Efficiency of Control Practices

Background & History

- Mid-1980’s:
  - Model expanded to include more management options beyond street cleaning
  - Nationwide Urban Runoff Program (NURP) projects provided large data set for model, especially: Alameda Co. CA; Bellevue, WA; and Milwaukee, WI
  - Ontario Ministry of the Environment (Ottawa)

Background & History

- Mid-1980’s - Model used in Agency Programs:
  - Toronto Area Watershed Management Strategy
  - Wis. Dept. of Natural Resources: Priority Watershed Program

- First Windows Version Developed in 1995 (Currently developing Windows version 9.4)
- Continuously being updated based on user needs and new research (recent and current support from Stormwater Management Authority of Jefferson County, AL; the TVA, Economic Development group; WI DNR; and the USGS)

Model Applications

Large Scale, City-wide Analysis Example

City-wide sediment load and runoff volume analysis for Wausau, WI (EarthTech)
Model Applications
Site Development Analysis Example

- Porous Pavement
- Biofilter
- Infiltration/Detention Pond
- Grass Swales
- Catchbasin with Sump

Model Applications
Detailed Practice Analysis Examples

Wet Detention Pond – Analyze the performance of a specific pond for a specific site (WinSLAMM or WinDETPOND)

Develop and analyze new controls – this inlet has a prototype upflow filter installed

CFD Modeling to Calculate Scour/Design Variations

- We are using CFD (Fluent 6.2 and Flow 3D) to determine scour from stormwater controls; results being used to expand WinSLAMM analyses
- This is an example of the effects of the way that water enters a sump on the depth of the water jet and resulting scour

WinSLAMM integrates site and development information:

- Soil Type
- Runoff Volume and Pollutant Loads
- Landuse Area
- Rainfall
- Development Characteristics
- Control Practices

Soil Type

Landuse Area

Rainfall

Development Characteristics

Control Practices
Residential Land Use
Source Areas
Pitched Roofs
Driveways
Sidewalks
Small Landscaped Areas

Commercial Land Use
Source Areas
Flat Roofs
Parking
Driveways
Sidewalks
Small Landscaped Areas

Other Urban
Land Use
Source Areas
Playground
Sidewalks
Large Landscaped Areas

Important WinSLAMM Features
• Hydrology stresses small and intermediate-scaled processes that are most important for water quality analyses.
• Sediment accumulation and washoff processes based on huge number of field observations from throughout North America.
• Stormwater control performance calculations based on extensive field observations; most are driven by site hydraulics and sediment characteristics.
• Stormwater controls can be evaluated in many combinations and located at many areas.
• Construction and operating costs of stormwater controls are calculated for most US locations.
• Model output can be exported to support further post-processing (integrated with detailed drainage system models, receiving water models, and decision analyses models).

Probability distribution of rains (by count) and runoff (by depth).

Birmingham Rains:
<0.5": 65% of rains (10% of runoff)
0.5 to 3": 30% of rains (75% of runoff)
3 to 8": 4% of rains (13% of runoff)
>8": <0.1% of rains (2% of runoff)

Many types of runoff monitoring used to calibrate and verify WinSLAMM, from small source areas to outfalls.
Example runoff plot for small paved area.

Field research has shown that the infiltration rates of urban soils are strongly influenced by compaction, probably more than by moisture saturation.

Infiltration Measurements for Noncompacted, Sandy Soils

\[ f = 14.6 \times (30.4 - 14.6) \times \exp(-4.6 \times t) \]

<table>
<thead>
<tr>
<th>Sandy Soils</th>
<th>Clayey Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987 Pitt</td>
<td>1999 Pitt et al.</td>
</tr>
</tbody>
</table>

Infiltration Measurements for Compacted, Sandy Soils

\[ f = 1.8 \times (9.1 - 1.8) \times \exp(-4.4 \times t) \]
A Nice Example of Runoff Model Verification using WinSLAMM

Observed vs. Predicted Runoff at Madison Maintenance Yard Outfall

Pollutant Probability Distributions (used in Monte Carlo Calculations)
- Depicts the pollutant concentrations for source areas and land uses
WinSLAMM uses an Extended Rainfall Period, Usually from One Year to Several Decades Long

Measured Street Particulate Loading, Keyes – Smooth Asphalt Test Area

Observed Particulate Removal by Street Cleaning
Referential removal of large particulates by street cleaners

Observed Washoff of Street Dirt by Particle Size, Bellevue, WA

Pitt 1979

Pitt 1979

Pitt 1985
Particle Resuspension of Street Dirt Caused by Vehicle Passage for an Asphalt Road

Fugitive dust losses from streets account for excessive material that is not washed off during rains.

Bedload sampler installations. About 5% of annual sediment was in bedload fraction.

Wisconsin DNR and USGS Recent Street Cleaning Tests

Measured Versus Modeled Street Loads With Mechanical Broom Street Cleaning - Residential 2004
### Annual TSS Reductions, %, for Vacuum Assisted Cleaner With & Without Parking Control

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Parking Density</th>
<th>With Parking Controls</th>
<th>Without Parking Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 \ Week</td>
<td>1 \ Month</td>
<td>1 \ Week</td>
</tr>
<tr>
<td>Med. Den Res.</td>
<td>Med.</td>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>High Den Res.</td>
<td>Med.</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Strip Comm</td>
<td>Med.</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>Downtown</td>
<td>Exten</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Light Indus.</td>
<td>Med.</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

### Pollutant Control in Grass Swales

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

### Settling of Different Sized Particulates as a Function of Flow Characteristics (depth and velocity), Particle Settling Characteristics and Grass Type and Height

**Date: 10/11/2004**

- **TSS: 10 mg/L**
- **TSS: 20 mg/L**
- **TSS: 30 mg/L**
- **TSS: 35 mg/L**
- **TSS: 63 mg/L**
- **TSS: 84 mg/L**
- **TSS: 102 mg/L**

**Graph:**

- **X-axis:** Settling frequency
- **Y-axis:** Percent reduction (%)
- **Lines:**
  - Ratio: 0 - 1.0
  - Ratio: 1.0 - 1.5
  - Ratio: 1.5 - 4

**Legend:**

- **Total Dissolved Solids (≤0.45 µm)**
- **Ratio:**
  - 0 - 1.0
  - 1.0 - 1.5
  - 1.5 - 4
From such graphs swale hydraulic characteristics can be predicted on the basis of flow rate, cross sectional geometry, slope, and vegetation type.

Three Components to Modeling Wet Detention Ponds

1. Pond Geometry
2. Flow, Initial Stage and Particle Size Data
3. Outlet Information

Wet Detention Pond Data Entry Form
- particle size distribution
- stage-area info
- initial stage conditions
- inflow hydrograph shape factors or actual hydrograph in DETPOND)
- many outlet options (including conventional hydraulic outlets, beneficial use withdrawals, seepage, evaporation, pumped outlet, stone weepers, etc.)
Measured Particle Sizes, Including Bed Load Component, at Monroe St. Detention Pond, Madison, WI

Consistently high TSS removals for all influent concentrations (but better at higher concentrations, as expected)

Vortechs Monitoring Site

Proprietary devices modeled using basic settling methods with bypass; scour currently being added to model.

Suspended Solids Control at Monroe St. Detention Pond, Madison, WI (USGS and WI DNR data)

TSS Load Reduction Results Used for Model Verification

- Sum of Loads; TSS Loads, kg

<table>
<thead>
<tr>
<th></th>
<th>Influent</th>
<th>Effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vortechs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(18 events, no bypass)</td>
<td>63</td>
<td>51</td>
</tr>
<tr>
<td>Stormceptor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(15 events, bypass)</td>
<td>939</td>
<td>895</td>
</tr>
</tbody>
</table>
Sources of Cost Data

- Pre-Determined Costs
  - SEWRPC 1991 Cost Report
  - Costs Updated Using ENR Cost Indices
  - Cost Indices Available for 20 Cities

Construction Cost Index by City
WinSLAMM v 9.2 Output Summary

- Runoff volume
- Particulate solids concentration
- Particulate solids yield
- Pollutant concentration
- Pollutant yield
- Many export options to link to other models

Detailed Model Input/Output Data Available for:

- Runoff volume
- Particulate solids concentration
- Particulate solids yield
- Pollutant concentration
- Pollutant yield
- Many export options to link to other models

Example Flow Duration Curves

Use these curves to compare the attenuation of the control practices at the outfall to a no controls condition.
Current and Planned Expansions to WinSLAMM
Based on recent research results and field verification

- Expand full routing capabilities in grass swales and incorporate advanced particulate trapping algorithms (current). Will expand to grass filtering stormwater controls.
- Add more detailed ET analyses and pollutant trapping processes to bioretention and biofiltration devices (current). Will expand to green roofs.
- Adding scour removal of particulates from hydrodynamic devices (current). Will expand to ponds.
- Currently developing drag and drop front-end to model to enable more flexible placement of controls.
- Other enhancements as requests, data, and resources allow!

Selected WinSLAMM General Descriptions