SWAT LID Module

2015 SWAT Conference
Pula/Sardinia/Italy
18 June 2015

Jeong, J., Her, Y., Arnold, J., Gossenlink, L., Glick, R., & Jaber, F
SWAT & Urban Modeling

- Urbanization & Hydrology
  - Increase in impervious cover promotes higher runoff and lower infiltration
  - Stream flow gets flashy
  - Urban Non-Point Sources

(Roesner et al., 2001)
## LID Practices of Interest

- **Low Impact Development (LID)**
  - Stormwater management practices
  - On-site micro-scale controls

- **Types of Lands where LIDs are placed**

<table>
<thead>
<tr>
<th>Land-Use Type</th>
<th>Green Roof</th>
<th>Rain Garden</th>
<th>Cistern</th>
<th>Porous Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>Commercial</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>Industrial</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>Civic</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>Parks</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Transportation</td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Parking Lots</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
</tr>
</tbody>
</table>

- A cistern is usually connected to a green roof
LID Simulation Strategies

- SWAT subdaily simulation module
- Urban BMPs & LID (Green Infrastructure)

**Subdaily model**
- SWAT modules for sub-hourly simulation
- Overland flow, stream flow, ponds, reservoirs, and point sources
- Soil erosion and sediment transport

**Urban BMPs**
- Sedimentation-Filtration basin
- Retention-Irrigation basin
- Detention pond
- Wet pond

**Green Infrastructure**
- Green roof
- Rain garden
- Cistern
- Porous pavement
LID Simulation Strategies

- Direct runoff partitioning

Urban HRU

- Unconnected Impervious Cover + Pervious Cover

Cistern

Green Roof

Porous Pavement

Connected Impervious Cover

‘Q from impervious cover’

Rain Garden

HRU Water Yield

‘Q from pervious cover’
# LID Simulation Strategies

- **Storages of the LID practices**

<table>
<thead>
<tr>
<th>Storage Type</th>
<th>Green Roof</th>
<th>Rain Garden</th>
<th>Cistern</th>
<th>Porous Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amended soil layer</td>
<td>O</td>
<td>O</td>
<td>×</td>
<td>O</td>
</tr>
<tr>
<td>Surface storage</td>
<td>X</td>
<td>O</td>
<td>O</td>
<td>X</td>
</tr>
<tr>
<td>Gravel bed layer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
</tr>
<tr>
<td>No. Storages</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

---

**Storage on Surface**

**Storage in Soil**

**Green Roof**

**Rain Garden**

**Cistern**

**Porous Pavement**

---

*Image sources: AgriLIFE RESEARCH, Texas A&M System*
LID Simulation Strategies

- Infiltration & percolation rates
  - Infiltration rate: Green-Ampt equation
  - Unsaturated hydraulic conductivity: Van Genuchten equation
  - Percolation rate = Anisotropic coefficient * Sat. Hyd. Cond.

Fig. 1. Comparison of excess rainfall hydrographs calculated using Green-Ampt & CN

Fig. 2. Response of unsaturated hydraulic conductivity ratio to soil water content
SWAT for Brentwood Watershed

- **Brentwood WS**
  - Austin, TX
  - 149.8 ha
  - Highly urbanized
  - Monitored by City of Austin

- **SWAT**
  - Prepared by City of Austin
  - Great details
    - 137 subbasins (1.1 ha/sub)
    - 1212 HRUs (0.12 ha/HRU)
  - Calibrated by BRC
SWAT for Brentwood Watershed

- **Calibrated SWAT**
  - ‘Good’ performance; overestimated runoff volume

**Fig. 1. Comparison of observed & simulated daily runoff**

**Fig. 2. Comparison of observed & simulated monthly runoff hydrographs**

**Table. 1. Performance statistics of the calibrated SWAT model**

<table>
<thead>
<tr>
<th>Period</th>
<th>NSE</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15-min</td>
<td>Daily</td>
</tr>
<tr>
<td>Calibration</td>
<td>0.88</td>
<td>0.91</td>
</tr>
<tr>
<td>Validation</td>
<td>0.71</td>
<td>0.84</td>
</tr>
</tbody>
</table>
Sensitivity Analysis

- Runoff sensitivity to LID configurations
  - Green roof: porosity
  - Rain garden: hydraulic conductivity
  - Porous pavement: gravel depth & porosity

- Sensitivity is responsive to storm events
  - 38.1-mm, 1-hour uniform storm vs. 1-year, 3-hour design storm (49 mm, City of Austin)
  - Critical storm event

Fig. 1. Comparison of design and uniform storms
Sensitivity Analysis

**Green Roof**

- Hydraulic Conductivity
- Porosity
- Field Capacity
- Wilting Point
- Soil Depth

**Rain Garden**

- Hydraulic Conductivity
- Porosity
- Field Capacity
- Wilting Point
- Soil Depth
- Storage Depth
- Orifice Diameter

**Porous Pavement**

- Hydraulic Conductivity
- Porosity
- Field Capacity
- Wilting Point
- Soil Depth
- Gravel Depth
- Gravel Porosity
Scenario Analysis

- As LID adaptation rate increases:
  - Surface runoff decreases
  - ET increases
Scenario Analysis

- As LID adaptation rate increases:
  - Peak runoff & runoff volume decreases
Scenario Analysis

- Hydrographs at the watershed outlet
Field Scale Validation

- Green Roof

Lady Bird Johnson Wildflower Center (U of Texas, Austin) & City of Austin

Fig. 1. Simulated runoff of a green roof