Enhancement of Tile and Pothole Flow Components in SWAT: Application to the Walnut Creek Watershed, Iowa

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OBJECTIVES

- To enhance the SWAT model with new tile drainage and pothole surface storage components (SWAT-M)
- Evaluated the SWAT-M using measured data from Walnut Creek watershed (WCW) under the baseline and scenario conditions
METHODS AND MATERIALS
Walnut Creek Watershed (WCW)

- 5130 ha WCW, located in Story county, central Iowa
- 78% corn and soybeans
- About 66% tile drained and 57% of the total surface runoff directly flowed into potholes
- 10% pothole area
Subbasins, sites and measurement gages in WCW
Distributions of subsurface drains and streams across WCW
Monitoring

- Stream flow for sites 330 and 310
- Tile and stream flow for sites 210 and 220
- Precipitation and temperature data from 17 measured sites
Field site surface flume and drainage line monitoring stations
Stream gauging station with weir located on Walnut Creek.
SWAT Model

SWAT is a continuous-time (daily time-step) model which allows data input via GIS. SWAT was developed to predict the effect of different management scenarios on water quality, sediment yields, and pollutant loadings at watershed-level.
SWAT -M Modifications

- Depression storage water balance was modified
- Restrictive soil layer
- Soil profile saturation pattern
- Water table depth calculation
- Pothole/HRU orientation
SWAT2000 and SWAT-M Simulations

- Validation Period (1996-1998)
- Scenario (1992-2000)
Scenario

- Beginning in 1997, the LSNT (Late Spring Nitrogen Test) N-fertilizer management program was simulated within sub-basin 220.

- The LSNT program consisted of applying an initial 56 kg/ha application of N at or shortly before planting. After the corn plants had grown to a height of 15- to 30-cm (typically mid-June), soil samples were taken and analyzed for NO$_3$ content to determine the required rate of N to apply by sidedressing.
The annual rates of averaged nitrogen fertilizer application

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<tbody>
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<td>Sites</td>
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<tr>
<td>All</td>
<td>162</td>
<td>149</td>
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<td>148</td>
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<td>162</td>
<td>149</td>
<td>153</td>
<td>148</td>
<td>164</td>
<td>164</td>
<td>168*</td>
<td>118*</td>
<td>174*</td>
<td>109*</td>
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</table>

* Split application based on LSNT (Late Spring Nitrogen Test) treatment (56 kg/ha applied before planting and the rest was applied during June application) (Hatfield et al., 1999; Jaynes et al., 2003).
RESULTS AND DISCUSSION
## Water balance comparison

<table>
<thead>
<tr>
<th>Year</th>
<th>SWAT-M</th>
<th>SWAT2000</th>
<th>Measured</th>
<th>SWAT-M</th>
<th>SWAT2000</th>
<th>measured</th>
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<tbody>
<tr>
<td>1992</td>
<td>430.4</td>
<td>550.6</td>
<td>500.0</td>
<td>277.5</td>
<td>127.4</td>
<td>271.0</td>
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<tr>
<td>1993</td>
<td>507.9</td>
<td>535.6</td>
<td>370.0</td>
<td>636.1</td>
<td>442.4</td>
<td>865.0</td>
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<td>1994</td>
<td>497.3</td>
<td>572.8</td>
<td>440.0</td>
<td>129.4</td>
<td>98.3</td>
<td>69.0</td>
</tr>
<tr>
<td>1995</td>
<td>479.3</td>
<td>545.1</td>
<td>430.0</td>
<td>178.3</td>
<td>101.9</td>
<td>178.0</td>
</tr>
<tr>
<td>Average</td>
<td>478.7</td>
<td>551.0</td>
<td>435.0</td>
<td>305.3</td>
<td>192.5</td>
<td>345.8</td>
</tr>
</tbody>
</table>
Average and standard deviation (in parenthesis) of total monthly flow during calibration

<table>
<thead>
<tr>
<th>Site</th>
<th>SWAT2000</th>
<th>Measured</th>
<th>SWAT-M</th>
</tr>
</thead>
<tbody>
<tr>
<td>210</td>
<td>0.04 (0.05)</td>
<td>0.04 (0.06)</td>
<td>0.06 (0.07)</td>
</tr>
<tr>
<td>220</td>
<td>0.03 (0.03)</td>
<td>0.03 (0.04)</td>
<td>0.04 (0.04)</td>
</tr>
<tr>
<td>310</td>
<td>0.16 (0.20)</td>
<td>0.27 (0.43)</td>
<td>0.25 (0.29)</td>
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<tr>
<td>330</td>
<td>0.34 (0.41)</td>
<td>0.56 (0.87)</td>
<td>0.49 (0.57)</td>
</tr>
</tbody>
</table>
Average and standard deviation (in parenthesis) of monthly NO$_3$-N during calibration

<table>
<thead>
<tr>
<th>Site</th>
<th>SWAT2000</th>
<th>Measured</th>
<th>SWAT-M</th>
</tr>
</thead>
<tbody>
<tr>
<td>210</td>
<td>13.8</td>
<td>543.3</td>
<td>1,370.3</td>
</tr>
<tr>
<td></td>
<td>(42.6)</td>
<td>(1,178.3)</td>
<td>(2,300.4)</td>
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<tr>
<td>220</td>
<td>18.5</td>
<td>557.3</td>
<td>652.0</td>
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<tr>
<td></td>
<td>(66.3)</td>
<td>(997.8)</td>
<td>(1,003.5)</td>
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<tr>
<td>310</td>
<td>71.0</td>
<td>4,143.3</td>
<td>6,291.9</td>
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<tr>
<td></td>
<td>(130.7)</td>
<td>(7,298.5)</td>
<td>(9,951.0)</td>
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<tr>
<td>330</td>
<td>316.7</td>
<td>8,313.9</td>
<td>10,187.1</td>
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<tr>
<td></td>
<td>(1,046.4)</td>
<td>(15,290.8)</td>
<td>(15,823.9)</td>
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</table>
Average monthly Flow During Calibration - Site 330

\[ E_{SWAT2000} = 0.57 \]
\[ E_{SWAT-M} = 0.77 \]
Average Monthly Flow During Calibration - Site 220

Flow (m³/s)

- SWAT2000
- SWAT-M
- Measured

\[ E_{\text{SWAT2000}} = 0.76 \]
\[ E_{\text{SWAT-M}} = 0.83 \]
Average Monthly Sub-surface Flow During Calibration Site-220

\[
E_{SWAT2000} = 0.60
\]
\[
E_{SWAT-M} = 0.89
\]
NO$_3$ During Calibration - Site 330

During Calibration - Site 330

Measured $E_{\text{SWAT-M}} = 0.73$

$E_{\text{SWAT2000}} = -0.29$
NO\textsubscript{3} During Calibration - Site 220

\begin{align*}
E\textsubscript{SWAT2000} &= -0.31 \\
E\textsubscript{SWAT-M} &= 0.71
\end{align*}
Simulated NO3-N reduction under LSNT treatment at site 220.
Conclusions (1 of 3)

- The modification of tile drain and pothole components of SWAT resulted in better prediction of water balance components for such conditions.

- The Avg. and trend of monthly and daily total and subsurface flows predicted by SWAT-M, compared to SWAT 2000, were closer to measured values during both calibration and validation periods at all sites.
Conclusions (2 of 3)

- The Avg. monthly Nitrate-N predicted by SWAT2000 were much lower than the measured values.
- The patterns of predicted Nitrate-N by SWAT-M were much closer to those of measured values.
Conclusions (3 of 3)

- The SWAT-M was able to predict the effect of N-management scenario similar to what was measured during field study.
- The modifications regarding tiles and potholes will be incorporated into SWAT 2003.
Ongoing Project

- More modification of SWAT to better address pesticides loading in Walnut Creek Watershed.
- Collection of monitoring data such organic nitrogen and Phosphorous (soluble and organic) for model validation.
Thank You