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

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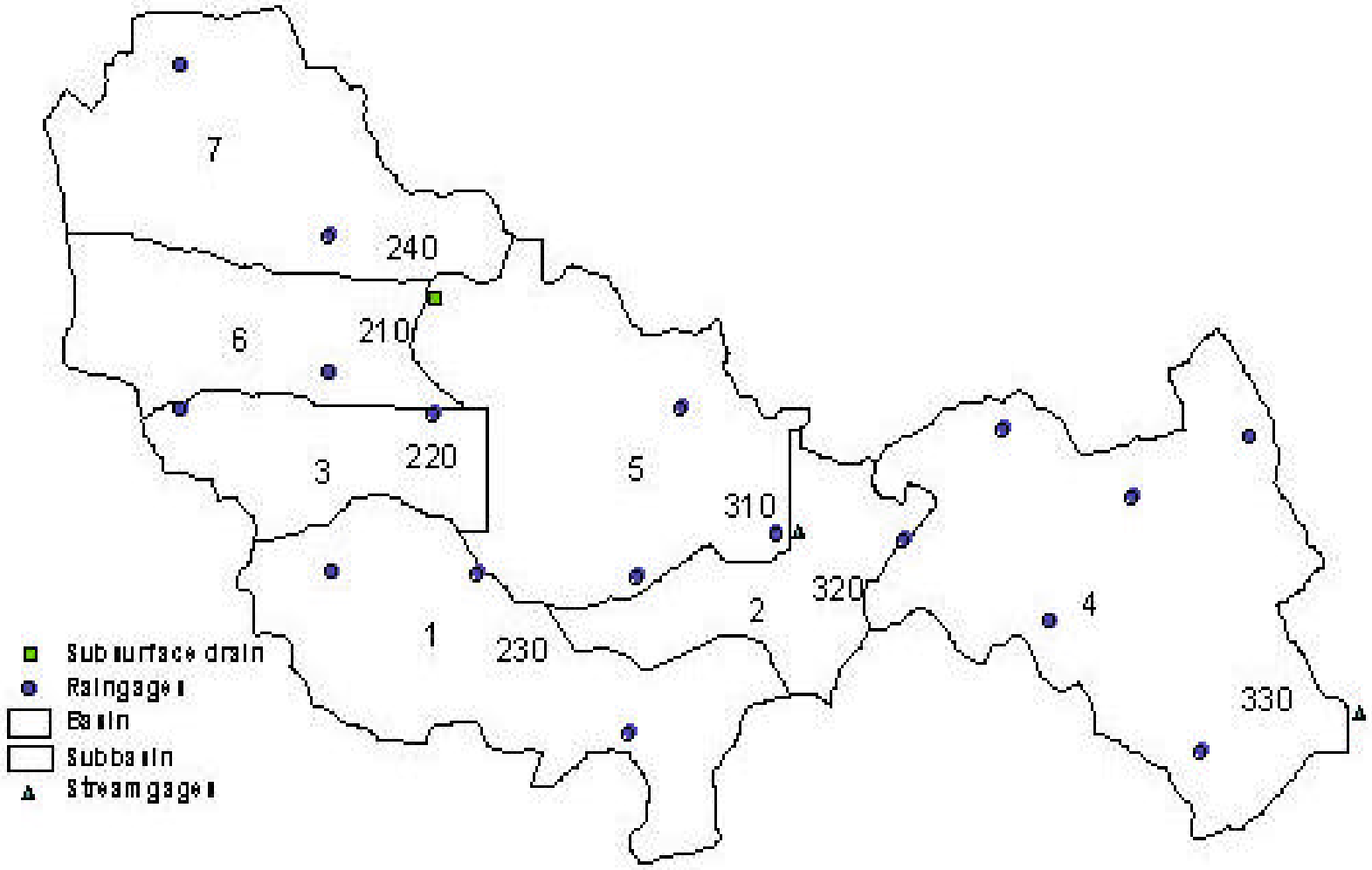
# OBJECTIVES

- 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

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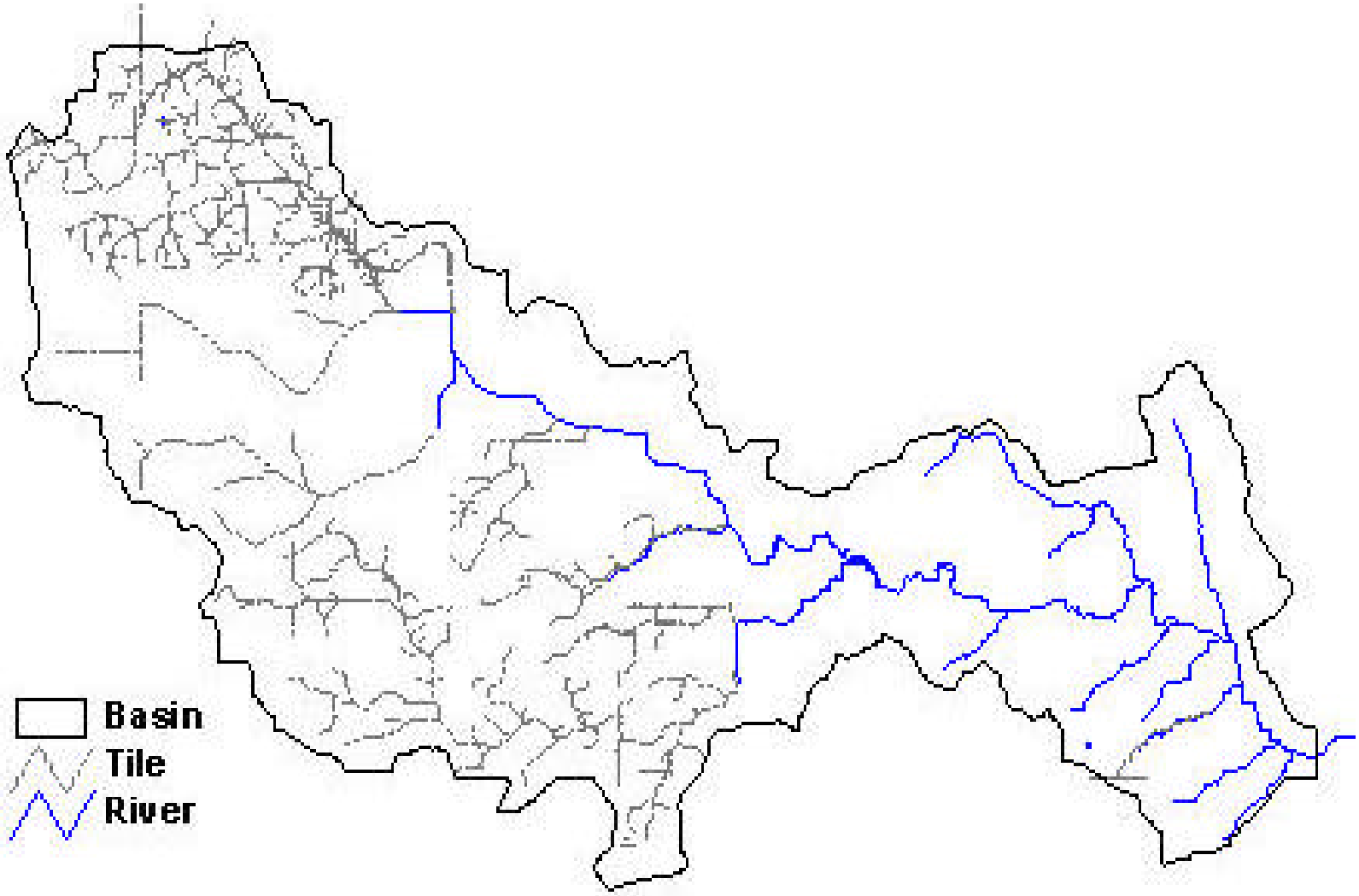
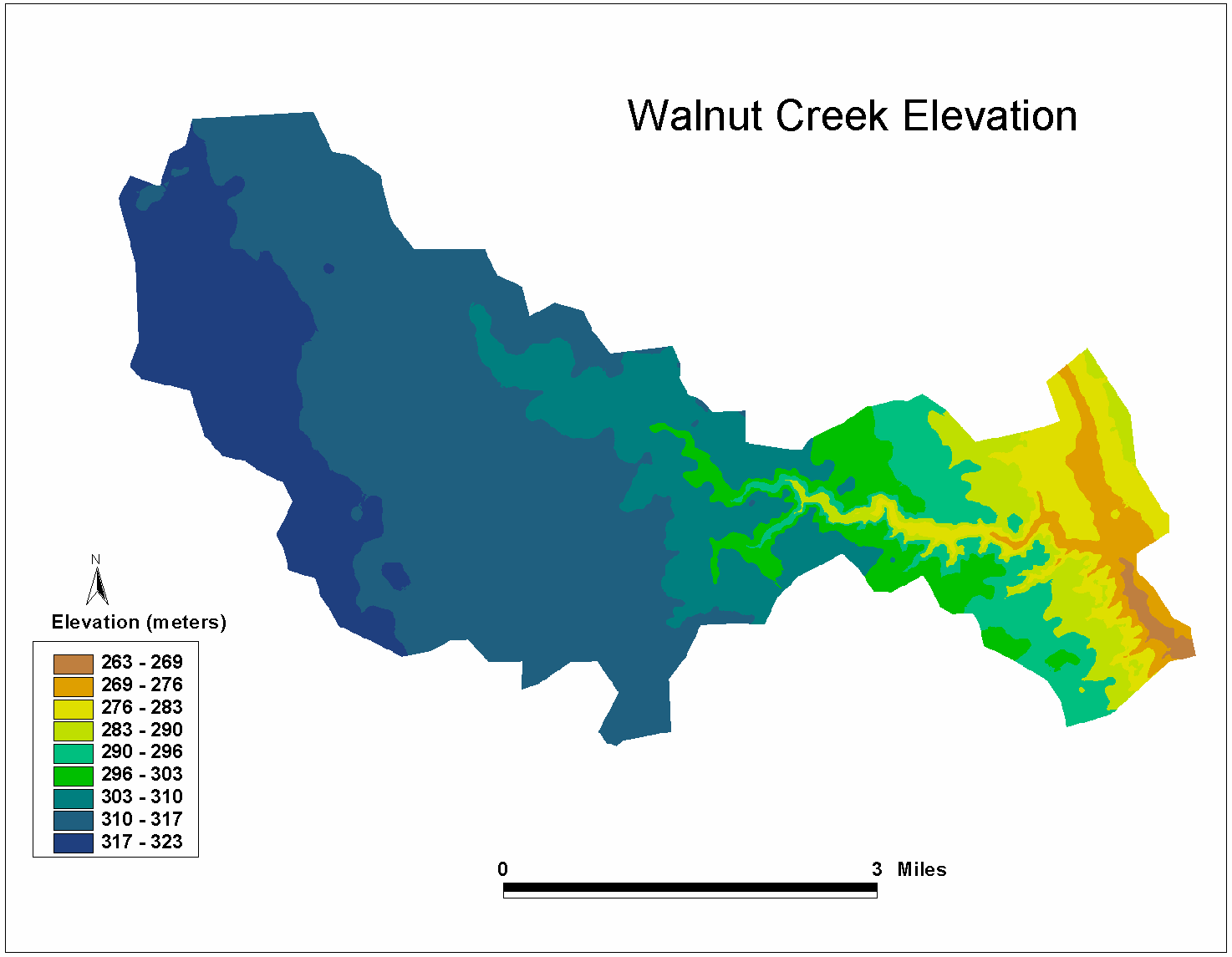



Distributions of subsurface drains and streams across WCW


Walnut Creek Elevation
N
Elevation (meters)
263 - 269
269 - 276
276 - 283
283 - 290
290 - 296
296 - 303
303 - 310
310 - 317
317 - 323
0
3 Miles

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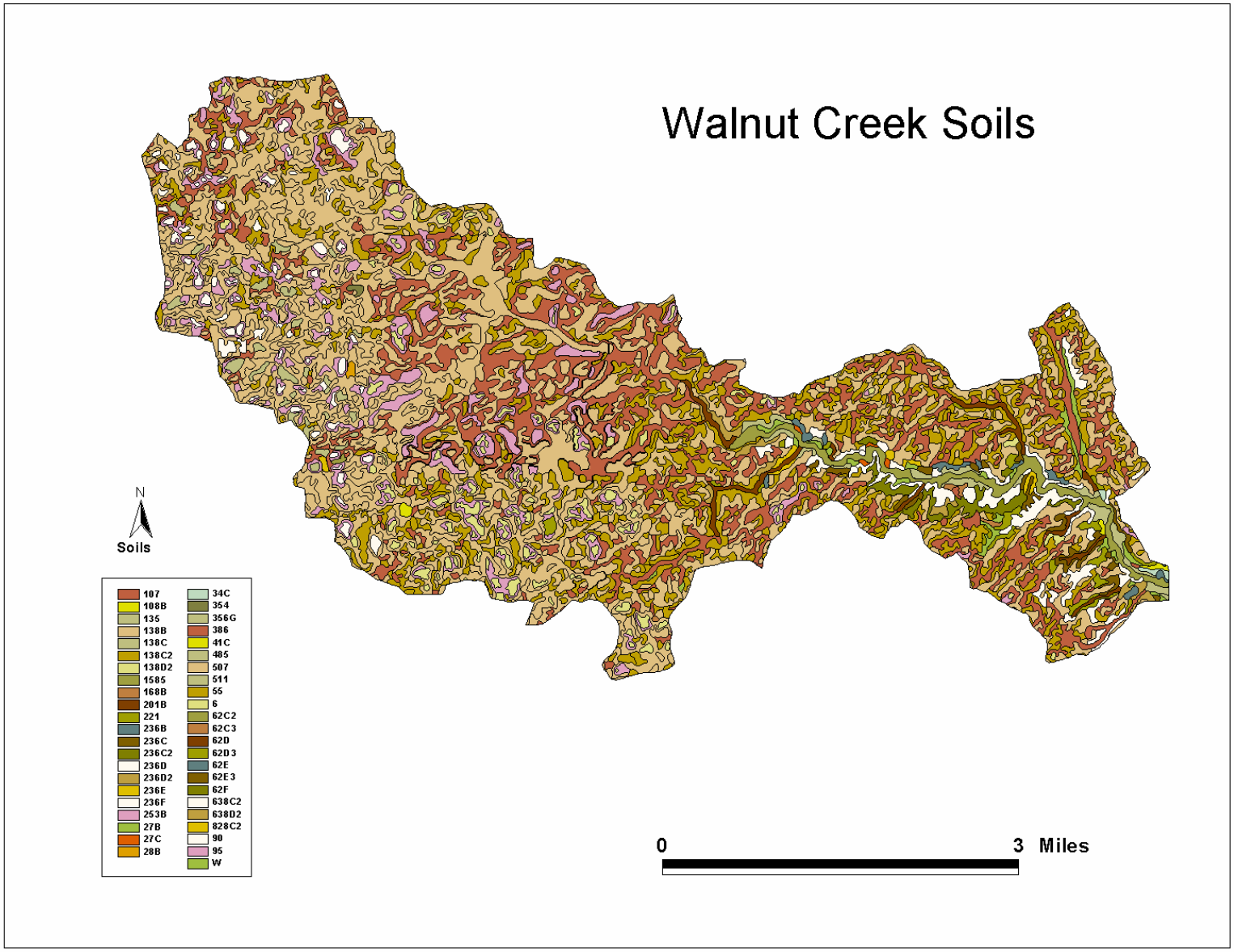
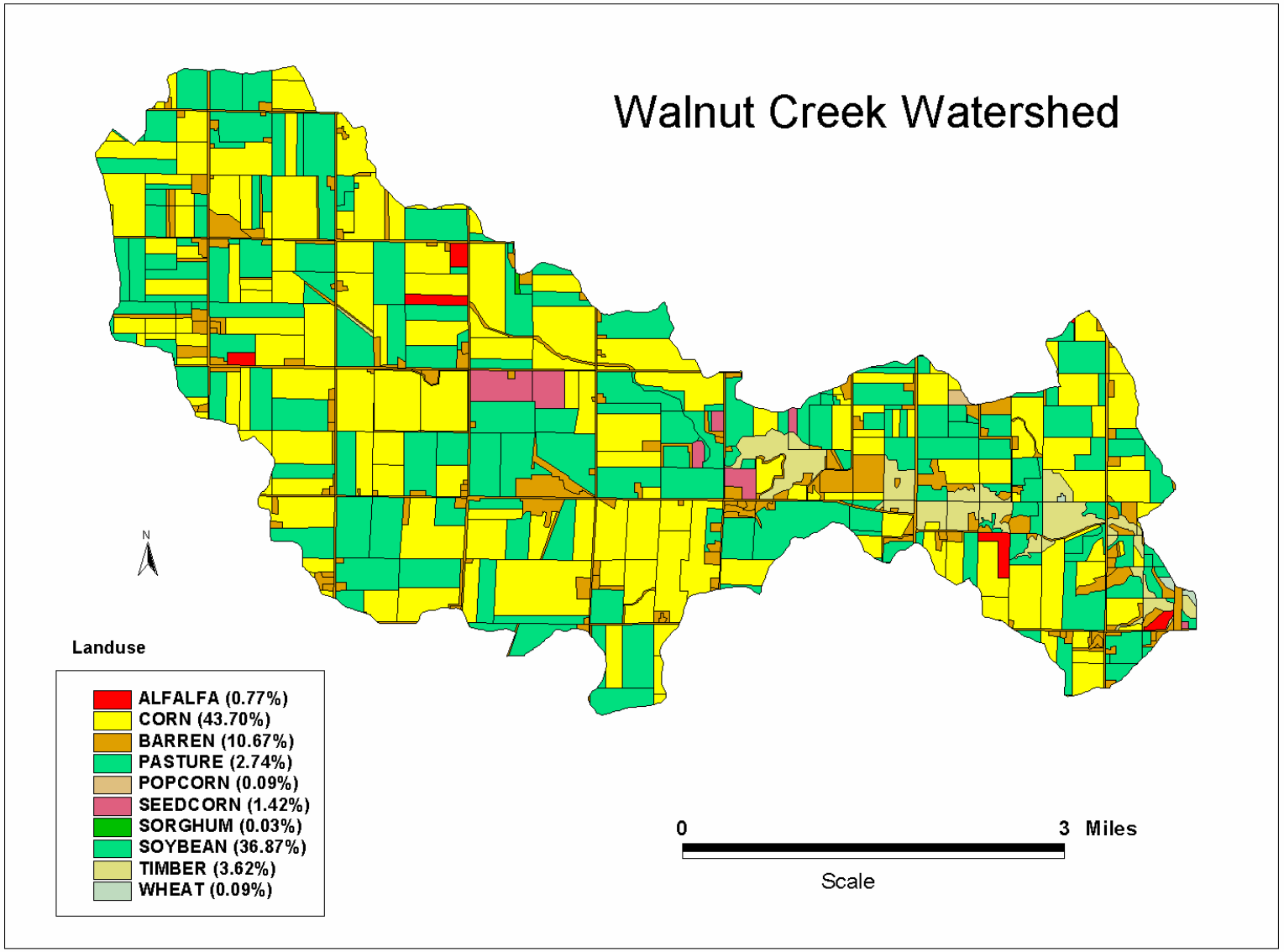

Walnut Creek Soils
N
Soils
107
108B
135
138B
138C
138C2
138D2
158S
168B
201B
221
236B
236C
236C2
236D
236D2
236E
236F
253B
27B
27C
28B
34C
354
356G
386
41C
485
507
511
55
6
62C2
62C3
62D
62D3
62E
62E3
62F
638C2
638D2
828C2
90
95
W
0
3 Miles


Walnut Creek Watershed
N
Landuse
ALFALFA (0.77%)
CORN (43.70%)
BARREN (10.67%)
PASTURE (2.74%)
POPCORN (0.09%)
SEEDCORN (1.42%)
SORGHUM (0.03%)
SOYBEAN (36.87%)
TIMBER (3.62%)
WHEAT (0.09%)
0
3 Miles
Scale

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# 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

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# 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

- Calibration Period (1991-1995)
- 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

| | YEAR | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sites** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** |
| **All** | 162 | 149 | 153 | 148 | 164 | 164 | 164 | 164 | 187 | 182 |
| **220** | 162 | 149 | 153 | 148 | 164 | 164 | 168* | 118* | 174* | 109* |

* 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).

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# RESULTS AND DISCUSSION

# Water balance comparison

| | ET | | | Stream Discharge | | |
|---|---|---|---|---|---|---|
| | ----------mm ---------- | | | | | |
| Year | **SWAT-M** | **SWAT2000** | **Measured** | **SWAT-M** | **SWAT2000** | **measured** |
| 1992 | 430.4 | 550.6 | 500.0 | 277.5 | 127.4 | 271.0 |
| 1993 | 507.9 | 535.6 | 370.0 | 636.1 | 442.4 | 865.0 |
| 1994 | 497.3 | 572.8 | 440.0 | 129.4 | 98.3 | 69.0 |
| 1995 | 479.3 | 545.1 | 430.0 | 178.3 | 101.9 | 178.0 |
| **Average** | **478.7** | **551.0** | **435.0** | **305.3** | **192.5** | **345.8** |

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# Average and standard deviation (in parenthesis) of total monthly flow during calibration

| Site | *SWAT2000* (m3/seg) | *Measured* (m3/seg) | *SWAT-M* (m3/seg) |
|---|---|---|---|
| 210 | 0.04 (0.05) | 0.04 (0.06) | 0.06 (0.07) |
| 220 | 0.03 (0.03) | 0.03 (0.04) | 0.04 (0.04) |
| 310 | 0.16 (0.20) | 0.27 (0.43) | 0.25 (0.29) |
| 330 | 0.34 (0.41) | 0.56 (0.87) | 0.49 (0.57) |

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# Average and standard deviation (in parenthesis) of monthly $NO_3$-N during calibration

| Site | SWAT2000 (kg) | | Measured (kg) | | SWAT-M (kg) | |
|---|---|---|---|---|---|---|
| 210 | 13.8 | (42.6) | 543.3 | (1,178.3) | 1,370.3 | (2,300.4) |
| 220 | 18.5 | (66.3) | 557.3 | (997.8) | 652.0 | (1,003.5) |
| 310 | 71.0 | (130.7) | 4,143.3 | (7,298.5) | 6,291.9 | (9,951.0) |
| 330 | 316.7 | (1,046.4) | 8,313.9 | (15,290.8) | 10,187.1 | (15,823.9) |

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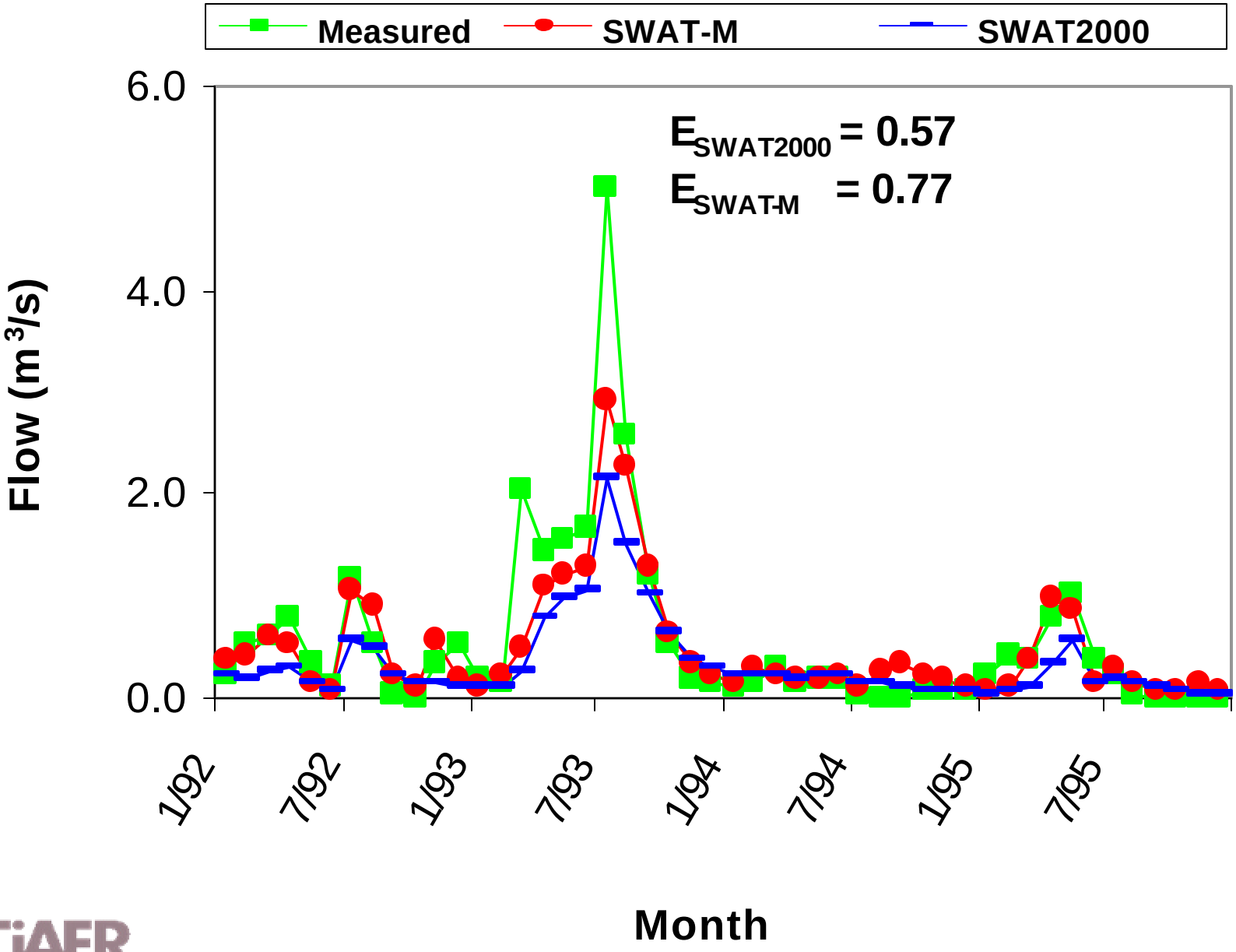
# Average monthly Flow During Calibration - Site 330

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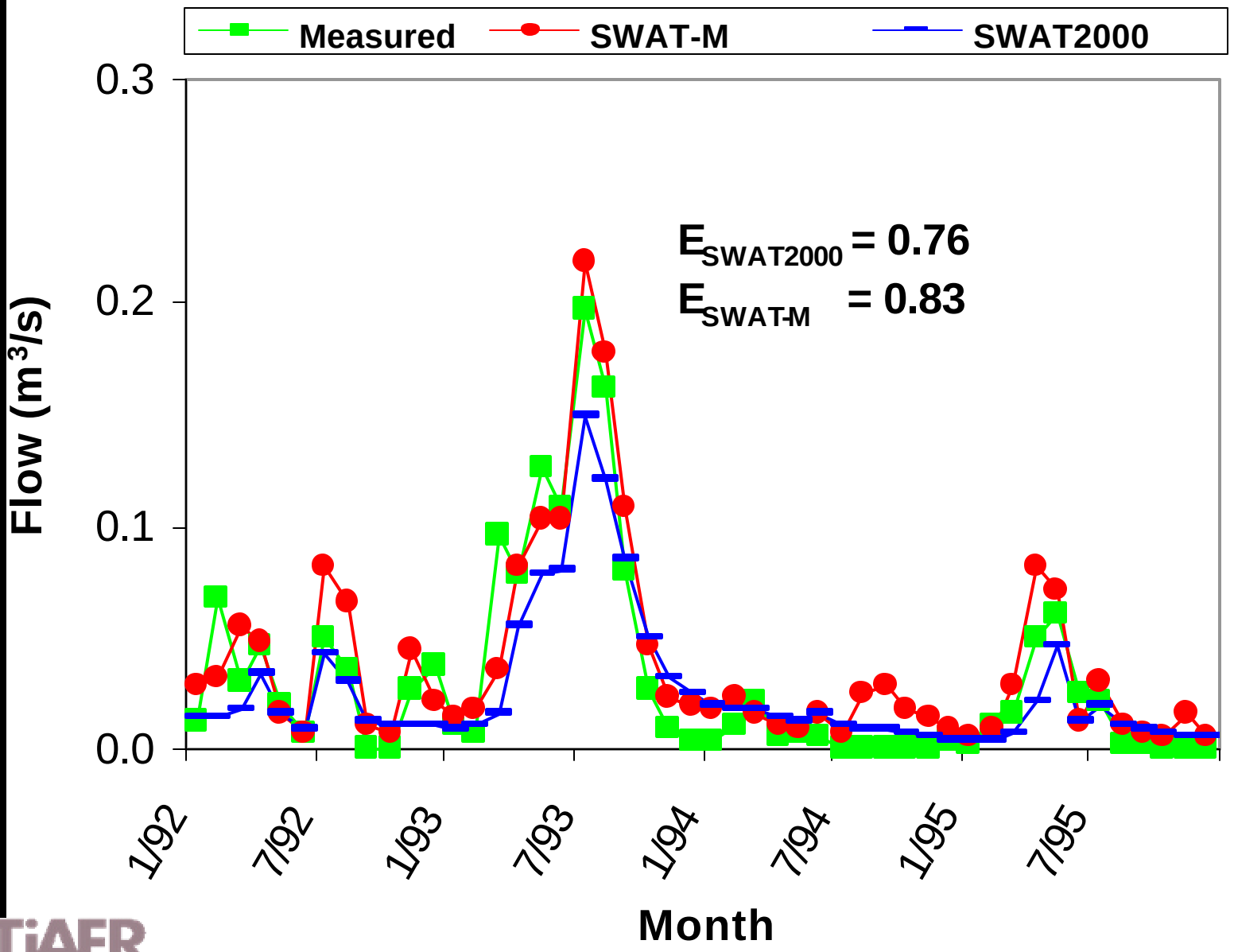
# Average Monthly Flow During Calibration - Site 220

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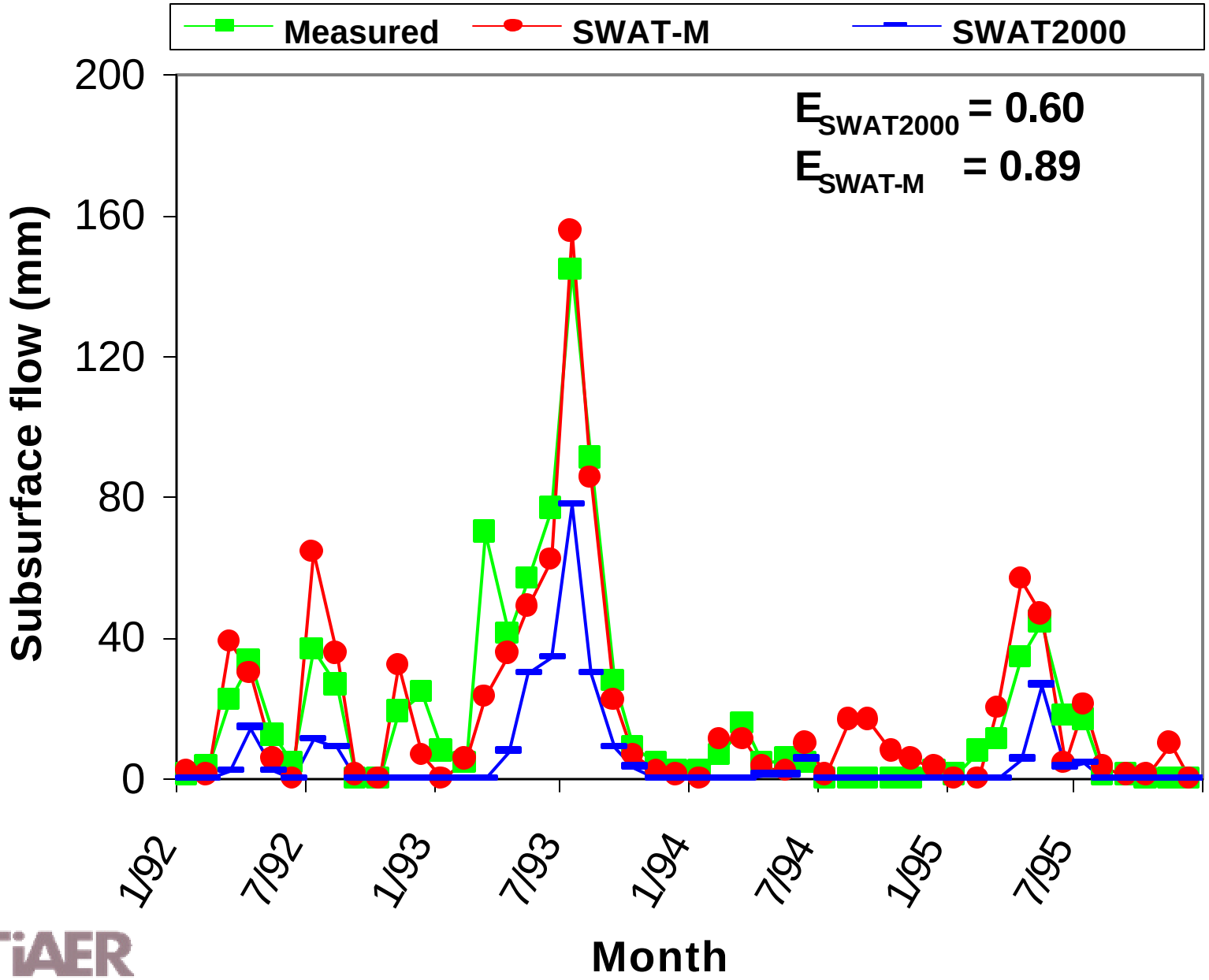
# Average Monthly Sub-surface Flow During Calibration Site-220

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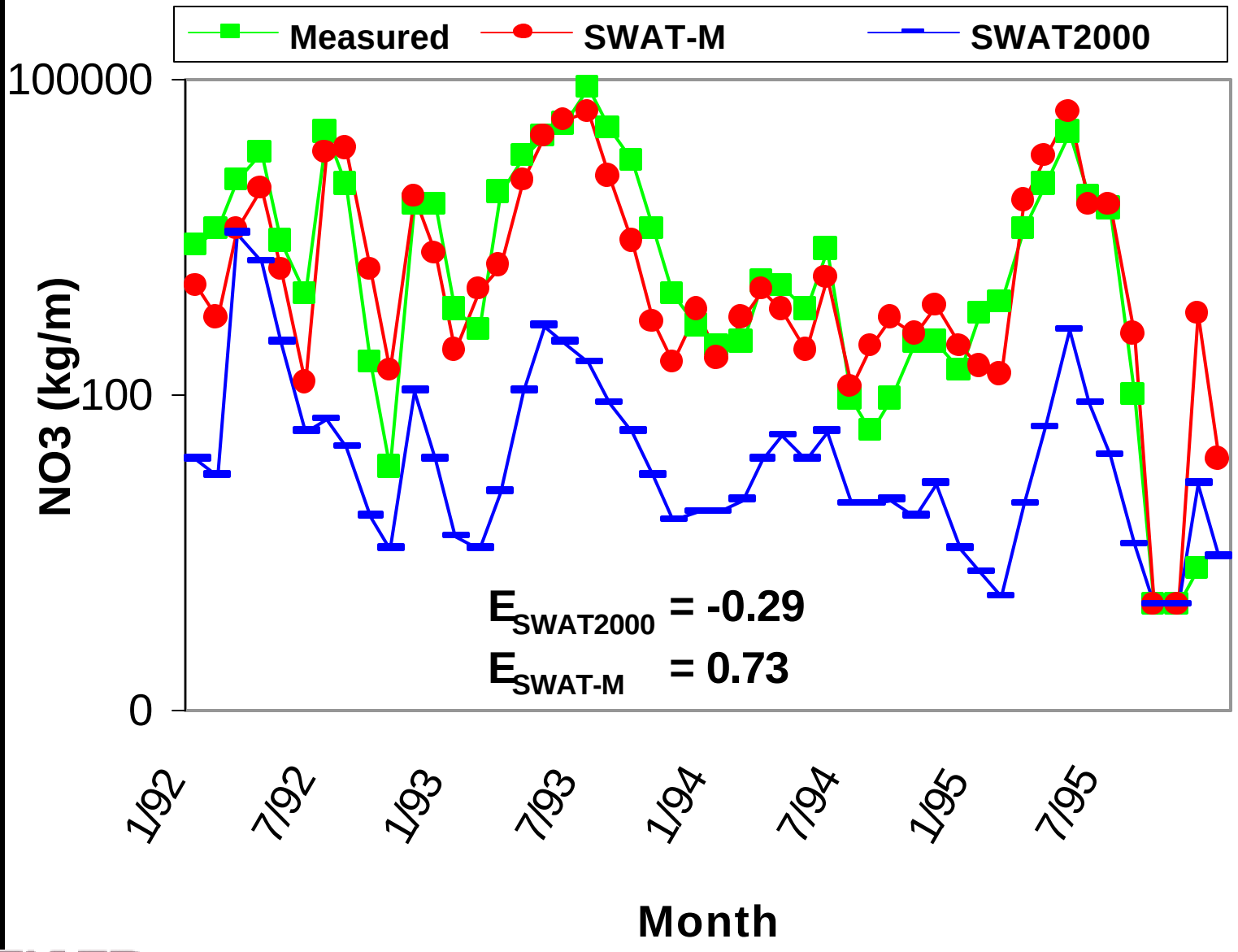
# $NO_3$ During Calibration - Site 330

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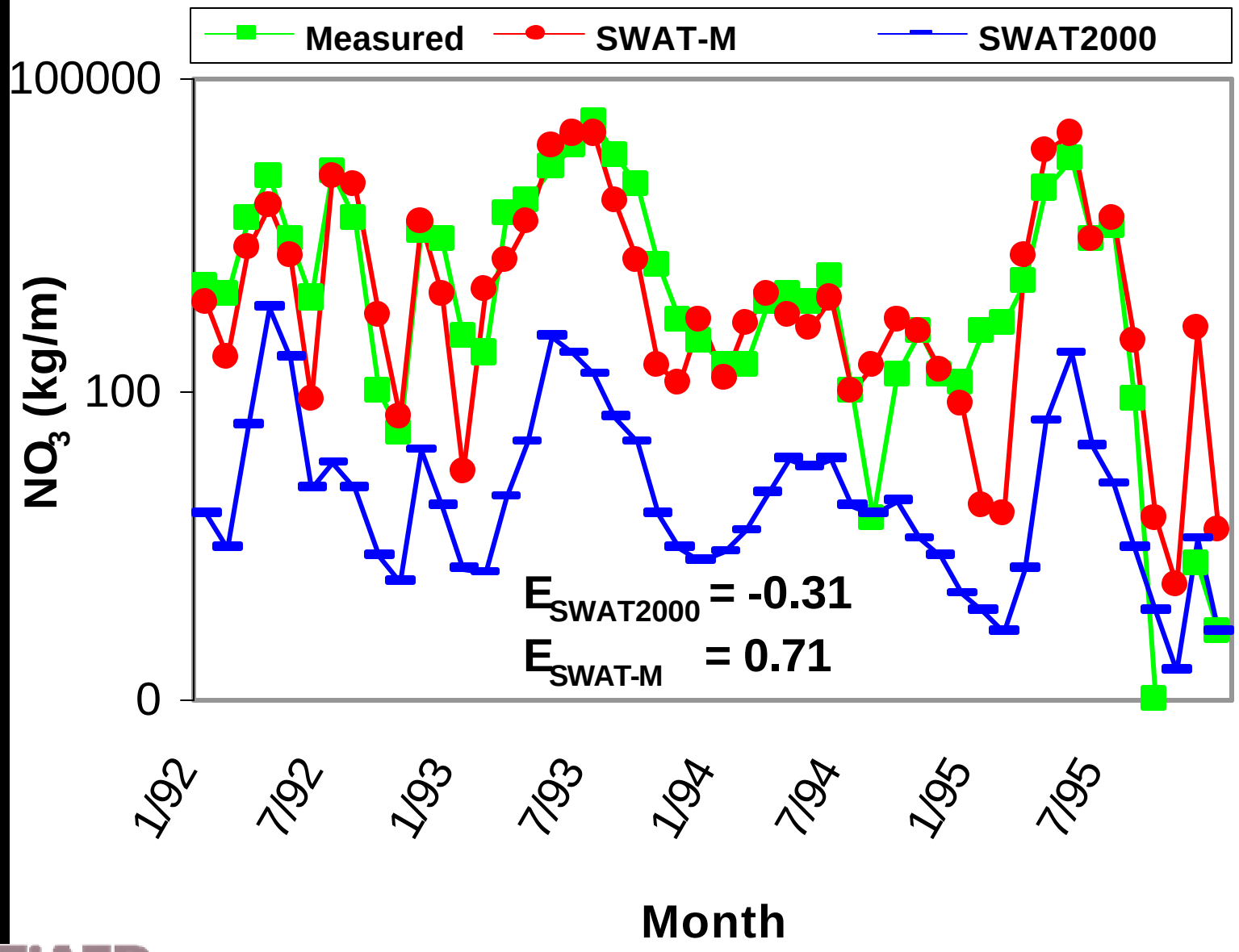
# $NO_3$ During Calibration - Site 220

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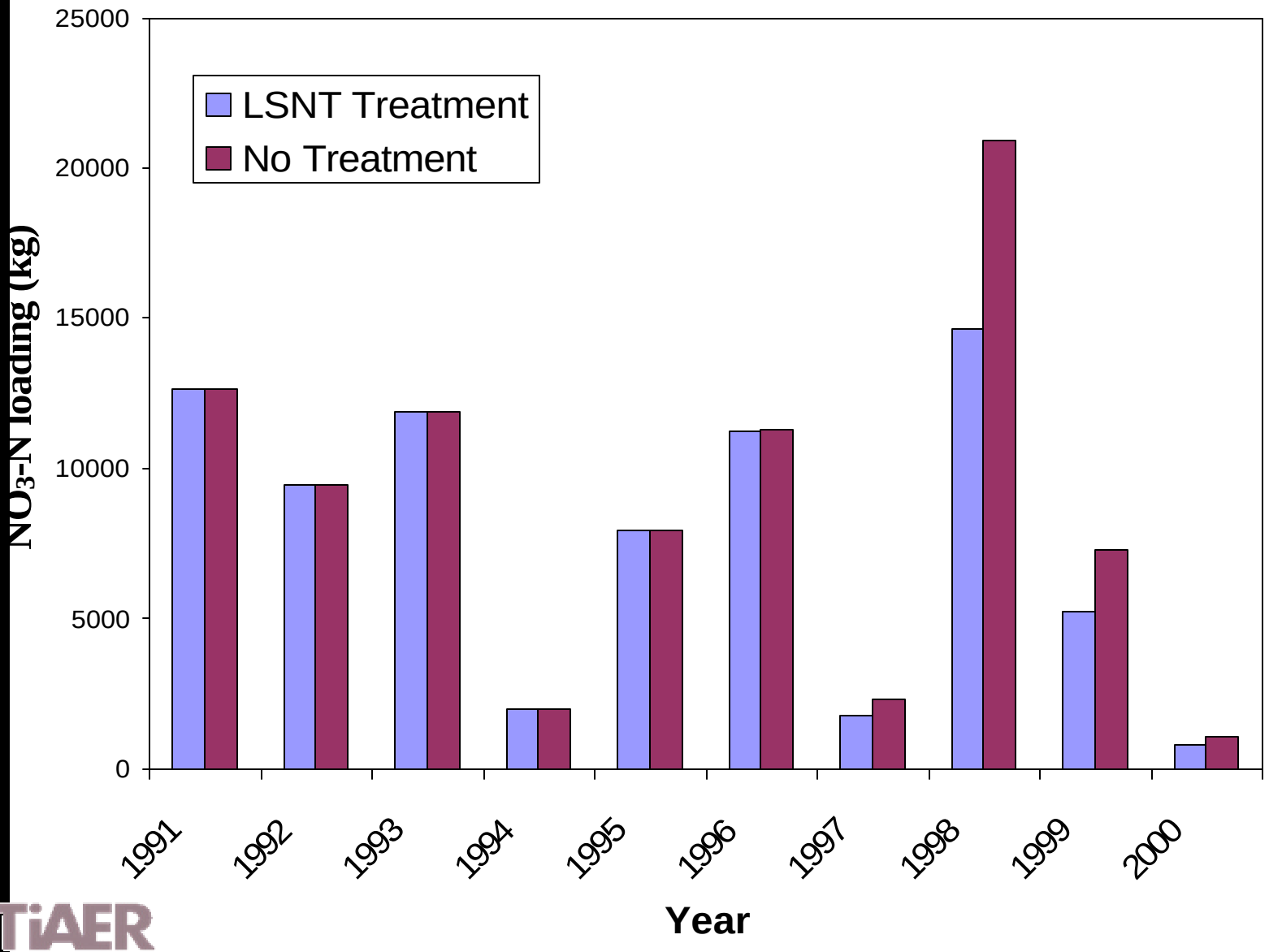
# Simulated NO3-N reduction under LSNT treatment at site 220.

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# 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)

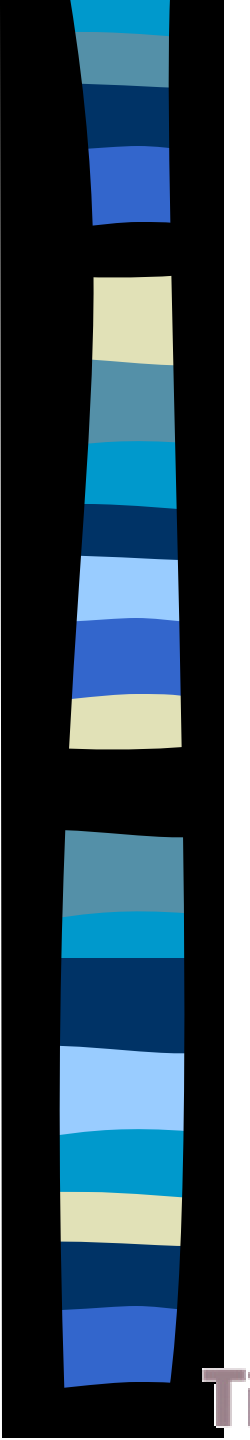
- The Avg. monthly Nitrate-N predicted by SWAT2000 were much lower than the measured values
- The patterns of predicted Nitrate-N by SWAT-M were much closer to those of measured values

# 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*