Grid Based Mercury Model (GBMM) Application in McTier Creek and Fishing Brook Watersheds: Progress and Updates

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Mercury in Streams Ecosystems Team Meeting

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U.S. Environmental Protection Agency
Office of Research and Development

Grid Based Mercury Model

- watershed-scale
- spatially-explicit
- process-based
- estimates daily water, sediment, and mercury fluxes from each land cover type to surface waters

H_2O, Hg, and sediment cycling, mass balance, and flow routing per grid cell

Legend:
— stream network
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Mixed Shrubland (scrub/shrub)
- Grassland/Herbaceous
- Pasture/Hay
- Row Crops (cultivated crops)
- Woody Wetlands
- Herbaceous Wetlands

0   1,250   2,500   5,000 Meters
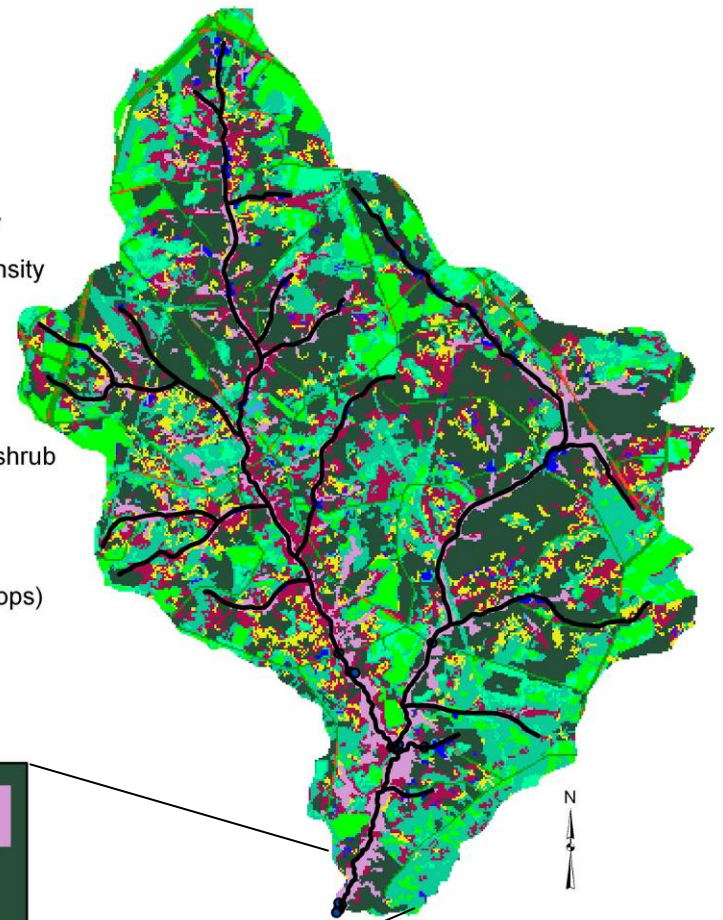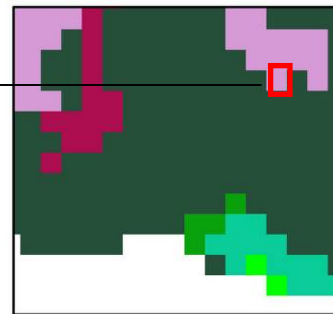
Application of Grid Based Mercury Model (GBMM) SC & NY Watersheds USGS-EPA Collaboration: GOALS

- Assess simulated watershed Hg loadings, asking questions such as:

  - *Does GBMM produce similar output compared to empirical methods applied in these studies?*

  - *Is the primary driver of Hg loading in GBMM water fluxes, similar to other methods for estimating Hg fluxes in at these study sites?*

  - *What type of modeling application is needed to assess Hg dynamics in these watersheds? (i.e., is a simple, empirical method "good enough" or will a process-based spatial model help identifying important Hg cycling dynamics?)*

- Advance watershed-based mercury science & improve understanding of watershed Hg processes using this data-rich study

- Improve Hg processing in GBMM & calibration of model using project soil Hg data as input and water quality data for calibration
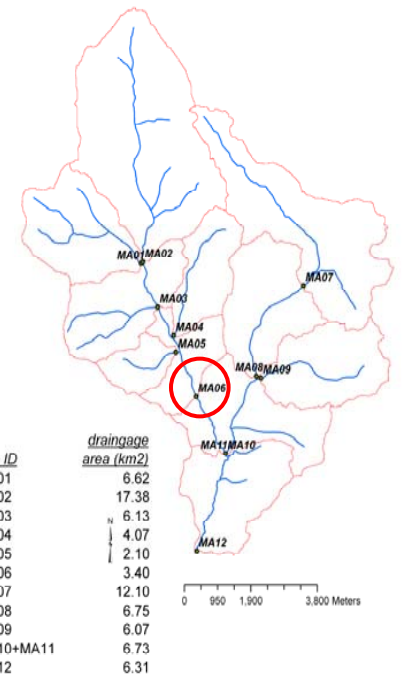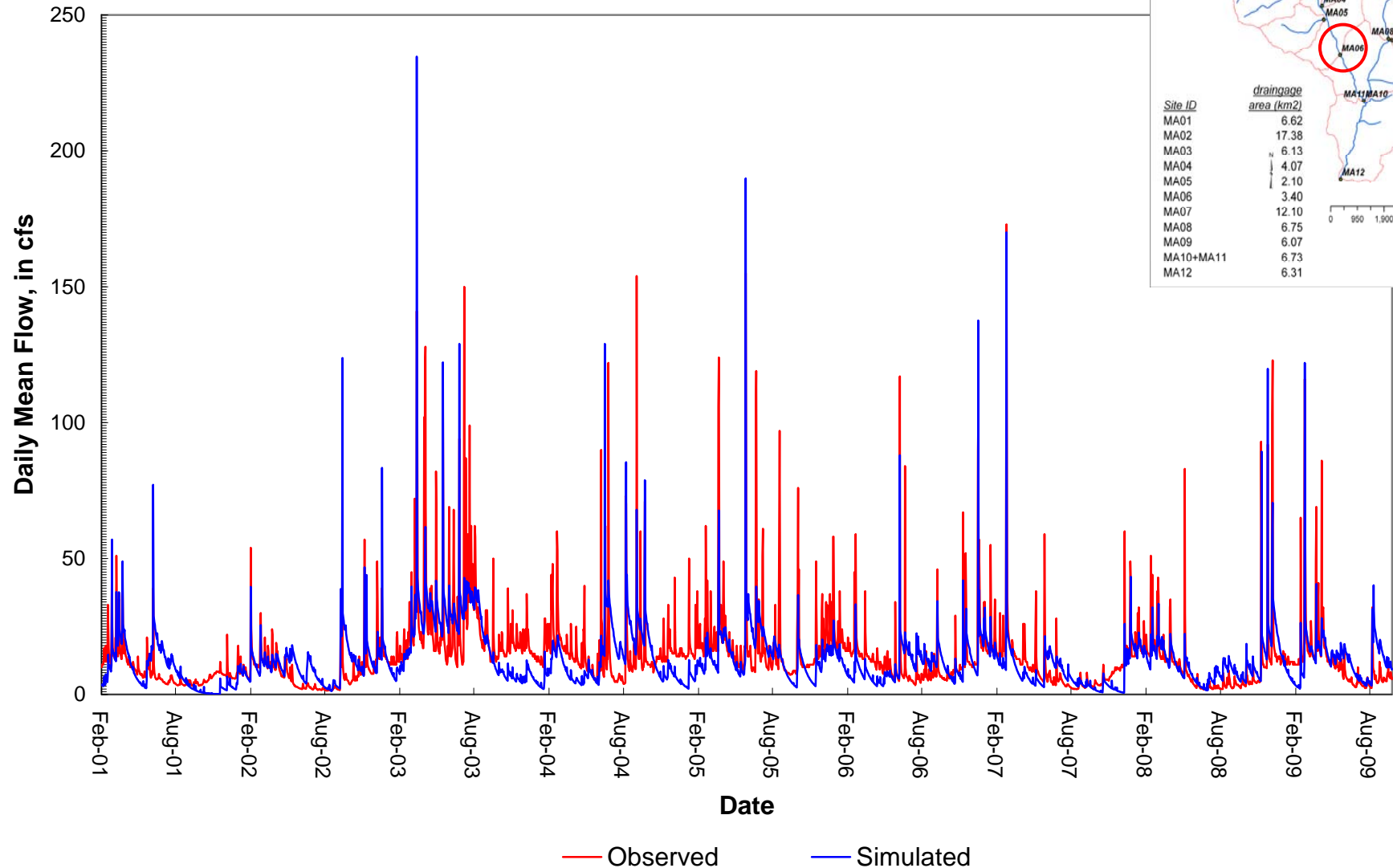
⊕EPA   ECOSYSTEMS SERVICES RESEARCH PROGRAM
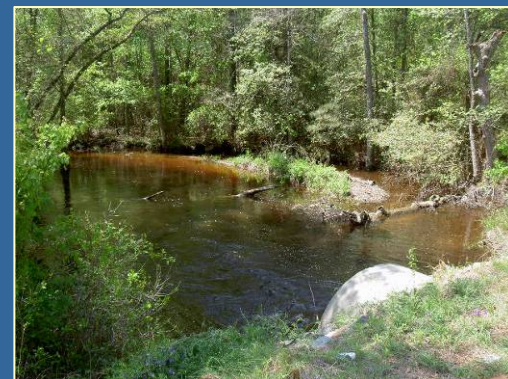
Status of GBMM modeling in McTier Creek Watershed: Hydrology

Included in Feaster et al. Scientific Investigations Report (in prep):
Simulation of the Quantity, Variability, and Timing of Streamflow in the McTier Creek Basin, South Carolina

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Calibrated hydrology: McTier near Monetta

Station 02172300, McTier Creek near Monetta, SC (020701 to 093009)

Site ID	drainage area (km2)
MA01	6.62
MA02	17.38
MA03	6.13
MA04	4.07
MA05	2.10
MA06	3.40
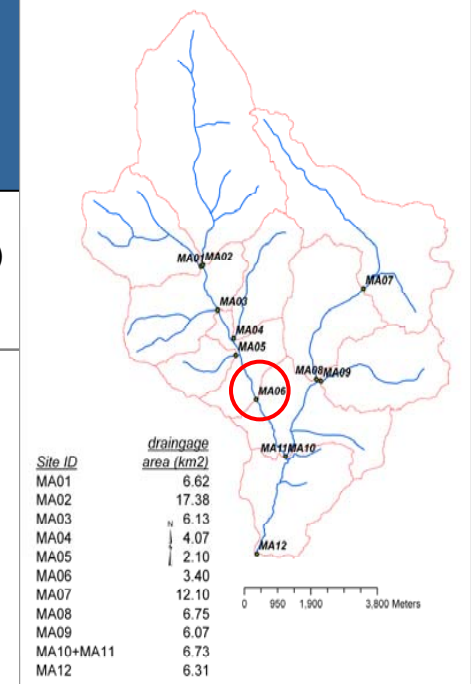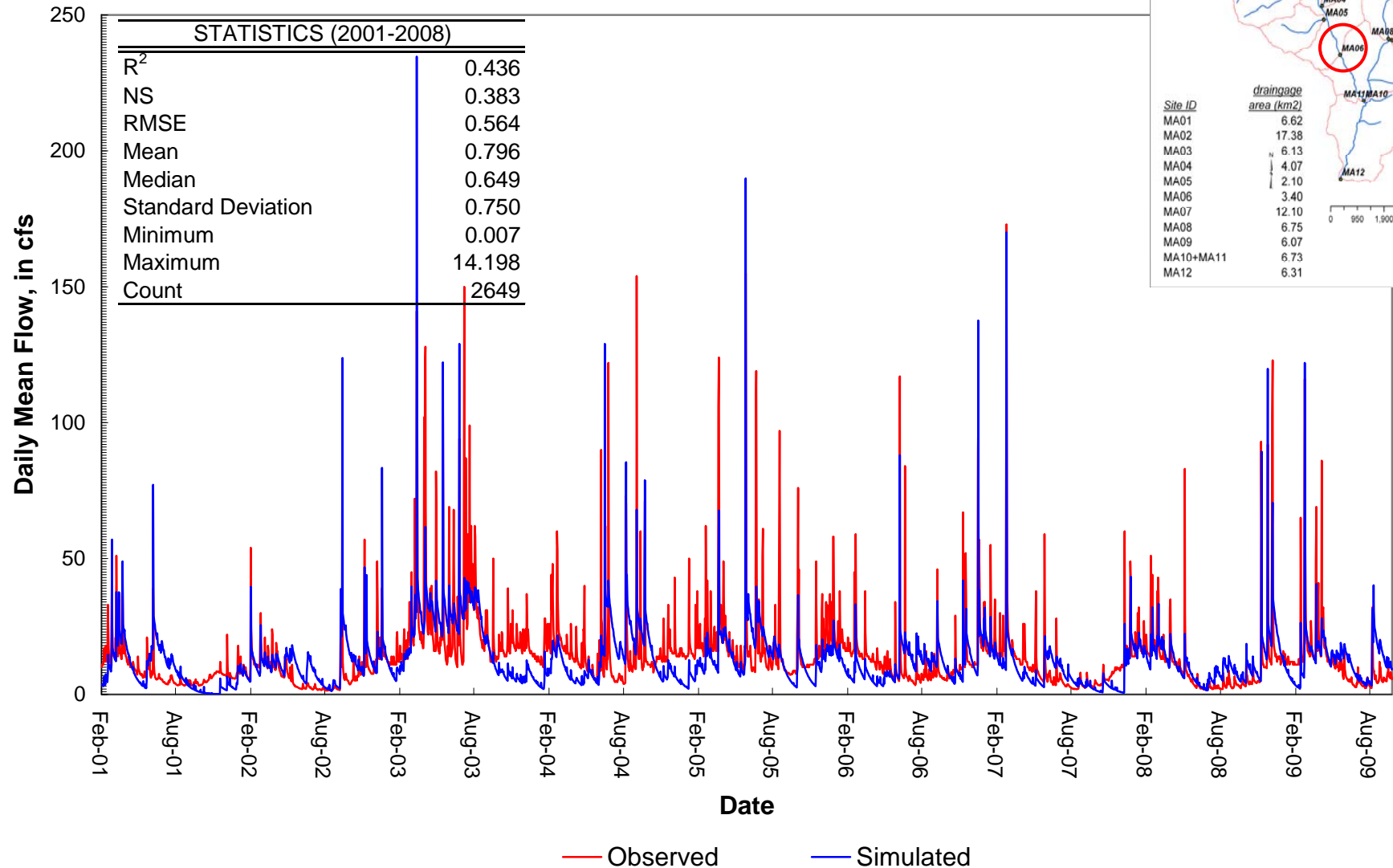MA07	12.10
MA08	6.75
MA09	6.07
MA10+MA11	6.73
MA12	6.31

Calibrated hydrology: McTier near Monetta

Station 02172300, McTier Creek near Monetta, SC (020701 to 093009)

STATISTICS (2001-2008)	
R^2	0.436
NS	0.383
RMSE	0.564
Mean	0.796
Median	0.649
Standard Deviation	0.750
Minimum	0.007
Maximum	14.198
Count	2649

Site ID	drainage area (km2)
MA01	6.62
MA02	17.38
MA03	6.13
MA04	4.07
MA05	2.10
MA06	3.40
MA07	12.10
MA08	6.75
MA09	6.07
MA10+MA11	6.73
MA12	6.31

Daily Mean Flow, in cfs — Date

— Observed   — Simulated

Calibrated hydrology: McTier near New Holland

Station 02172305, McTier Creek at New Holland, SC (061307 to 093009

Site ID	drainage area (km2)
MA01	6.62
MA02	17.38
MA03	6.13
MA04	4.07
MA05	2.10
MA06	3.40
MA07	12.10
MA08	6.75
MA09	6.07
MA10+MA11	6.73
MA12	6.31

Daily Mean Flow, in cfs

Date

— Observed   — Simulated
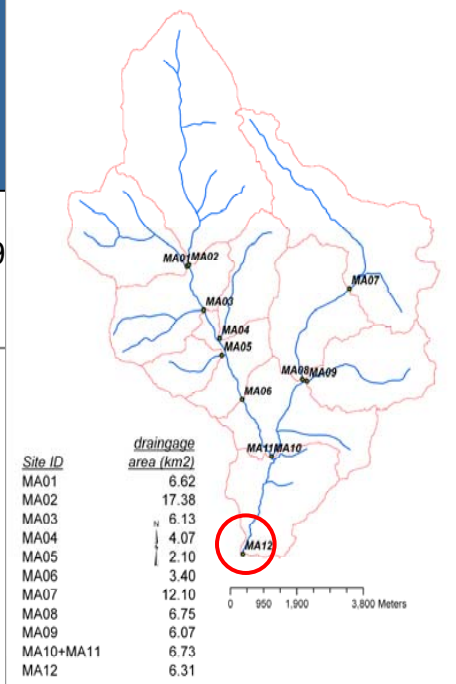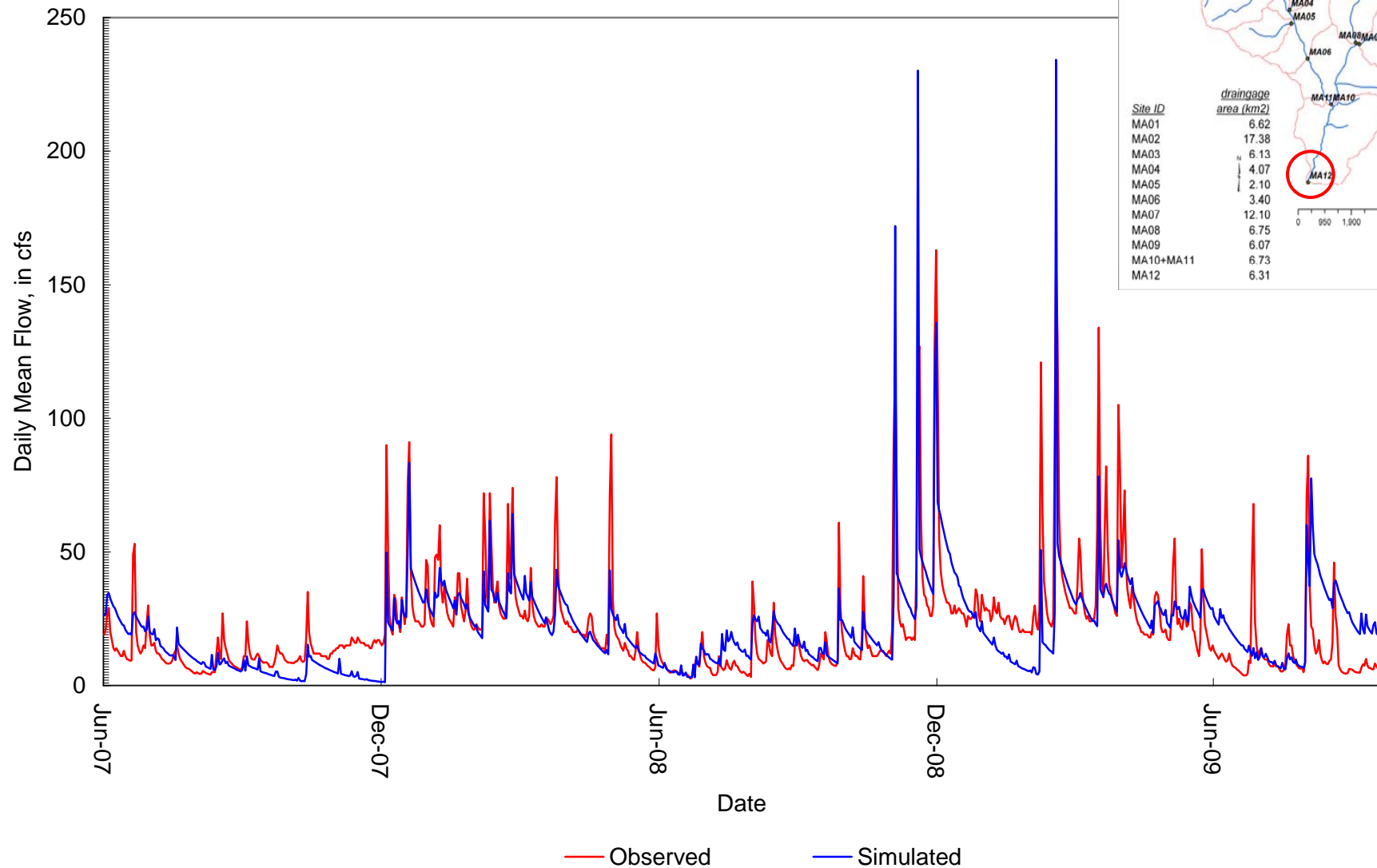
GBMM-TOPMODEL Comparisons
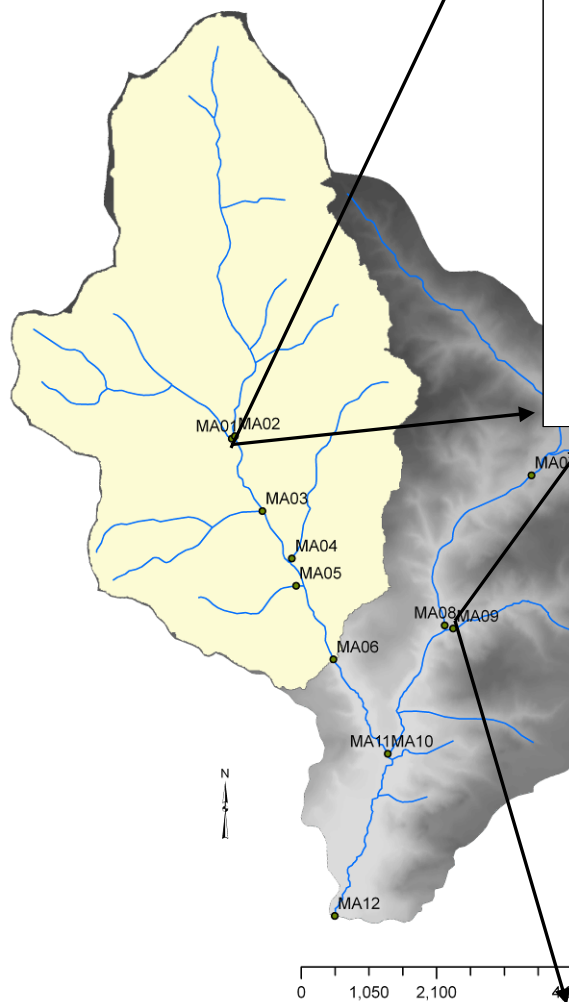
Simulated runoff (mm): MA02

Simulated runoff (mm): MA09

Status of GBMM modeling in McTier Creek Watershed: Mercury

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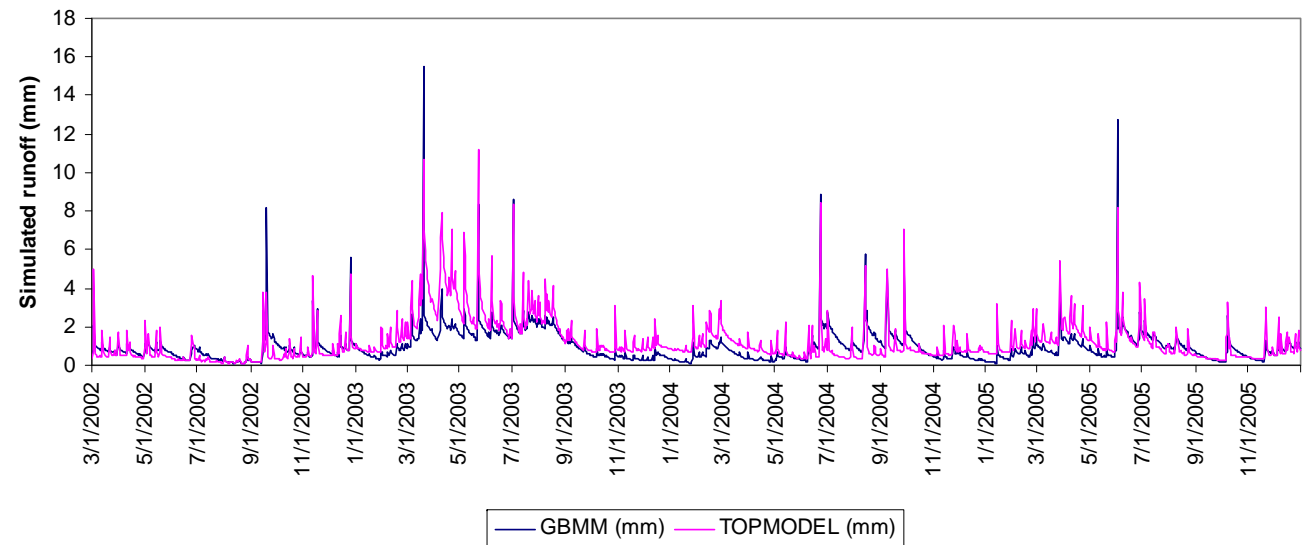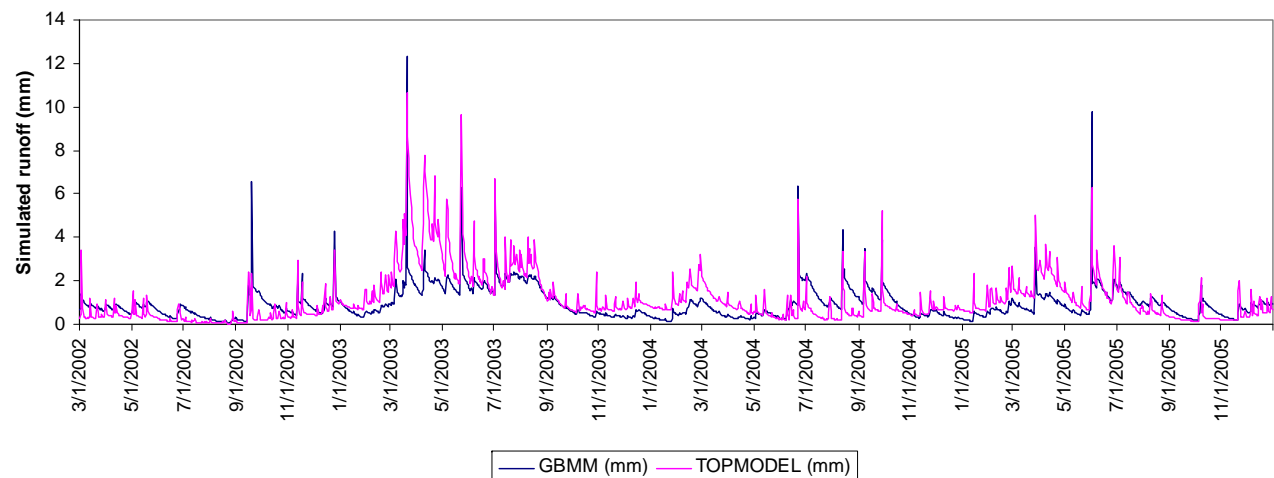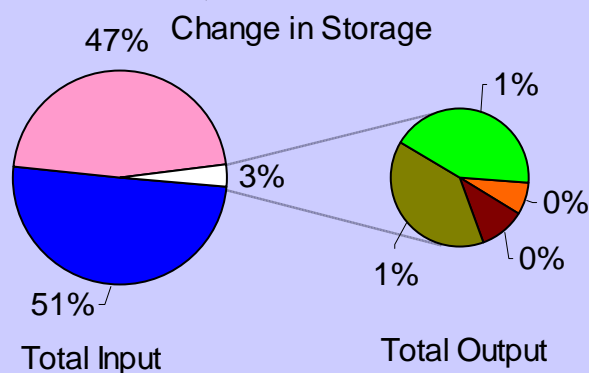ECOSYSTEMS SERVICES RESEARCH PROGRAM

Hg flux: current status

THg: McTier near Monetta (Station 02172300)

Concentrations low: range from <0.000 ng/L to 0.005 ng/L

Project soils data and water quality used for calibration
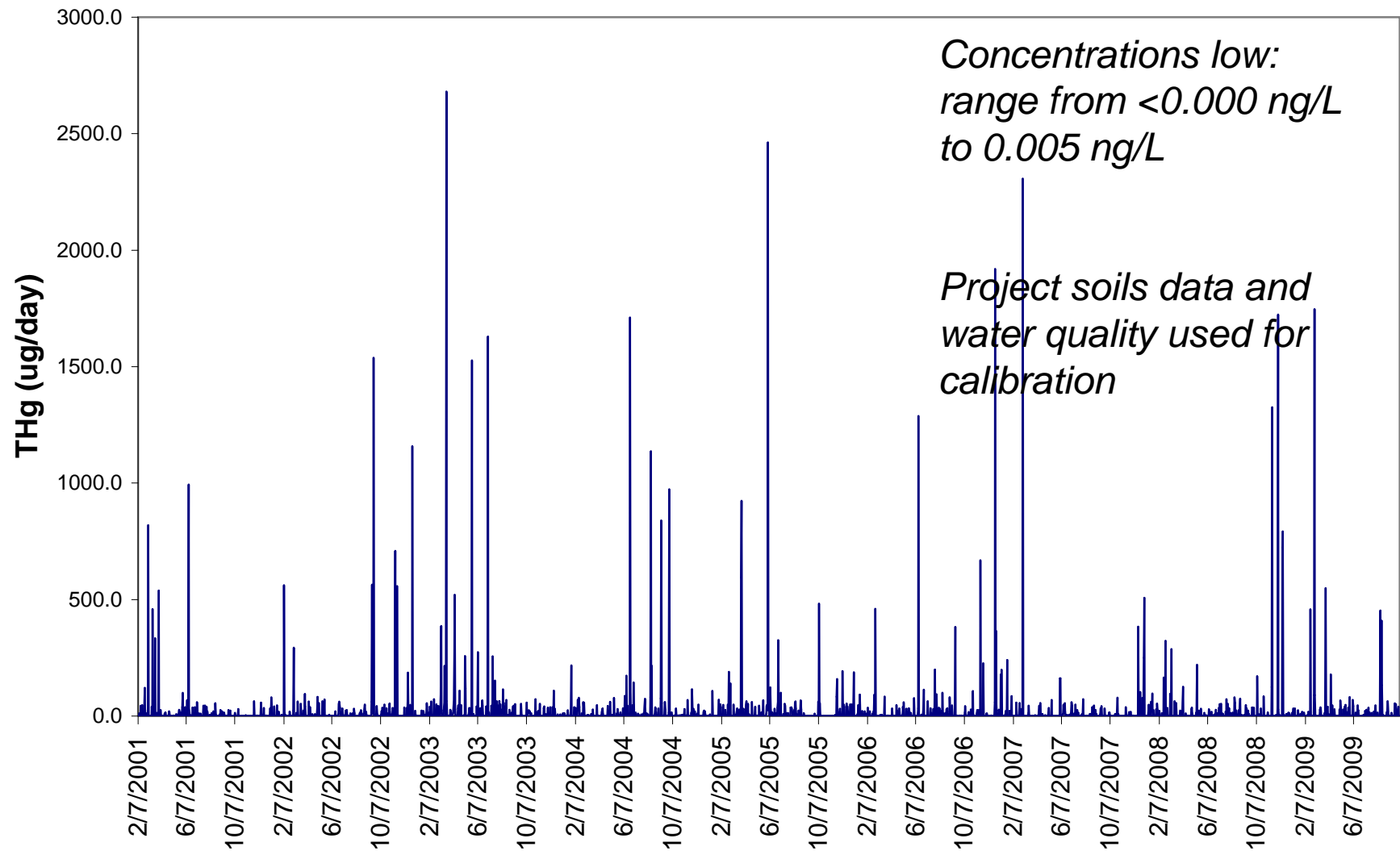
Hg flux: current status

McTier near Monetta: mass balance and landscape sources, example year 2004

Annual Mercury Mass Balance
(μg/m^2/day)

Change in Storage

47%

3%

1%

51%

1%

0%

0%

Total Input

Total Output

- ■ Mercury atmospheric deposition
- ■ Mercury loss due to runoff
- ■ Mercury loss due to erosion
- ■ Mercury loss due to leaching
- ■ Mercury loss due to soil reduction
- ■ Mercury mass in soil

Source Land Area (m^2)

15%

21%

29%

10%

5%

7% 1% 4%

7%

- ■ Developed
- ■ Open Water
- ■ Developed
- ■ Woody Wetlands
- ■ Pasture/Hay
- ■ Row Crops (cultivated crops)
- ■ Grassland/Herbaceous
- ■ Herbaceous Wetlands
- ■ Mixed Shrubland (scrub/shrub)
- ■ Deciduous Forest
- ■ Evergreen Forest
- ■ Mixed Forest
- ■ Developed

Annual Mercury Load (μg)

73%

3%

19%

1% 3% 1%

- ■ Developed
- ■ Open Water
- ■ Developed
- ■ Woody Wetlands
- ■ Pasture/Hay
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MA10+MA11	6.73
MA12	6.31

Hg flux: current status

THg: McTier near New Holland (Station 02172305)

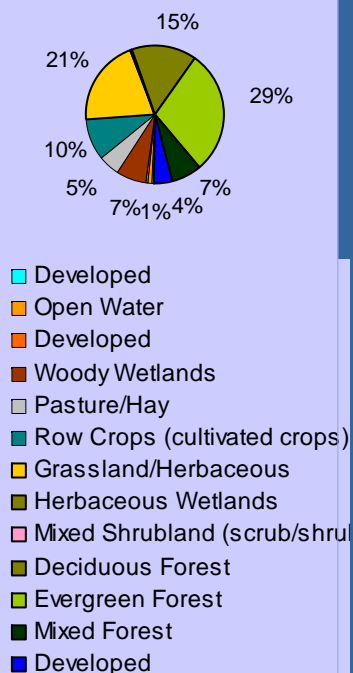*Concentrations low: range from <0.000 ng/L to 0.004 ng/L*

Hg flux: current status

McTier near New Holland: mass balance and landscape sources, example year 2008

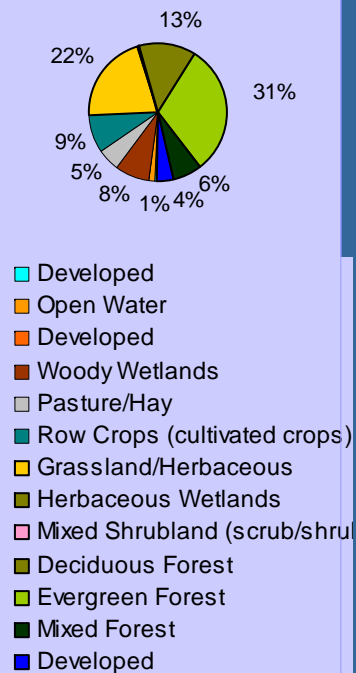## Annual Mercury Mass Balance
(μg/m^2/day)

Change in Storage

49%

1%

1%

50%

Total Input

0%

0%

0%

Total Output

- Mercury atmospheric deposition
- Mercury loss due to runoff
- Mercury loss due to erosion
- Mercury loss due to leaching
- Mercury loss due to soil reduction
- Mercury mass in soil

Source Land Area (m^2)

13%

22%

31%

9%

5%

8% 1% 4% 6%

- Developed
- Open Water
- Developed
- Woody Wetlands
- Pasture/Hay
- Row Crops (cultivated crops)
- Grassland/Herbaceous
- Herbaceous Wetlands
- Mixed Shrubland (scrub/shrub)
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Developed

Annual Mercury Load (μg)

81%

17% 1%

- Developed
- Open Water
- Developed
- Woody Wetlands
- Pasture/Hay
- Row Crops (cultivated crops)
- Grassland/Herbaceous
- Herbaceous Wetlands
- Mixed Shrubland (scrub/shrub)
- Deciduous Forest
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- Developed

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Status of GBMM modeling in Fishing Brook Watershed: Hydrology

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Calibrated hydrology: Fishing Brook at County Line Flow

Fishing Brook @ County Line Flow: 12/1/2002 - 5/31/08
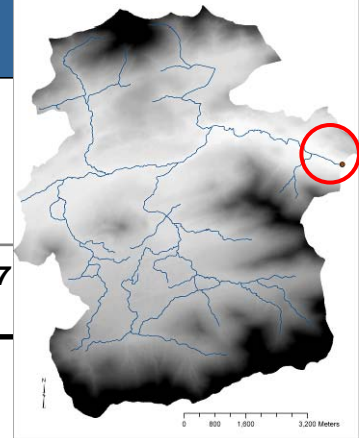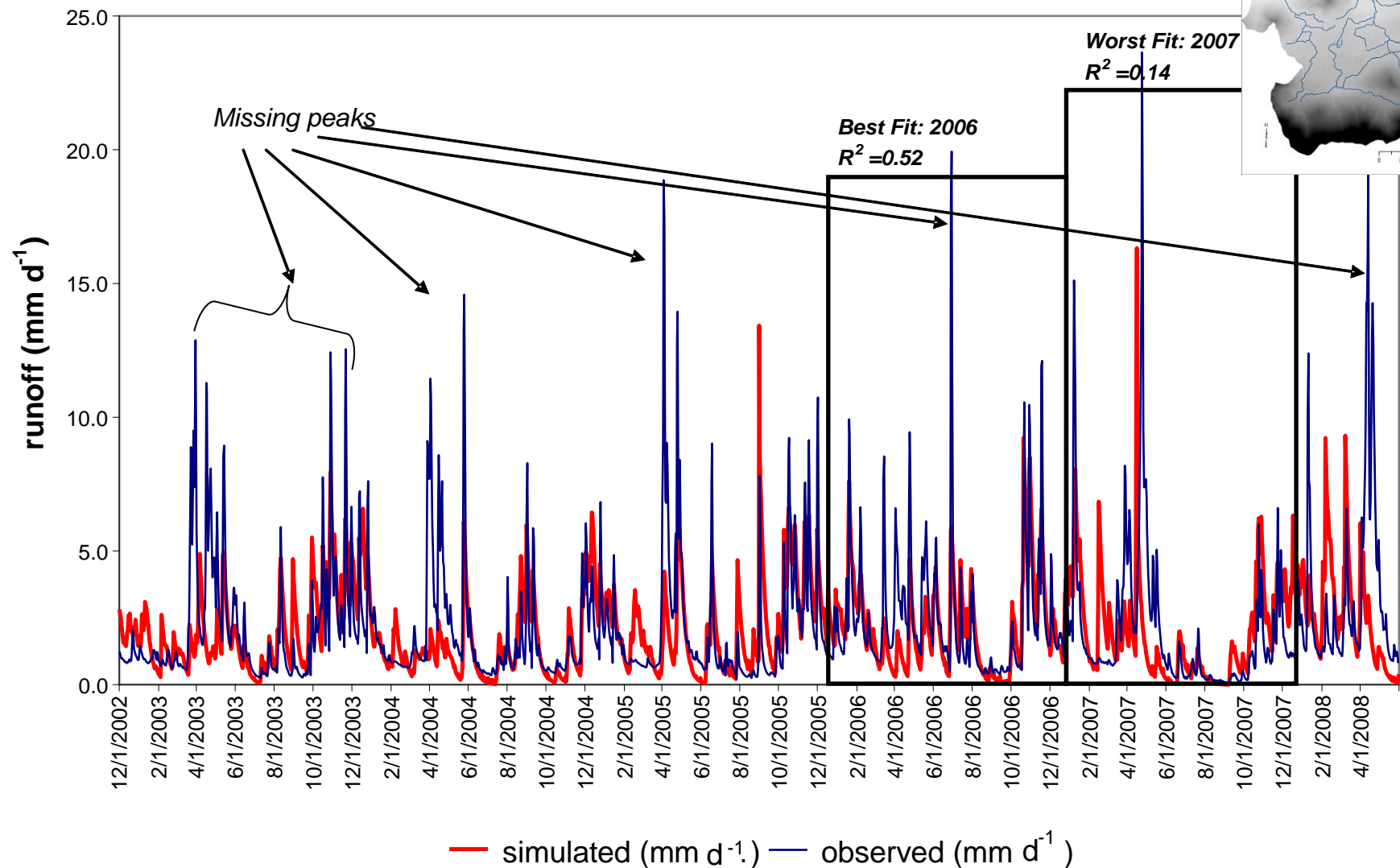
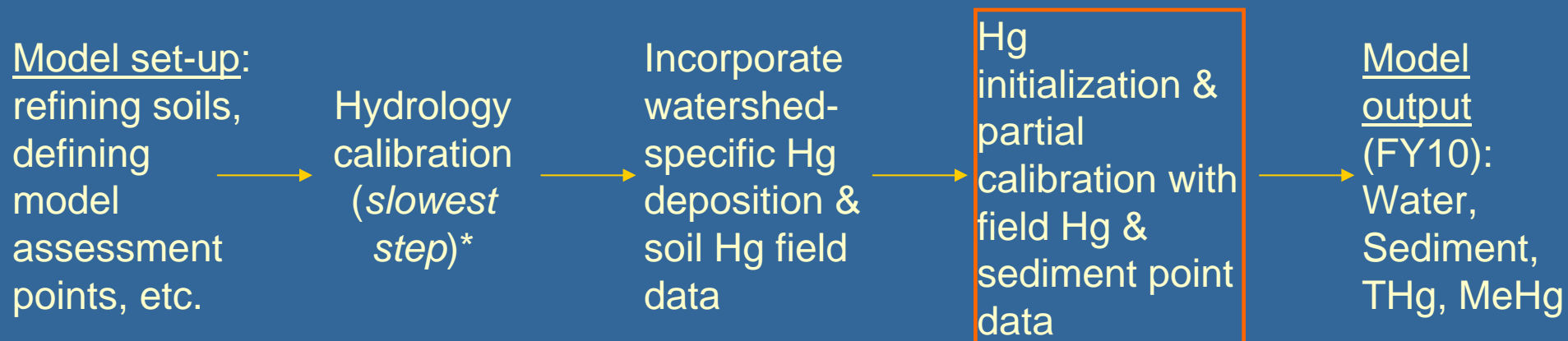*<10% difference in observed vs. simulated volume during 6+ year period*

Calibration Statistics: Fishing Brook @ County Line Flow

STATISTICS (2002-2008)	
R^2	0.274
NS	0.235
RMSE	1.480
Mean	2.047
Median	1.621
Standard Deviation	1.697
Minimum	0.002
Maximum	16.319
Count	2009

Units for RMSE, Mean, Median, STD, Min, Max = mm

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Status of GBMM Modeling

For both McTier (SC) and Fishing Brook (NY) watersheds:

Model set-up: refining soils, defining model assessment points, etc. → Hydrology calibration (*slowest step*)* → Incorporate watershed-specific Hg deposition & soil Hg field data → Hg initialization & partial calibration with field Hg & sediment point data → Model output (FY10): Water, Sediment, THg, MeHg

Potential manuscripts & next steps

- Calibrate Hg in McTier

- Move to Fishing Brook

- Potential papers using GBMM (external to current report plan):

  - EPA/USGS multi-media model linkage using bioaccumulation data from this project to predict and understand affects of Hg fluxes and on bioaccumulation.

  - Others to be discussed this week…

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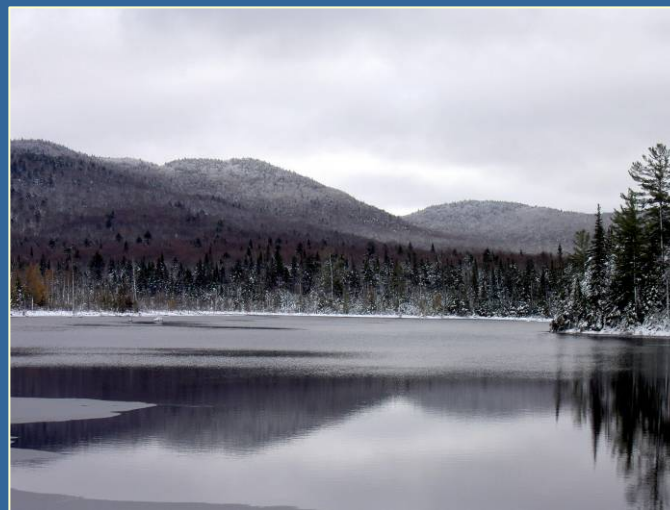
Links: USGS-USEPA Collaboration & USEPA Ecosystem Services Research Program (ESRP) Initiatives

Improve GBMM for ESRP projects via:

- Sharing soil Hg data: range of values for calibrating model in multiple geophysical settings

- Improving and developing wetland module processes

- Improving understanding of Hg processing in different land uses

- Comparing GBMM outputs to empirical tools: What are we getting right? What are we missing?

- Refining ability to scale Hg processes to/from small watersheds (NAWQA in NY and SC) & larger basins (e.g., Coastal Carolinas for ESRP)

- Developing cross-cutting products: presentations, publications

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