Best management practices for reducing nutrient loads in a sub-watershed of Chesapeake Bay

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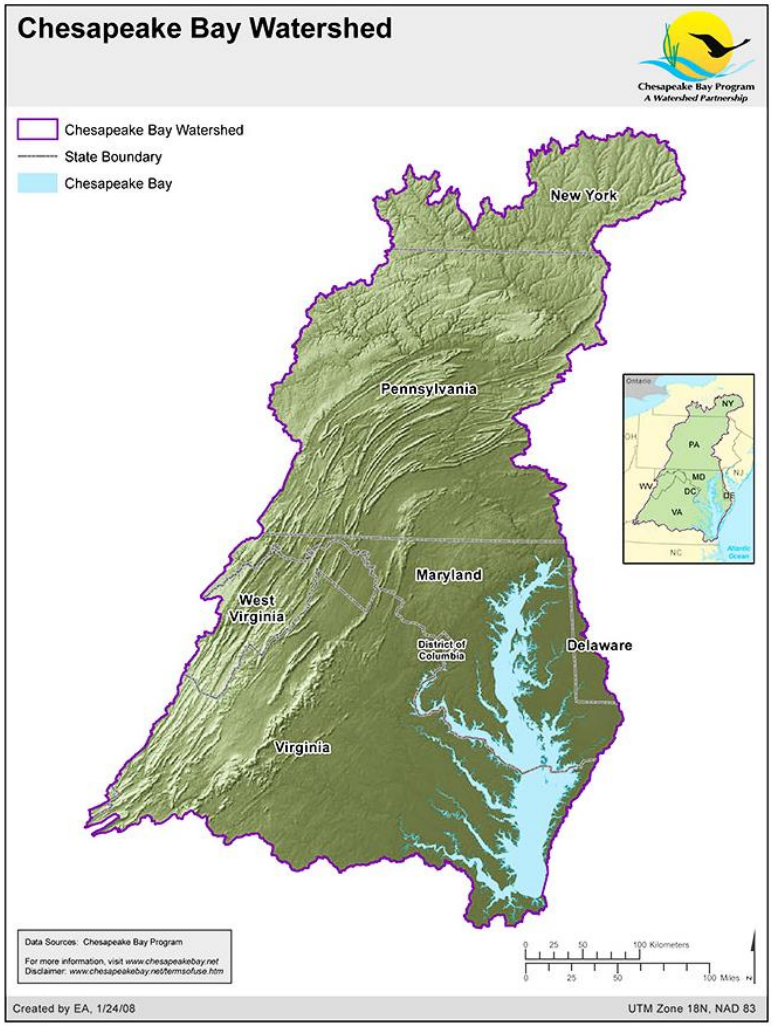
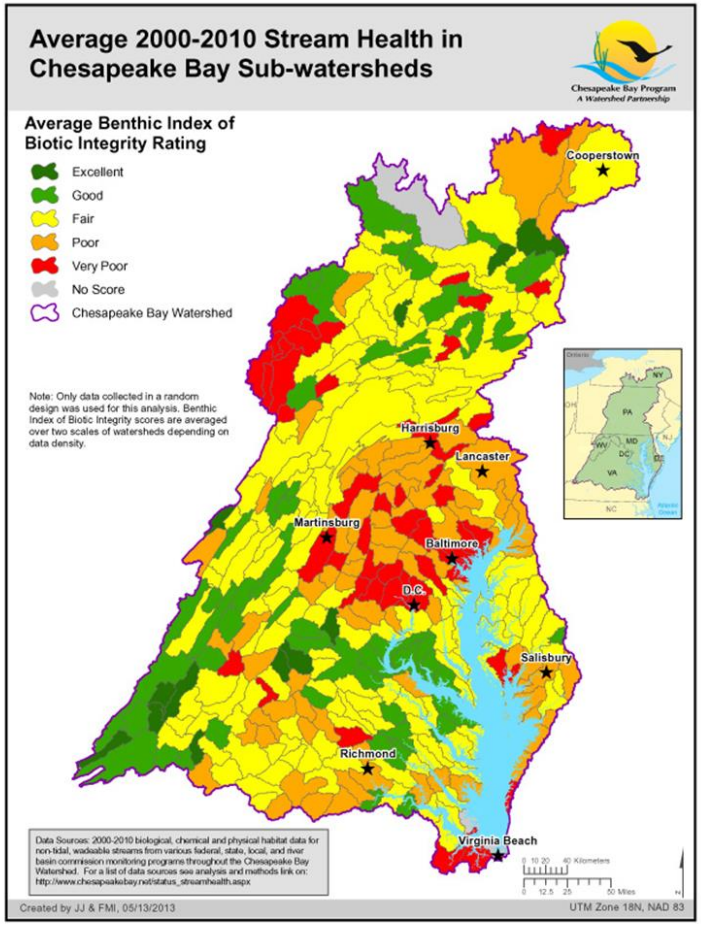


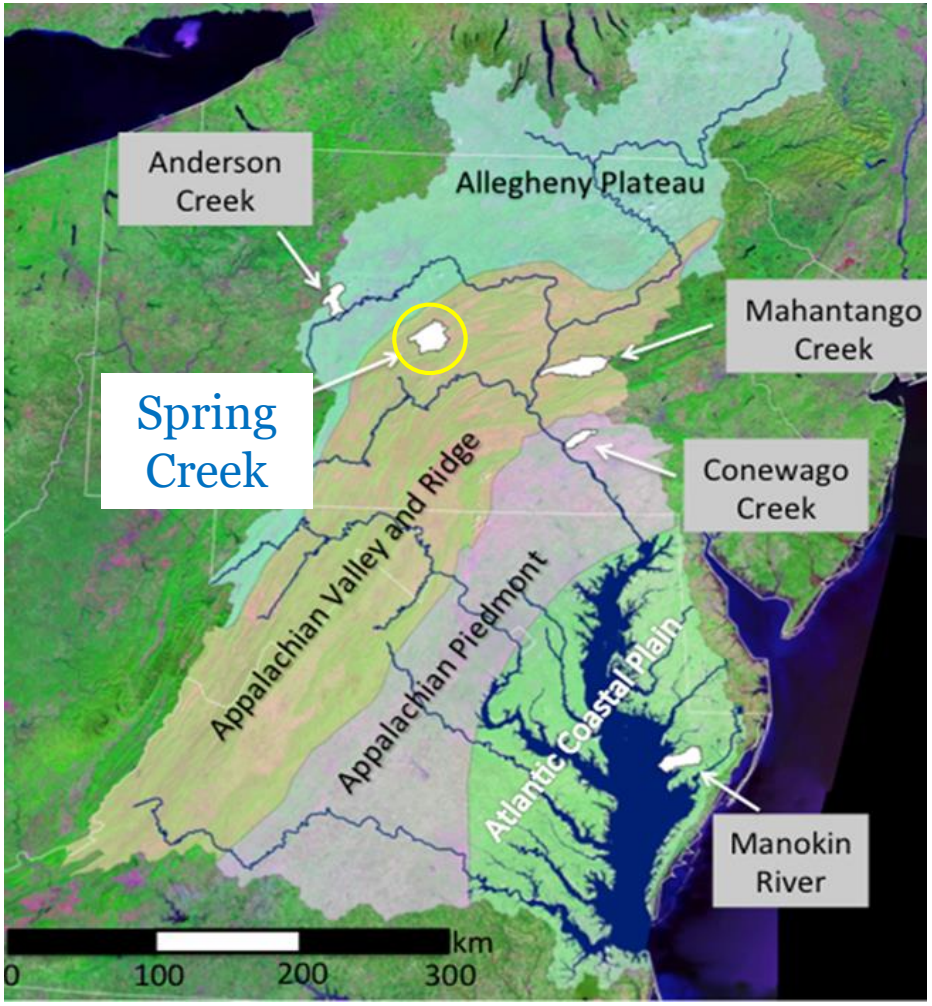
Background

- Water quality improvement in the Chesapeake Bay
  - TMDL (total maximum daily load)
  - 20 to 30% reduction by 2025
  - Nitrogen, phosphorus, & sediment
- WIP (Watershed Implementation Plan)
  - Provides guideline with a set of BMPs (best management practices)
- Field-scale implementation plan
  - Finer scale needed to improve targeting

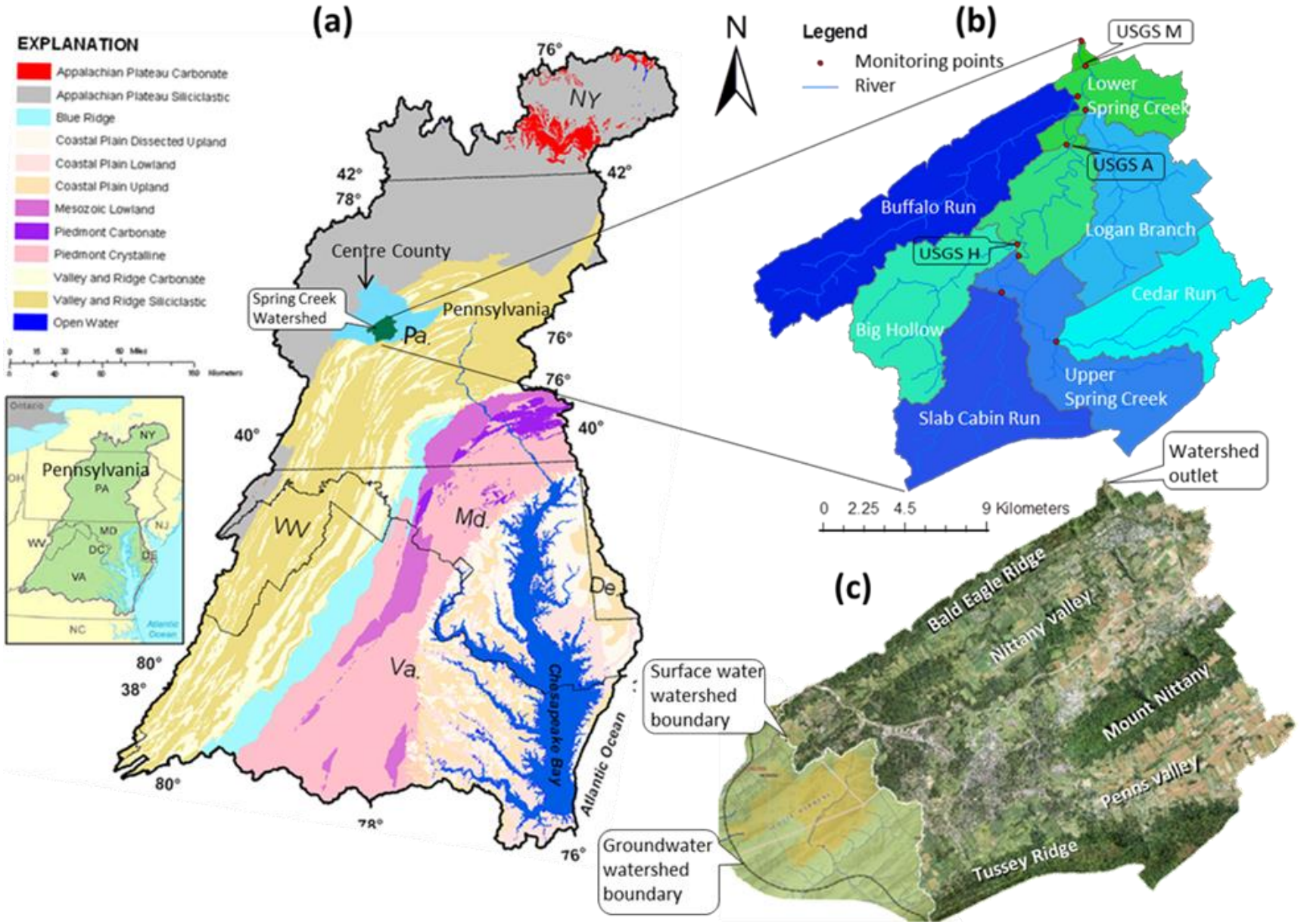


Objective

To Investigate the **effectiveness of BMPs** and develop an **implementation plan** using the **Soil and Water Assessment Tool (SWAT)** for **Spring Creek Watershed** in Centre County, Pennsylvania

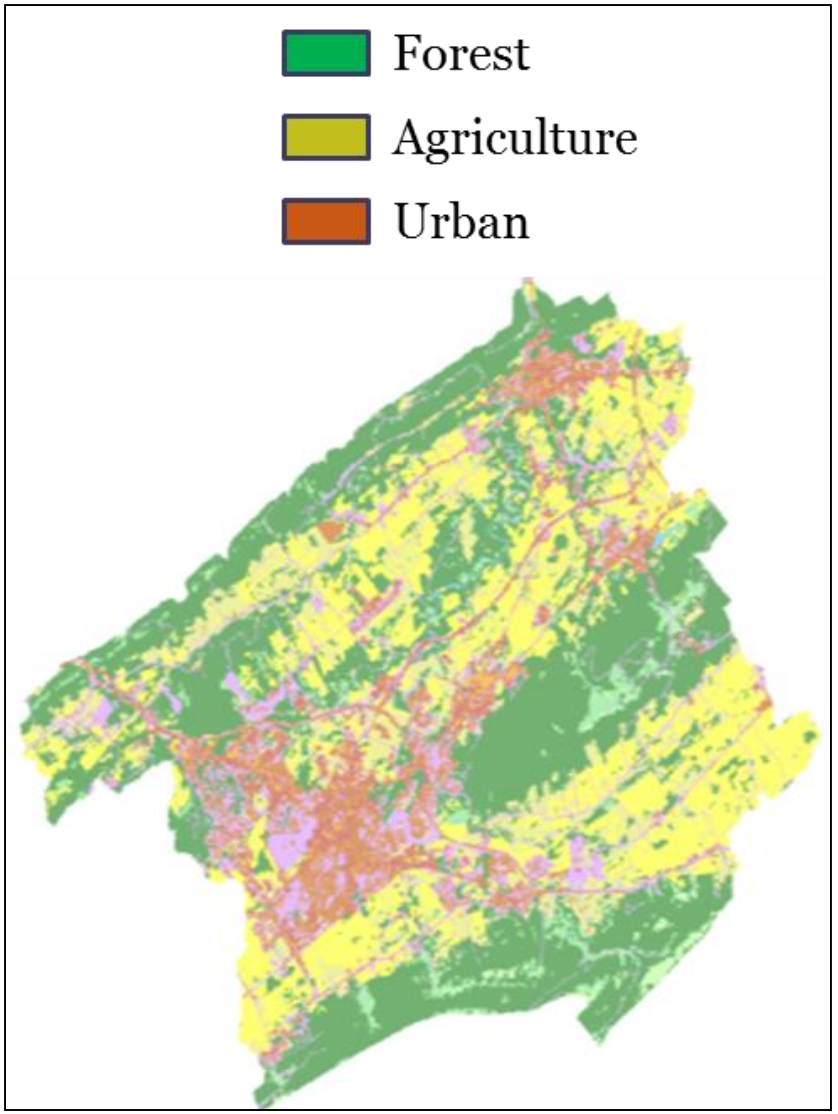


Map of the Spring Creek Watershed



Spring Creek Watershed

- Tributary to the West Branch Susquehanna River of Chesapeake Bay
- Total area: 369 km^2
- Land use: 34% agriculture
  21% developed
  43% forest
- Precipitation: 800-1270 mm
- Total runoff: 260-730 mm
- Aquifer: Karst type
- Base-flow: > 80% of stream flow



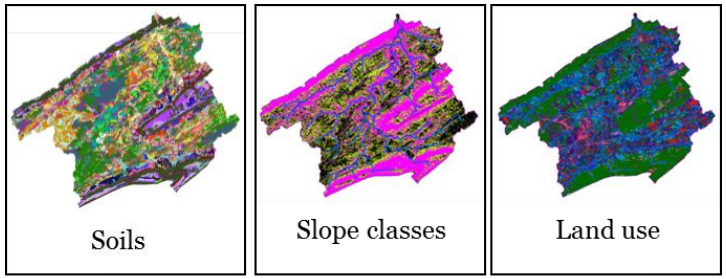
Watershed Implementation Plans (WIP)

- Developed for Chesapeake Bay Program by local states and stakeholders
- To meet TMDL goals for Bay established by EPA
- Identify watershed-level changes to collectively meet each state's nutrient and sediment reduction targets
- WIP guidelines include:
  - List of BMPs
  - Acreage of BMPs
  - Implementation requirements
  - Placement by land use

List of WIP-BMPs simulated in SWAT

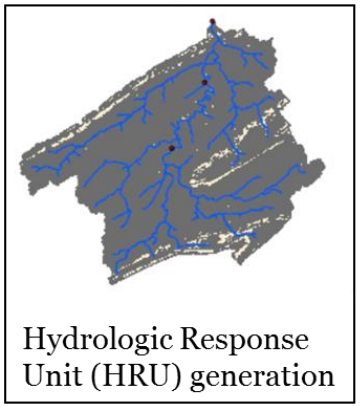
- Grass/forest buffers (30-m strip: 2.8% ag land)
- Land retirement as hay/pasture (8% ag land)
- Cover crop (12% ag land)
- Conservation tillage (No-till & min-till on 95% ag land)
- Carbon sequestration (Permanent grass on 2.6% ag land)
- Wetland restoration (1.5% ag land)
- Manure injection (0.8% ag land)
- Enhanced nutrient management (15% less N on ag land)

SWAT Framework



Digital Elevation Model

Subbasin and Watershed Delineation



Climate data

Land/field management

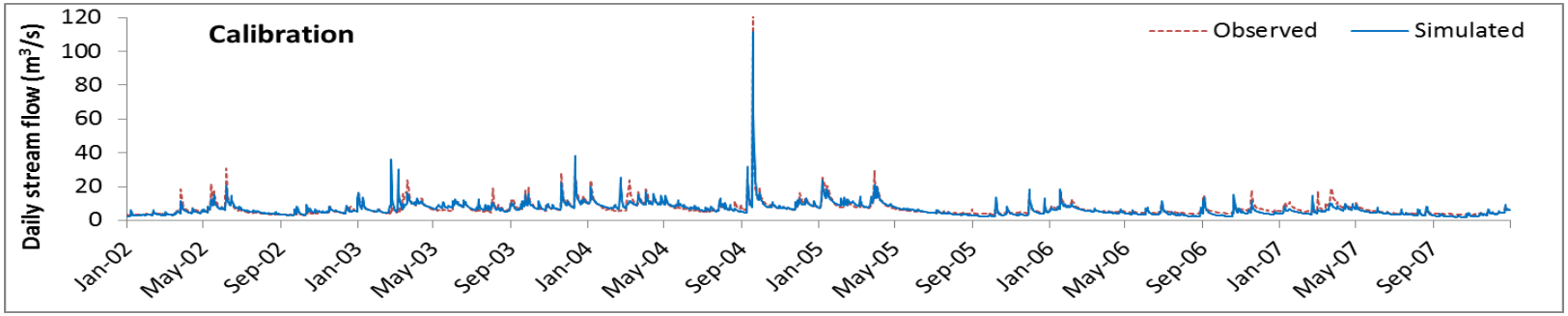
Write all input tables

User Inputs

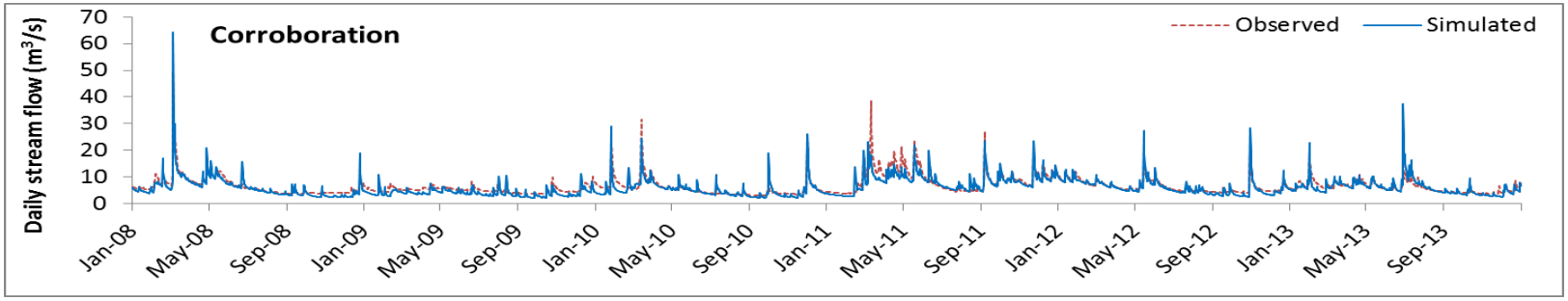
SWAT Defaults

Specify model run duration, time step, and additional outputs

Results: Calibration and Corroboration with USGS data

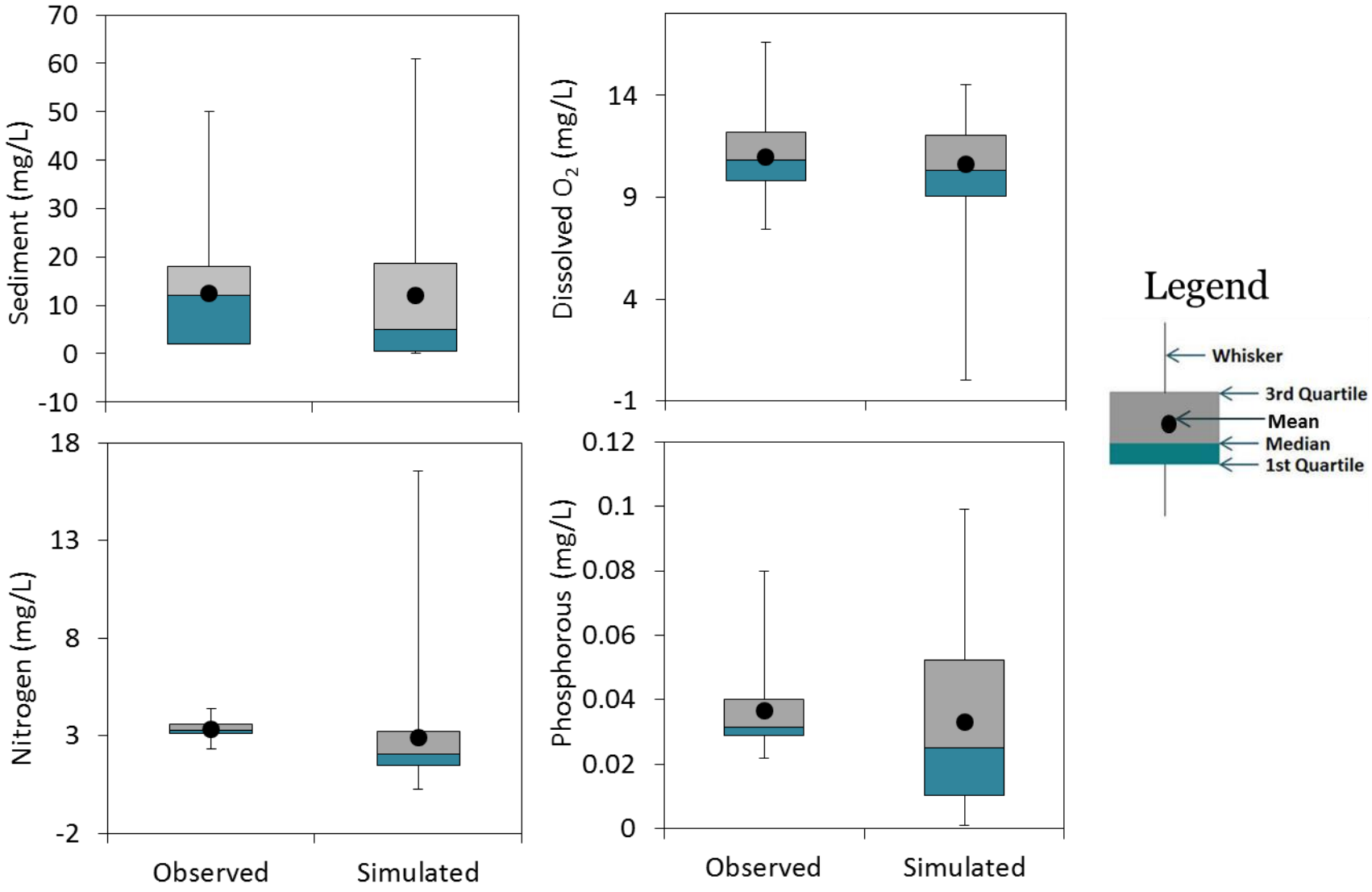


Daily NSE	Monthly NSE	PBIAS	R^2
0.78 to 0.81	0.80 to 0.87	-1 to -7.5	0.72 to 0.80

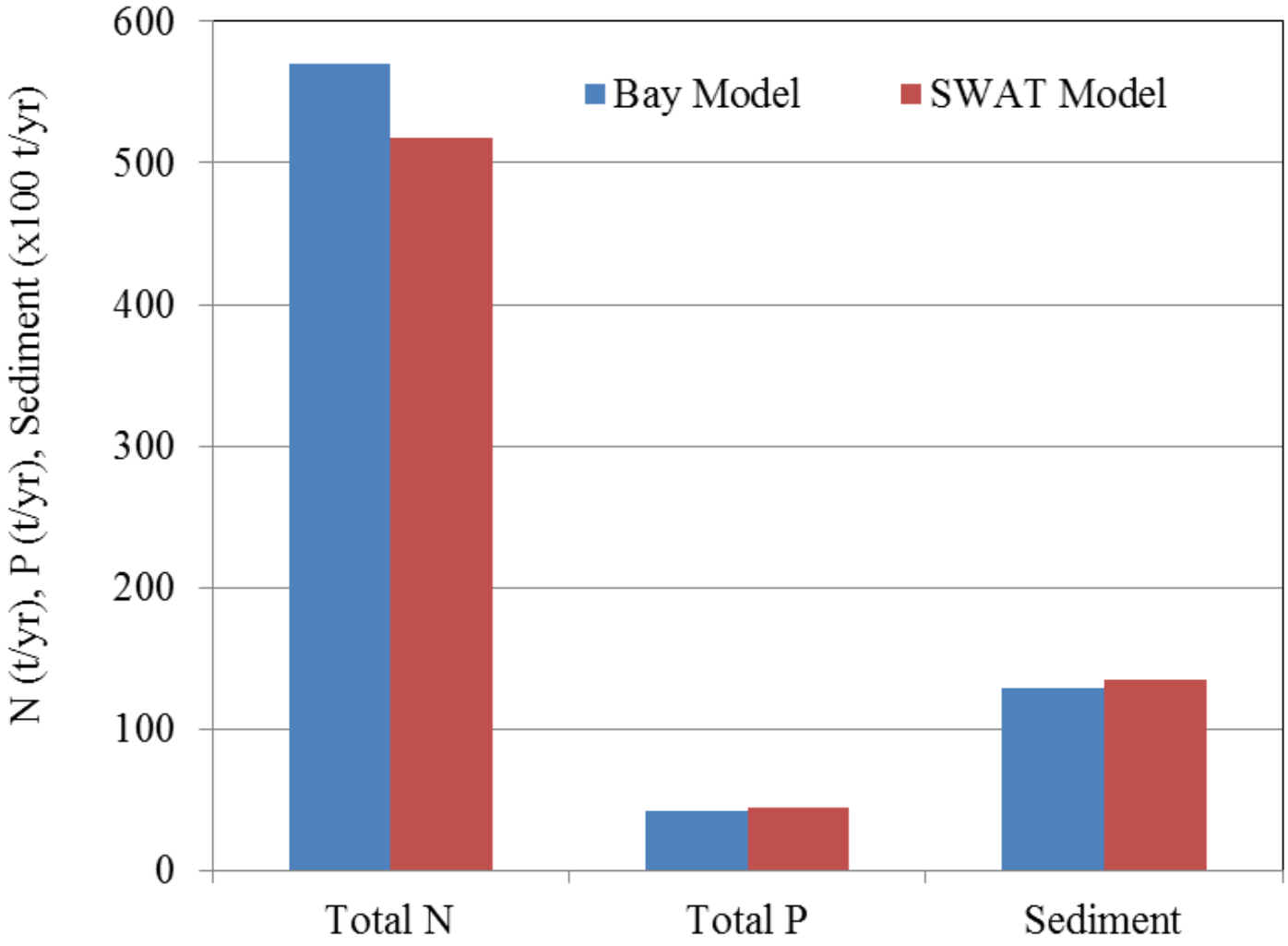


Daily NSE	Monthly NSE	PBIAS	R^2
0.72 to 0.75	0.79 to 0.80	3.4 to -9.9	0.61 to 0.85

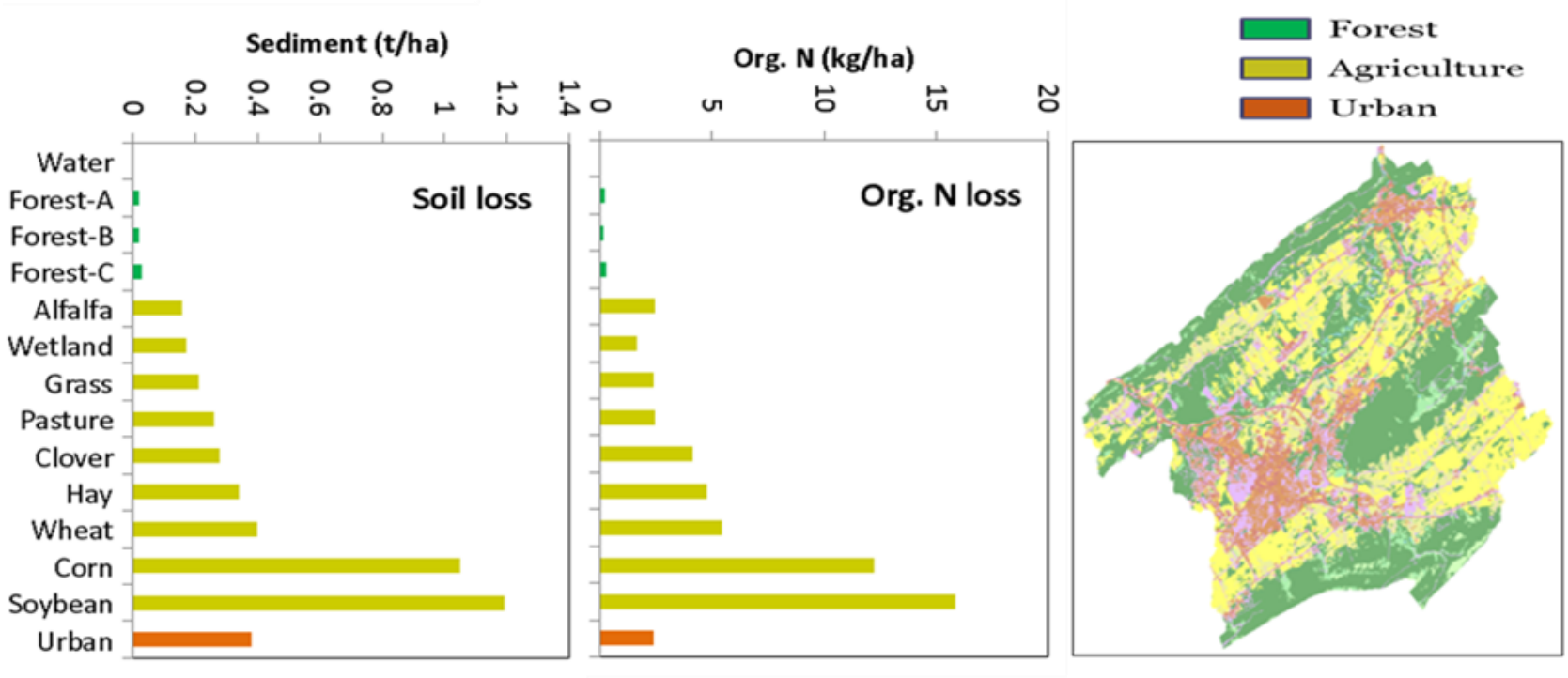
Results: Corroboration with USGS and local data



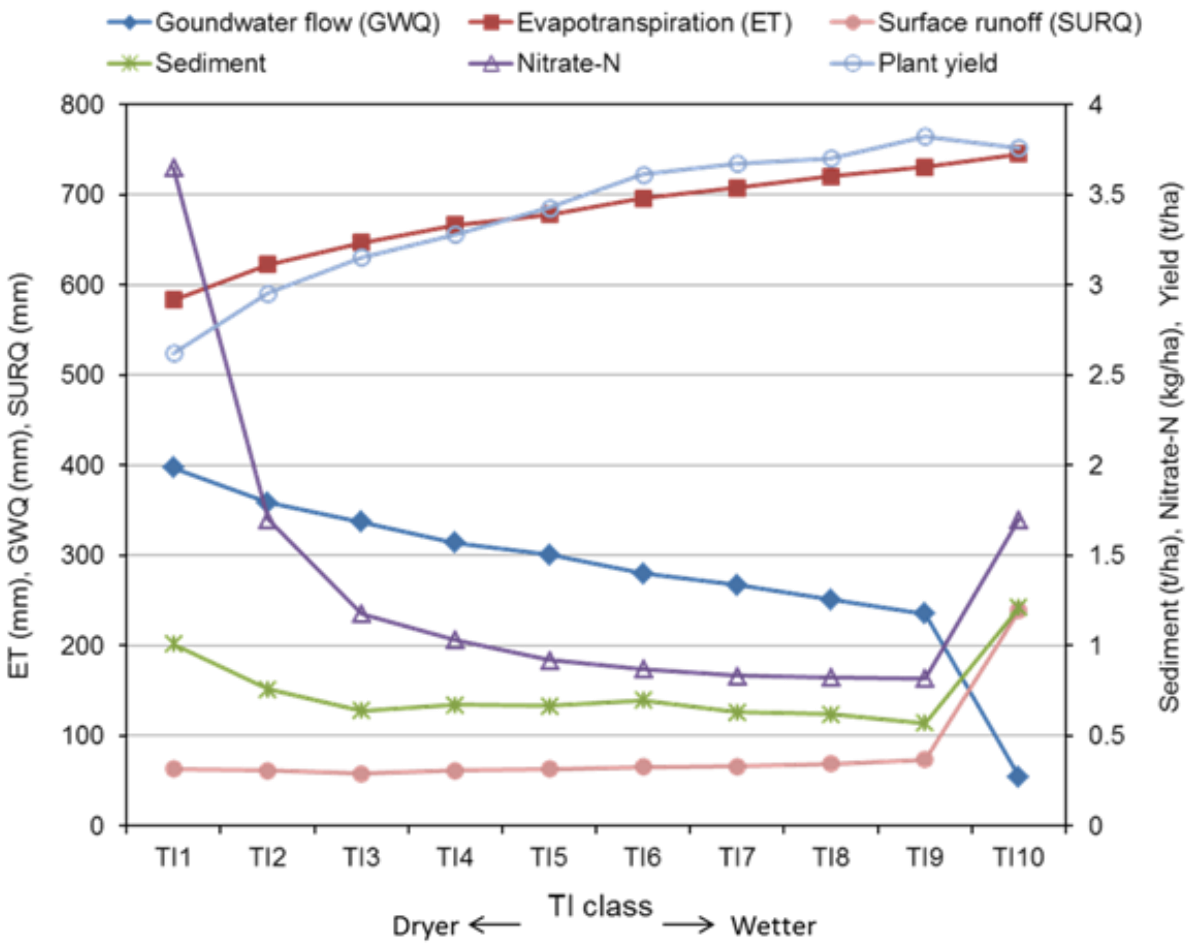
Results: Comparison of WIP Baseline (2012 status)



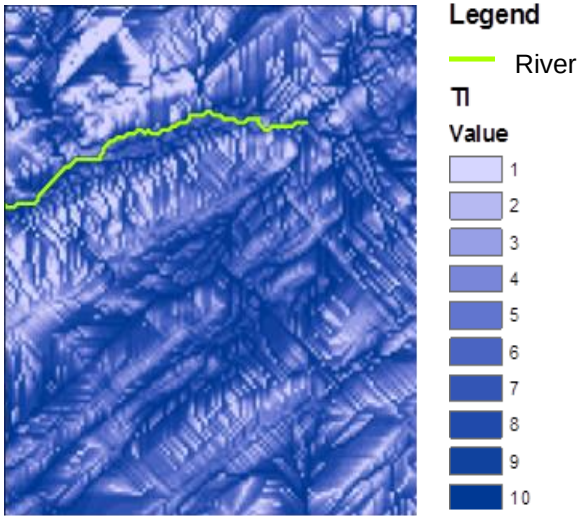
Results: SWAT-simulated critical source areas by land use (baseline)



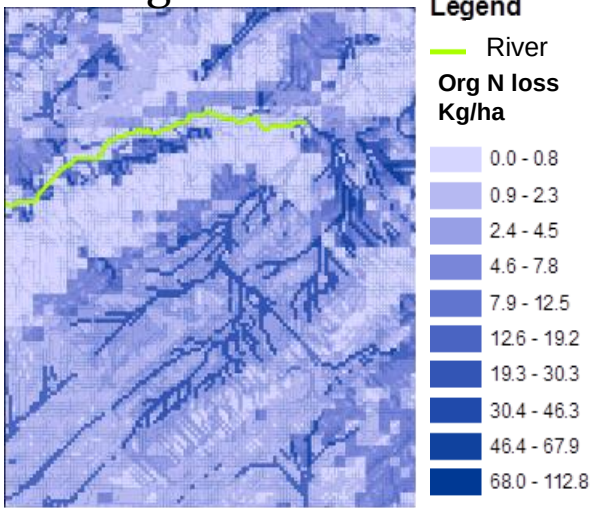
Results: Critical source areas by wetness class (baseline)



TI (wetness) class

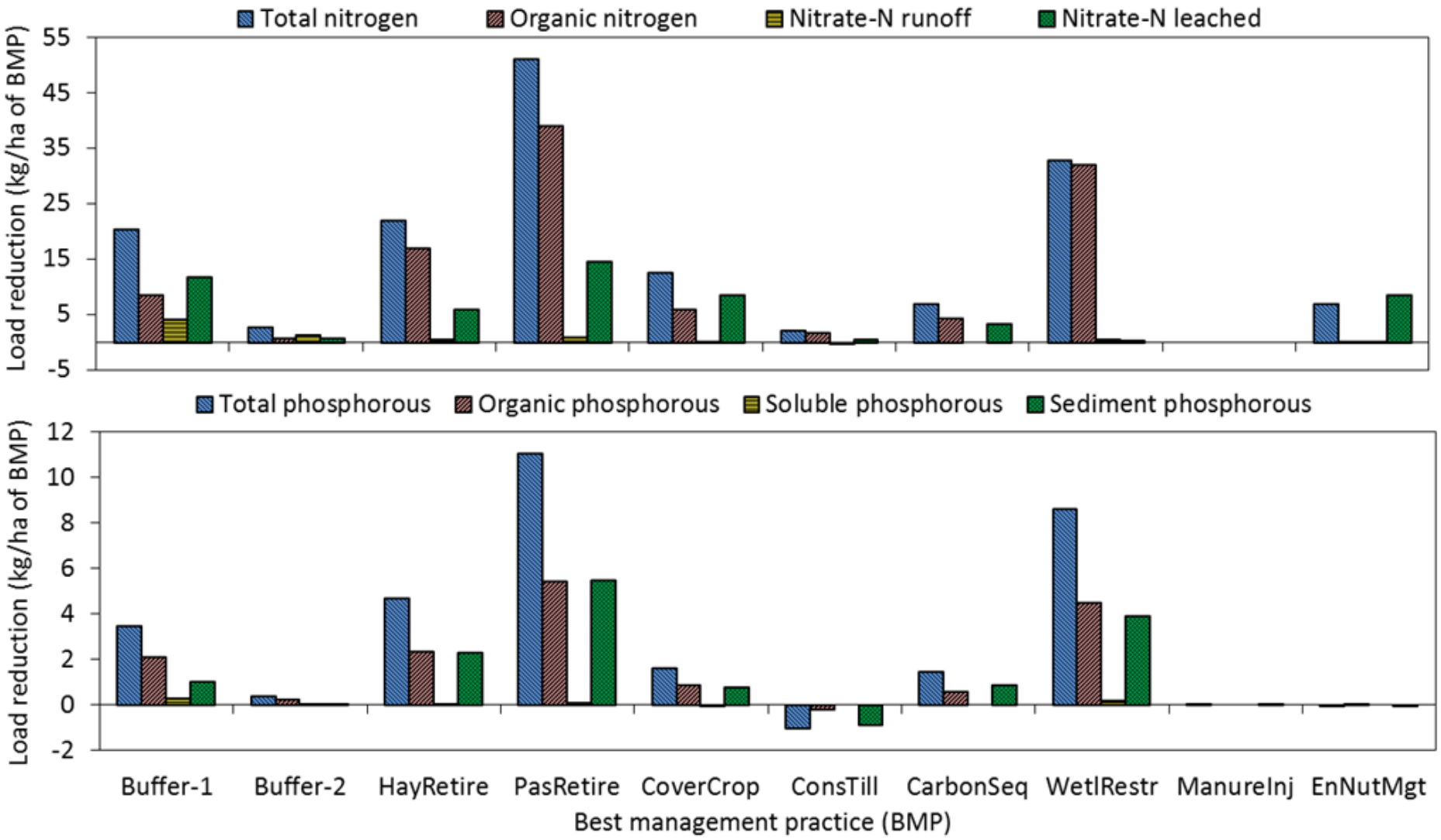


Org N loss

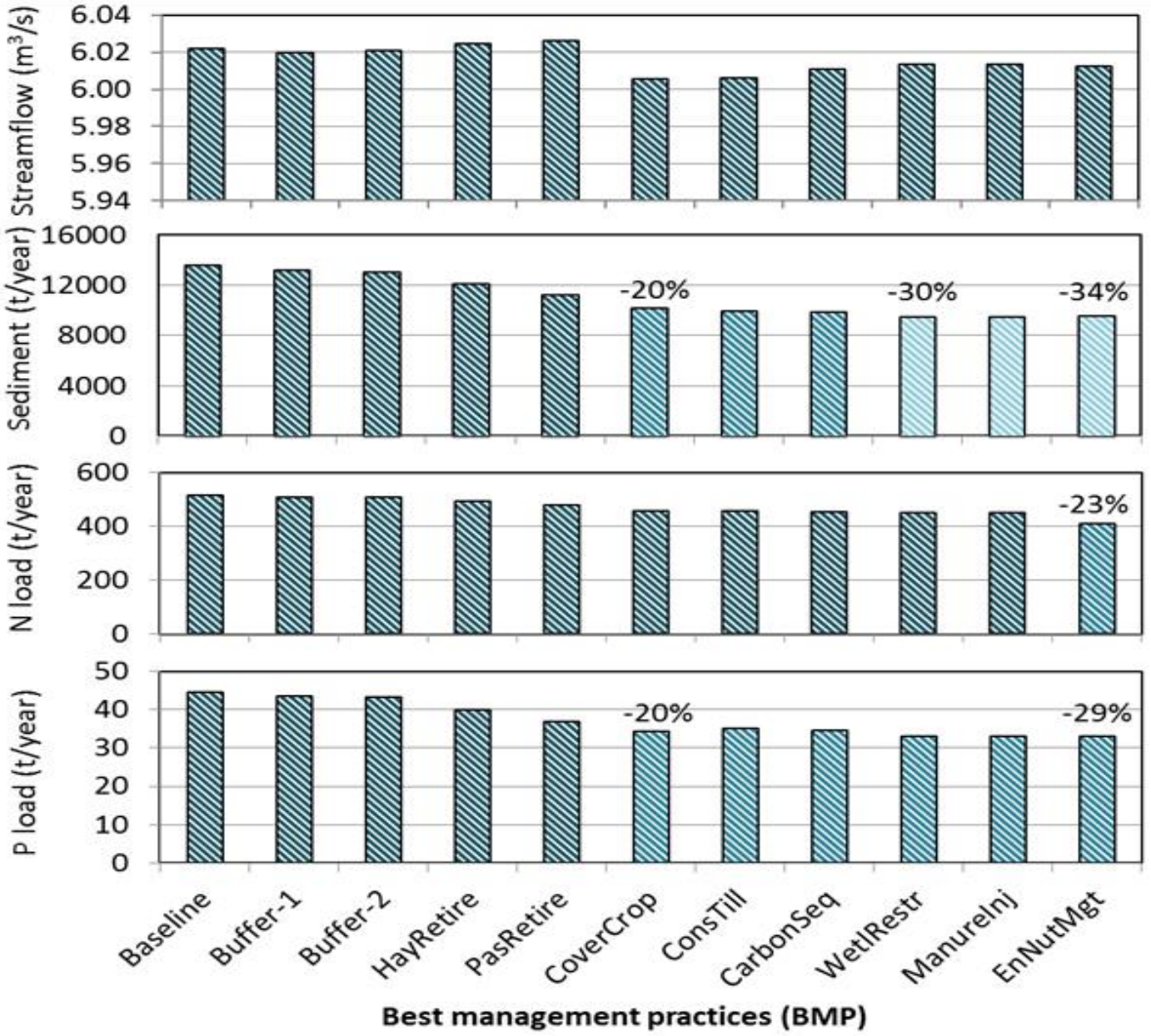


Results: SWAT-simulated effects of WIP-BMPs

BMP	Reduction (%)		
	Total N	Total P	Sediment
Buffer (30-m: 2.8% ag land)	1.7	2.66	3.8
Land retirement (8% ag land)	6.1	15.67	14.0
Cover crop (12% ag land)	4.0	6.81	10.1
Conservation tillage (95% ag land)	0.3	-1.98	2.1
Carbon sequestration (2.6% ag land)	0.5	1.33	0.9
Wetland restoration (1.5% ag land)	1.3	4.50	3.8
Manure injection (0.8% ag land)	0.0	0.00	0.0
Enh. nutrient mgt. (15% less N)	9.2	-0.11	-0.4
Total reduction	23	29	34
Bay TMDL goal for 2025	25	25	30


Total nitrogen
Organic nitrogen
Nitrate-N runoff
Nitrate-N leached
Load reduction (kg/ha of BMP)
55
45
35
25
15
5
-5
Total phosphorous
Organic phosphorous
Soluble phosphorous
Sediment phosphorous
Load reduction (kg/ha of BMP)
12
10
8
6
4
2
0
-2
Buffer-1
Buffer-2
HayRetire
PasRetire
CoverCrop
ConsTill
CarbonSeq
WetlRestr
ManureInj
EnNutMgt
Best management practice (BMP)

Results: Cumulative effects of BMPs



Conclusions

- Hydrologic & nutrient transport processes simulated adequately
- BMPs least effective in N load reduction
- Overall effectiveness:
  Land retirement >wetland restoration >buffer strip >cover crop
- Cover crop worked without sacrificing crop production

Future Work

- Non-targeted BMPs met 2025 TMDL goals
- More effective and watershed-specific implementation plans of BMPs can be developed
- Finer-scale modeling will enable targeting of BMPs to critical source areas

Acknowledgements

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