Use of a calibrated SWAT model to support (BMP) evaluations in the Maumee River watershed

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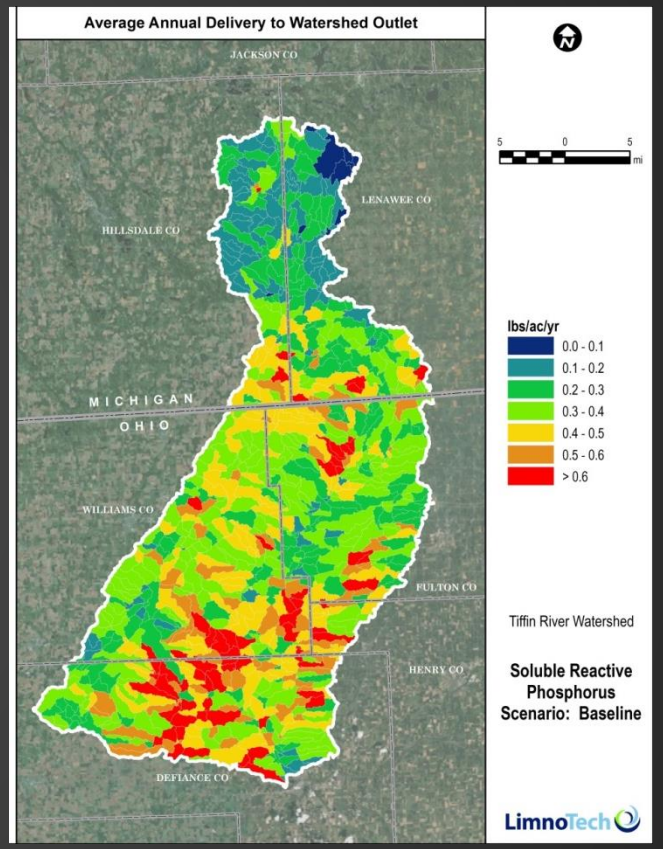
LimnoTech
Water Environment | Scientists Engineers

Presentation Outline

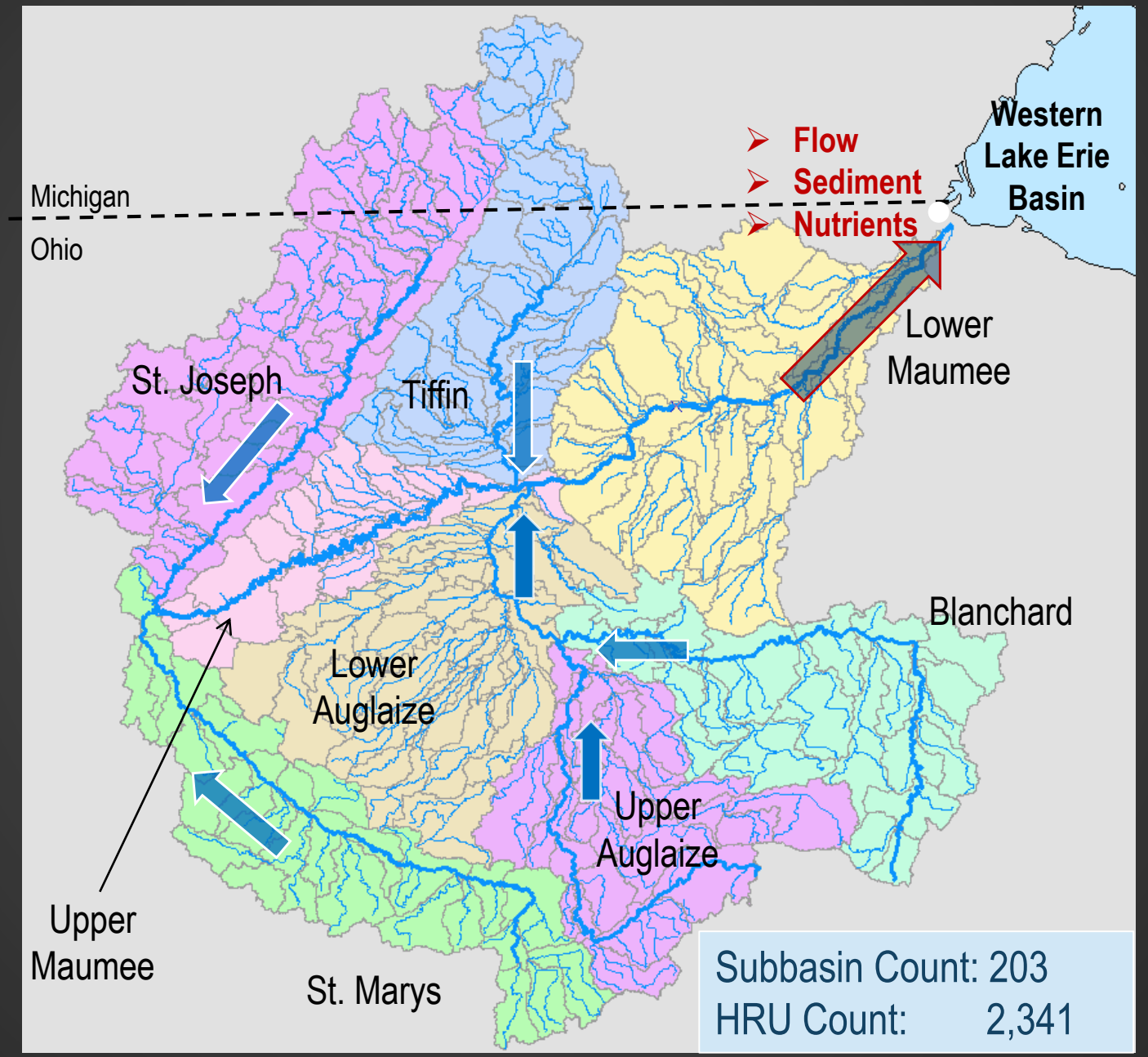
- Summary of LimnoTech modeling activities in WBLE
- Overview of Maumee SWAT model
- Maumee SWAT calibration:
  - "Goodness of fit" calibration statistics (flow, pollutant loads)
  - Additional model-data comparisons (e.g., tile flow, crop yield)
- SWAT scenario evaluation:
  - Review chosen scenarios
  - Results of scenario runs

Relevant Modeling Activities in WBLE

- Watershed Modeling:
  - Blanchard River – AnnAGNPS (USACE, 2009-10)
  - Tiffin River – SWAT (USACE, 2011-12)
    - Ephemeral gully erosion represented
    - Farmer reverse auctions – cover crops, filter strips, tile drain management
  - Maumee SWAT modeling (2011-present)
    - Preliminary evaluation of "upscaled" BMPs (GLPF) - e.g., cover crops, conservation tillage
    - "4R" nutrient management evaluation (IPNI)
- "Western Lake Erie Ecosystem Model" (WLEEM)
  - Simulates nutrient transport & fate, harmful algal bloom (HABs)
  - Various funding sources - recently applied for Annex 4



Maumee Basin SWAT Model – Subbasin Delineation



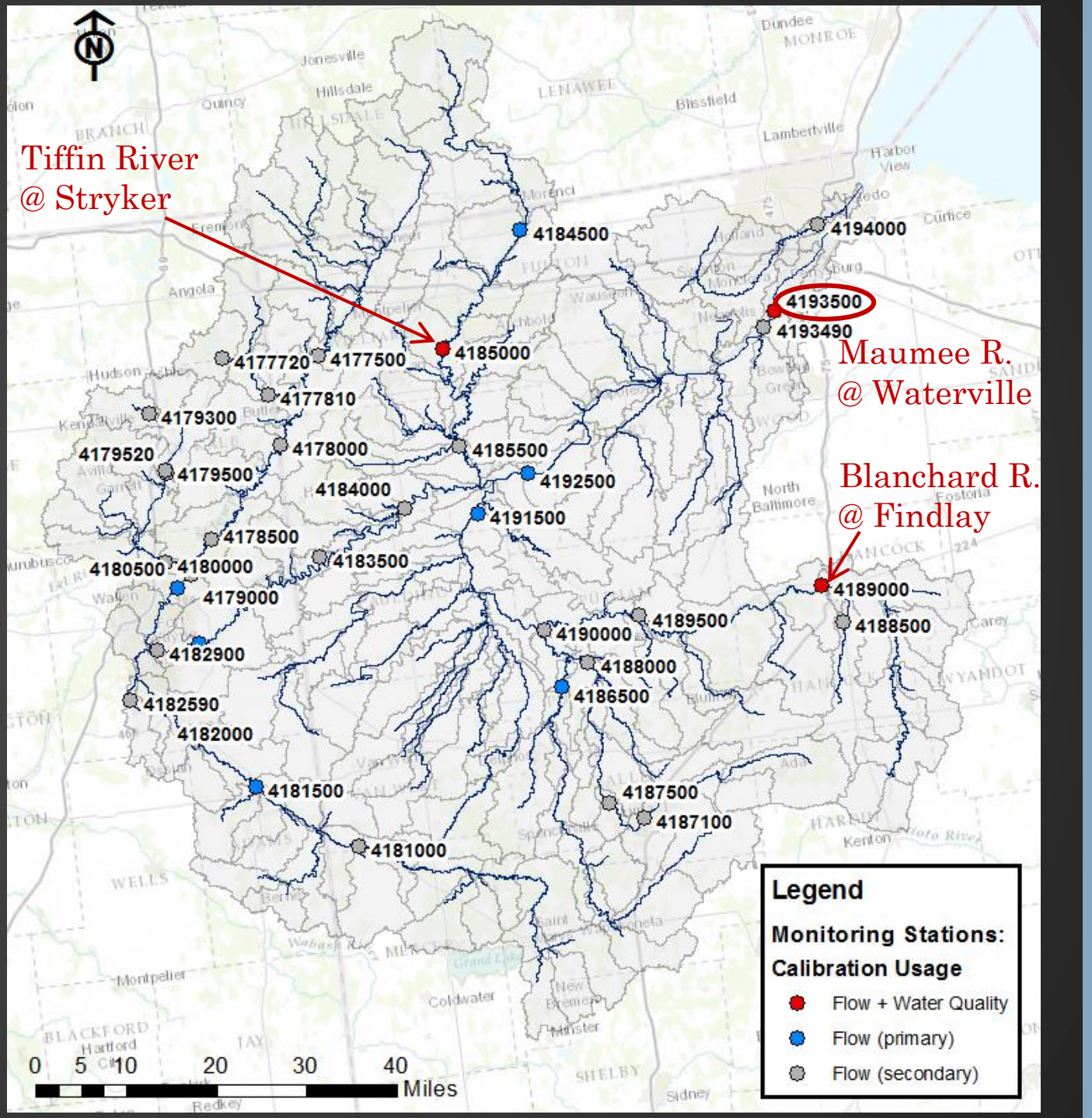
Maumee SWAT Model Lineage

- Based on original EcoFore SWAT model (Bosch et al. 2011):
  - Subbasin delineation roughly based on HUC-12 delineation
  - Simulation time period: 1995-2005
- Key LimnoTech refinements include:
  - SWAT 2012 framework adopted (updated from SWAT 2005)
  - Simulation period updated to 1995-2010
  - Incorporation of detailed cropland management input data from ARS Maumee CEAP SWAT model
  - Preliminary representation of soluble reactive P (SRP) transport through tile drains

Hydrology Calibration Metrics

Model Calibration Locations

- Model originally calibrated to Waterville station:
  - USGS gage: 04193500
  - Heidelberg monitoring (sediment, nutrients)
- Additional stations to monitor model fit for tributary branches and stations upstream of Waterville
- At least one station on each major tributary considered for flow calibration



Flow Calibration Statistics

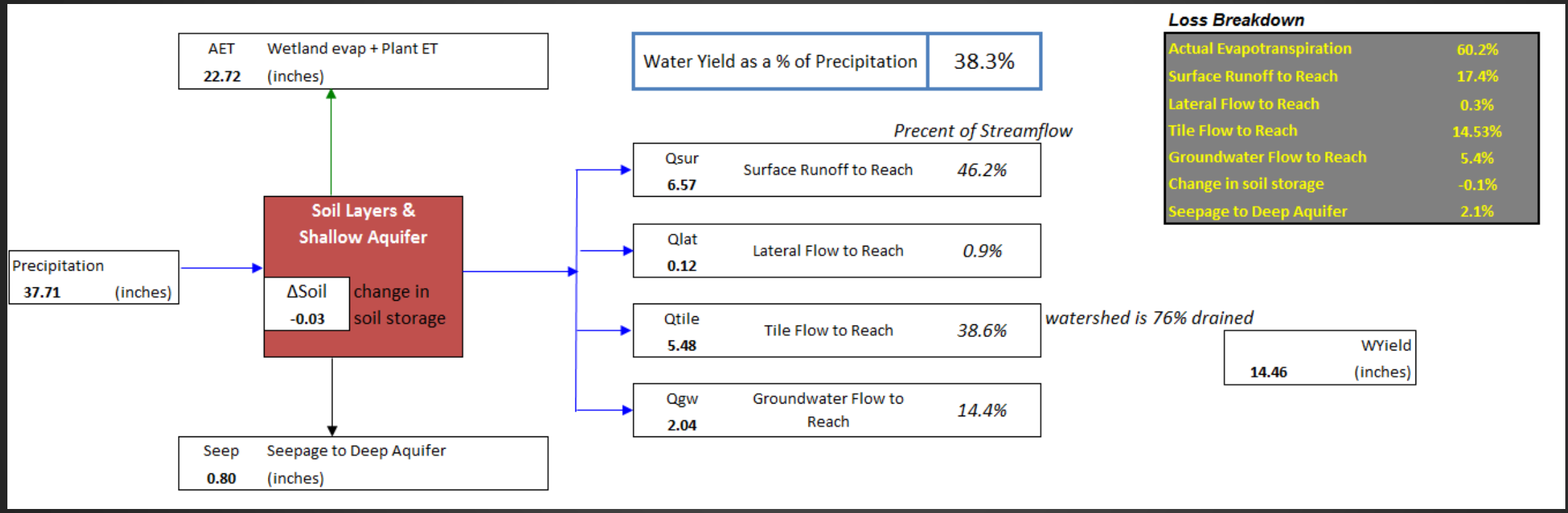
- All stations meet the standards confirming at least a "Satisfactory" calibration for monthly guidelines
- Most stations meet the "Very Good" guidelines for monthly NSE
- No Moriasi et al., 2007 standards given for R^2, but statistic is greater than 0.50 for all locations

	Monthly			Daily	
	R-Sq	*NSE*	*P-Bias*	*R-Sq*	*NSE*
Maumee at Waterville	0.93	0.91	-11.50	0.81	0.81
Maumee near Defiance	0.93	0.91	-12.32	0.81	0.80
Maumee at New Haven	0.90	0.89	-6.55	0.72	0.71
Blanchard near Findlay	0.82	0.78	15.61	0.57	0.55
St. Joseph near Ft. Wayne	0.85	0.77	-16.98	0.66	0.44
Auglaize near Defiance	0.92	0.91	-9.66	0.75	0.73
Auglaize near Ft. Jennings	0.86	0.83	-16.78	0.57	0.55
St. Mary's near Ft. Wayne	0.89	0.89	-1.19	0.72	0.72
St. Mary's near Decatur	0.90	0.89	-5.36	0.70	0.69
Tiffin at Stryker	0.81	0.74	-11.68	0.65	0.56
Bean Creek at Powers	0.75	0.72	-0.68	0.62	0.57

Moriasi, D. N., J. G. Arnold, M. W. Van Liew, R. L. Bingner, R. D. Harmel, and T. L. Veith. 2007. "Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations." *Transactions of the ASABE* 50 (3): 885–900.

Note: Daily PBIAS values equal monthly PBIAS values.

Water Budget for Entire Maumee Basin



Tile Drainage (as % of precipitation):

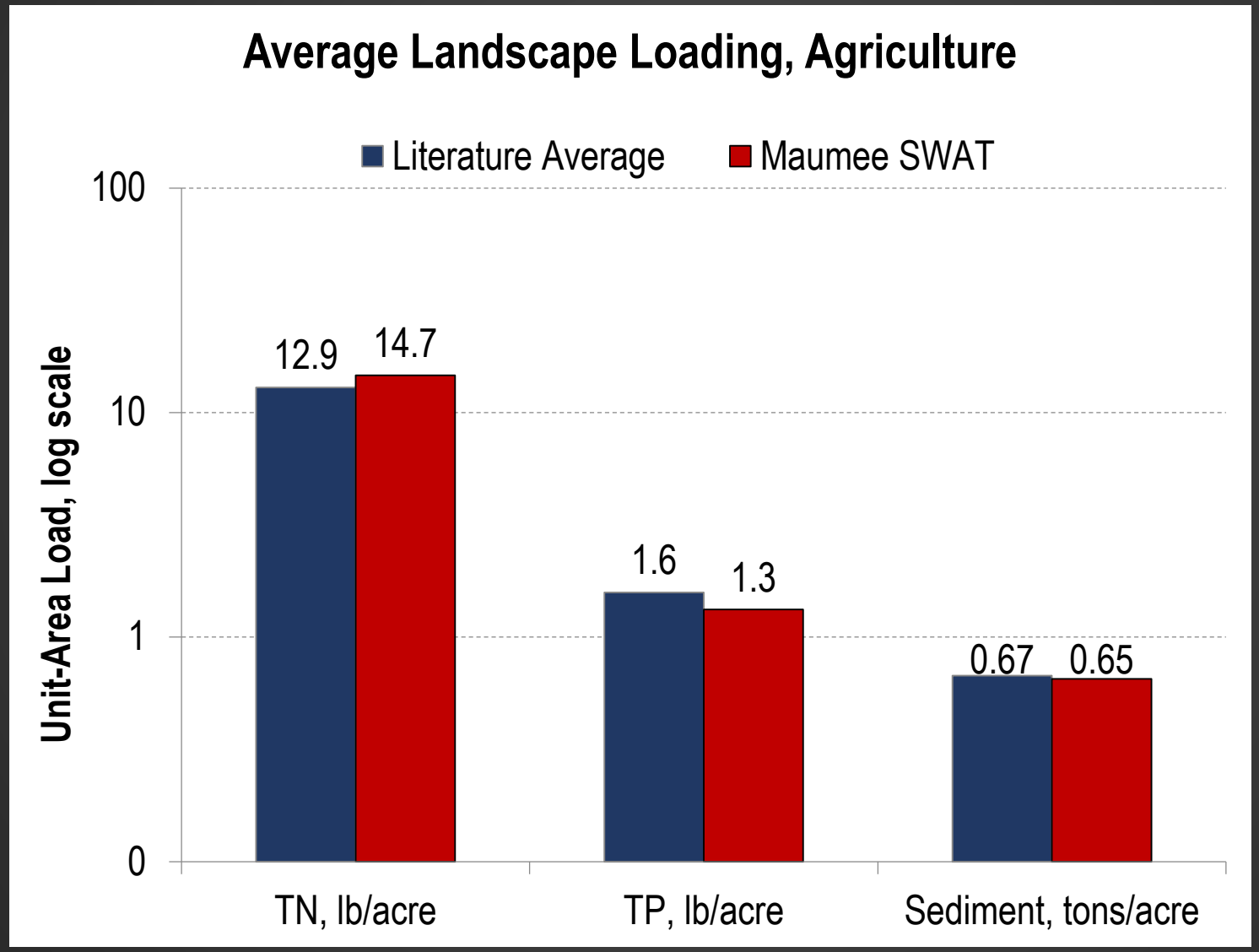
- Target range: 10-31% (mean: ~21%)
- Model: ~19% on tile-drained land

Tile Flow by HUC-8 Watershed

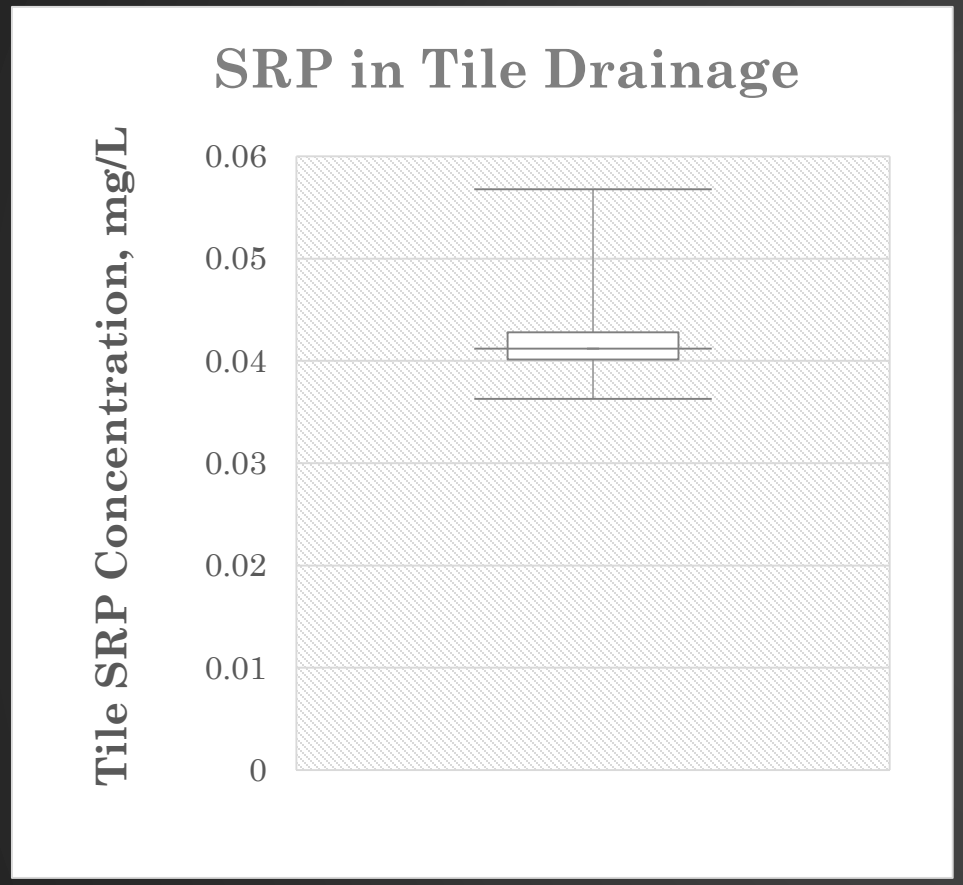
	From Model		*Target Tile %*		
HUC8	Tile Flow (Avg., % of Precip)	% Area Tiled	*MIN*	*MAX*	In Range?
Blanchard	15%	85%	*8%*	*31%*	YES
Lower Auglaize	12%	88%	*8%*	*33%*	YES
Lower Maumee	10%	67%	*6%*	*25%*	YES
St. Joseph	17%	63%	*6%*	*23%*	YES
St. Marys	17%	82%	*8%*	*31%*	YES
Tiffin	16%	71%	*7%*	*26%*	YES
Upper Auglaize	16%	79%	*8%*	*29%*	YES
Upper Maumee	16%	80%	*8%*	*30%*	YES

Water Quality Calibration Metrics

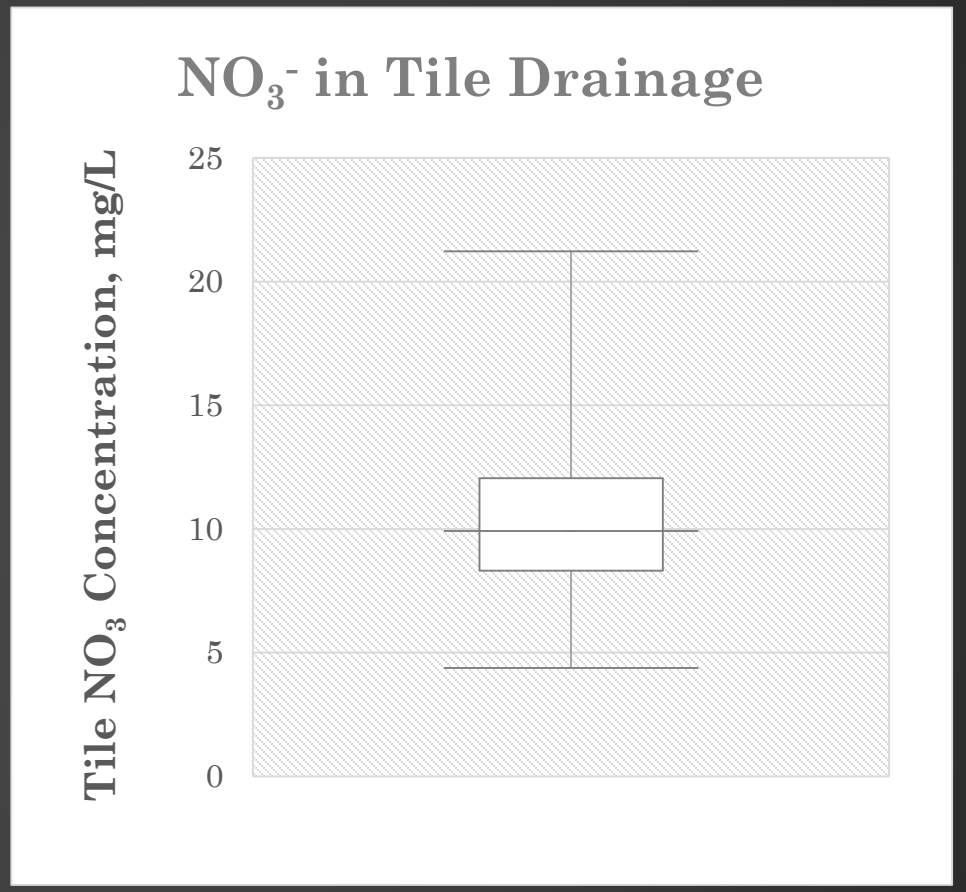
Landscape Nutrient Yields



Tile Drainage: Dissolved Nutrients



Observed Range: ~ 0.01 – 1.0 mg/L (K. King, OSU)



- *Simulated NO_3 loading of **21.15 kg/ha** for tile-drained AGRR lands.*
- *Compares favorably with **23.17 kg/ha** measured by Kladivko et al., 2004 for Indiana*

Nutrient & Sediment Calibration Metrics

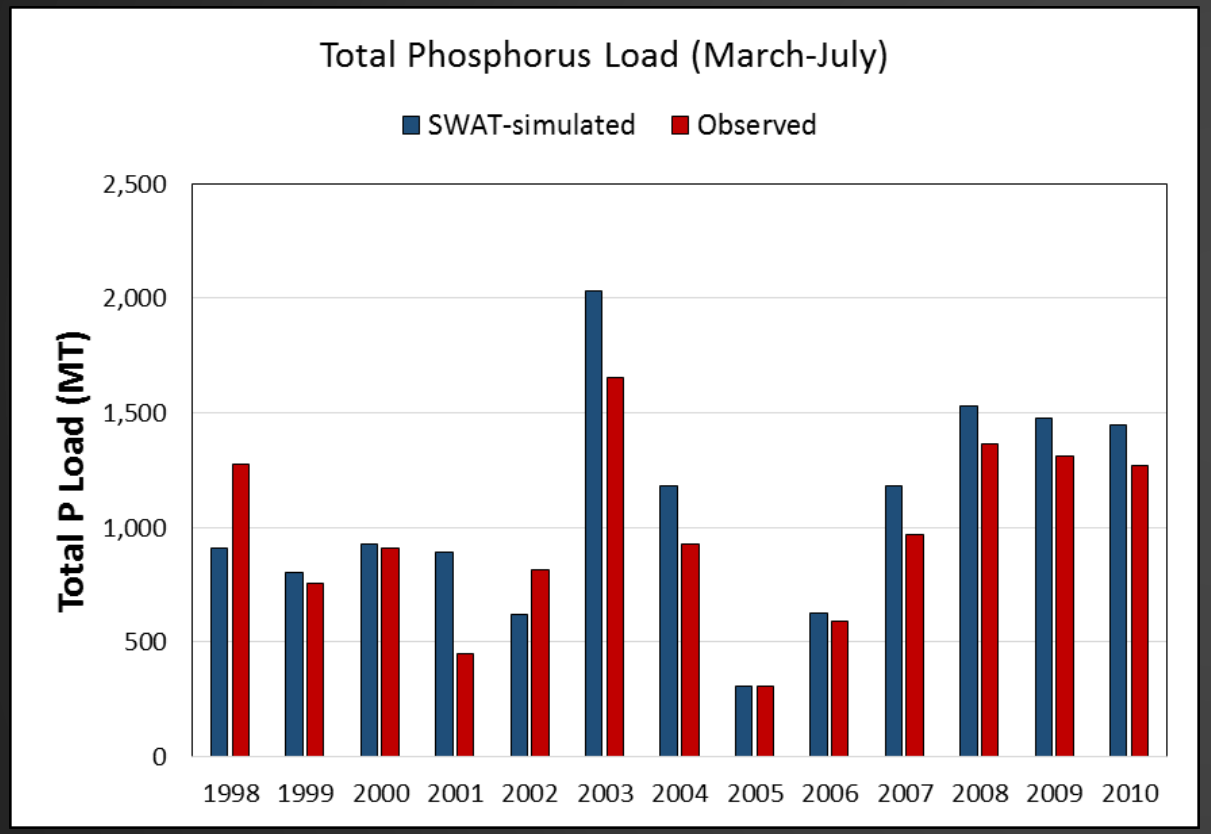
- All stations meet the standards confirming at least a "Satisfactory" calibration for monthly guidelines for nitrogen and phosphorus constituents.
- Most stations meet the "Very Good" guidelines for *PBIAS (Abs(PBIAS) < 25)*
- Monthly sediment loads at Waterville are just outside the "Satisfactory" range (±55)

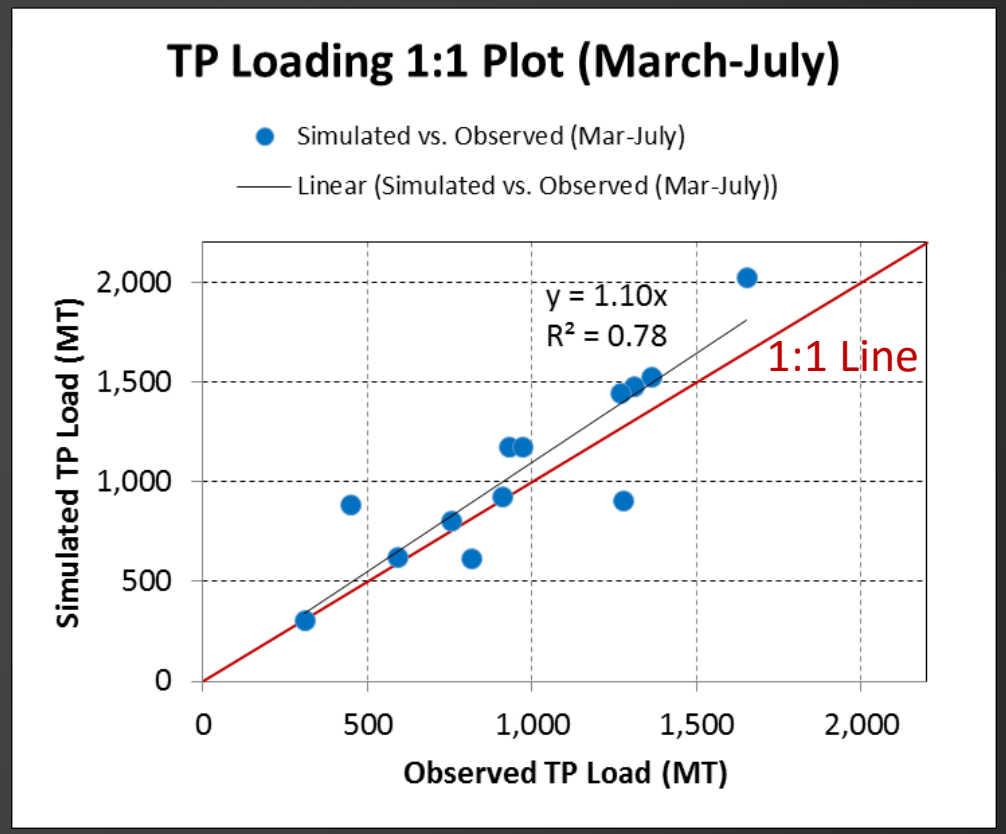
Note: Instream sediment calibration has no influence on nutrients

		Maumee at Waterville	Blanchard near Findlay	Tiffin at Stryker
SRP load	***R-squared***	0.72	0.62	0.88
	P-Bias	-17.69	51.96	2.31
TN load	***R-squared***	0.81	0.46	0.70
	P-Bias	-21.50	4.76	-51.24
NO_3 load	***R-squared***	0.73	0.37	0.65
	P-Bias	-22.49	2.98	-57.71
TP load	***R-squared***	0.79	0.87	0.91
	P-Bias	-0.42	24.52	-42.16
Sed Load	***R-squared***	0.75	0.80	0.57
	P-Bias	57.46	-23.71	-200.63

All values reported are on a monthly time-step

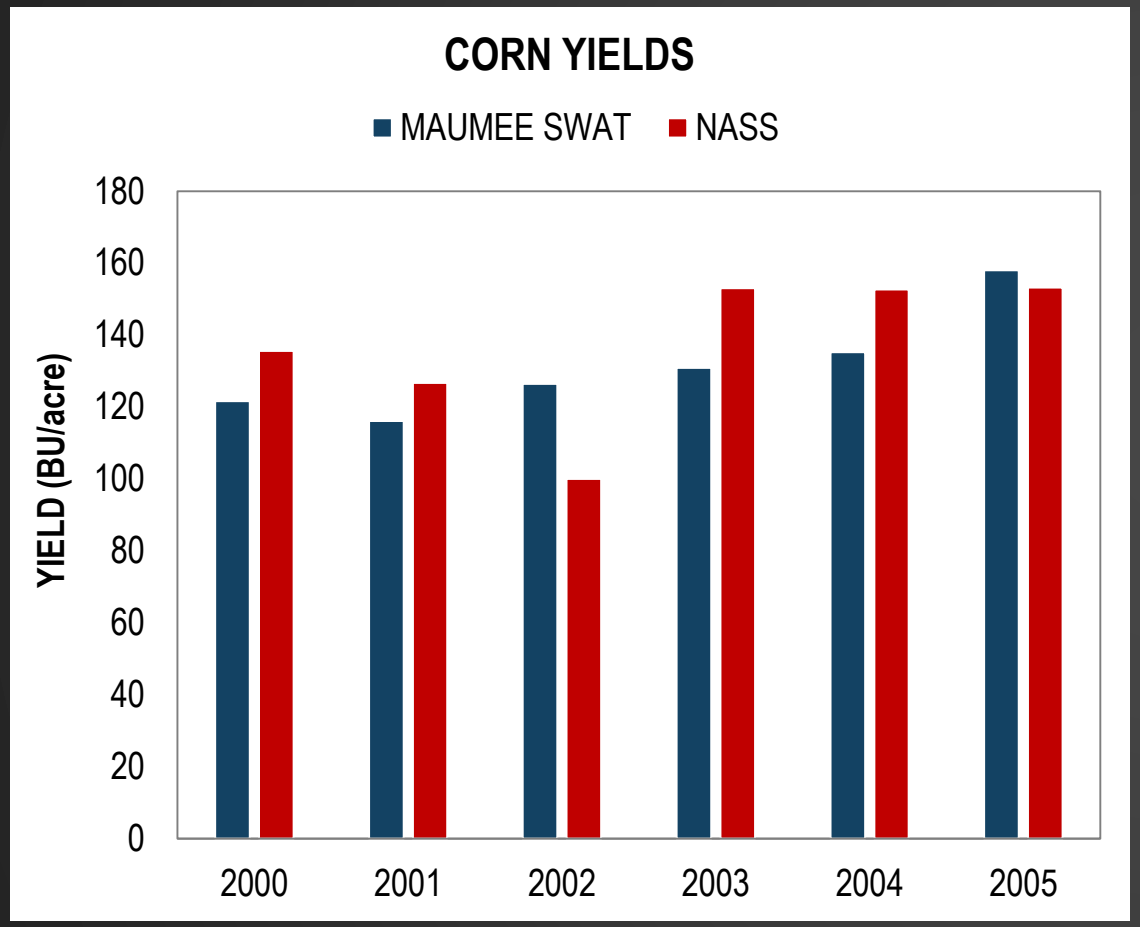
“Spring” P Loads: Feeding Harmful Algal Bloom Production (Waterville)

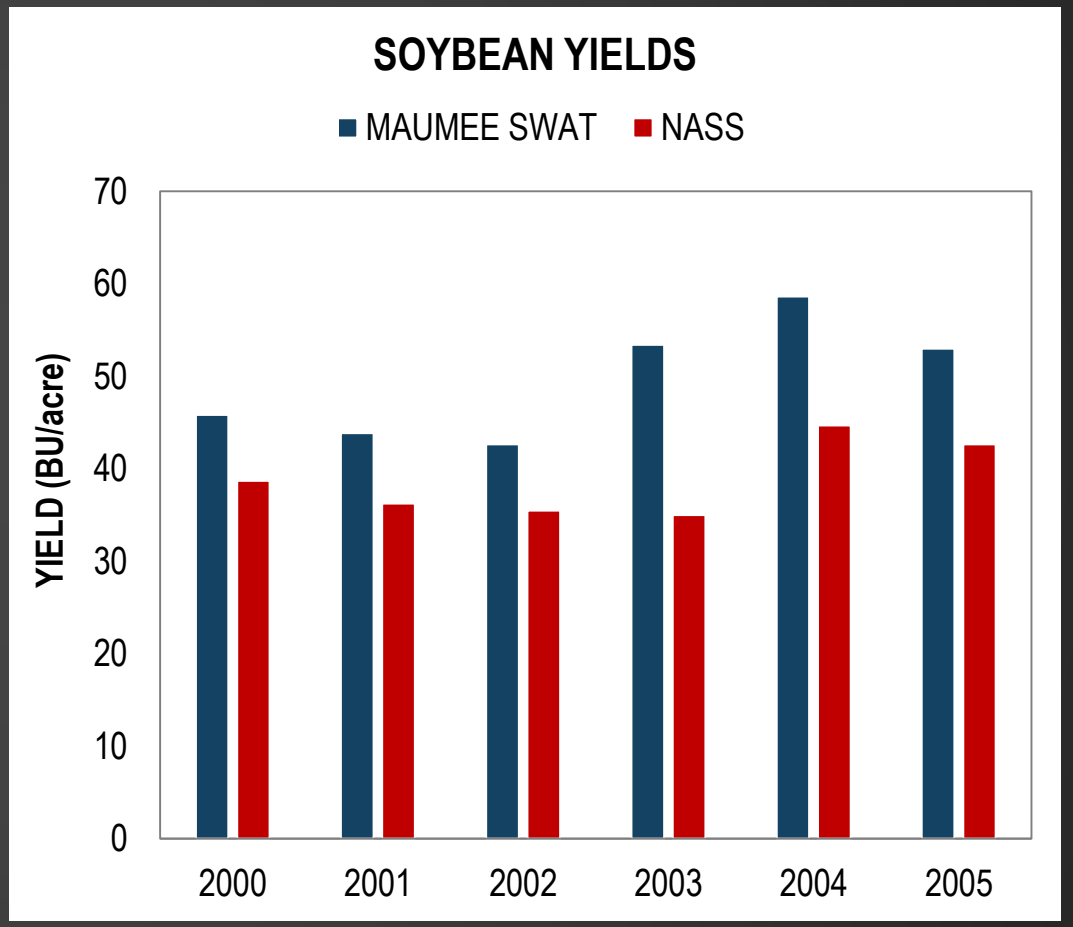




R^2: 0.78
NSE: 0.62 (Good / Satisfactory)
PBIAS: -10.6 (Very Good)

Crop Yield Comparison (2000 – 2005)





Maumee SWAT: Evaluating Extreme Scenarios

Inclusion in the WLEB Assemblage

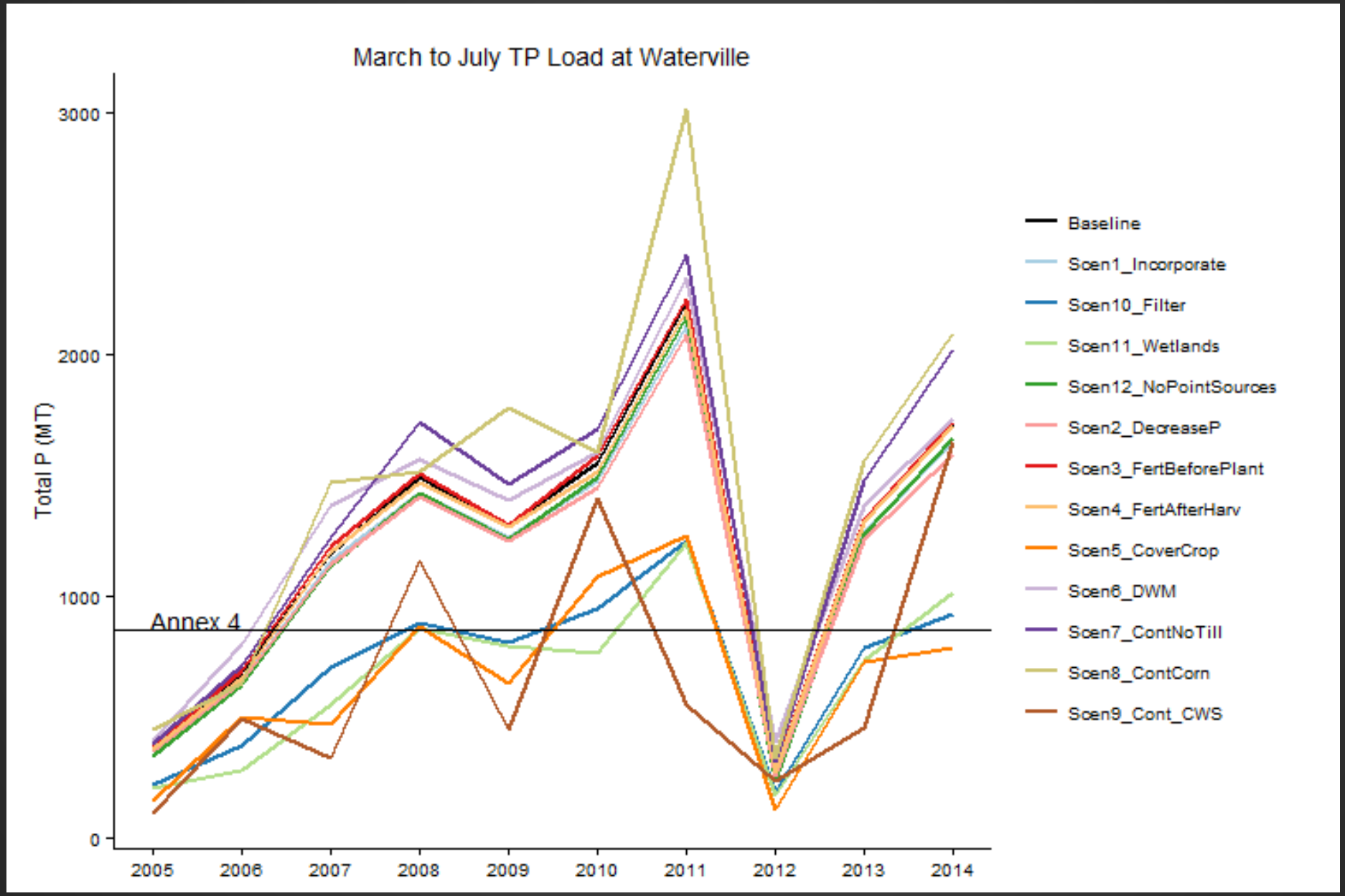
- Modeling teams presented their calibrated Maumee models at a workshop in June at the University of Michigan Water Center
- All models were updated to run a common time period (2000 to 2014) with first five years used as model warmup
- All models were given a common set of precipitation and temperature inputs
- All models were given a common set of point source inputs
- No recalibration

What Scenarios?

1	***Fertilizer placement:*** Subsurface fertilizer application	All cropland will have fertilizers applied to the subsurface.
2	***Fertilizer rate:*** P fertilizer rate cut in half	All cropland will have P fertilizer rates cut by 50% of baseline condition. N fertilizer rates are the same as baseline.
3	***Fertilizer timing I:*** P applied in spring	All cropland will have P applied in the spring prior to planting
4	***Fertilizer timing II:*** P applied in fall	All cropland will have P applied in the fall following harvest
5	***Cover crop:*** Cereal rye	All cropland will have a cereal rye cover crop applied in all winters that the ground was bare.
6	***Drainage water management:*** Testing the approach	All cropland will have tile drains held near the soil surface over winter and summer months.
7	***Tillage:*** *Continuous no-till*	All cropland will be managed without any tillage except for a no-till drill at crop planting.
8	***Crop rotation I:*** *Continuous corn*	All cropland will be converted to a continuous corn crop rotation.
9	***Crop rotation II:*** *Winter wheat*	All cropland will be converted to a rotation including at least one year of wheat, using whatever wheat-containing rotation each model already includes in the baseline.
10	***Buffer strips:*** *Average effectiveness*	All cropland will be given a buffer strip of average effectiveness.
11	***Wetlands:*** *Testing the approach*	One wetland scenario will potentially be run through all models to test the approach of simulating wetlands in SWAT.

Each scenario is applied to 100% of the applicable AGRR HRU areas

Total P Results



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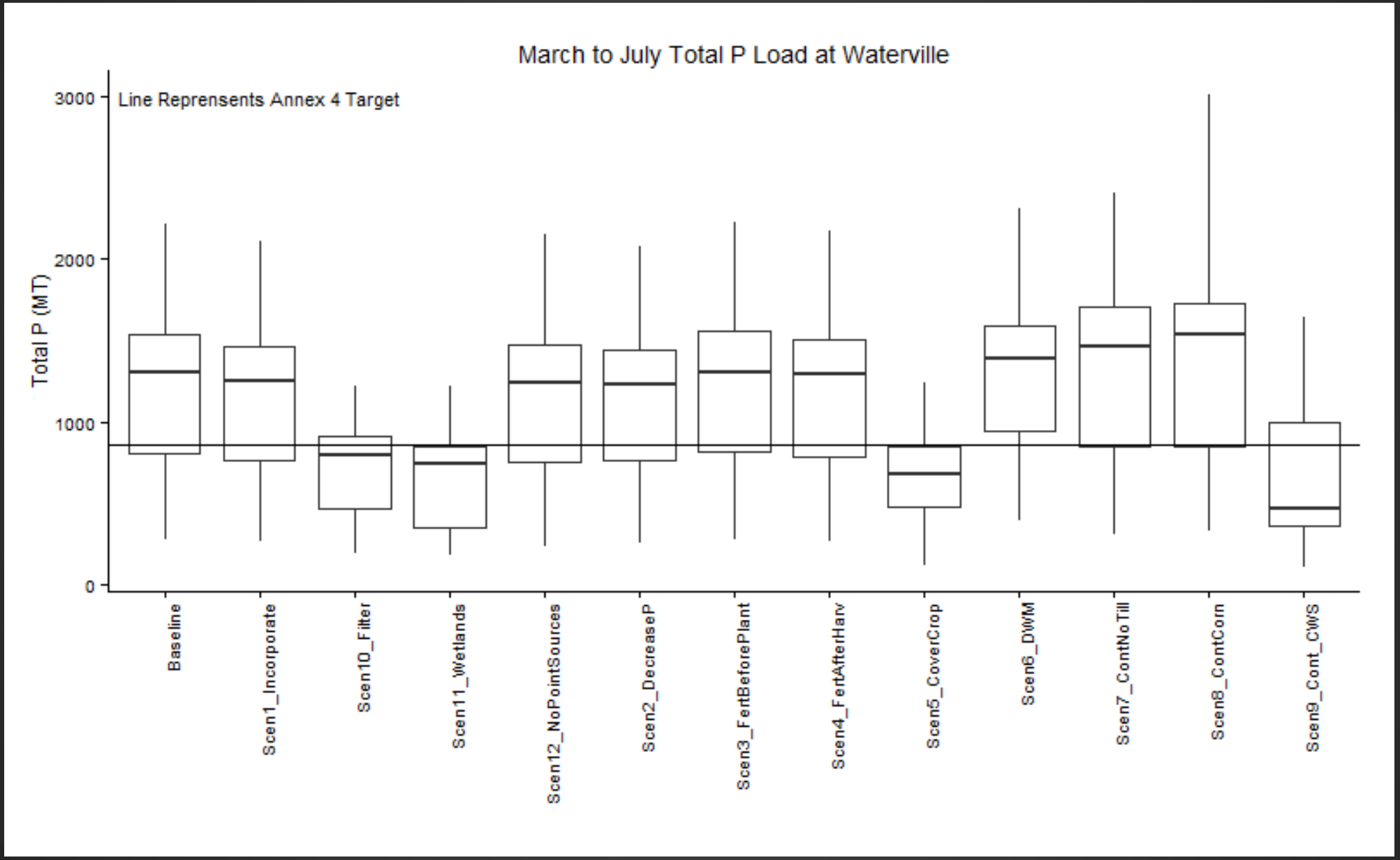
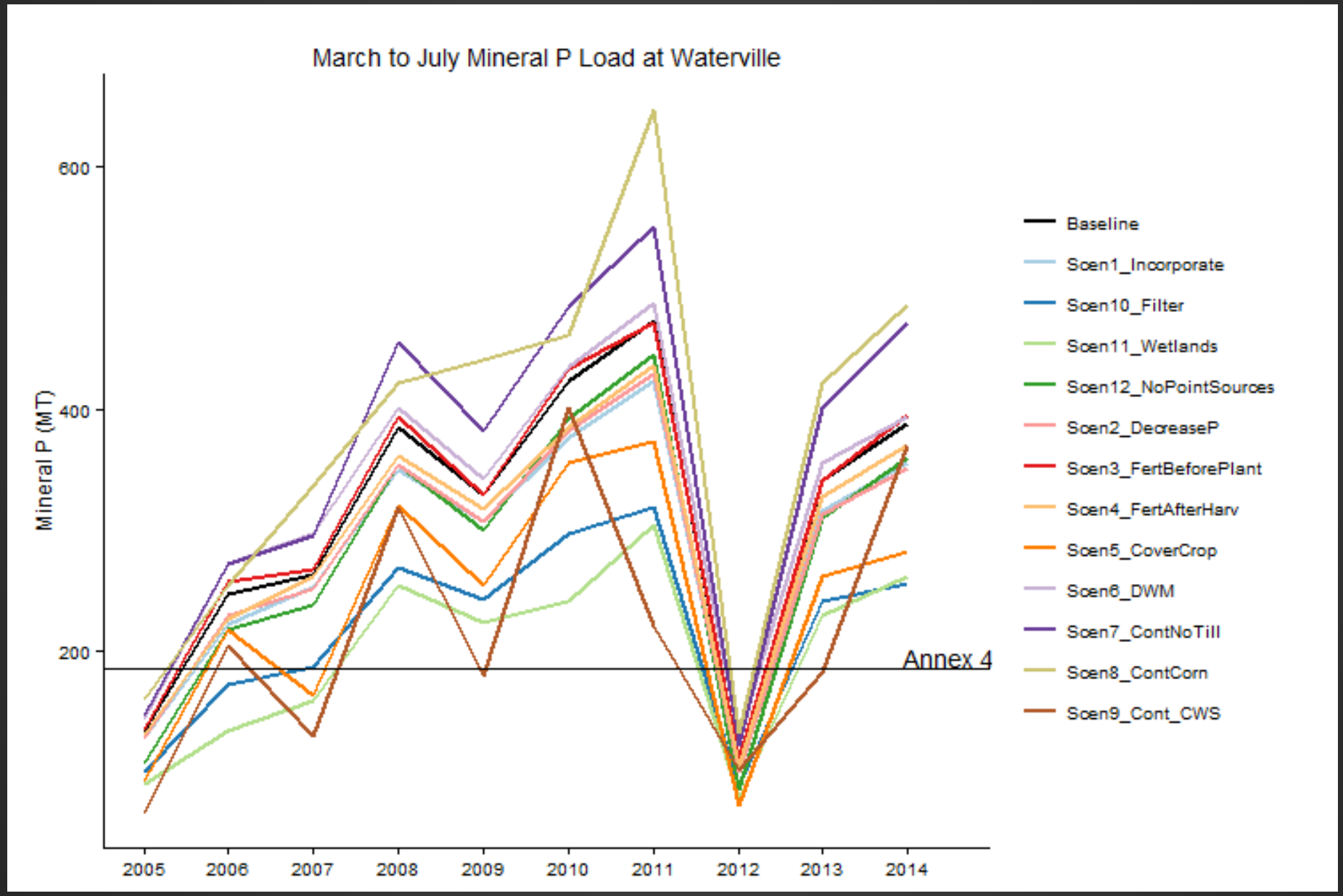


Mineral P Results



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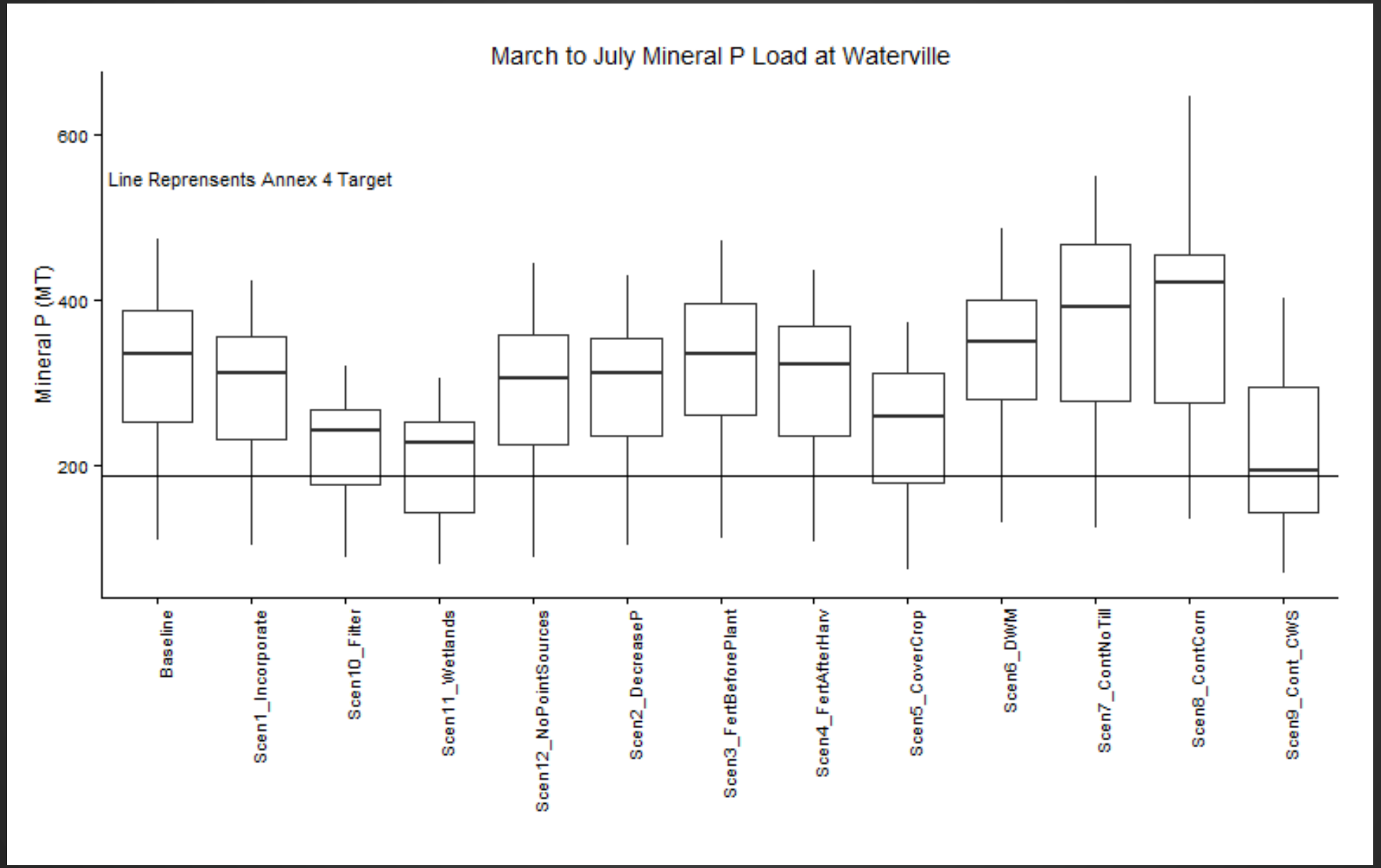
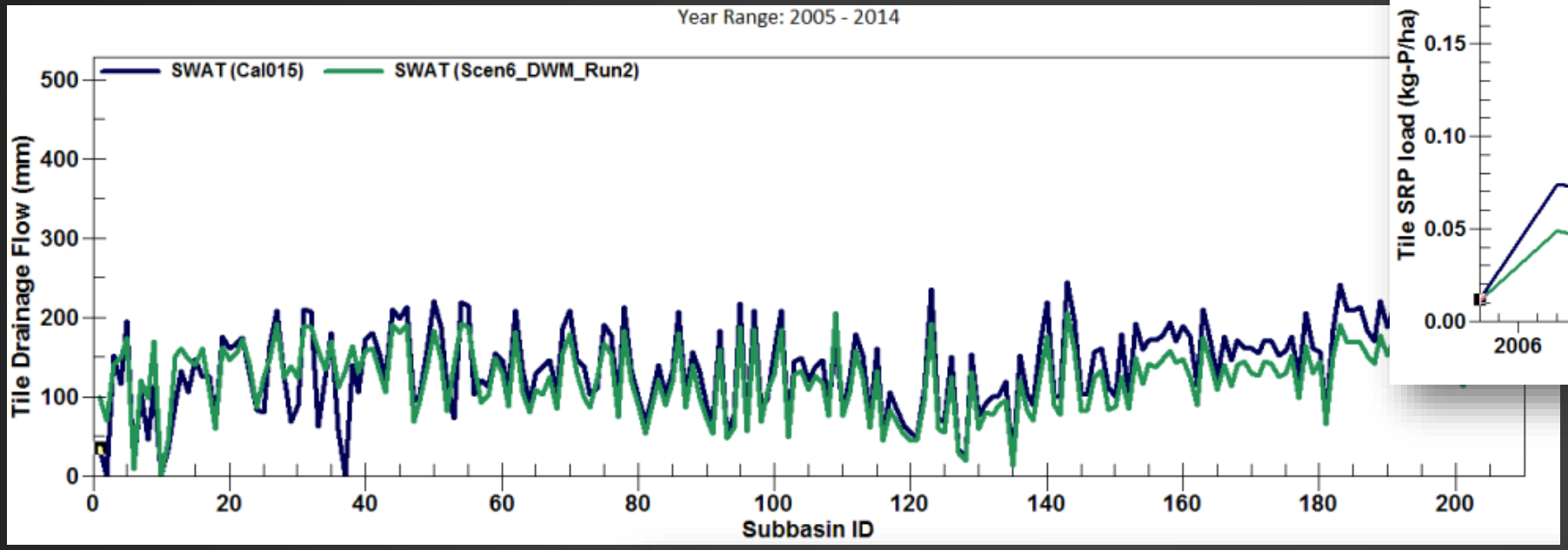
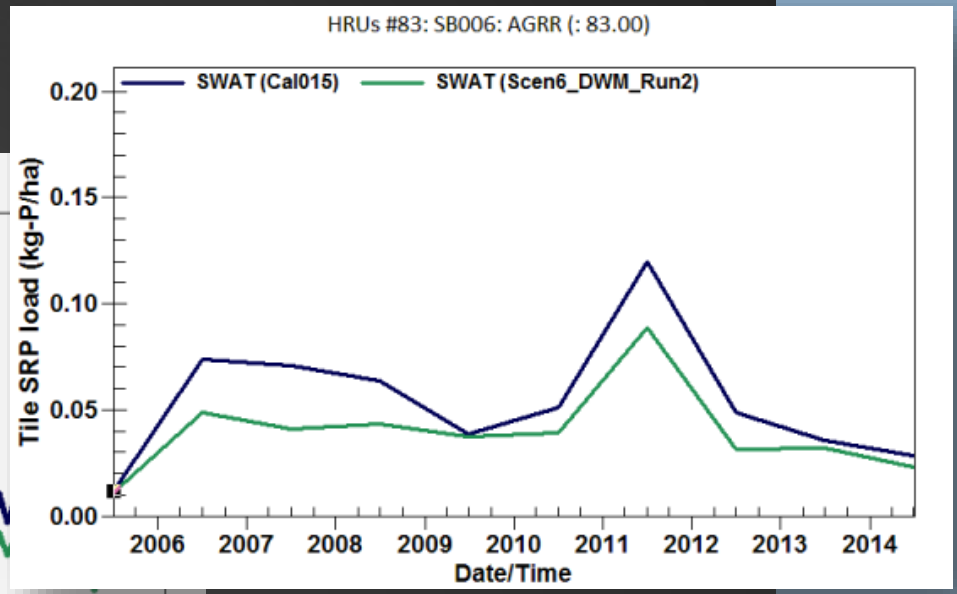
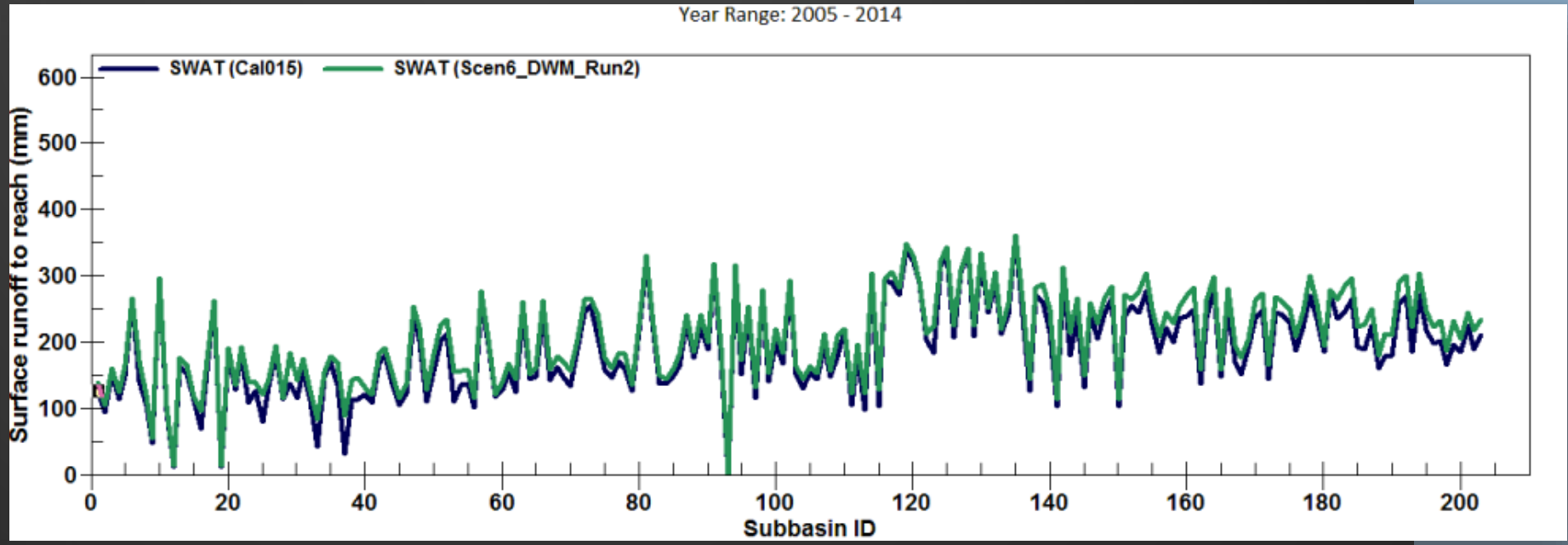


Behind the Scenes….







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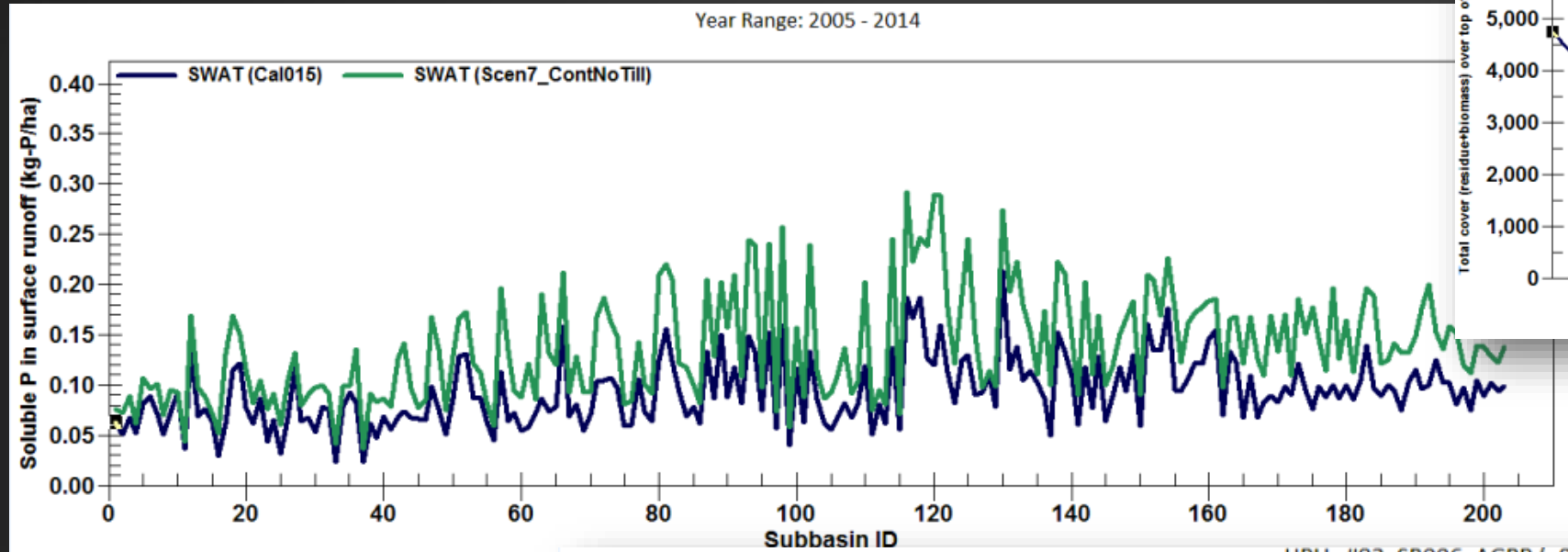

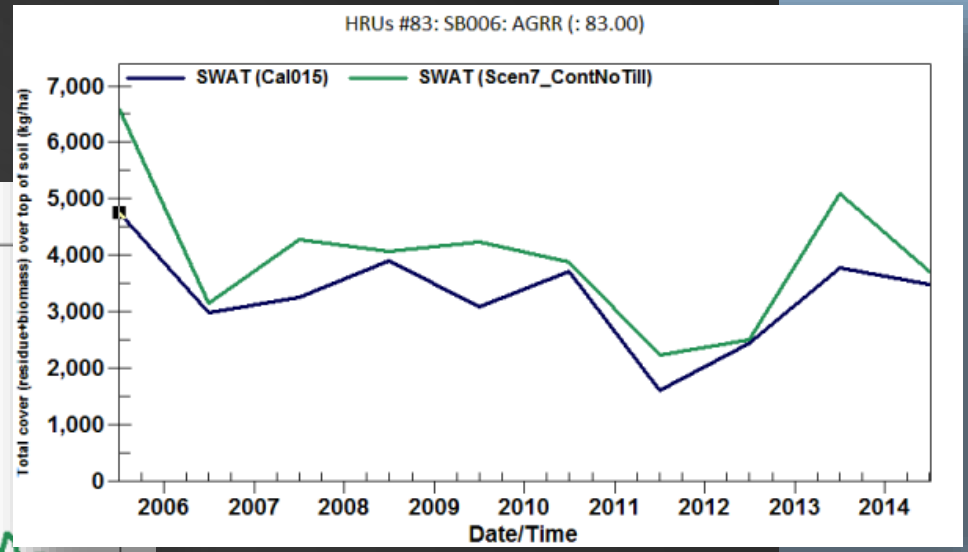

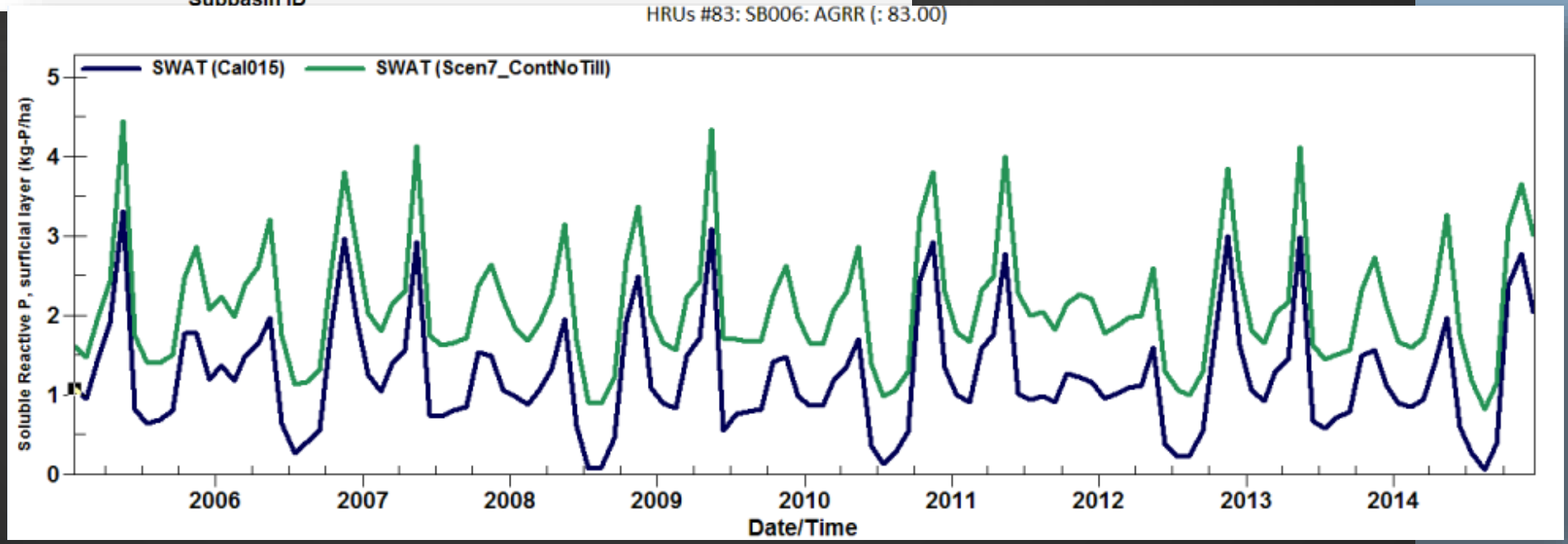

Questions?

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