Phase 6 Watershed Model – Beta 1

Modeling Quarterly Review Meeting

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Penn State University

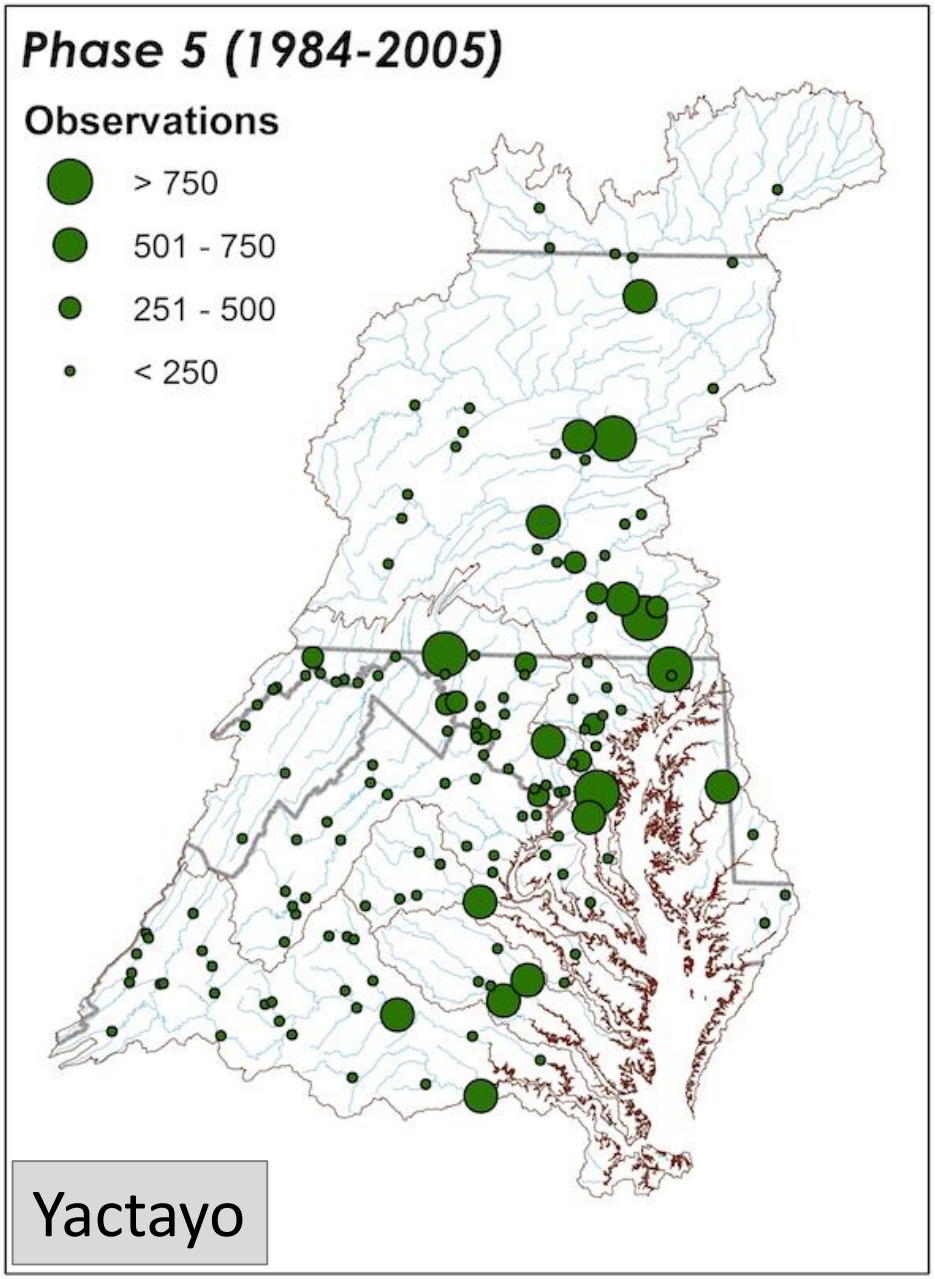
Presentation outline

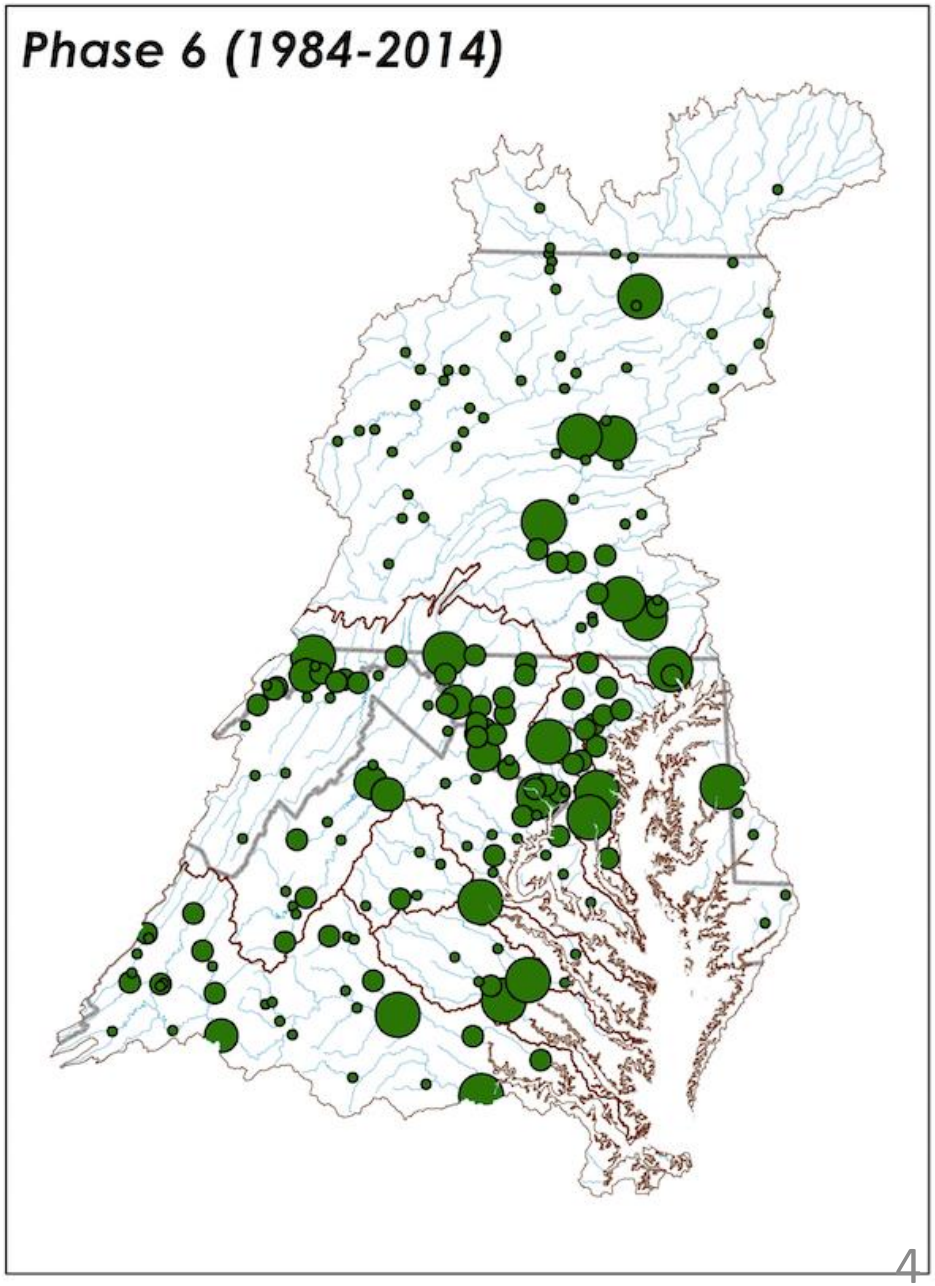
1. Overview of Phase 6 Watershed Model – Beta 1
2. Lower Susquehanna reservoirs
3. WRTDS loads adjustment factors
4. Updated total phosphorus loads
5. Seasonality of the simulated loads
6. Phase 6 Beta 2

1. Overview of Phase-6 WSM – Beta 1

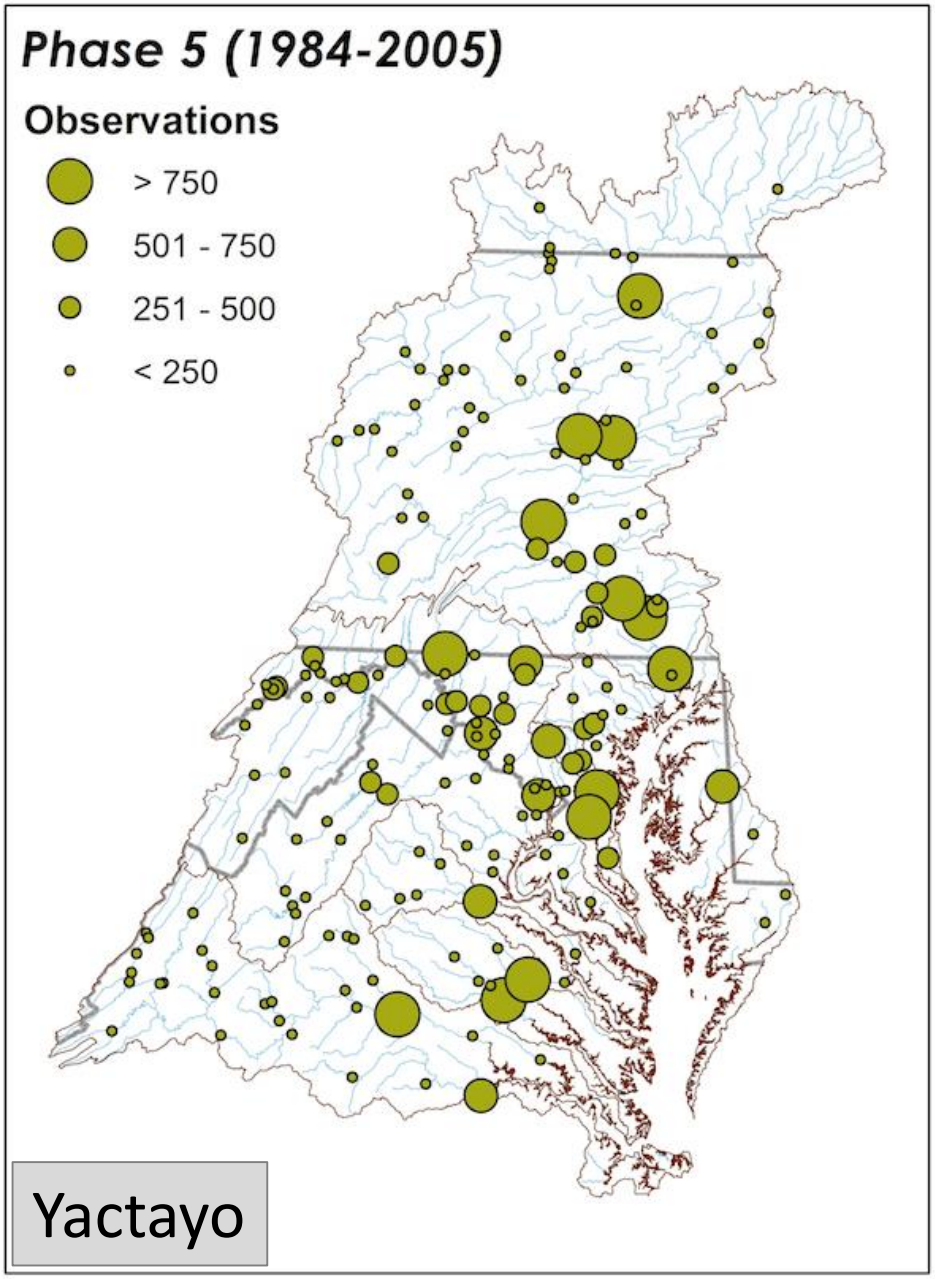
- Refined Phase-6 land-river segmentations.
- Revised Phase-6 land uses and Scenario Builder inputs.
- Expanded 30-year simulation/calibration period of 1985-2014.
- Sediment simulation is based on RUSLE-2 erosion targets.
- Nutrient simulation is based on:
  - export targets that use a mass balance approach based on **relative loading ratios** and **sensitivities**.
  - a synthesis of lag time estimates and hydrology & sediment transport.
- Spatial variability in the watershed response is simulated using *Land to Water delivery variances* from the SPARROW model.
- Effects of small streams, and more than 4000 small impoundments are incorporated through *Stream to River factors from* the SPARROW model.

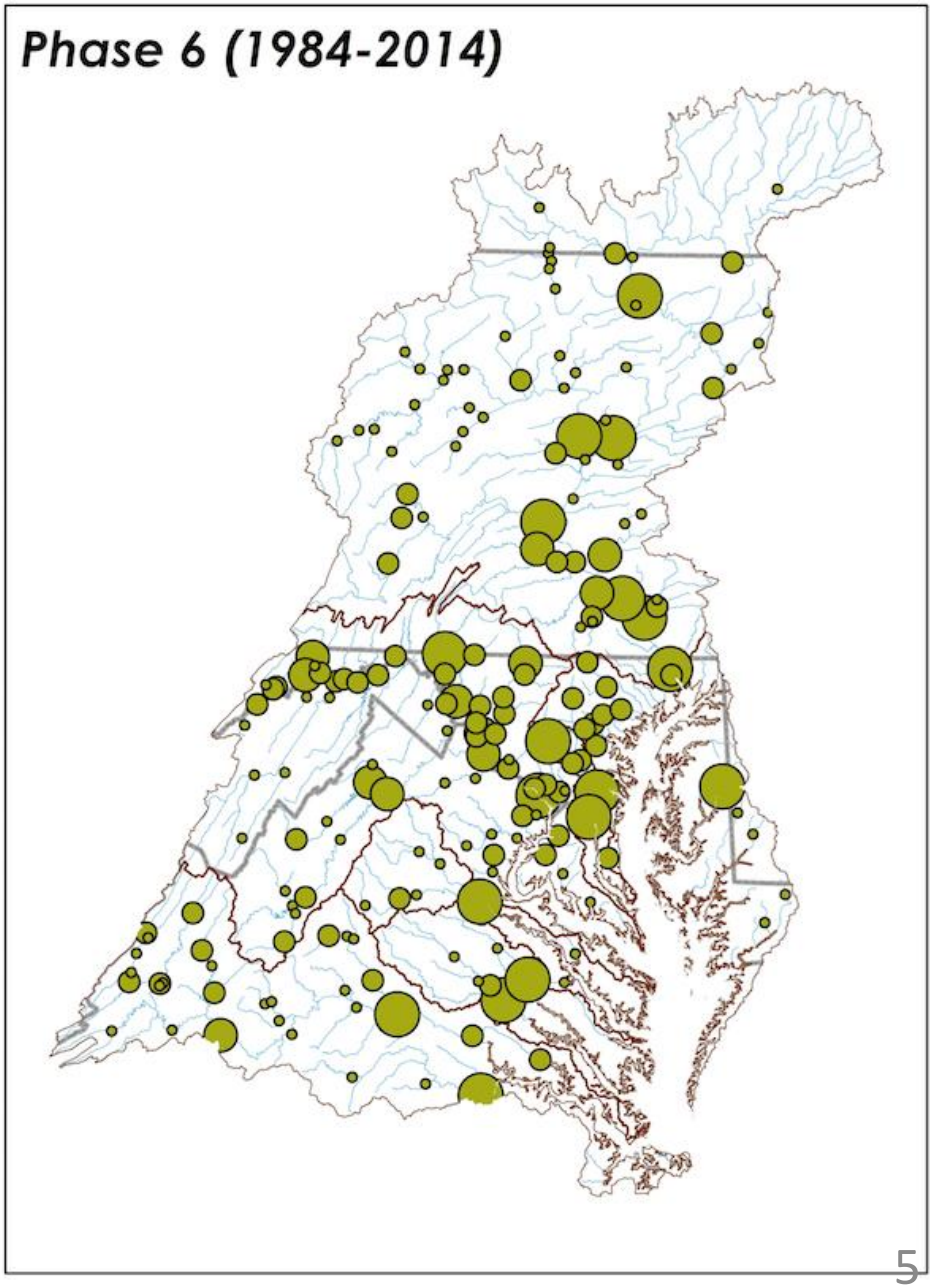
Observed Total Nitrogen - Number of Observations





Observed Total Phosphorus - Number of Observations





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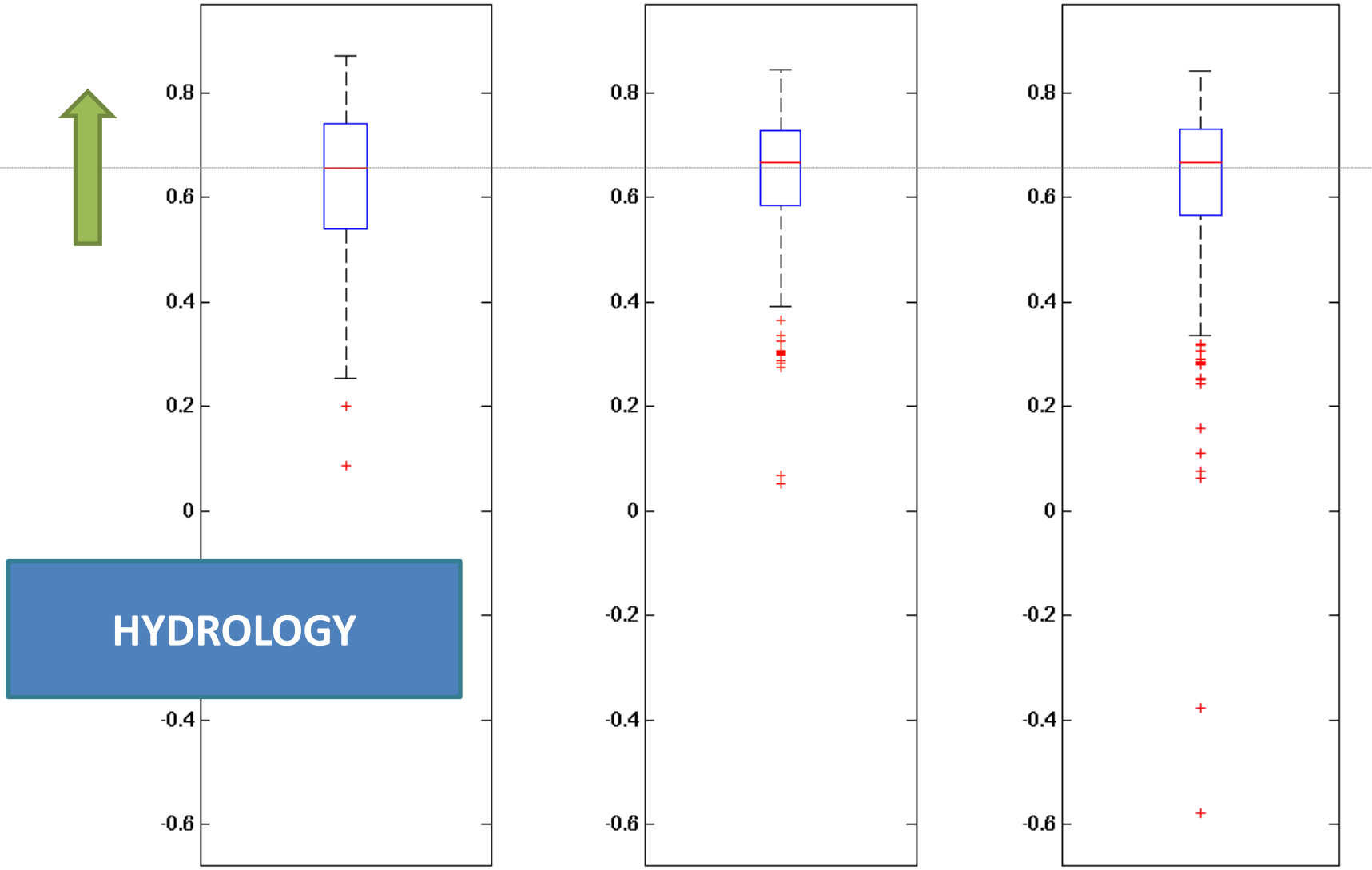
Nash-Sutcliffe Efficiency at 191 Calibration Stations



Phase 5 [1985-2005] | **Phase 6 [1985-2014]** | **Phase 6 [1985-2014]**

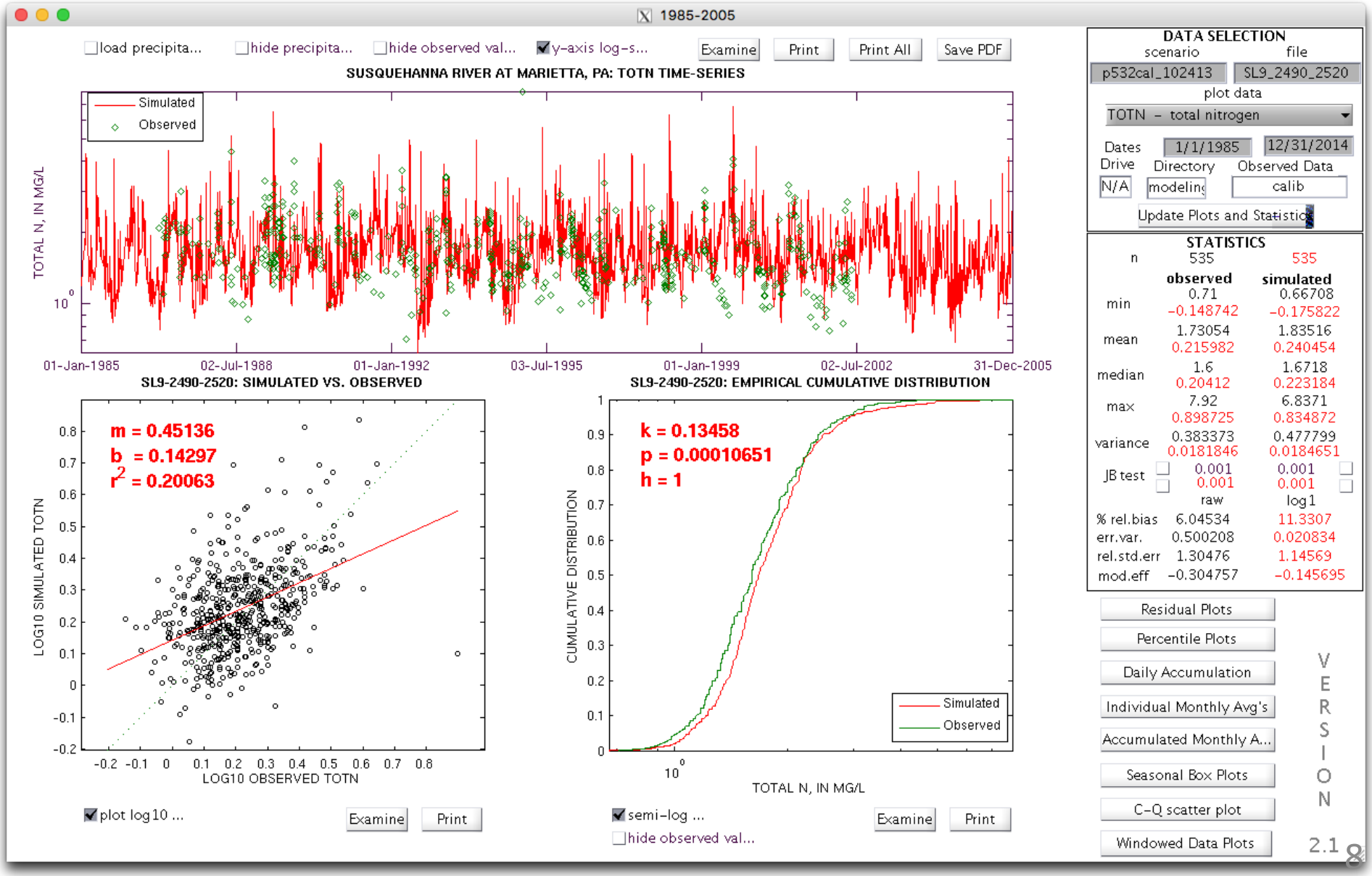
{P6 land segments and landuse*}

* August version with provisional datasets

SUSQUEHANNA AT MARIETTA

PHASE 5
1985 - 2005

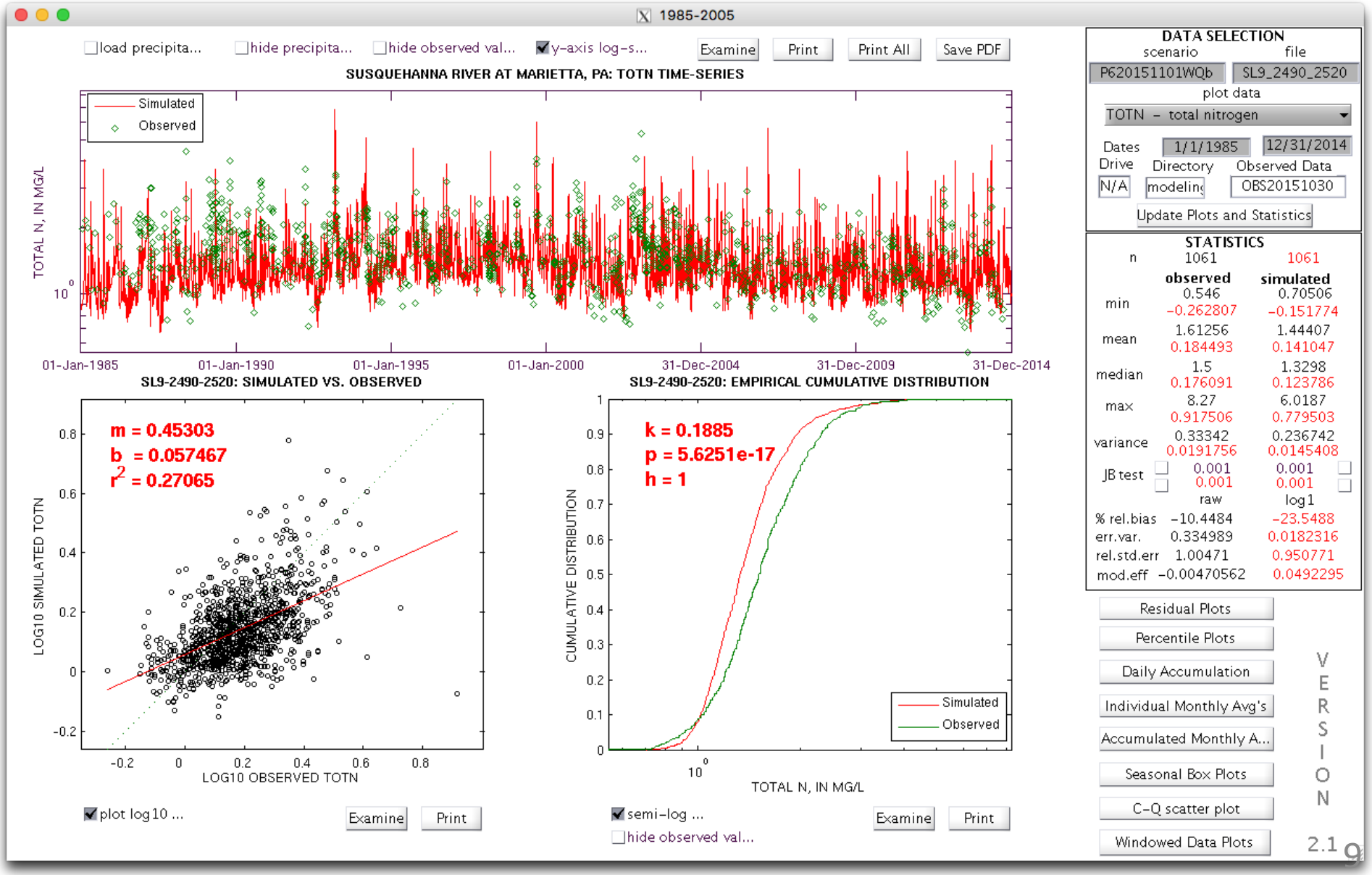
NITROGEN



SUSQUEHANNA AT MARIETTA

PHASE 6
1985 - 2014

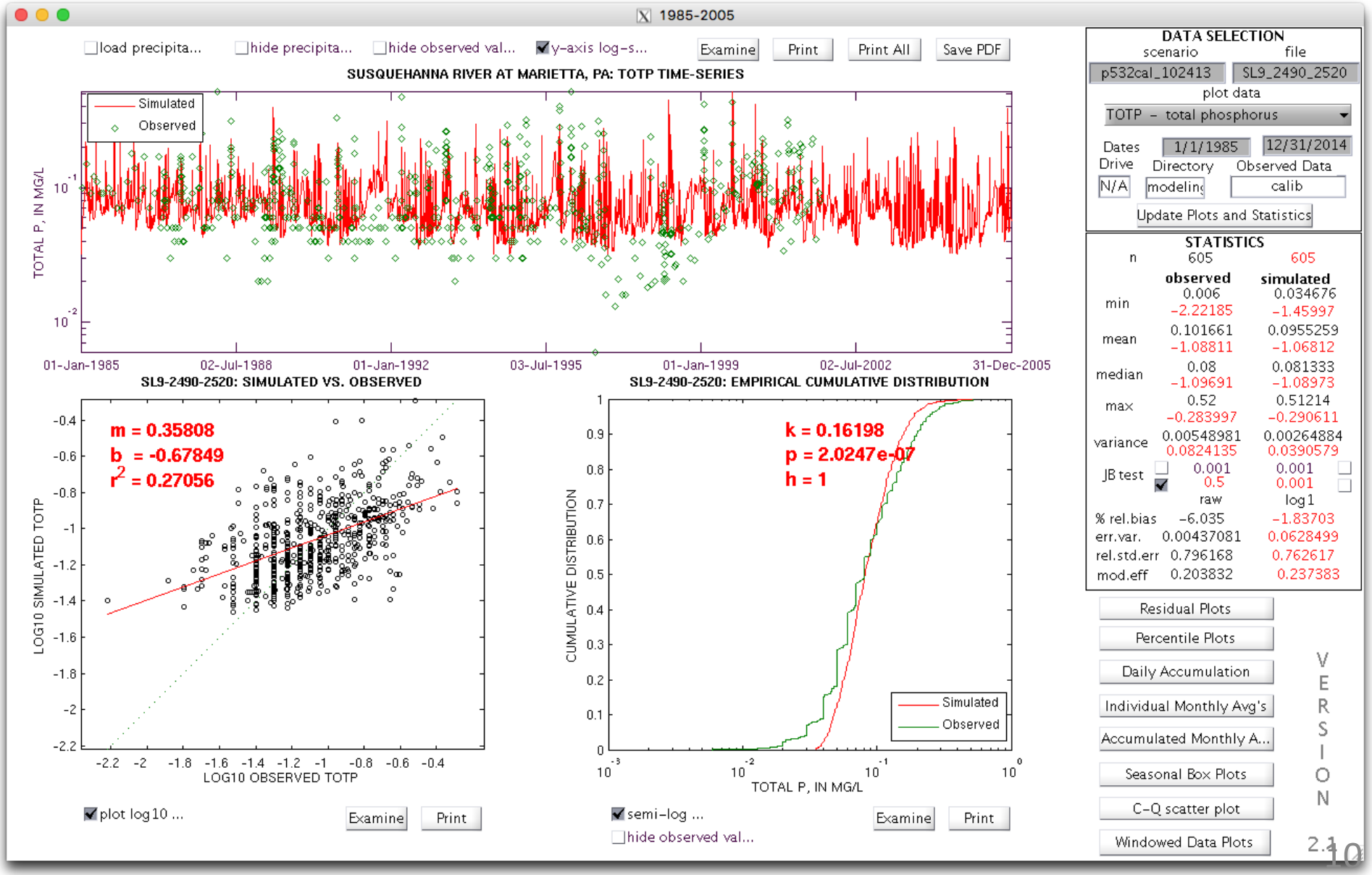
NITROGEN



SUSQUEHANNA AT MARIETTA

PHASE 5
1985 - 2005

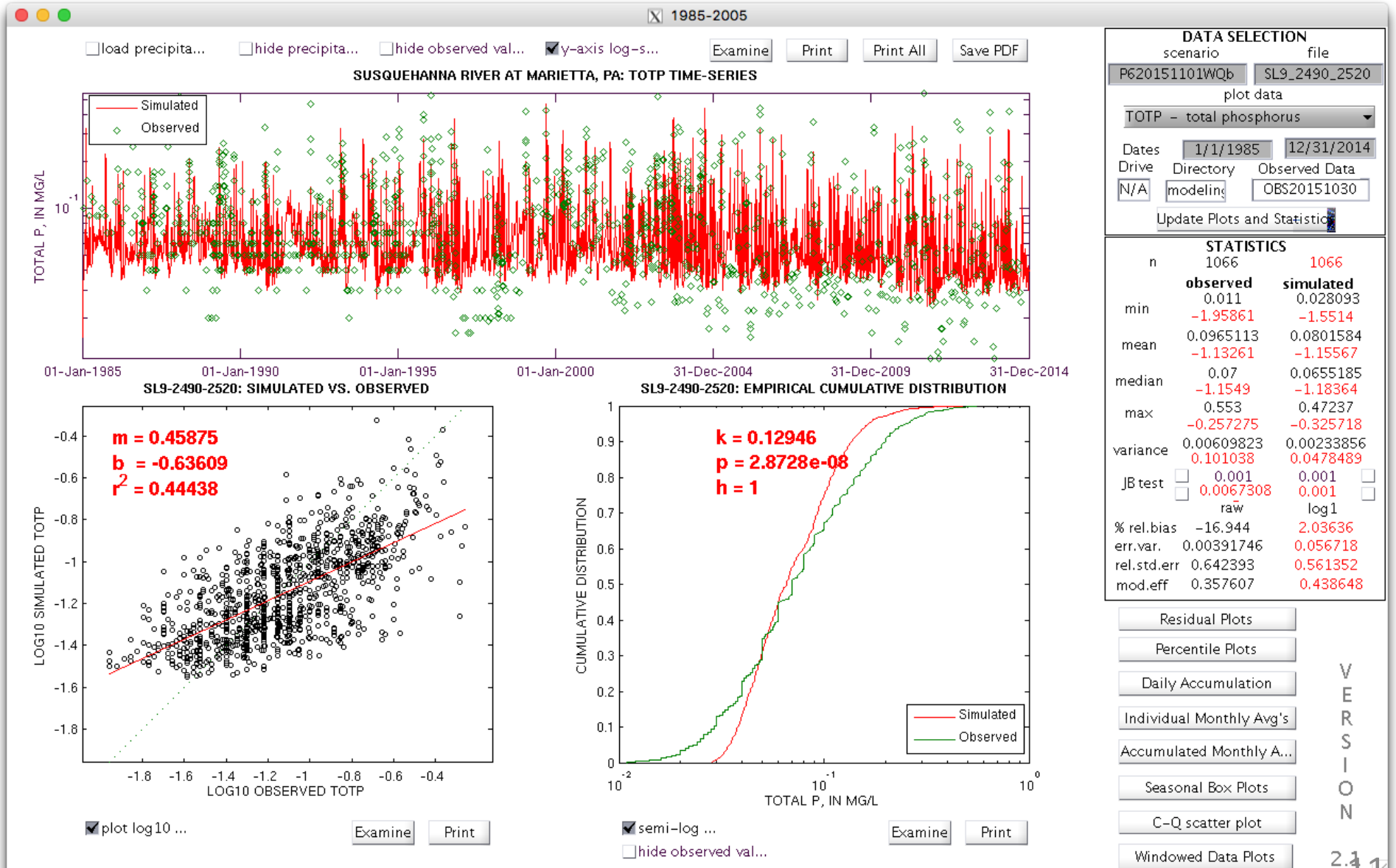
PHOSPHORUS



SUSQUEHANNA AT MARIETTA

PHASE 6
1985 - 2014

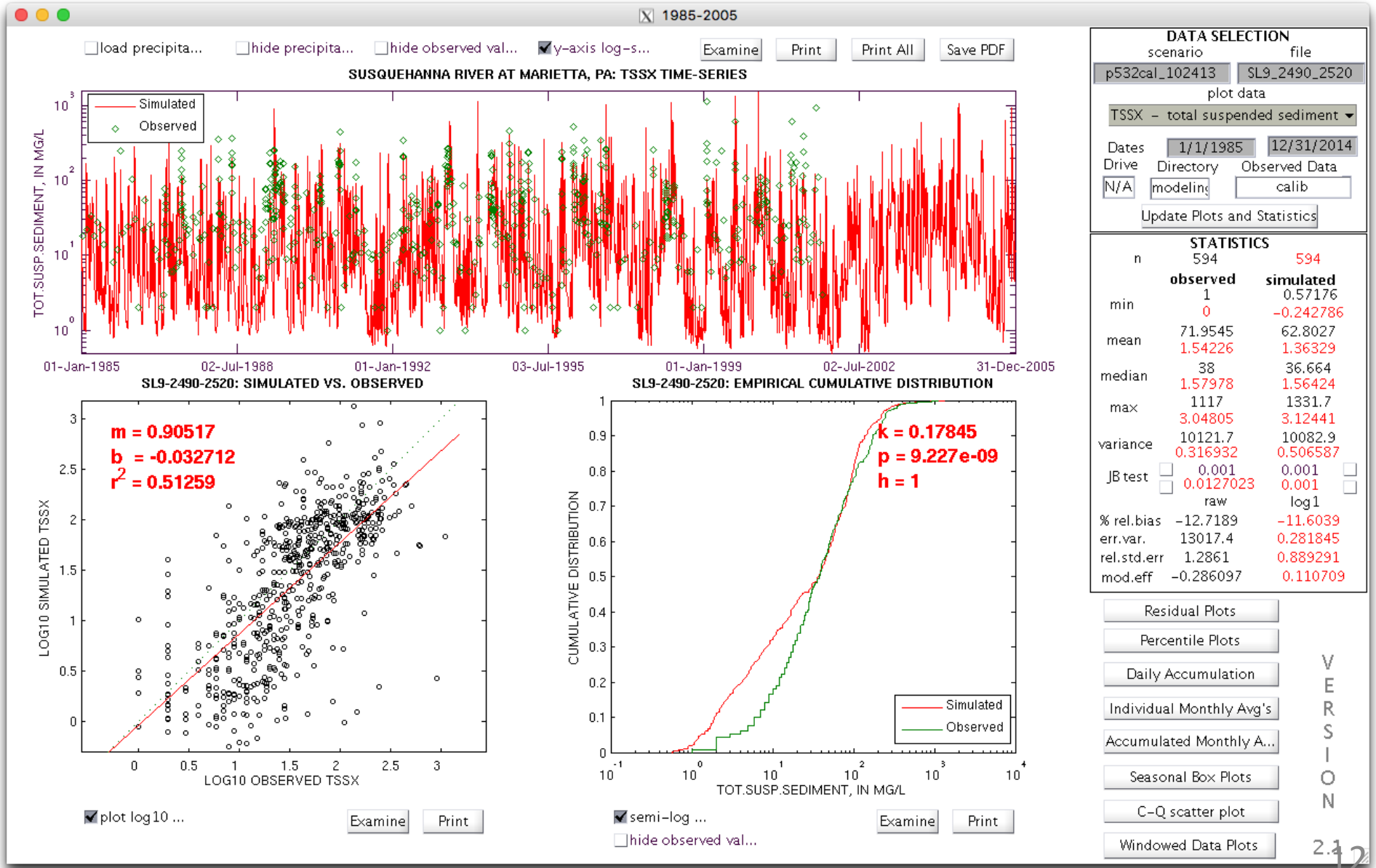
PHOSPHORUS



SUSQUEHANNA AT MARIETTA

PHASE 5
1985 - 2005

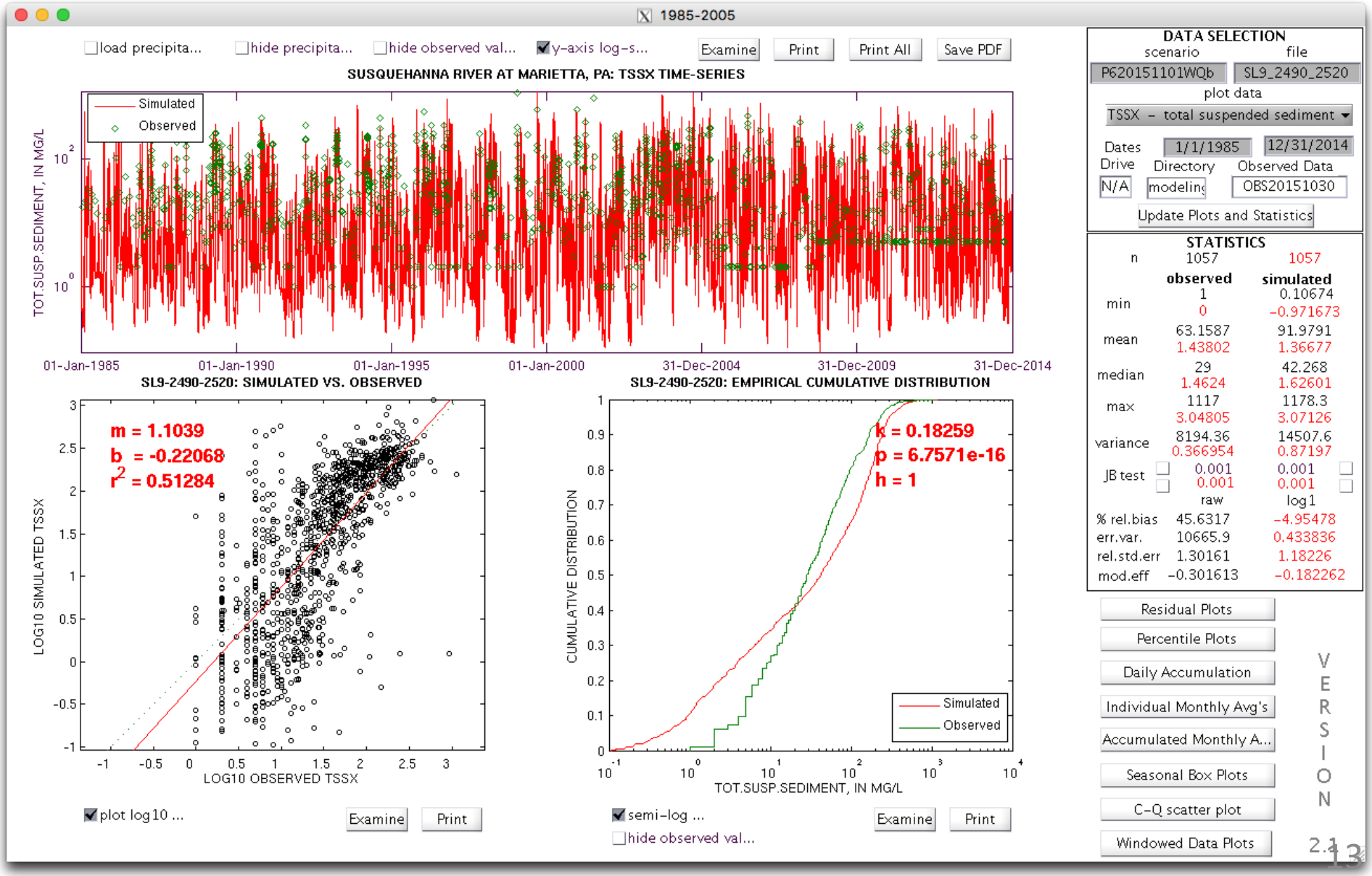
SEDIMENT



SUSQUEHANNA AT MARIETTA

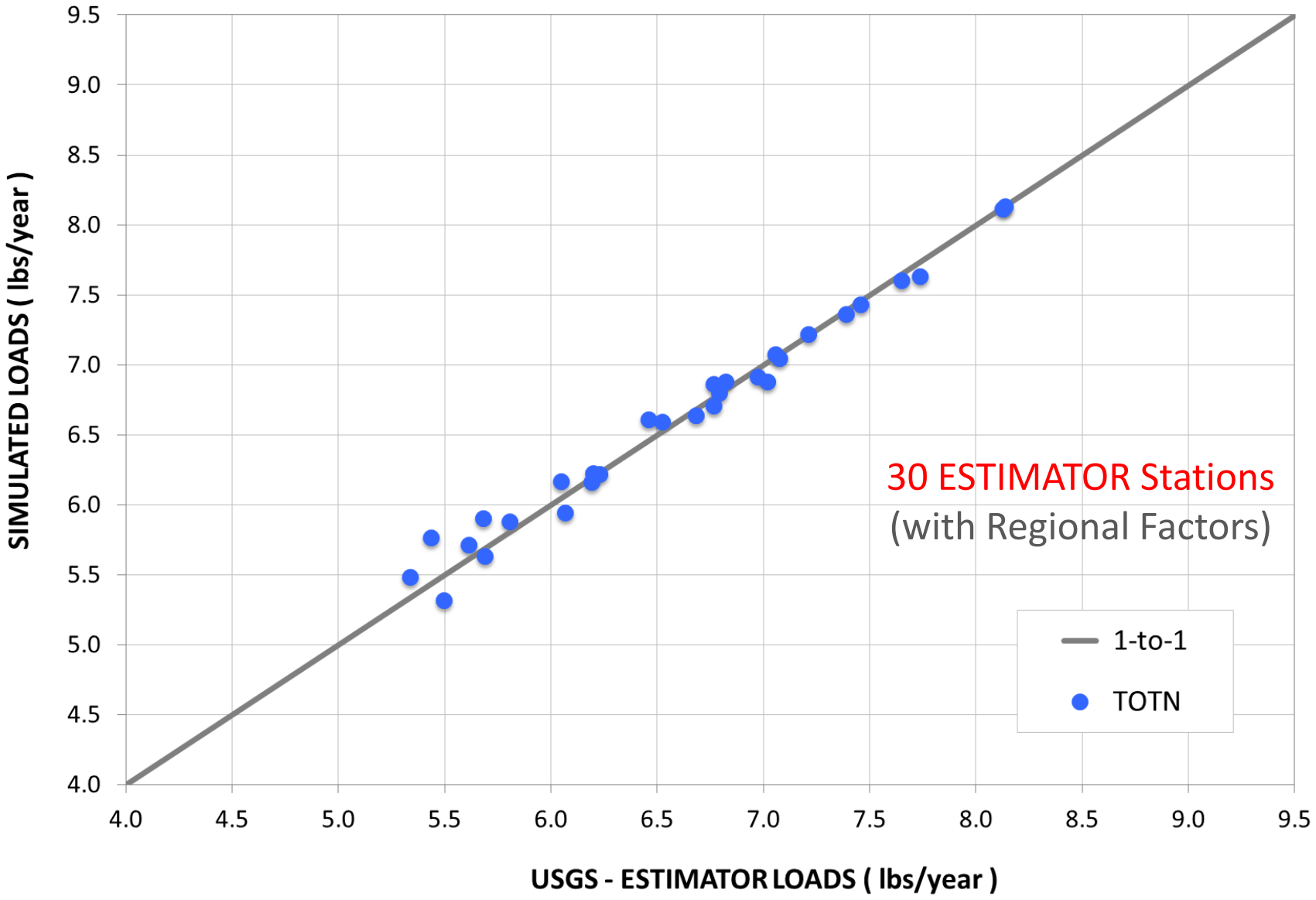
PHASE 6
1985 - 2014

SEDIMENT



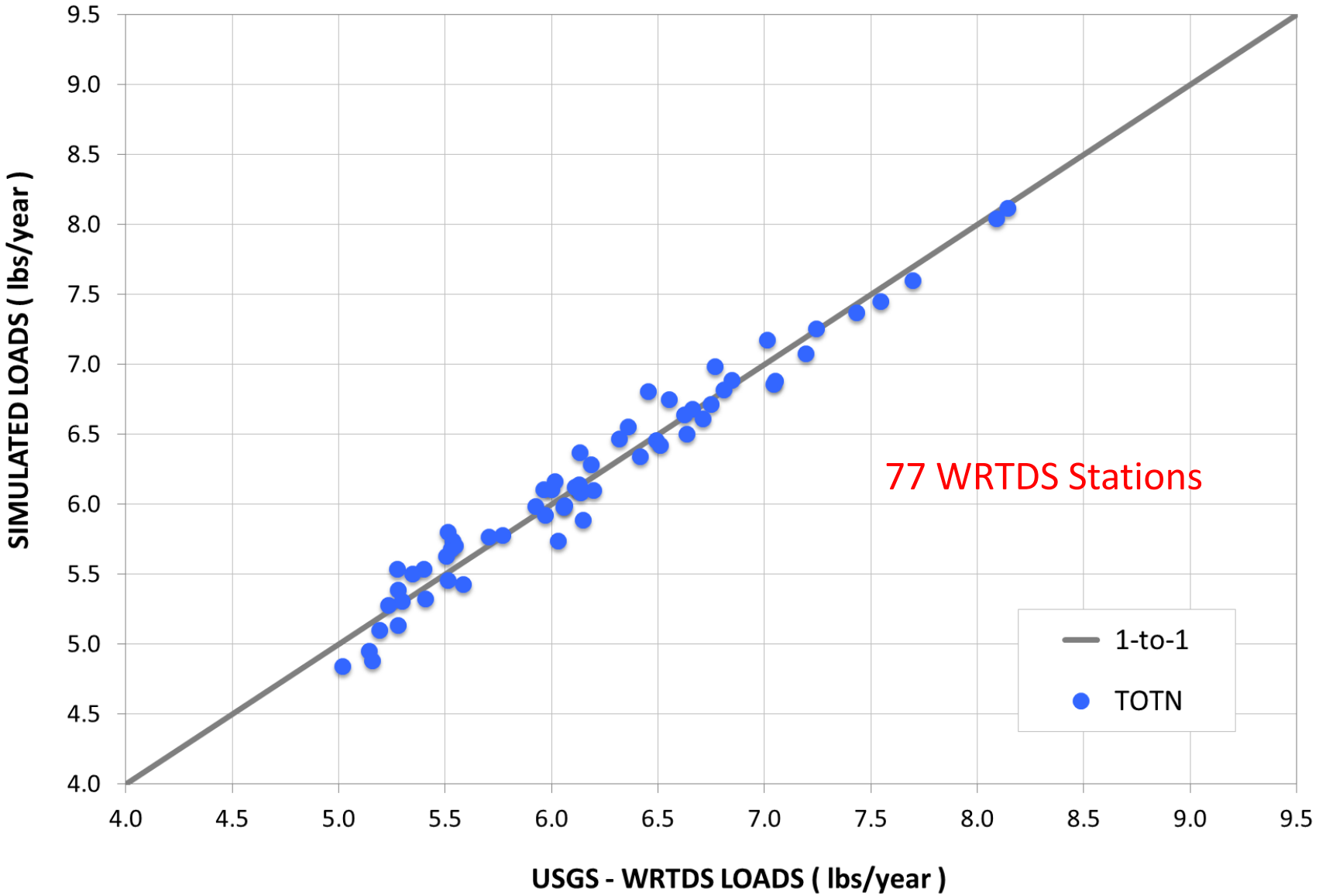
PHASE 5

NITROGEN



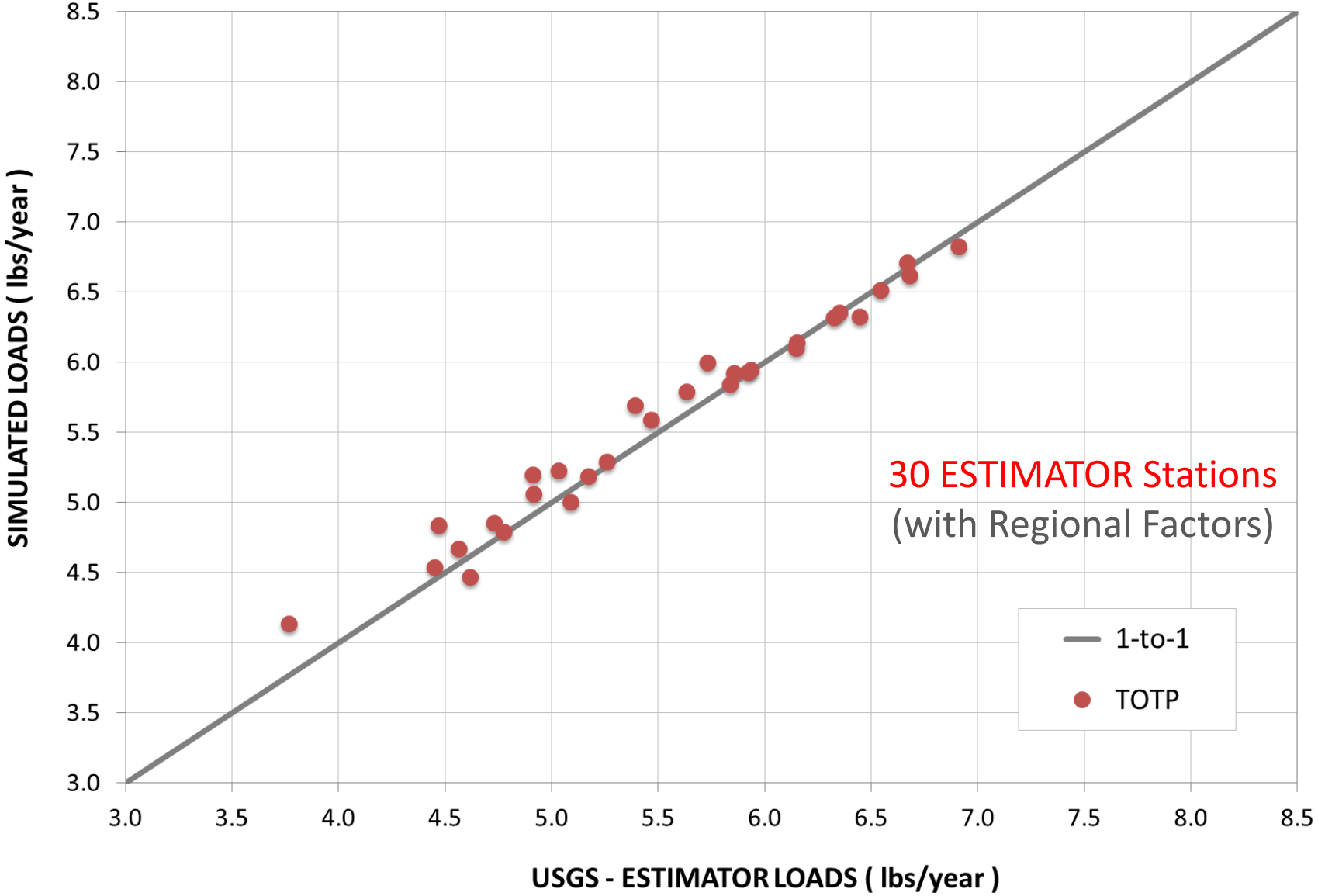
PHASE 6

NITROGEN



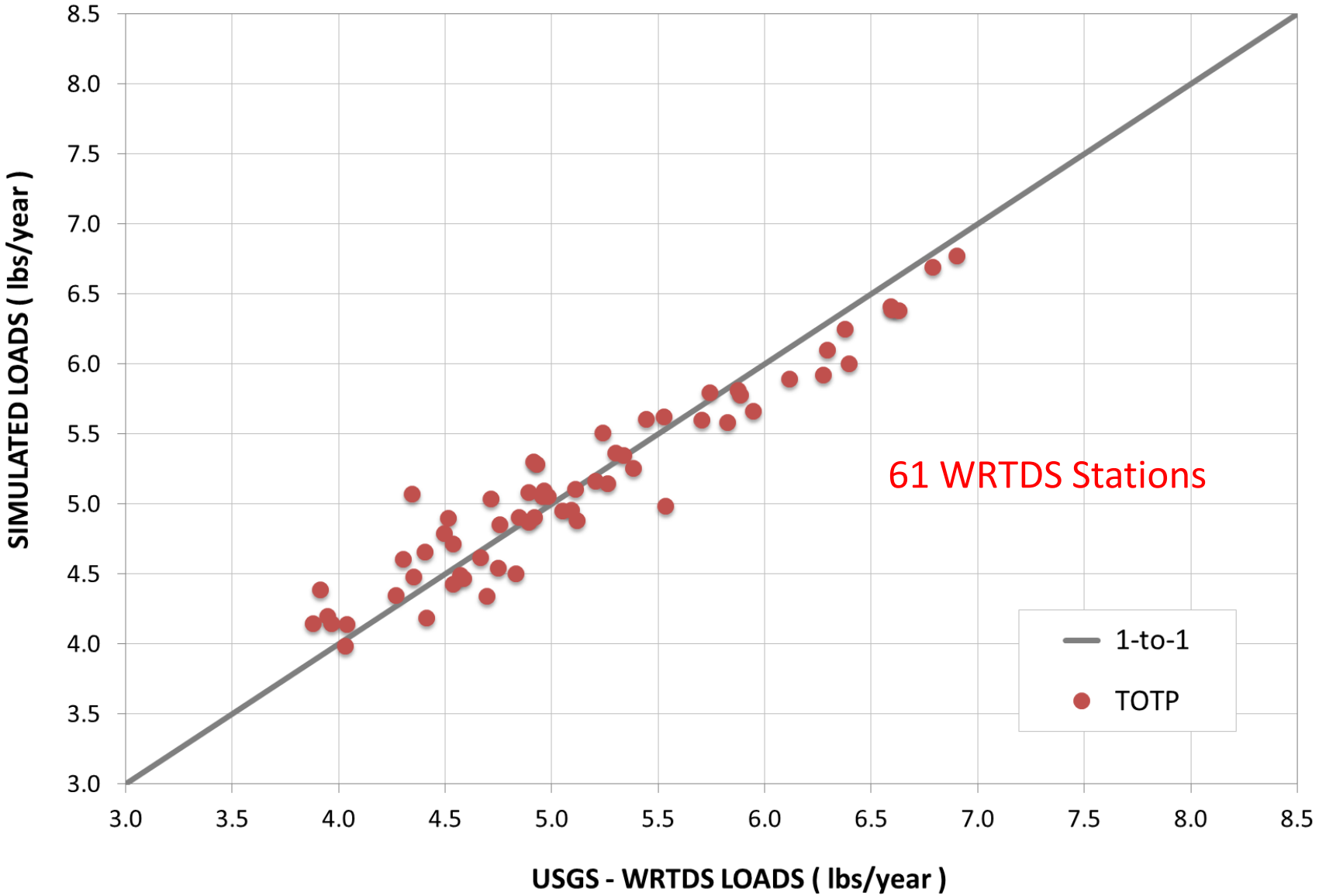
PHASE 5

PHOSPHORUS



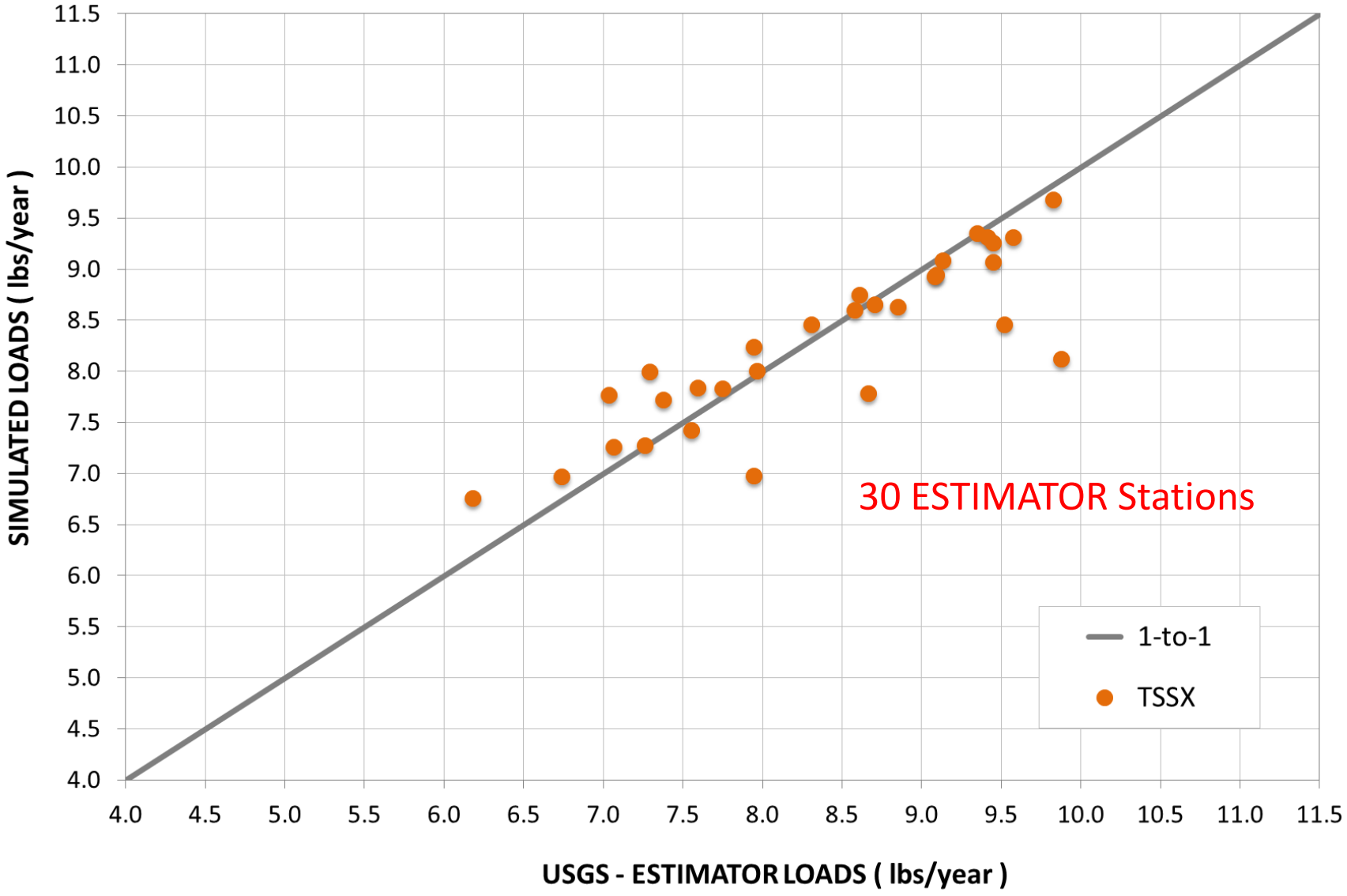
PHASE 6

PHOSPHORUS



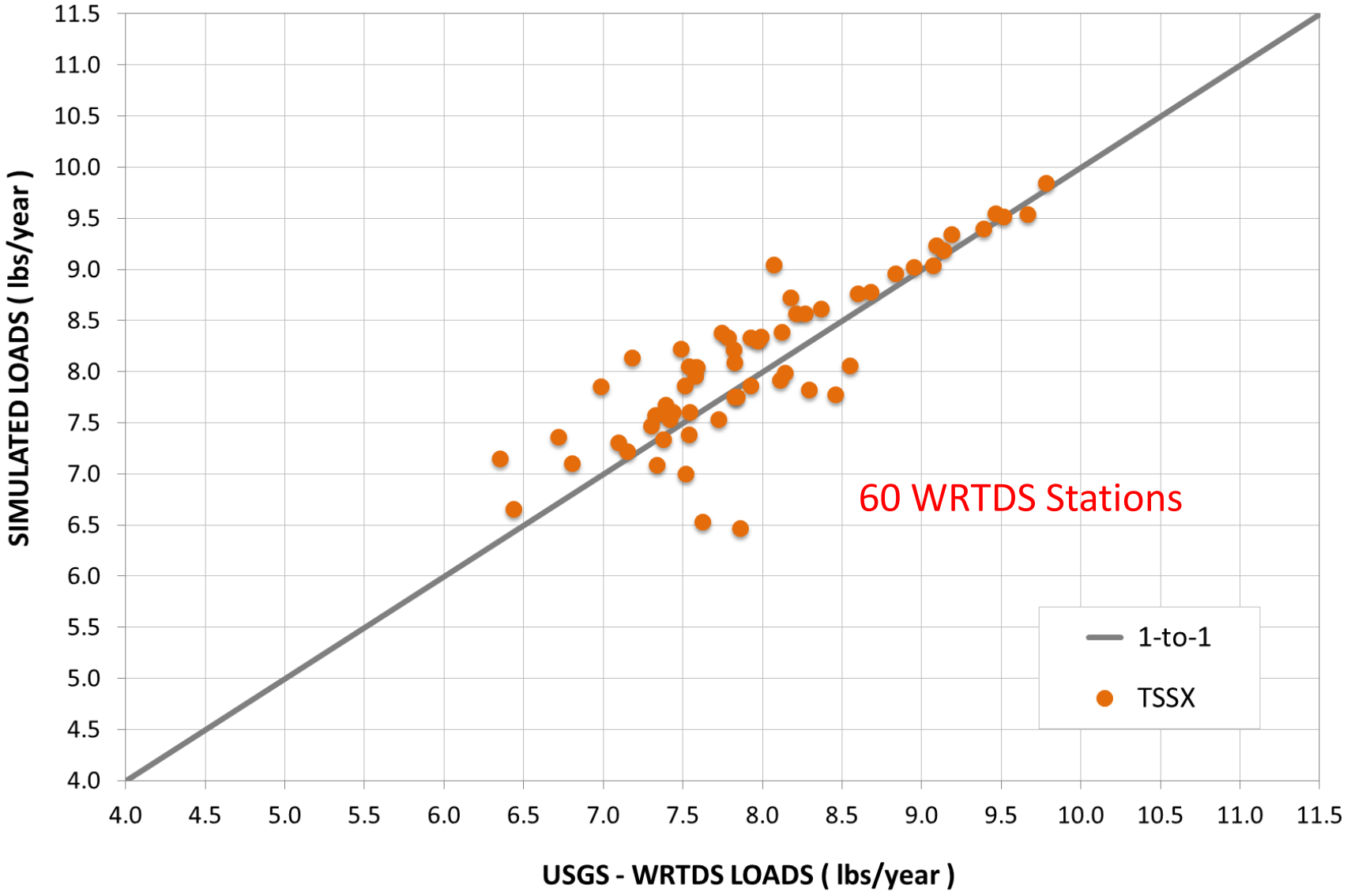
PHASE 5

SEDIMENT

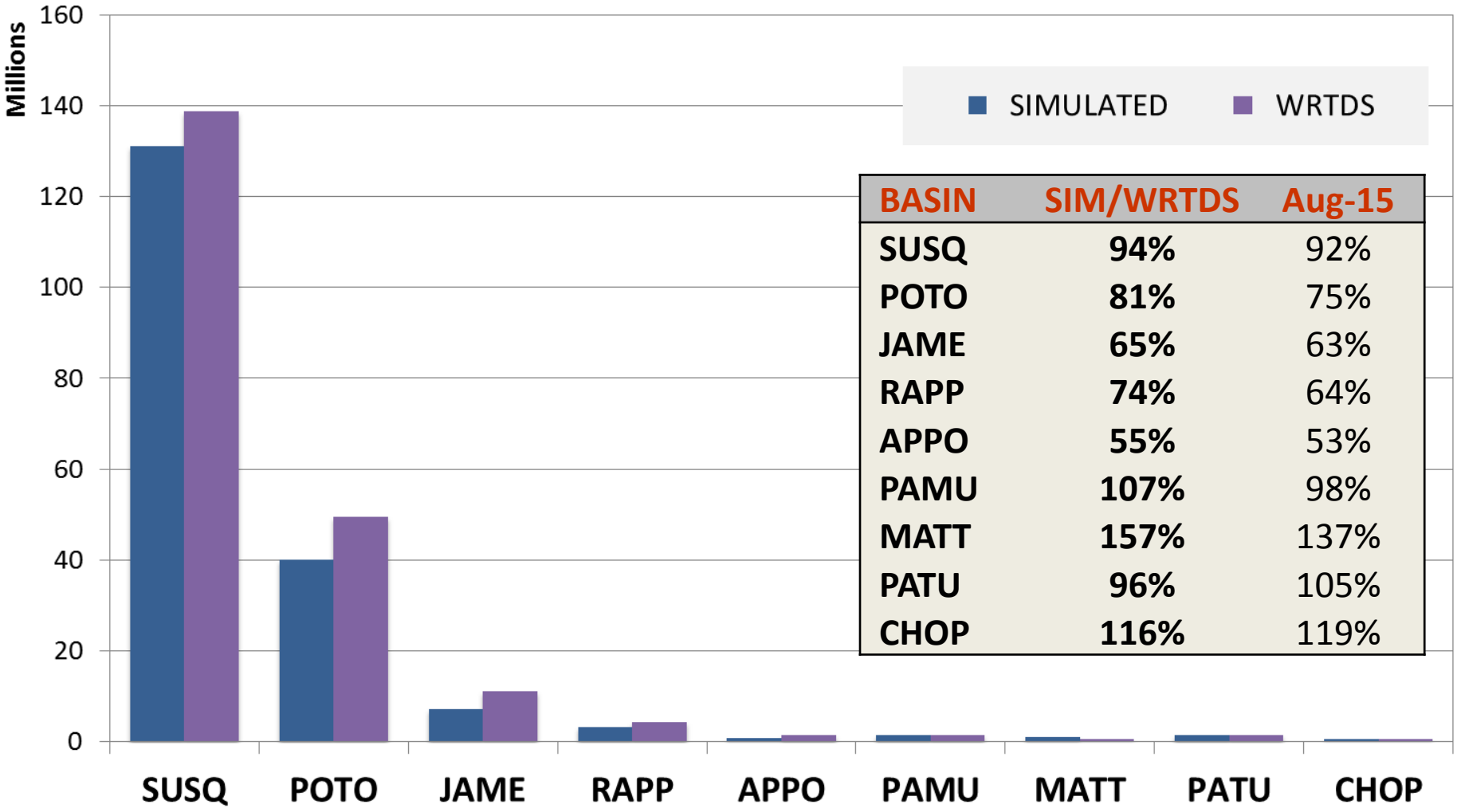


PHASE 6

SEDIMENT

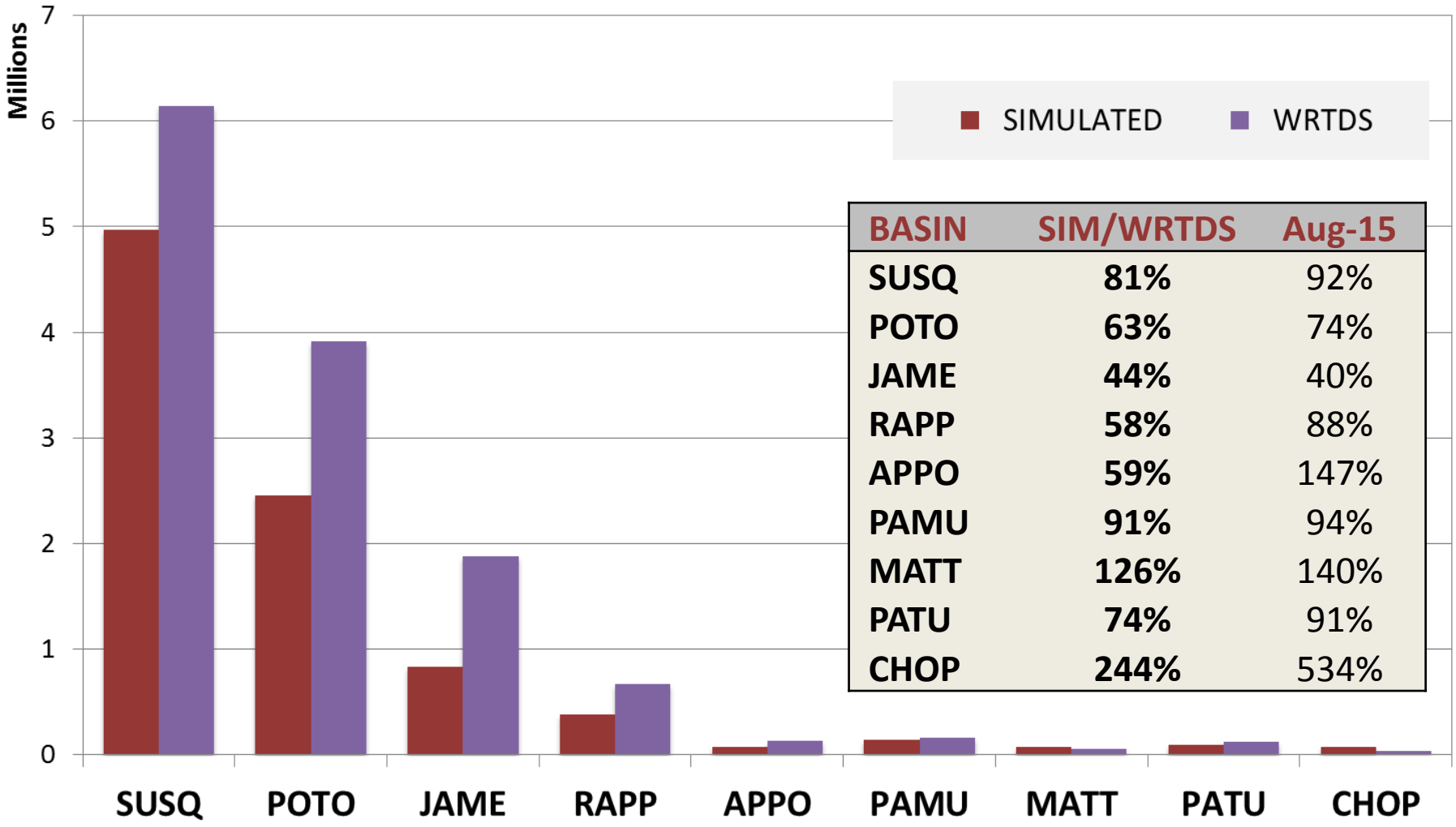


Total **Nitrogen** at RIM Stations



BASIN	SIM/WRTDS	Aug-15
SUSQ	94%	92%
POTO	81%	75%
JAME	65%	63%
RAPP	74%	64%
APPO	55%	53%
PAMU	107%	98%
MATT	157%	137%
PATU	96%	105%
CHOP	116%	119%

Total **Phosphorus** at RIM Stations

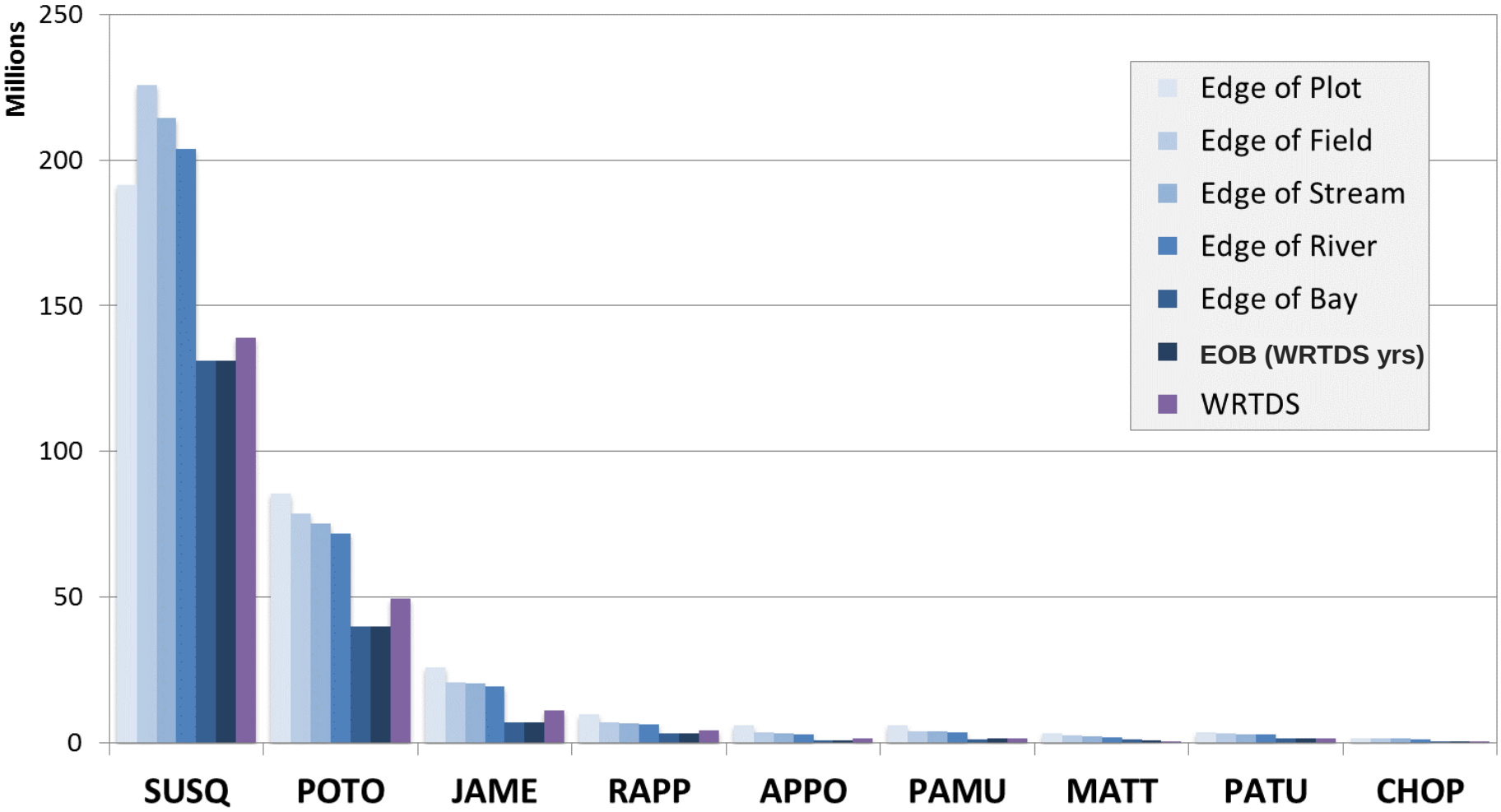


BASIN	SIM/WRTDS	Aug-15
SUSQ	81%	92%
POTO	63%	74%
JAME	44%	40%
RAPP	58%	88%
APPO	59%	147%
PAMU	91%	94%
MATT	126%	140%
PATU	74%	91%
CHOP	244%	534%

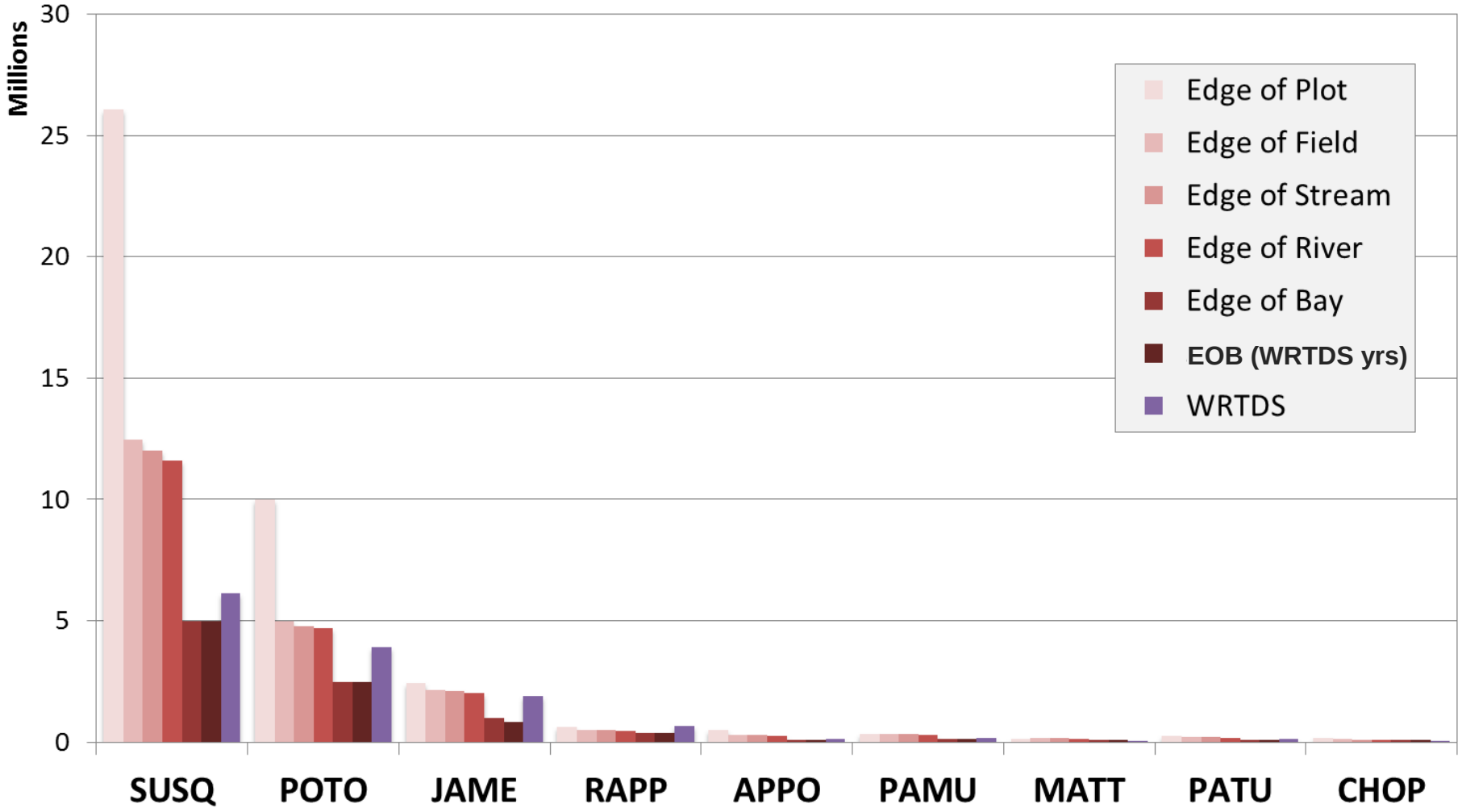
Phase-6 (process) simulation scales

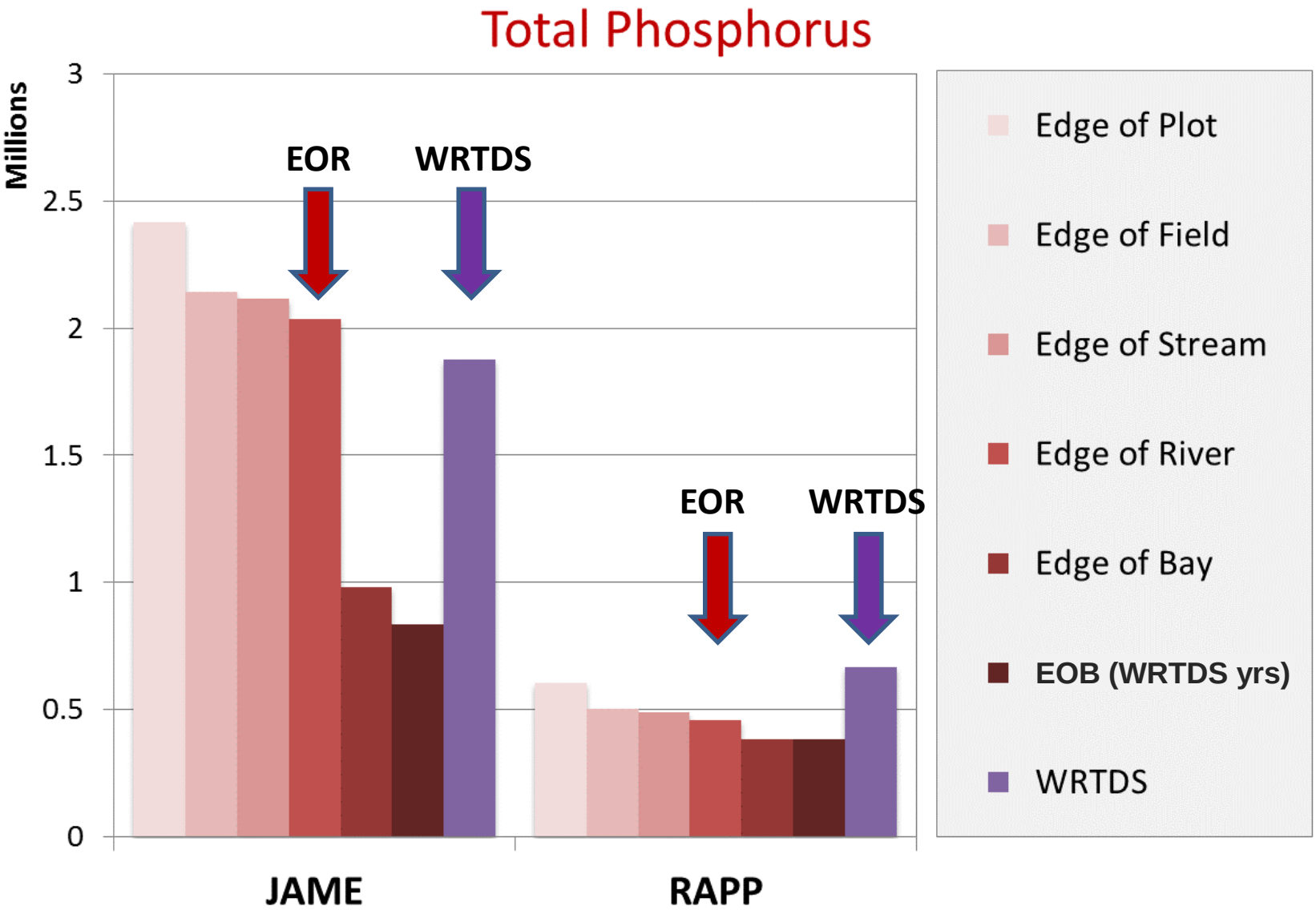
- **Edge of Plot** – loads from targets (e*ffect of source loads*)
- **Edge of Field** – loads after land-to-water variances
- **Edge of Stream** – loads after Septic, PS, & BMPs
- **Edge of River** – loads after stream-to-river factors
- **Delivered to Bay** – loads transported to the Bay

Nitrogen budgets at P6 simulation scales



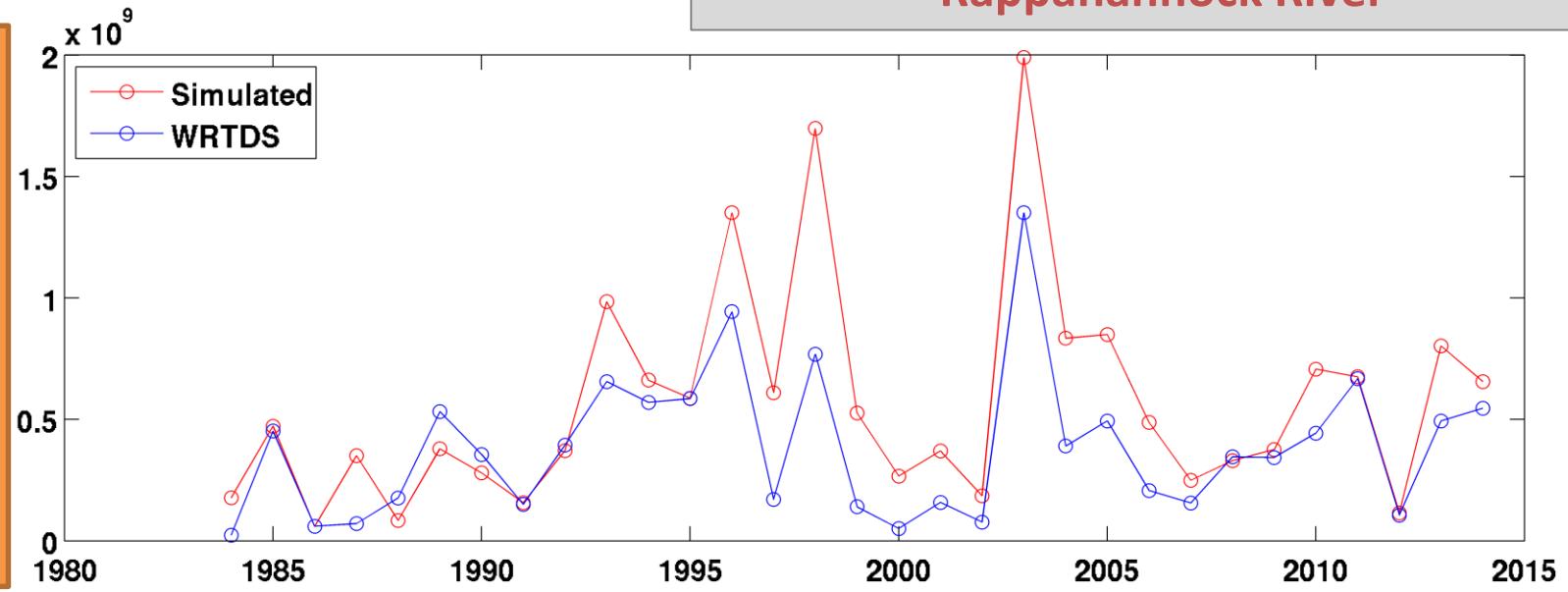
Phosphorus budgets at P6 simulation scales



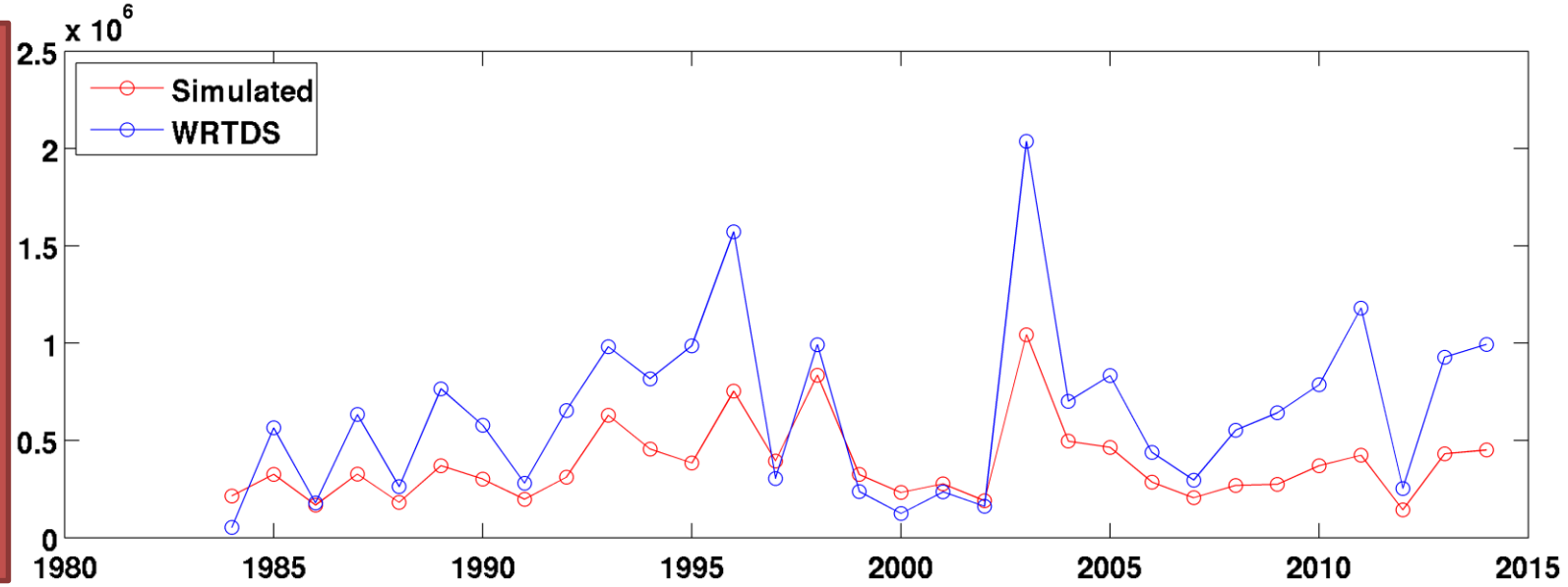

Total Phosphorus
Millions
3
2.5
2
1.5
1
0.5
0
EOR
WRTDS
EOR
WRTDS
JAME
RAPP
Edge of Plot
Edge of Field
Edge of Stream
Edge of River
Edge of Bay
EOB (WRTDS yrs)
WRTDS

Rappahannock River

TOTAL SUSPENDED SOLIDS



TOTAL PHOSPHORUS



2. Lower Susquehanna Reservoirs

PHASE-6 (1985-2014)		Safe Harbor	Holtwood	Conowingo
	Sand	0.00	0.00	0.00
	Silt	0.99	0.99	0.33
	Clay	0.98	0.98	0.79

ORIGINAL CALIBRATION			
	SIMULATED	WRTDS	% Difference
TOTN	1.31E+08	1.39E+08	-6%
TOTP	4.97E+06	6.14E+06	-19%
TSSX	3.45E+09	4.60E+09	-25%

AFTER HAND CALIBRATION of LSR			
	SIMULATED	WRTDS	% Difference
TOTN	1.33E+08	1.39E+08	-4%
TOTP	5.67E+06	6.14E+06	-8%
TSSX	4.91E+09	4.60E+09	7%

3. *WRTDS load adjustment factors*

for providing loads to the WQSTM

WRTDS LAF for TOTN

BASIN	P6 Beta 1
SUSQ	~~1.0491~~
POTO	1.2228
JAME	1.5015
RAPP	1.3368
APPO	1.7701
PAMU	0.9351
MATT	0.6359
PATU	1.0338
CHOP	0.8545

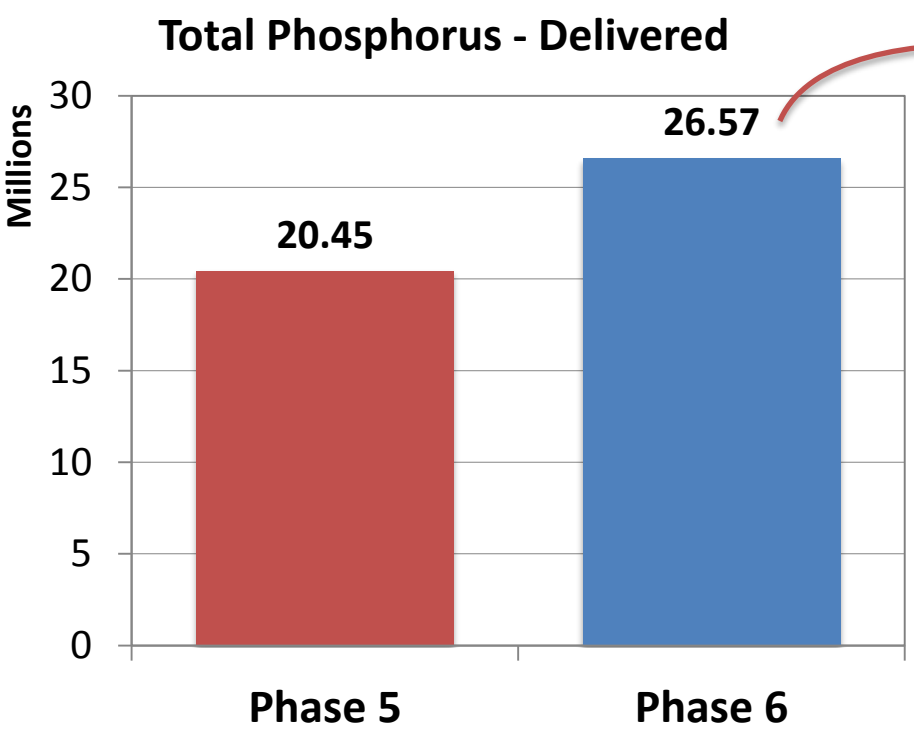
WRTDS LAF for TOTP

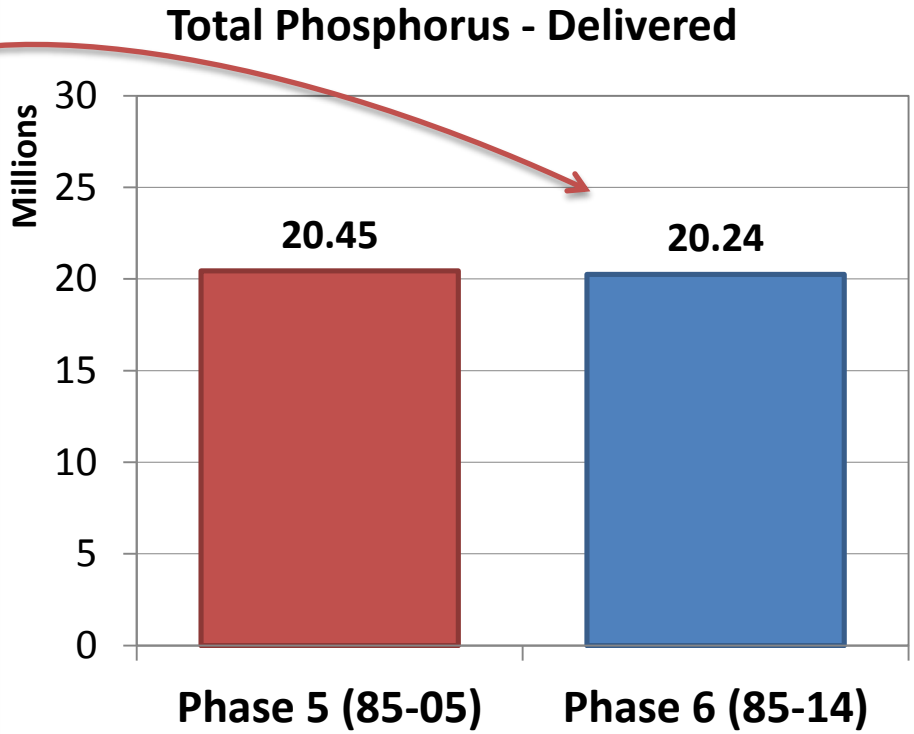
BASIN	P6 Beta 1
SUSQ	~~1.0827~~
POTO	1.5581
JAME	2.1873
RAPP	1.7185
APPO	1.7030
PAMU	1.0925
MATT	0.7899
PATU	1.3354
CHOP	0.4055

4. *Updated total phosphorus loads*

Phase 6 Aug 2015 → **Phase 6 Beta 1**

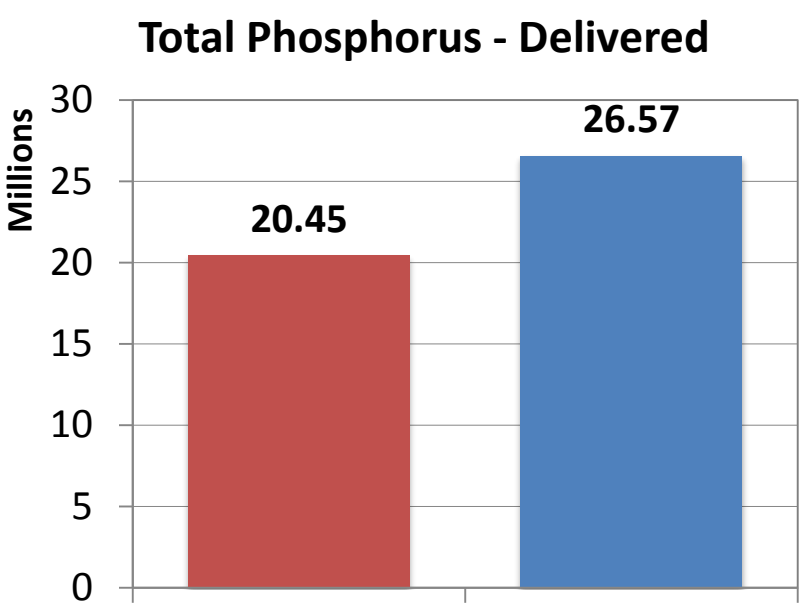
Total phosphorus load to the Bay has decreased!

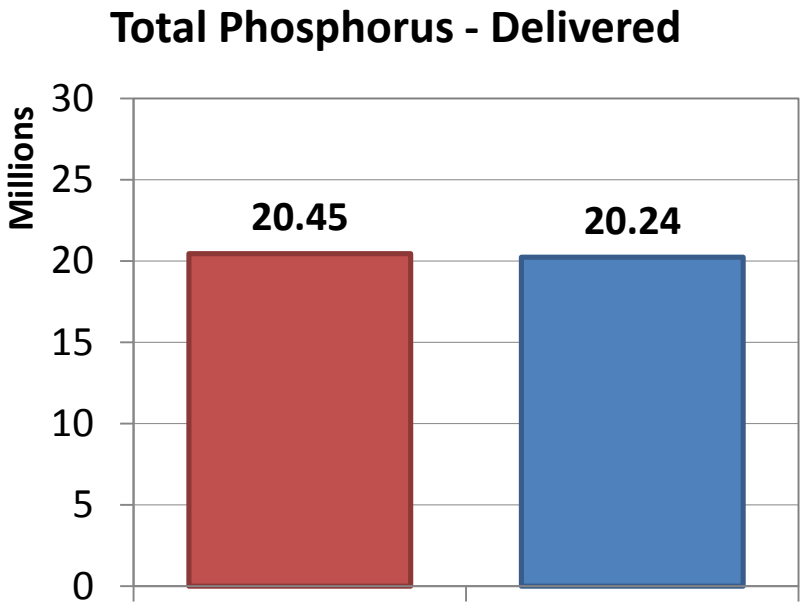


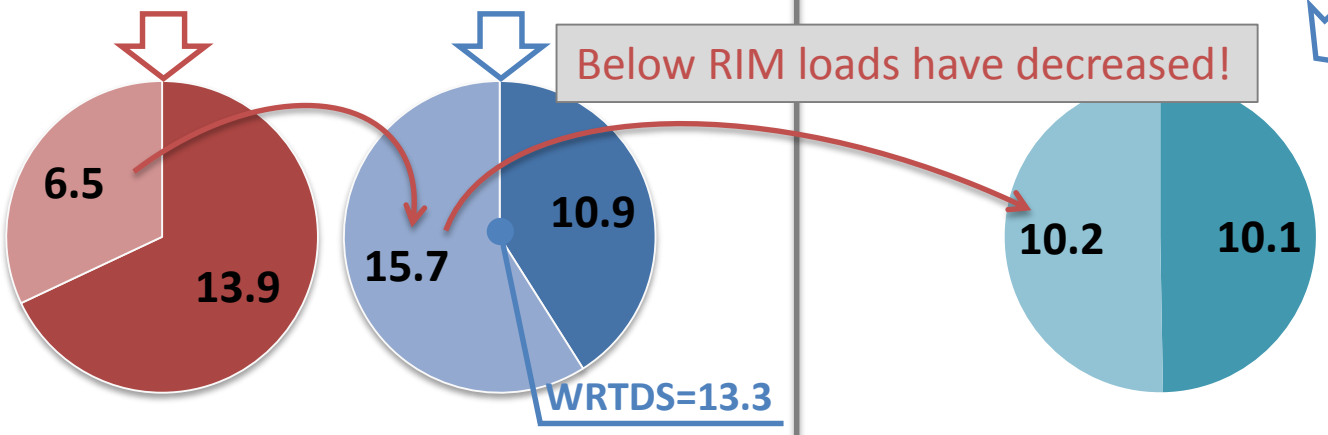


Phase 6 Aug 2015

Phase 6 Beta 1







* WRTDS load adjustment factors were applied at RIM stations as follows –

WRTDS LAF for TOTN

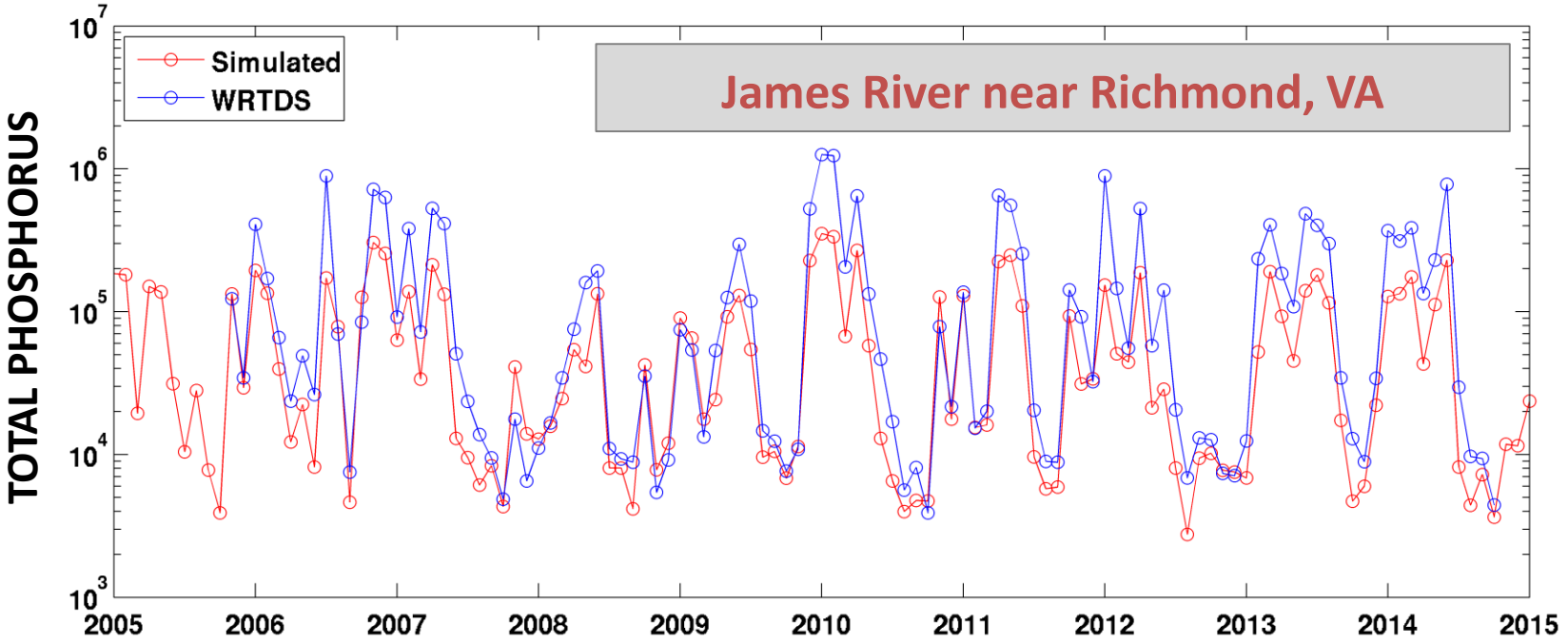
BASIN	P6 Beta 1
SUSQ	~~1.0491~~
POTO	1.2228
JAME	1.5015
RAPP	1.3368
APPO	1.7701
PAMU	0.9351
MATT	0.6359
PATU	1.0338
CHOP	0.8545

WRTDS LAF for TOTP

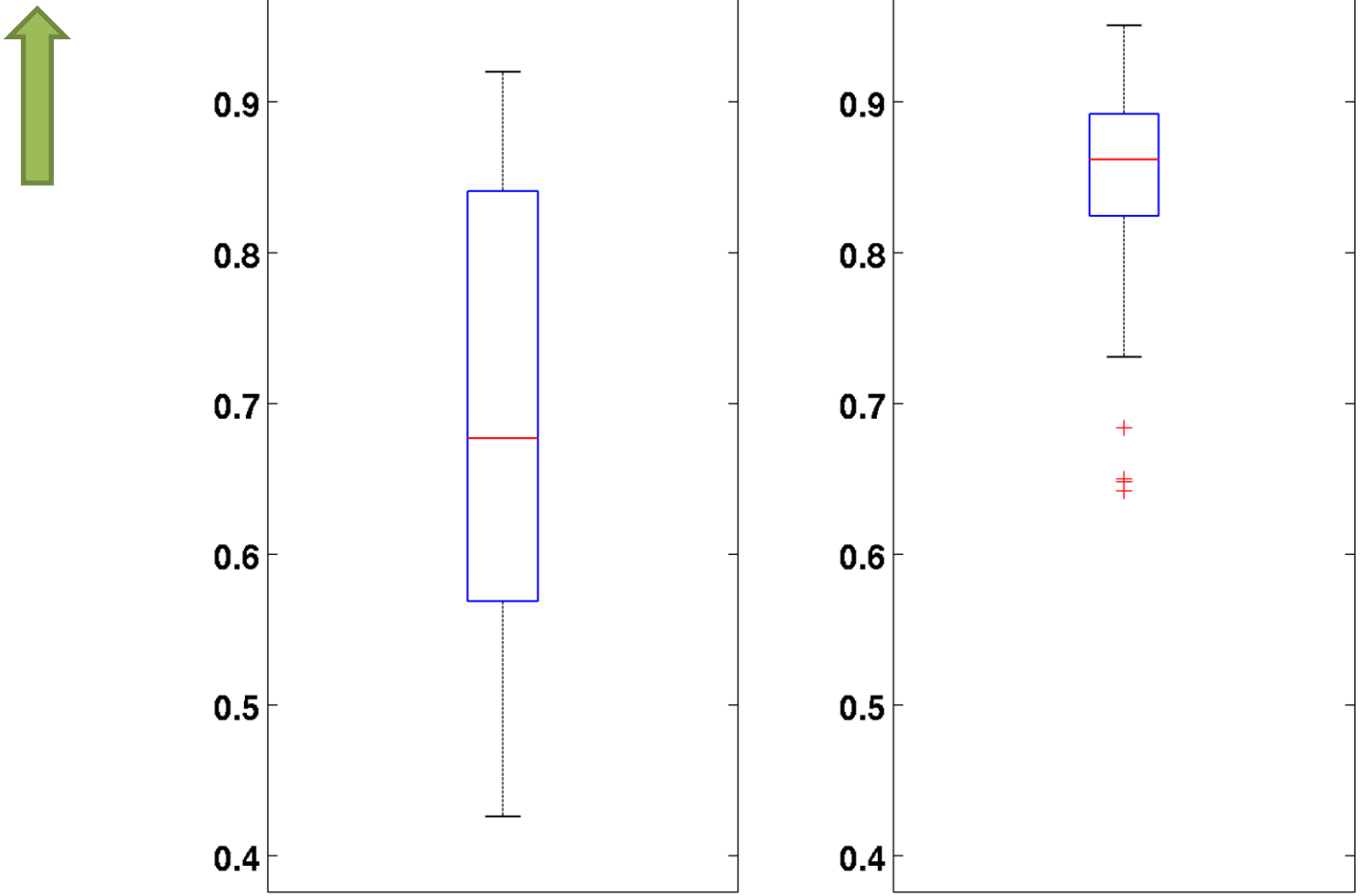
BASIN	P6 Beta 1
SUSQ	~~1.0827~~
POTO	1.5581
JAME	2.1873
RAPP	1.7185
APPO	1.7030
PAMU	1.0925
MATT	0.7899
PATU	1.3354
CHOP	0.4055

5. *Seasonality of simulated loads*

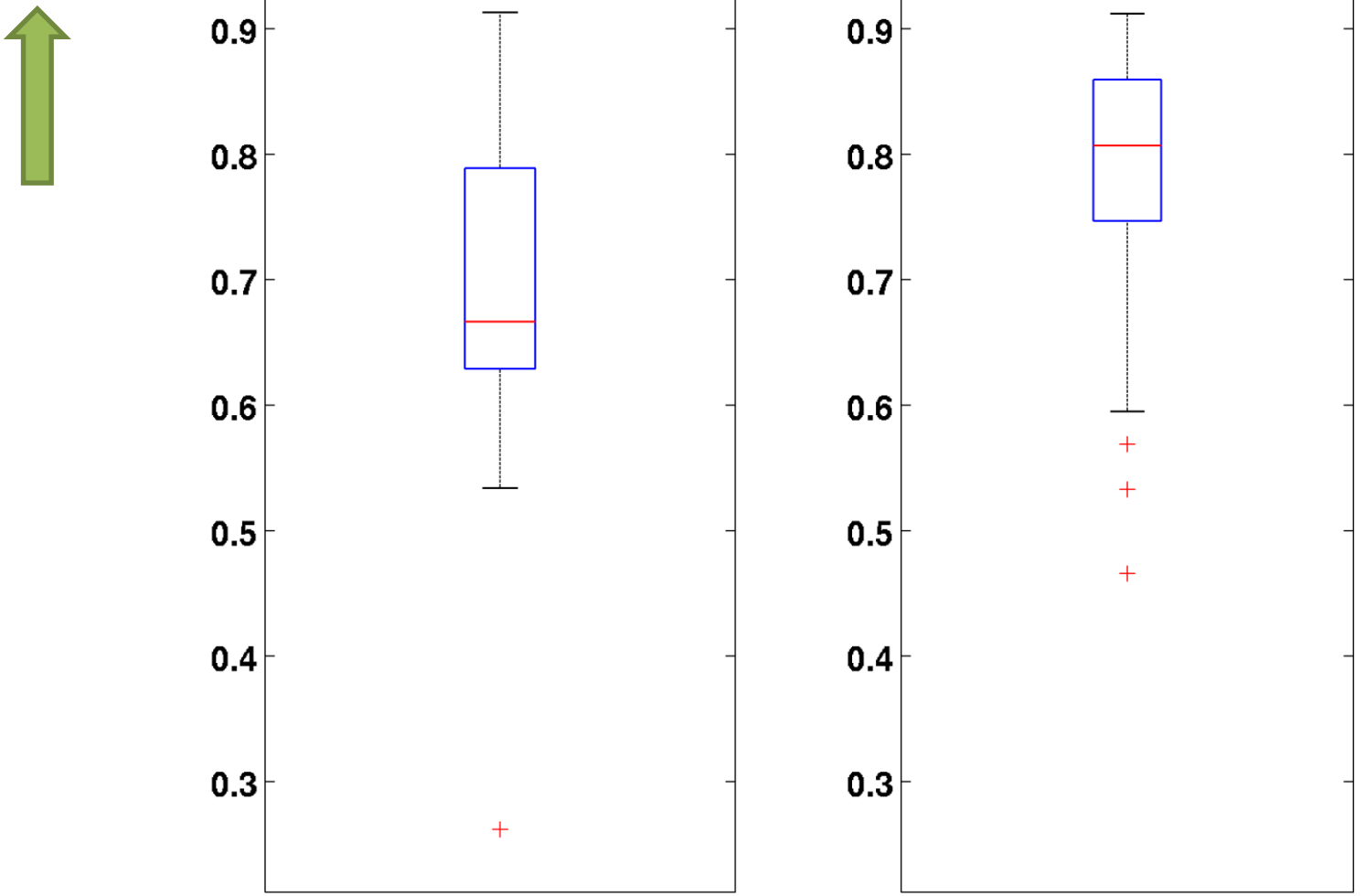
- Given the differences in the WRTDS and simulated *average annual loads*, how well the seasonality is captured in the Phase 6 Beta 1 loads?



Correlation – Total Nitrogen



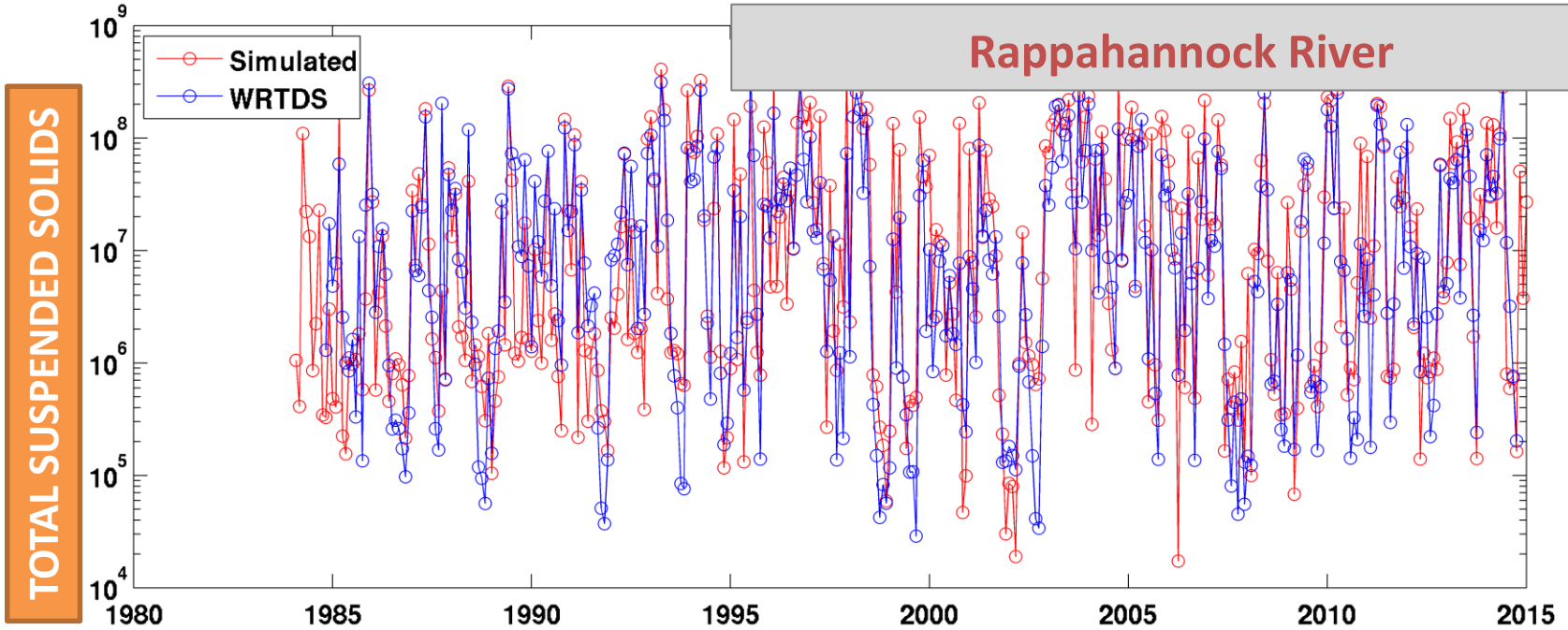
Correlation – Total Phosphorus

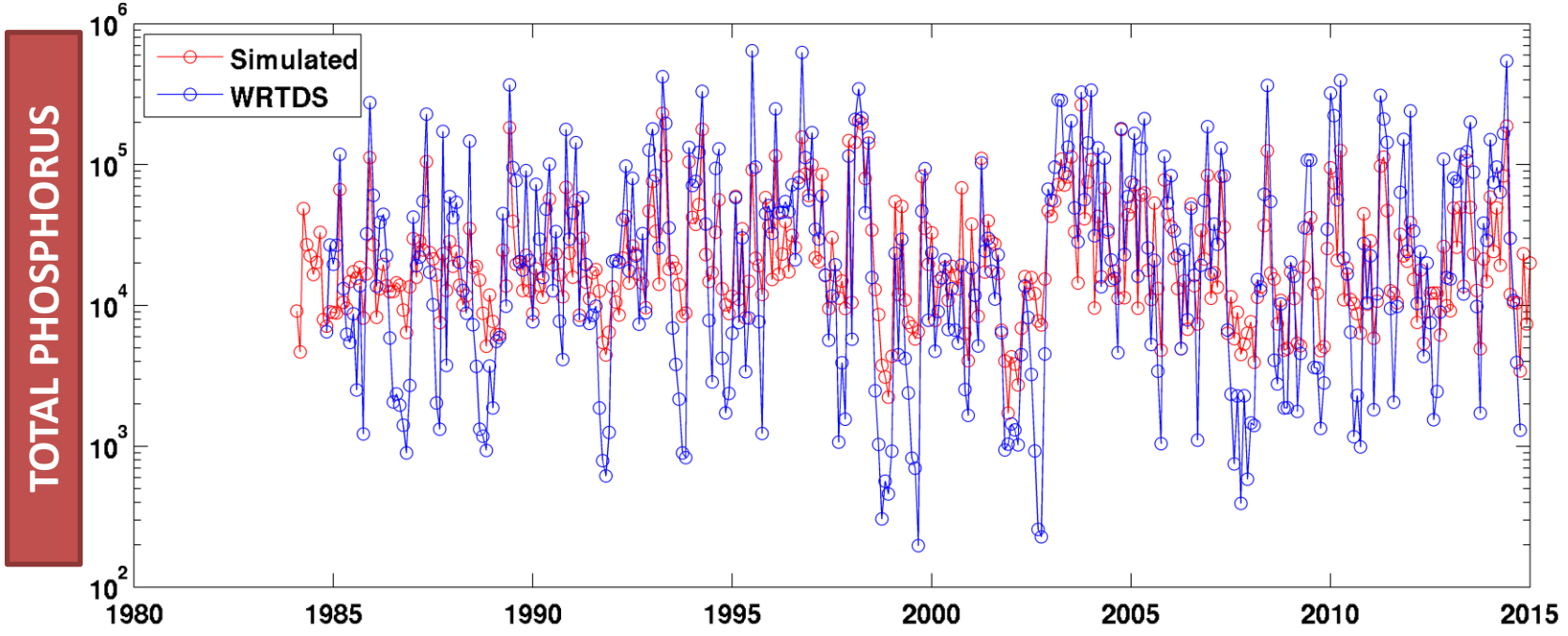


6. Phase 6 ***Beta 2***

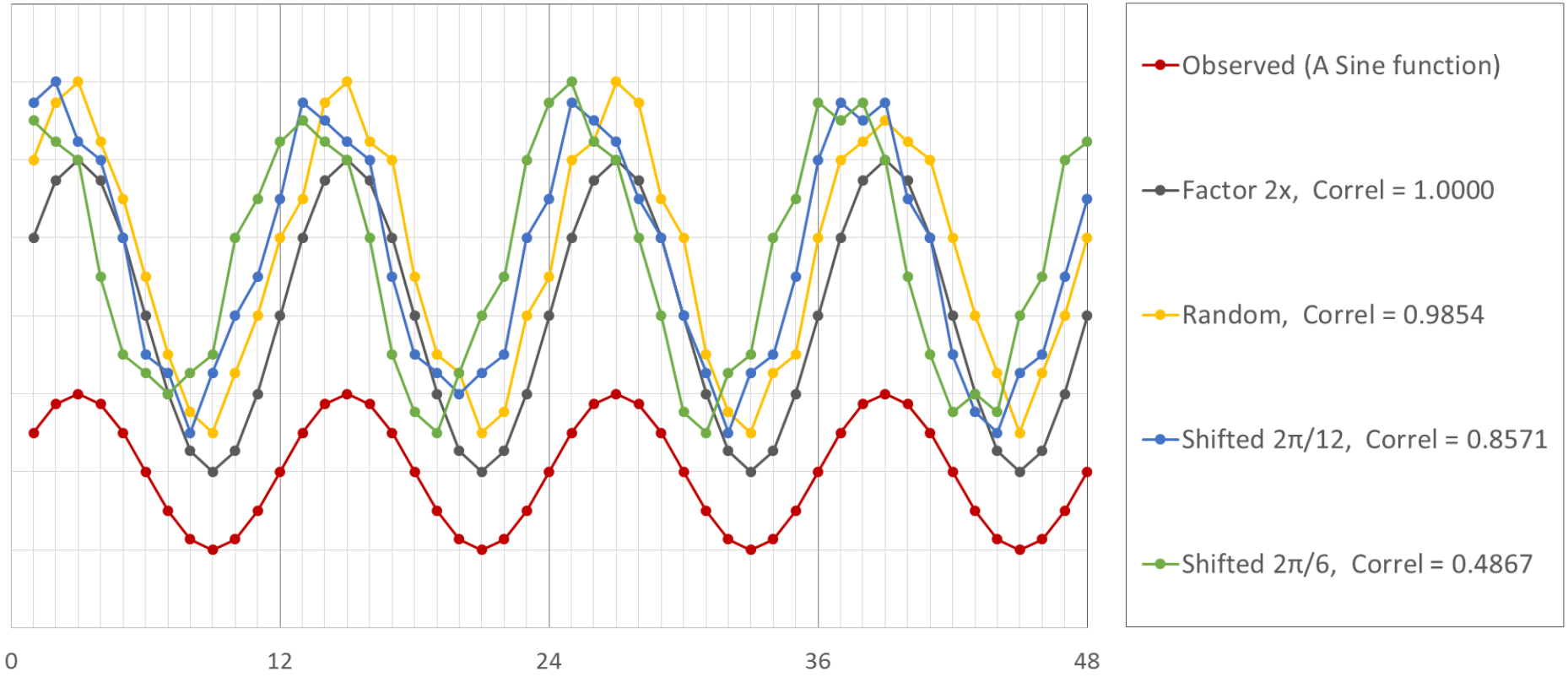
- Updated and refined atmospheric deposition data
- Diversions, and revised SB dataset
- Revised sediment targets, and sediment delivery ratios
  - Crop and Pasture were included in Beta 1
  - Data for Forest, Open space, Tree canopy (over herbaceous and over scrub-shrub), and Turf grass are now available.
- Bank and floodplain sediment and nutrient loads – Claggett and Noe
- Revised estimates of lag-times and rSAS
- Improvements to lower Susquehanna reservoirs (including Conowingo)
- Simulation of phosphate export (dissolved vs. sorbed)

Rappahannock River





5. Seasonality of the simulated loads

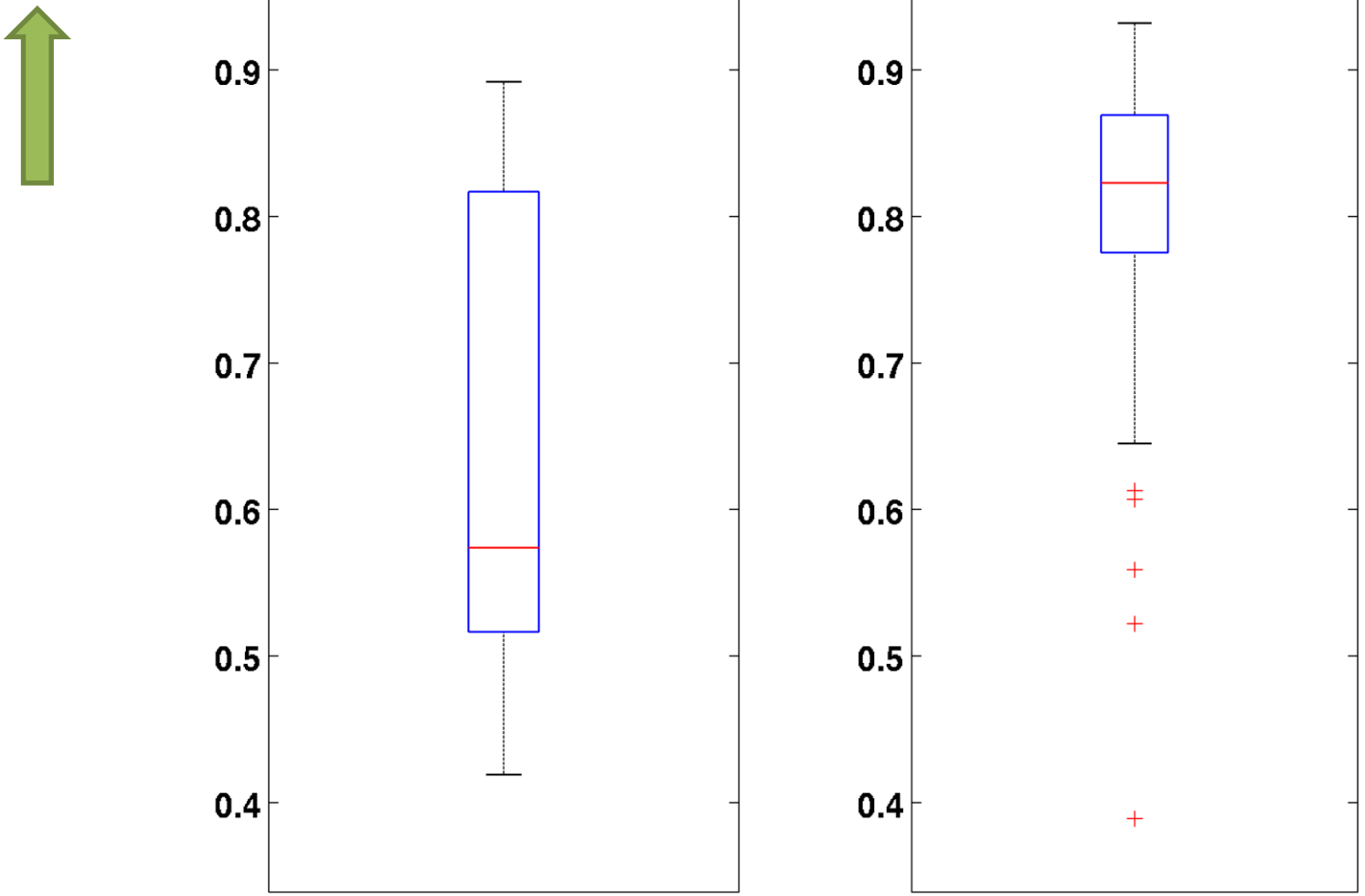


> 0.9 Excellent

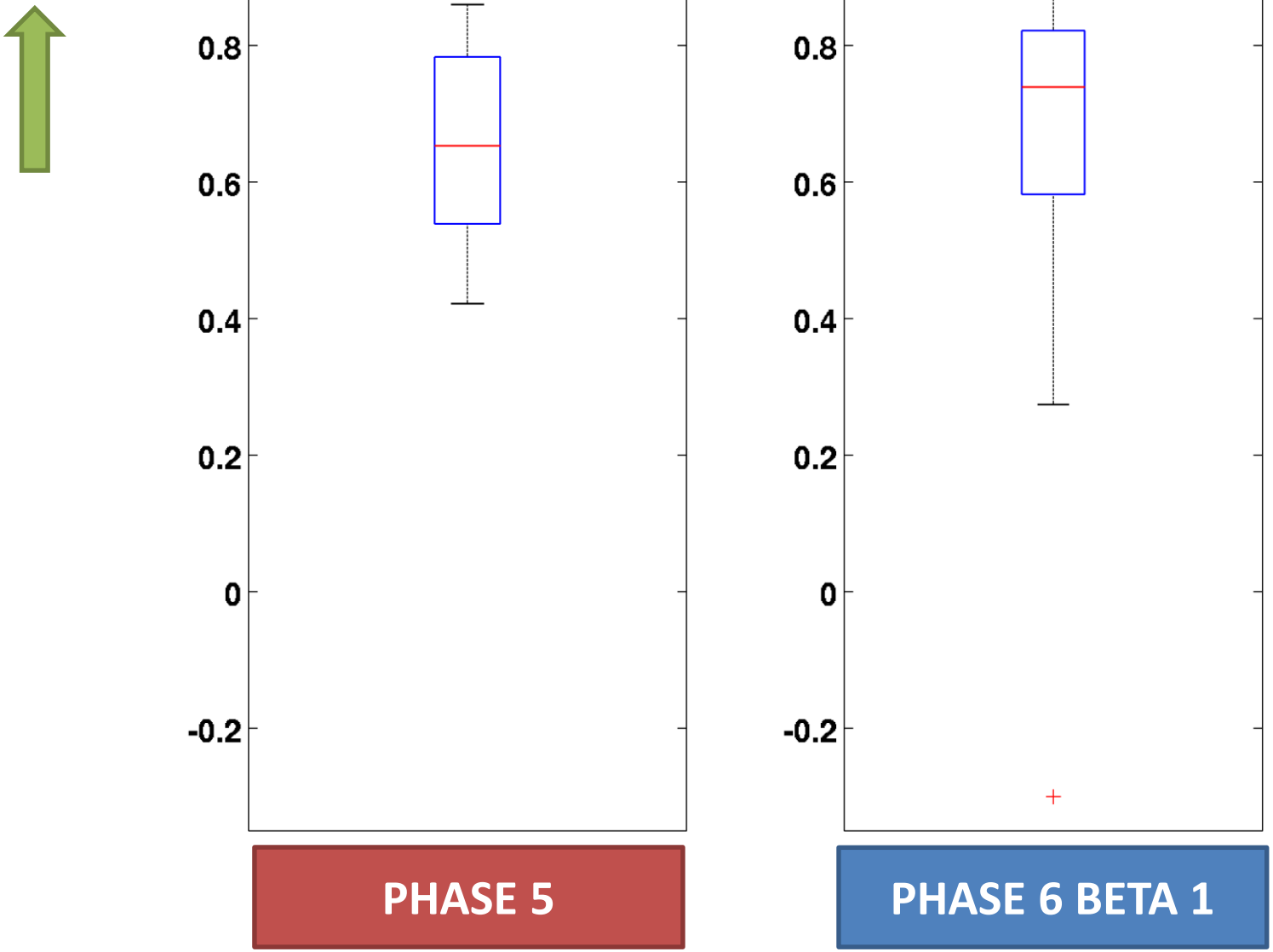
> 0.8 Good

> 0.5 Reasonable

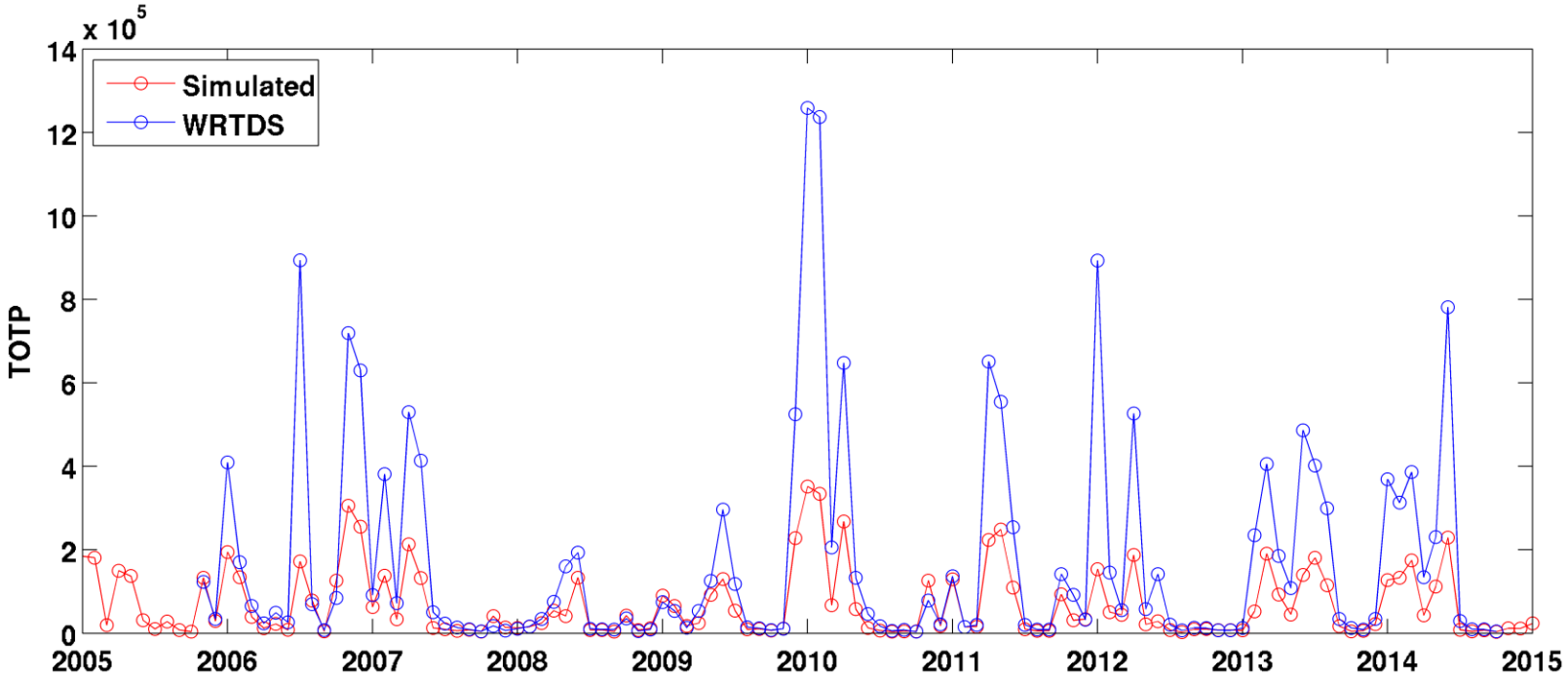
Correlation – Nitrate



Correlation – Phosphate

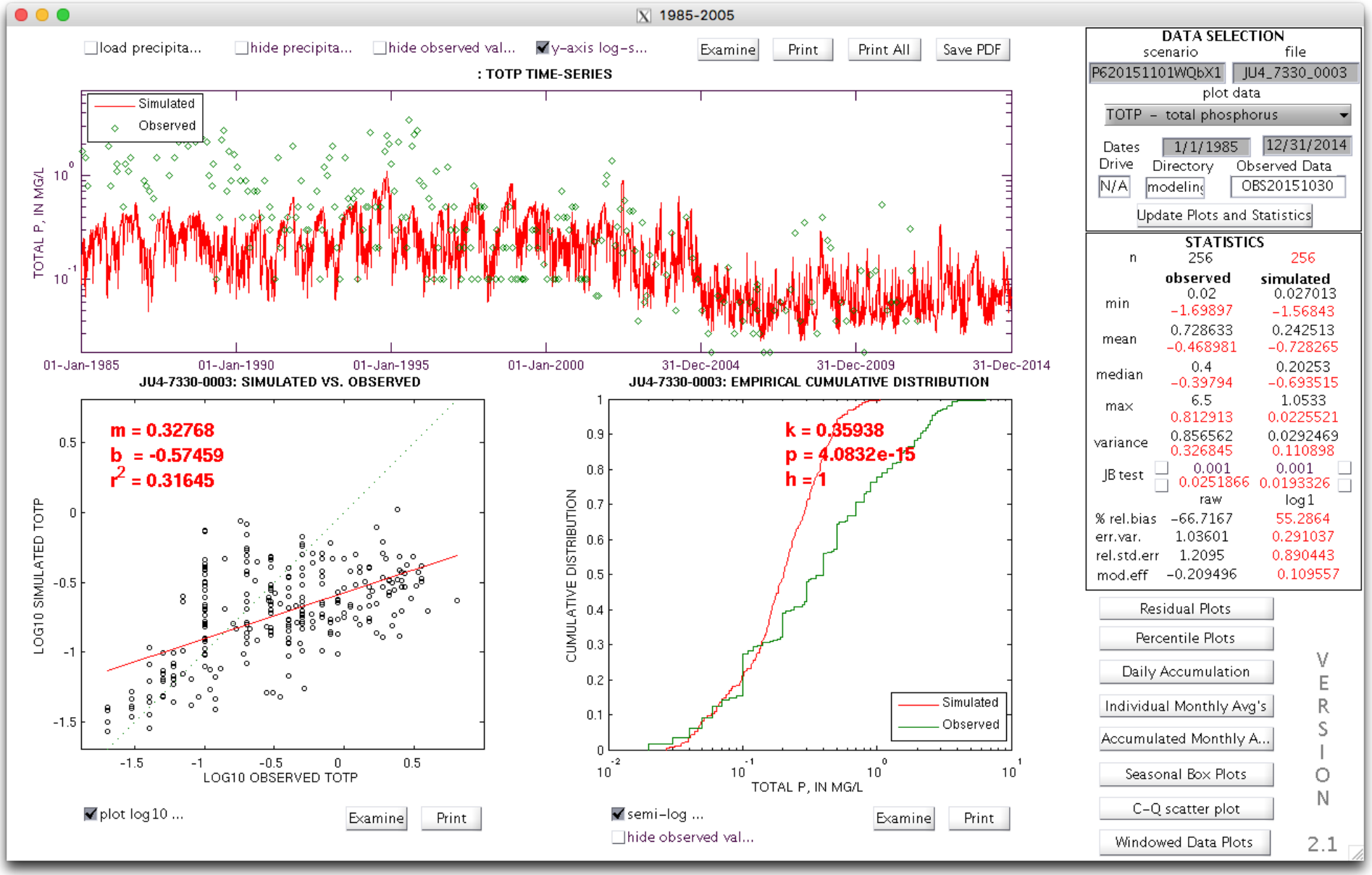


James River near Richmond, VA



Key questions

- Phase-6 has potential to simulate scour at the Conowingo for the 6 extreme storms between 1985-2014.
  - Is there an agreement that *changes in scour* with the bathymetry an important phenomenon to represent?
  - Is there an agreement that *changes in deposition* with the bathymetry an important phenomenon to represent?
- Should we calibrate rainfall during these 6 extreme events?
- Are there any other reservoir infill processes that should be considered in Phase-6 simulation?


1985-2005
load precipita...
hide precipita...
hide observed val...
y-axis log-s...
Examine
Print
Print All
Save PDF
: TOTP TIME-SERIES
Simulated
Observed
TOTAL P, IN MG/L
01-Jan-1985
01-Jan-1990
01-Jan-1995
01-Jan-2000
31-Dec-2004
31-Dec-2009
31-Dec-2014
JU4-7330-0003: SIMULATED VS. OBSERVED
m = 0.32768
b = -0.57459
r2 = 0.31645
LOG10 SIMULATED TOTP
LOG10 OBSERVED TOTP
plot log10 ...
Examine
Print
JU4-7330-0003: EMPIRICAL CUMULATIVE DISTRIBUTION
k = 0.35938
p = 4.0832e-15
h = 1
CUMULATIVE DISTRIBUTION
TOTAL P, IN MG/L
Simulated
Observed
semi-log ...
hide observed val...
Examine
Print
DATA SELECTION
scenario
file
P620151101WQbX1
JU4_7330_0003
plot data
TOTP - total phosphorus
Dates
1/1/1985
12/31/2014
Drive
Directory
Observed Data
N/A
modeling
OBS20151030
Update Plots and Statistics
STATISTICS
n 256 256
observed simulated
min 0.02 0.027013
-1.69897 -1.56843
mean 0.728633 0.242513
-0.468981 -0.728265
median 0.4 0.20253
-0.39794 -0.693515
max 6.5 1.0533
0.812913 0.0225521
variance 0.856562 0.0292469
0.326845 0.110898
JB test 0.001 0.001
0.0251866 0.0193326
raw log1
% rel.bias -66.7167 55.2864
err.var. 1.03601 0.291037
rel.std.err 1.2095 0.890443
mod.eff -0.209496 0.109557
Residual Plots
Percentile Plots
Daily Accumulation
Individual Monthly Avg's
Accumulated Monthly A...
Seasonal Box Plots
C-Q scatter plot
Windowed Data Plots
VERSION 2.1