Phase 7 WSM Progress – Towards completeness of the Dynamic Watershed Model (DWSM) development

Modeling Workgroup Quarterly Meeting – October 2025

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Presentation Outline

Phase 7 Dynamic Watershed Model (DWSM)

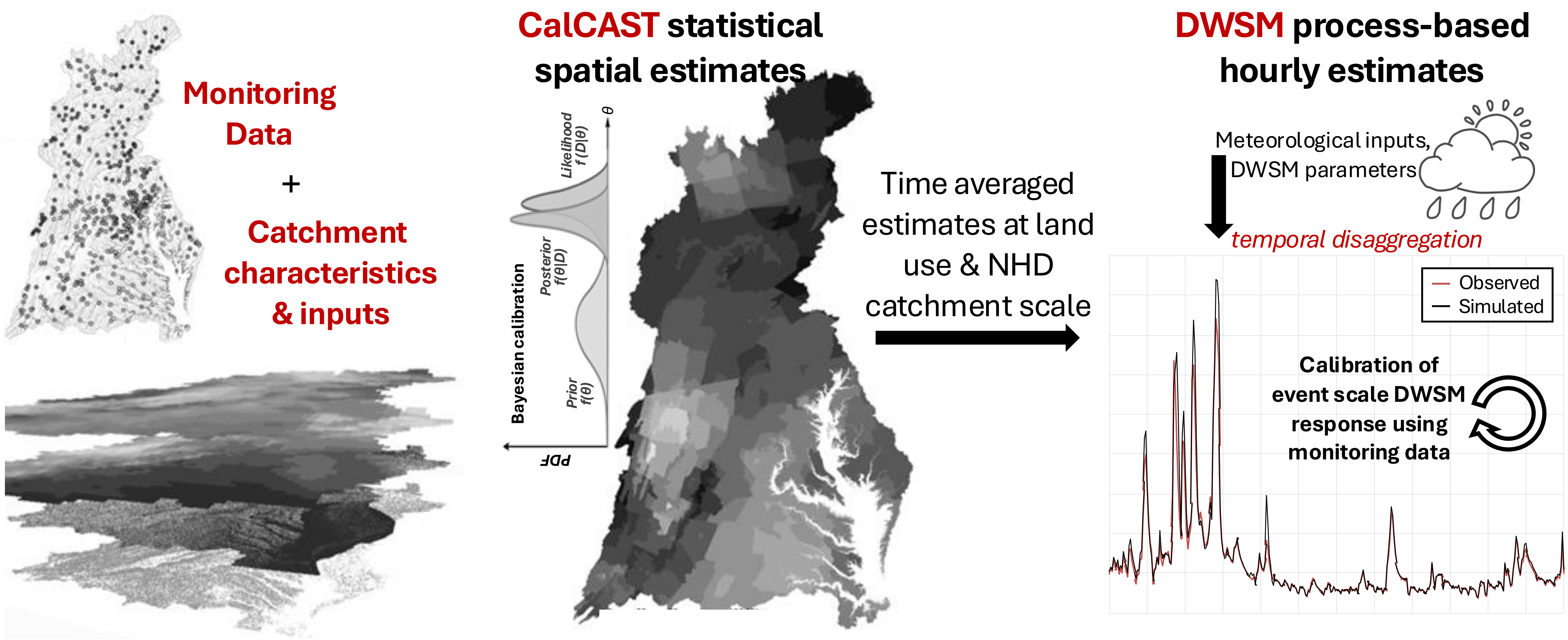
1. **Dynamic Watershed Model Overview**
2. **Review of prior model development progress**
3. **Linkage of the DWSM and Main Bay Model (MBM)**
   - July 2025 beta version
   - Implementation of organic nitrogen and phosphorus scour
   - Adding a trend component to generalized stream network routing
   - Incorporation of BMPs with *aggregated* CAST removal efficiencies
   - Other general progress
4. **Summary and next steps**

Purpose

NHD Scale Dynamic Watershed Model (DWSM)

- Inputs for the estuarine models (MBM/MTMs)
- Watershed model calibration and scenario applications
- Support research and collaboration activities

Framework: Statistical Model (CalCAST) → Dynamic Watershed Model (DWSM)



- Data-driven CalCAST informs DWSM parameters and responses.
- NHD-scale Phase 7 DWSM is using CalCAST *average annual* (a) total flow, (b) stormflow, (c) sediment erosion and delivery factors, and (d) total nitrogen and total phosphorus loads and delivery factors.

Dynamic Watershed Model (DWSM) Development

- Year 2022: NHD-scale model structure and prototypes for hydrology, sediment, and nutrients.
- Year 2023: Incremental refinements of model prototypes in terms of model segmentation, CalCAST→DWSM linkage, and simulation of the small streams.
- Year 2024: stream water quality routing based on β parameters; refinements of small stream flow and water temperature routing modules; mechanics of riverine water quality calibrations.
- **Year 2025:** Q1: development and testing of DWSM and MBM linkage through beta versions; Q2: April beta version, small stream routing with RF model estimated Beta-parameters, estimation of riverine transport parameters and further refinements of the DWSM calibration; **Q3: organic scour in rivers, trend component in stream routing, BMPs, etc.**

CY2022
[1] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/progress-in-phase-7-wsm-development-1.4.2022-gopal_bhatt_penn_state.pdf
[2] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/progress_in_phase_7_wsm_development_4.5.2022_-_gopal_bhatt_penn_state.pdf
[3] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/progress_in_phase_7_wsm_development_-_gopal_bhatt_penn_state_7.12.22.pdf
[4] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-10.4.22-v2.pdf
[5] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-1.10.2023.pdf

CY 2023
[1] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/20230404-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2023Q1.pdf
[2] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-6.20.2023.pdf
[3] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-10.17.2023.pdf
[4] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/20240109-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2023Q4.pdf

CY 2024
[1] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Progress-in-Phase-7-WSM-Development-Gopal-Bhatt-Penn-State-CBPO-4.2.2024.pdf
[2] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/Phase-7-WSM-Development-Modeling-WG-July-2024.pdf
[3] https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/3_1000_20241008-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2024Q3.pdf
[4] https://www.chesapeakebay.net/files/documents/1035-20250107-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2024Q4.pdf

CY 2025
[1] https://www.chesapeakebay.net/files/documents/1025_20250401-BHATT-Phase-7-WSM-Development-Dynamic-Model-Development-2025Q1.pdf
[2a] https://www.chesapeakebay.net/files/documents/1010_Phase-7-Model-Review_Gopal-Bhatt.pdf
[2b] https://www.chesapeakebay.net/files/documents/1035_Phase-7-WSM-Development-Dynamic-Model-Development_Gopal-Bhatt.pdf

July 2025 Beta Version

- At the July Quarterly meeting we reviewed isolated DWSM calibrations showing –

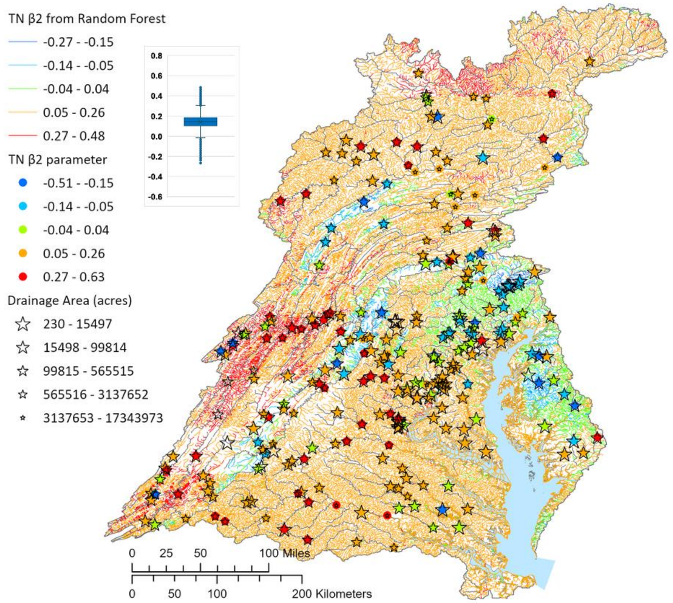
  [A] Generalized small stream routing for sediment; and Random Forest model estimated Beta parameters for TN, TP, and SS;

  [B] Estimation of riverine transport parameters in DWSM improved model performance;

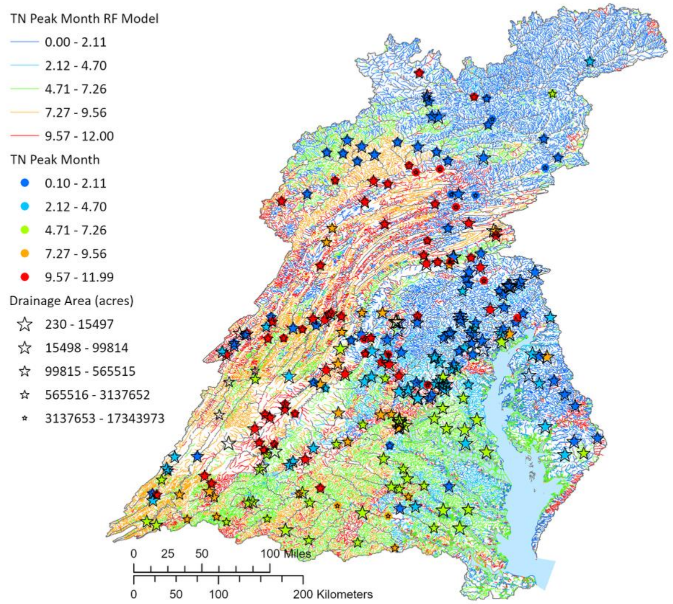
  [C] Constraint of best available (WRTDS) loads in calibration further improved model performance;

- We combined these elements in the July 2025 beta versions and produced 2 sets of MBM inputs –
  - Hybrid beta version with Phase 6 loads for 9 RIM stations, and all else based on Phase 7.
  - Full Phase 7 beta version – i.e., Phase 7 for both RIM and all else.

Nitrogen flow variability, β_2



Nitrogen seasonal variability, β_3 & β_4



July 2025 beta

CalCAST (v20250114) + SepticQ + PRISM + NO3 + βs + HSPF river + WRTDS

RIM stations: Phase 7 loads vs. WRTDS

Wq20250615cal

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	Flow	Nitrogen	Phosphorus	Sediment
Susquehanna Conowingo MD	+00.9% (+0.910)	-01.1% (+0.723)	+02.2% (+0.783)	+04.3% (+0.808)
Susquehanna Marietta PA	-00.9% (+0.944)	+01.1% (+0.776)	+04.4% (+0.840)	+07.9% (-0.047)
Potomac Washington, DC	+00.8% (+0.929)	-01.6% (+0.817)	+06.9% (+0.226)	+10.1% (-0.623)
James Cartersville, VA	+04.8% (+0.904)	-01.2% (+0.902)	+01.9% (+0.850)	+08.0% (-2.613)
Rappa. Fredericksburg, VA	+00.1% (+0.931)	-05.8% (+0.854)	-03.4% (+0.680)	-04.1% (+0.474)
Appomattox Matoaca, VA	+00.8% (+0.826)	-12.0% (+0.755)	-06.2% (+0.739)	-06.4% (+0.449)
Pamunkey Hanover, VA	+03.6% (+0.807)	-07.4% (+0.771)	-02.0% (+0.243)	-02.4% (-0.024)
Mattaponi Beulahville, VA	+09.3% (+0.789)	-10.2% (+0.655)	-07.3% (+0.237)	-09.4% (-0.533)
Patuxent Bowie, MD	+04.0% (+0.870)	-04.0% (+0.300)	-07.0% (-0.015)	-11.0% (-0.134)
Choptank Greensboro, MD	-05.3% (+0.721)	-04.4% (+0.722)	-02.3% (+0.501)	+01.5% (-0.805)

→ *some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period*

P7 (July 2025 beta) loads are working well in the MBM

- Zhengui Wang (VIMS) and Wenfan Wu (VIMS) have developed tools for assessing and tracking watershed model outputs and estuarine model performance.

Table: Comparison of Phase 6 and Phase 7β July 2025 watershed loads in main rivers. Data in parenthesis show RMSD of watershed model loads (Phase 6, Phase 7β v7) as compared to that of immediately downstream tidal monitoring stations.

Embayment	Ammonia	Nitrate	Phosphate	Nitrogen	Phosphorus	Sediment
Susquehanna	(0.0432,0.0437)	(0.2875,0.2991)	(0.0089,0.0106)	(0.3310,0.3425)	(0.0280,0.0243)	(11.5428,13.6488)
Patuxent	(0.1483,0.1814)	(0.6331,0.9060)	(0.0455,0.0680)	(0.7464,1.1992)	(0.0866,0.1336)	(35.6555,32.6645)
Potomac	(0.0963,0.0931)	(0.5480,0.5792)	(0.1282,0.1275)	(0.7700,0.5674)	(0.0637,0.1044)	(16.6087,14.0334)
Rappahannock	(0.0334,0.0430)	(0.2594,0.3228)	(0.0178,0.0133)	(0.6914,0.5231)	(0.2182,0.1911)	(104.7578,97.1951)
James	(0.0370,0.0414)	(0.2161,0.1410)	(0.0683,0.0488)	(0.3482,0.3166)	(0.1287,0.1314)	(66.3107,73.1921)
Choptank	(0.0424,0.0491)	(0.7703,0.3458)	(0.0272,0.0211)	(0.6864,0.3682)	(0.0919,0.0719)	(20.3460,8.3691)
Mattaponi	(0.0344,0.0404)	(0.1240,0.1050)	(0.0145,0.0215)	(0.3505,0.2198)	(0.0650,0.0682)	(15.3698,17.6690)
Pamunkey	(0.0298,0.0534)	(0.1702,0.1721)	(0.0209,0.0356)	(0.3722,0.2859)	(0.0548,0.0755)	(47.7405,53.3133)
Appomattox	(0.0343,0.0345)	(0.1621,0.1739)	(0.0076,0.0094)	(0.3941,0.2013)	(0.0292,0.0291)	(15.6633,13.1813)

Zhengui Wang & Wenfan Wu (VIMS)

P7 (July 2025 beta) loads are working well in the MBM

Table 1: Comparison of Phase 6 and Phase 7β (Jan 2025 Hybrid) watershed loads in small embayment. Data in parenthesis show RMSD of watershed model loads (Phase 6, Phase 7β v3) as compared to that of immediately downstream tidal monitoring stations.

Embayment	River Impact	Salinity	Ammonia	Nitrate	Phosphate	Nitrogen	Phosphorus	Sediment
Sassafrass R.	99.5%	1.91	(0.1553, 0.1724)	(2.1799, 1.5663)	(0.0506, 0.0303)	(2.1749, 2.2918)	(0.1157, 0.0708)	(83.4010, 64.0950)
Bush R.	95.9%	0.84	(1.5825, 0.8445)	(2.4744, 2.0285)	(0.1267, 0.1176)	(3.0666, 2.1254)	(0.1737, 0.1249)	(59.0322, 53.9453)
Gunpowder R.	94.7%	1.63	(0.0774, 0.0722)	(1.0177, 0.4990)	(0.0122, 0.0164)	(0.8905, 0.4488)	(0.0471, 0.0442)	(41.6804, 37.5875)
South R.	69.1%	9.84	(0.1297, 0.1260)	(3.9673, 1.0413)	(0.0467, 0.0570)	(3.8474, 0.8997)	(0.0784, 0.0691)	(72.0014, 40.8683)
Piscataway R.	100.0%	0.00	(0.3453, 0.3234)	(5.3081, 3.5262)	(0.0381, 0.0407)	(5.3026, 3.7516)	(0.0702, 0.0805)	(50.1494, 36.6836)
Mattawoman C.	100.0%	0.02	(0.2073, 0.1016)	(4.8008, 1.8416)	(0.4483, 0.1060)	(5.5305, 1.7449)	(0.7417, 0.1505)	(57.9953, 37.4156)
Corrotoman R.	56.6%	14.53	(0.1101, 0.0573)	(1.8100, 0.7028)	(0.0223, 0.0406)	(1.8435, 0.5316)	(0.0785, 0.0431)	(61.3329, 12.5883)
Chickahominy R.	99.7%	1.18	(0.9466, 0.0622)	(5.4596, 0.1991)	(0.0683, 0.0370)	(7.2374, 0.3392)	(0.1628, 0.0585)	(59.5836, 49.2633)
Nanticoke R.	99.8%	0.19	(0.1803, 0.1174)	(2.9407, 1.4765)	(0.0436, 0.0748)	(2.8671, 1.2300)	(0.0962, 0.0807)	(35.9075, 35.1593)
Manokin R.	49.0%	13.87	(1.1536, 0.1188)	(3.7258, 1.3950)	(0.0762, 0.1538)	(4.8577, 1.6415)	(0.1603, 0.1767)	(43.1494, 30.3107)
Big Annemessix R.	47.8%	15.41	(10.0068, 0.2549)	(17.8570, 1.7639)	(0.4463, 0.1978)	(25.9882, 2.5115)	(0.8129, 0.2395)	(85.0987, 19.1356)
Patapsco R.	80.8%	10.42	(3.5302, 3.2289)	(2.9920, 2.4831)	(0.2444, 0.2266)	(6.6460, 5.9269)	(0.3410, 0.3307)	(55.0892, 39.3605)
Anacostia R.	100.0%	0.17	(0.2177, 0.2341)	(2.7501, 0.3297)	(0.0824, 0.0522)	(1.7004, 0.8990)	(0.0571, 0.0756)	(95.3317, 80.2096)
Elizabeth S.	46.9%	19.08	(1.8986, 0.4678)	(4.3389, 1.0248)	(0.8990, 0.2319)	(7.6235, 1.3427)	(1.2829, 0.3256)	(14.6792, 13.5410)
Chester R.	99.3%	0.49	(0.1221, 0.1062)	(1.0766, 1.2225)	(0.0301, 0.0733)	(0.9874, 1.1437)	(0.1563, 0.1110)	(87.0498, 91.7857)
Pocomoke R.	100.0%	0.20	(0.2716, 0.0722)	(0.7283, 0.6284)	(0.0953, 0.0869)	(1.1926, 0.6074)	(0.1445, 0.1108)	(30.9019, 23.7107)

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Table 2: Comparison of Phase 7β (April 2025 Hybrid) and Phase 7β (July 2025 ~~Hybrid~~) watershed loads in small embayments. Data in parenthesis show RMSD of watershed model loads (Phase 7β v4, Phase 7β v7) as compared to that of immediately downstream tidal monitoring stations.

Embayment	Ammonia	Nitrate	Phosphate	Nitrogen	Phosphorus	Sediment
Sassafrass R.	(0.1823,0.1320)	(1.4854,2.7223)	(0.0302,0.0273)	(2.2593,2.6860)	(0.0594,0.0598)	(49.1427,40.3539)
Bush R.	(0.8858,0.8922)	(1.8011,2.3498)	(0.1090,0.1017)	(2.1012,2.5281)	(0.1229,0.1135)	(26.4053,25.8072)
Gunpowder R.	(0.0647,0.0535)	(0.5028,0.6381)	(0.0185,0.0150)	(0.4385,0.4197)	(0.0451,0.0453)	(27.7806,26.4902)
South R.	(0.1141,0.0711)	(1.0163,1.2951)	(0.0538,0.0516)	(0.8464,0.8738)	(0.0667,0.0632)	(23.7436,14.3373)
Piscataway R.	(0.4604,0.4396)	(3.3839,3.3781)	(0.0414,0.0428)	(3.7830,3.7361)	(0.0782,0.0882)	(26.4851,24.6814)
Mattawoman C.	(0.0984,0.0919)	(1.8191,1.5988)	(0.1002,0.0977)	(1.6432,1.3970)	(0.1394,0.1345)	(18.1706,10.7982)
Corrotoman R.	(0.0605,0.0547)	(0.6748,0.7305)	(0.0414,0.0449)	(0.5454,0.5219)	(0.0429,0.0436)	(12.7431,7.3679)
Chickahominy R.	(0.0656,0.0659)	(0.1914,0.1568)	(0.0365,0.0253)	(0.3223,0.4886)	(0.0352,0.0443)	(26.0526,26.0285)
Nanticoke R.	(0.1189,0.0979)	(1.4959,1.4710)	(0.0743,0.0627)	(1.2518,1.2843)	(0.0799,0.0784)	(28.8704,26.7130)
Manokin R.	(0.1235,0.0830)	(1.4136,1.8581)	(0.1448,0.1620)	(1.6160,1.6766)	(0.1647,0.1807)	(24.0913,19.3087)
Big Annemessix R.	(0.2729,0.1772)	(1.7622,2.3882)	(0.1833,0.1897)	(2.4569,2.5141)	(0.2211,0.2241)	(15.2829,11.0865)
Patapsco R.	(3.5756,3.5692)	(2.1879,2.3088)	(0.2286,0.2232)	(5.6865,5.7518)	(0.3230,0.3106)	(23.8751,19.4416)
Anacostia R.	(0.3184,0.3556)	(0.4647,0.3999)	(0.0518,0.0492)	(1.1469,1.2848)	(0.0810,0.0730)	(90.8186,88.8498)
Elizabeth S.	(0.5307,1.0394)	(1.1256,1.9357)	(0.3627,0.9572)	(1.7113,3.0640)	(0.5050,1.3484)	(9.2259,12.2521)
Chester R.	(0.1045,0.0948)	(1.1741,2.3536)	(0.0708,0.0593)	(1.0956,1.8124)	(0.0979,0.1032)	(74.9775,73.3785)
Pocomock R.	(0.0780,0.0690)	(0.6219,1.1817)	(0.0874,0.0947)	(0.6916,1.0027)	(0.1296,0.1363)	(16.5084,14.6002)

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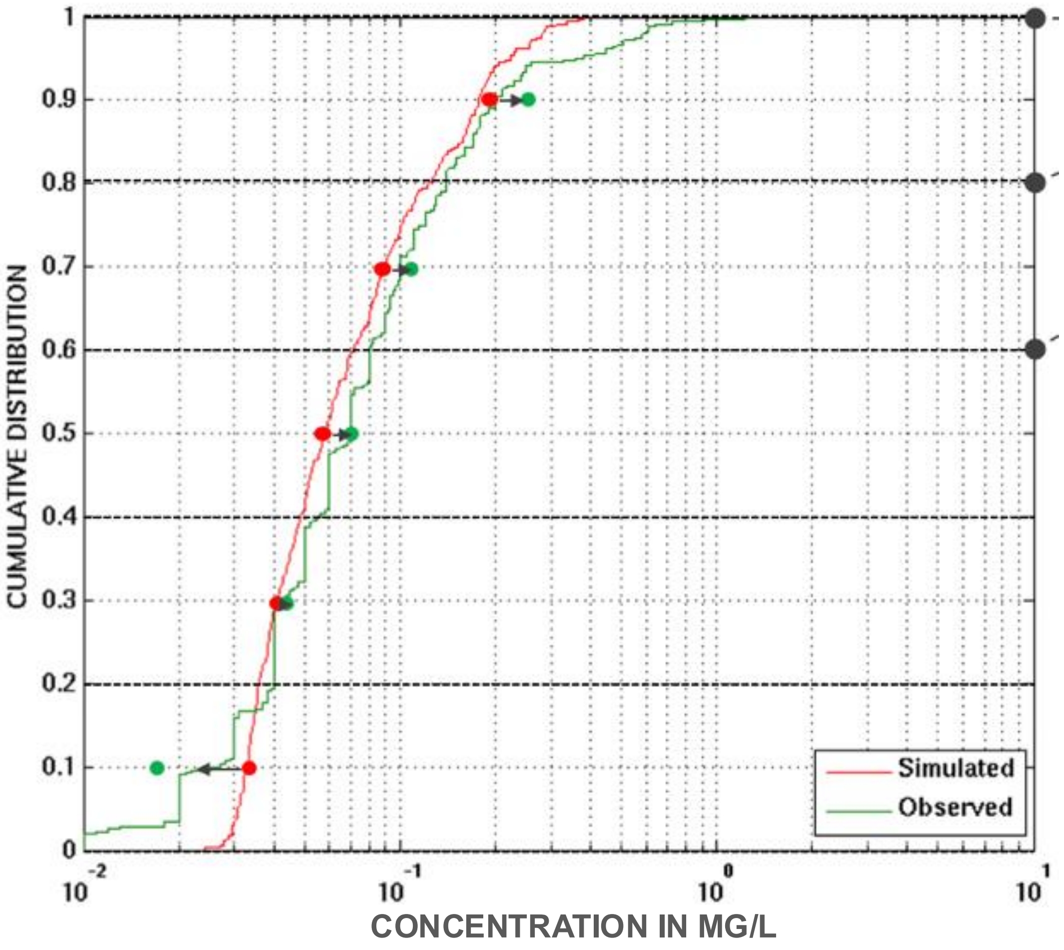
Implementation of <u>organic</u> nitrogen and phosphorus scour

Figure: Cumulative distribution of concentrations at a monitoring station



We implemented an organic source module within P7 DWSM water quality calibration framework to improve agreement in cumulative frequency distribution (CFD) of observed and simulated high flow concentrations.

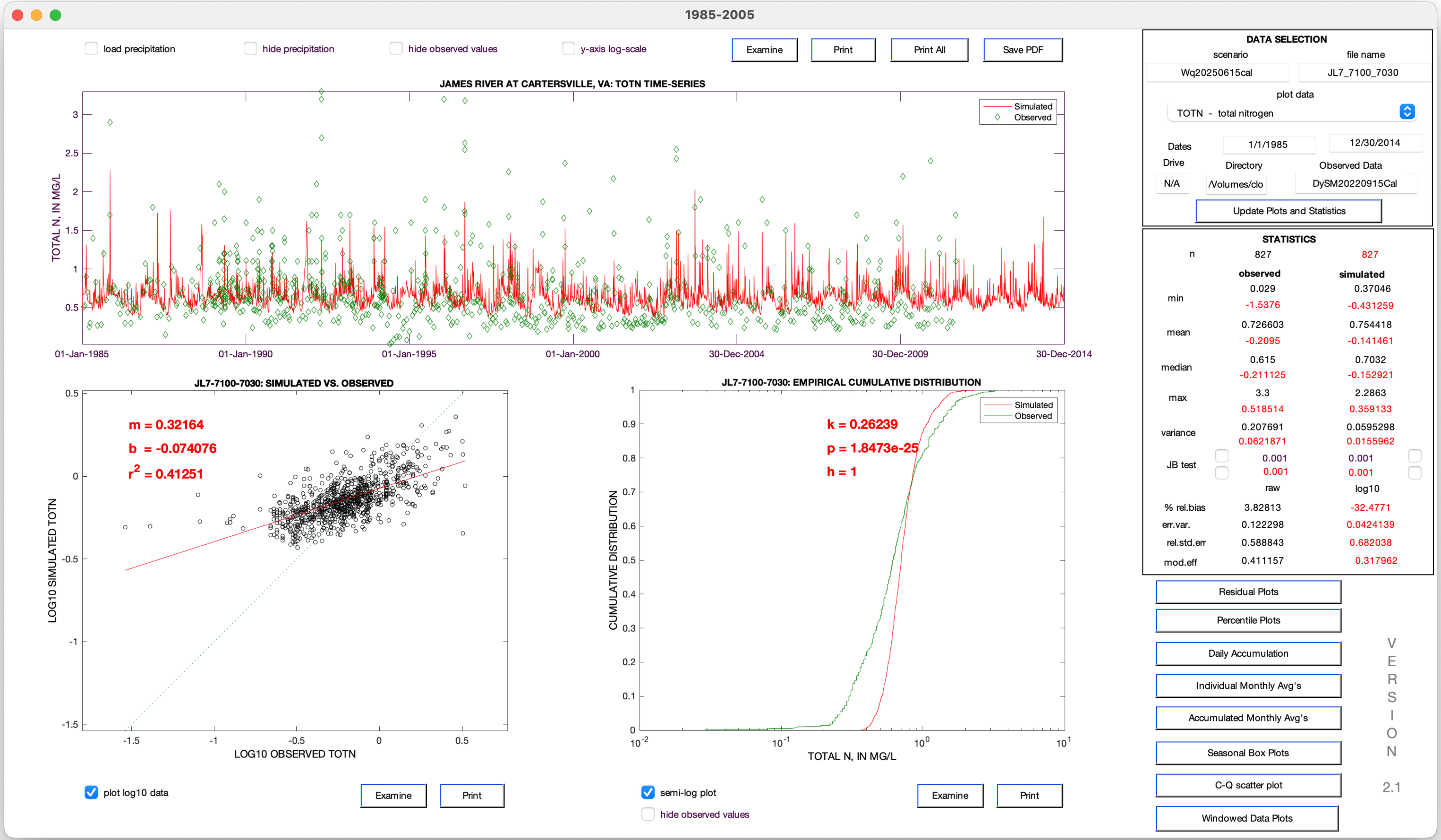
→ The module includes 2 parameters for concentrations of organic N and organic P in the scoured sediment:

- HSPF estimated net hourly scoured sediment flux is used
- Calibration v1: organic N and organic P scour model parameters are independently calibrated
- **Calibration v2**: organic N is calibrated and Redfield N:P ratio is maintained

Riverine simulation without organic scour

James River at Cartersville, VA

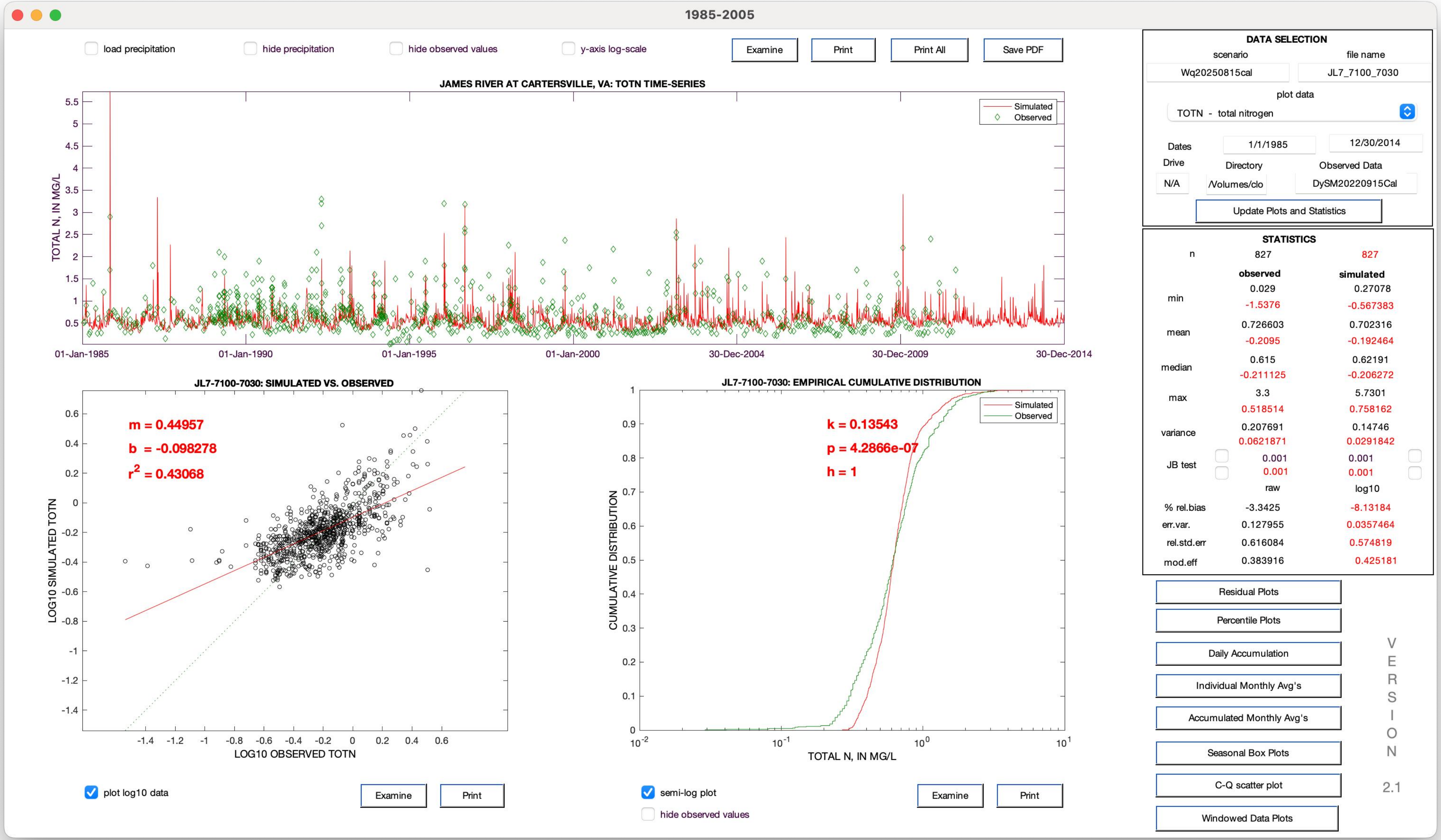
Nitrogen



Riverine simulation with organic scour

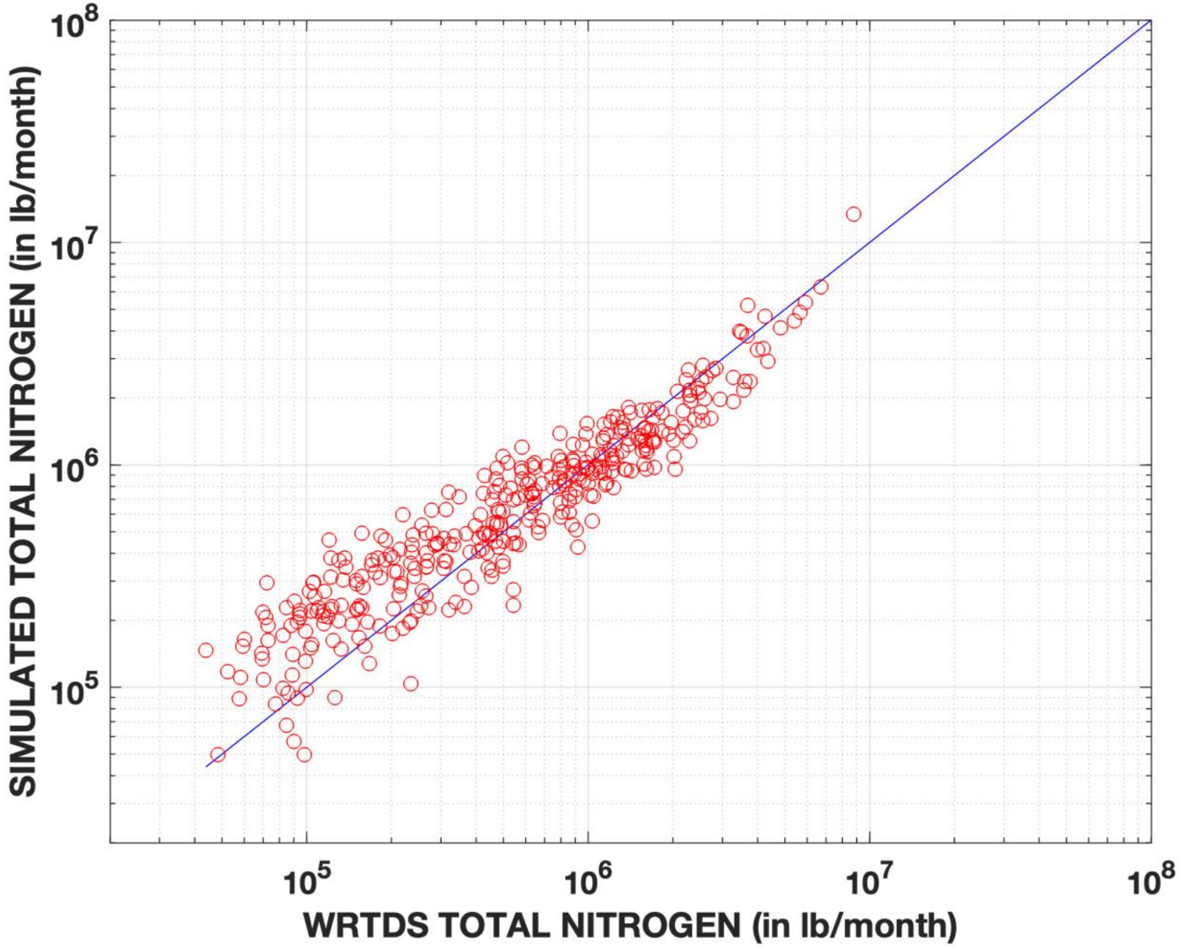
James River at Cartersville, VA

Nitrogen

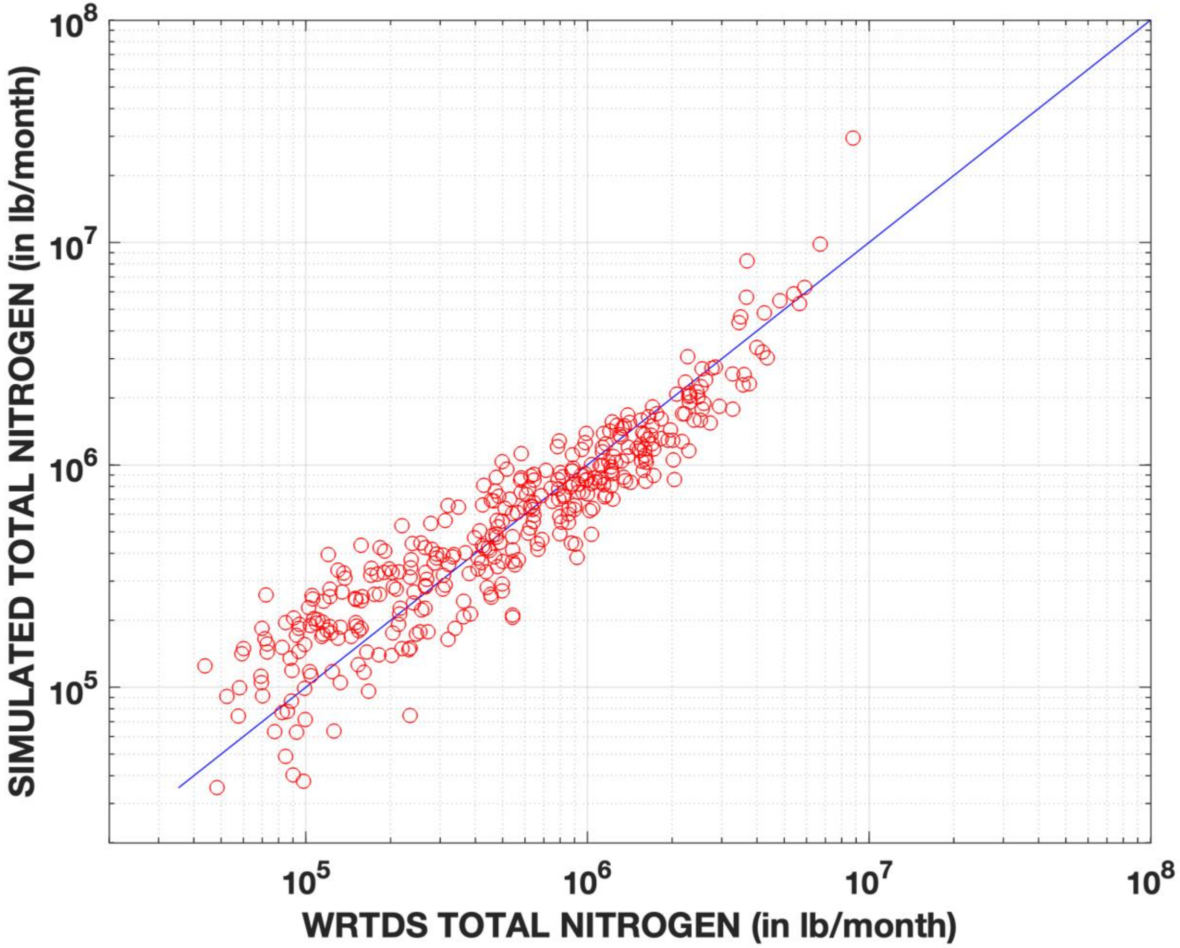


1985 – 2014 Monthly loads | **James River at Cartersville, VA** | **Nitrogen**

Without Organic Scour Module



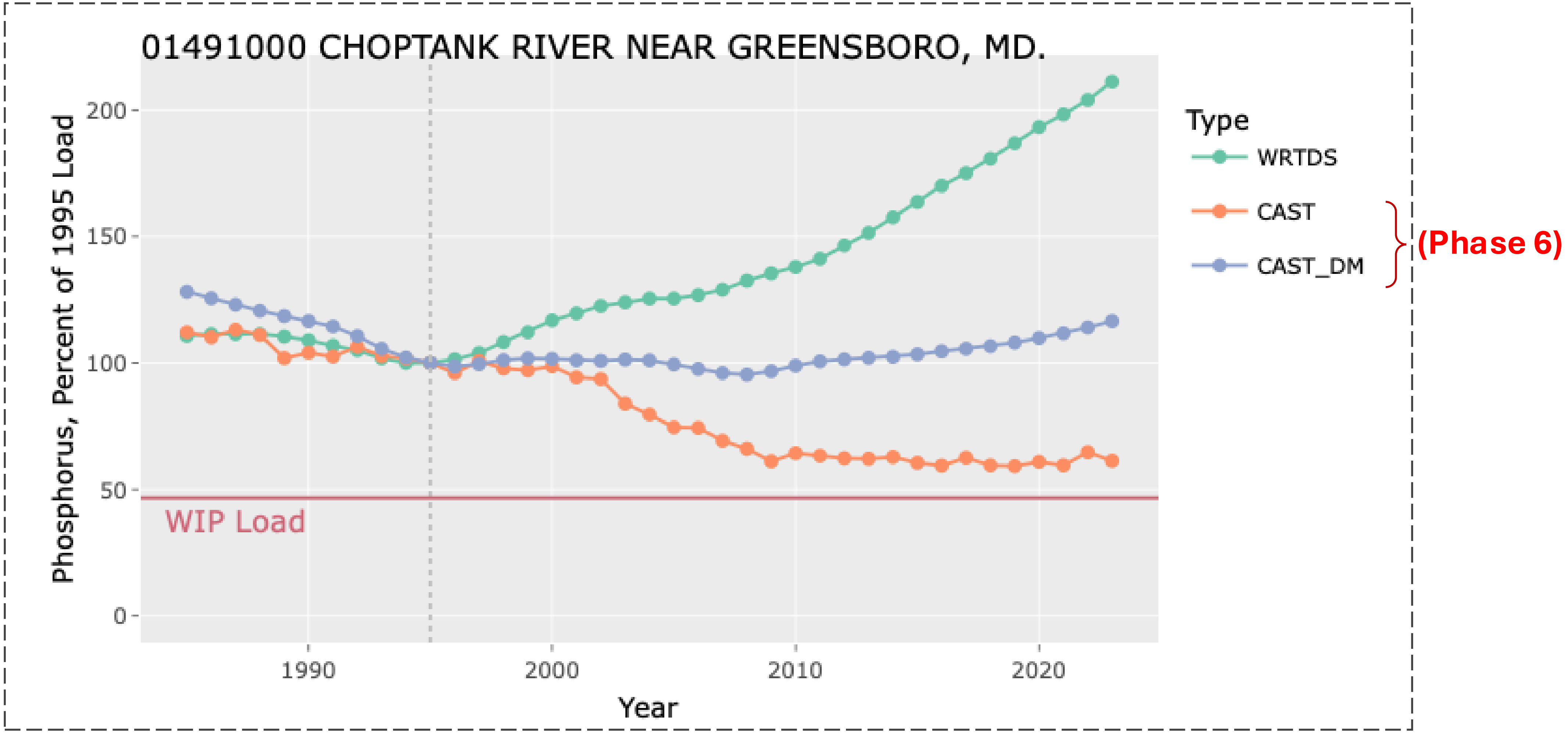
With Organic Scour Module



Adding a trend component to generalized stream network routing

Monitored and Expected Total Reduction Indicator for the Chesapeake (METRIC)
https://metric.chesapeakebay.net/metric/

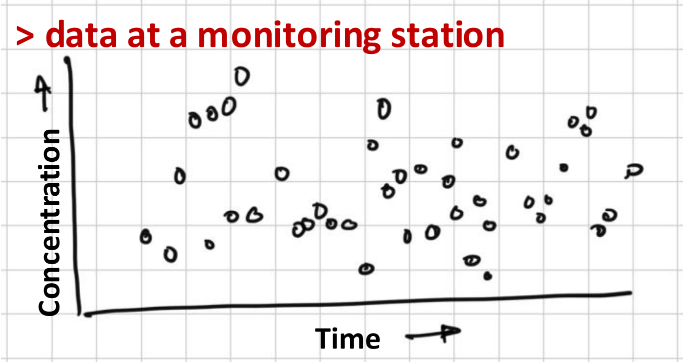
>> for comparing the monitored load trend and CAST-estimated load trend

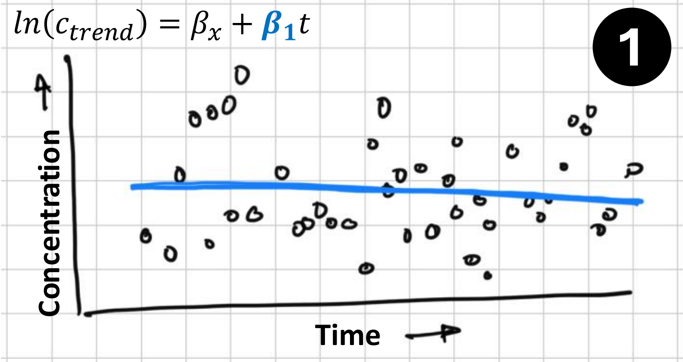


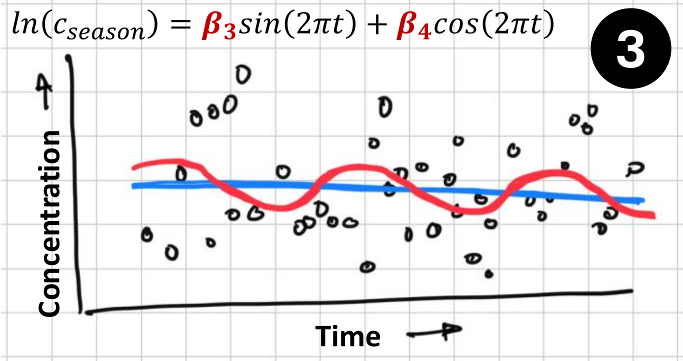
Adding a trend component to generalized stream network routing

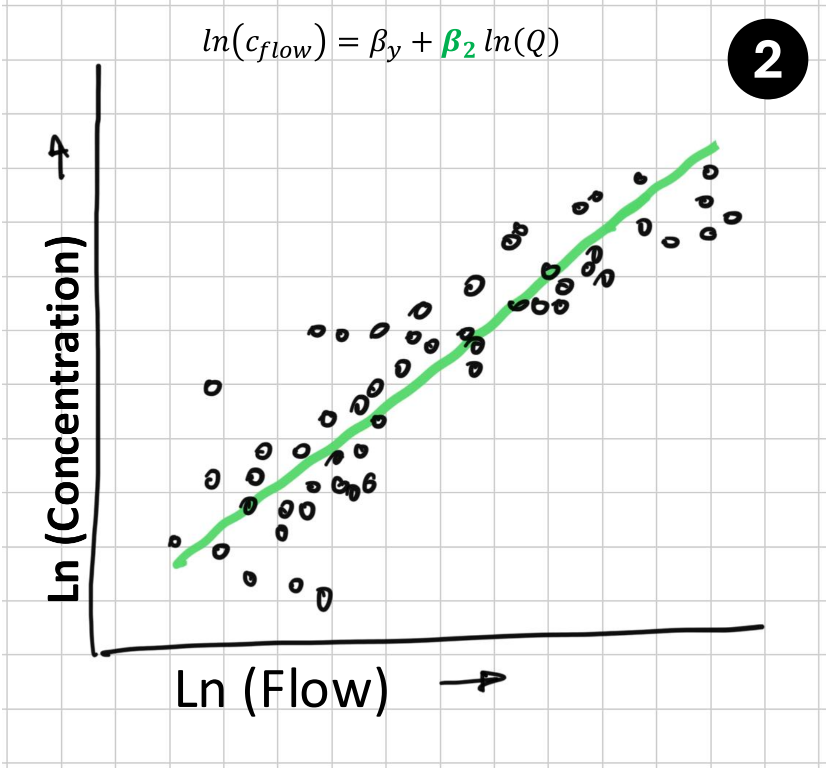
$$ln(c) = \beta_o + \boldsymbol{\beta_1 t} + \boldsymbol{\beta_2} ln(Q) + \boldsymbol{\beta_3} sin(2\pi t) + \boldsymbol{\beta_4} cos(2\pi t) + \varepsilon$$ [FluxMaster]

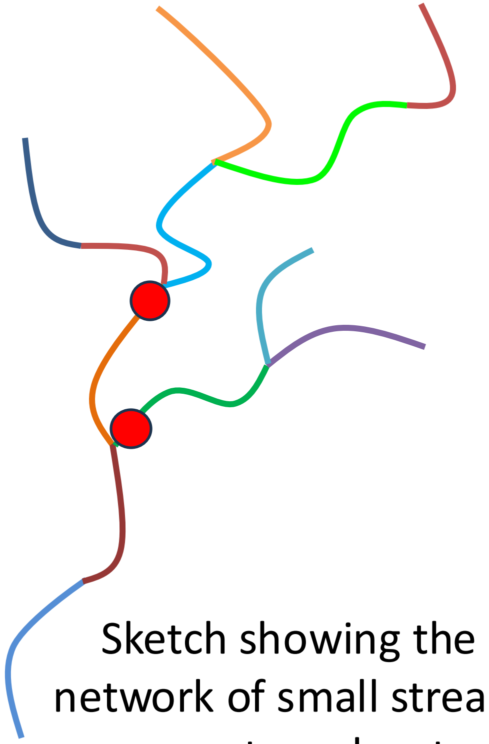
1 ($\boldsymbol{\beta_1 t}$) 2 ($\boldsymbol{\beta_2} ln(Q)$) 3 ($\boldsymbol{\beta_3} sin(2\pi t) + \boldsymbol{\beta_4} cos(2\pi t)$)











Sketch showing the network of small stream segments and water quality and streamflow monitoring stations

Adding a trend component to generalized stream network routing

HSPF model: hourly surface and groundwater hydrology of land uses

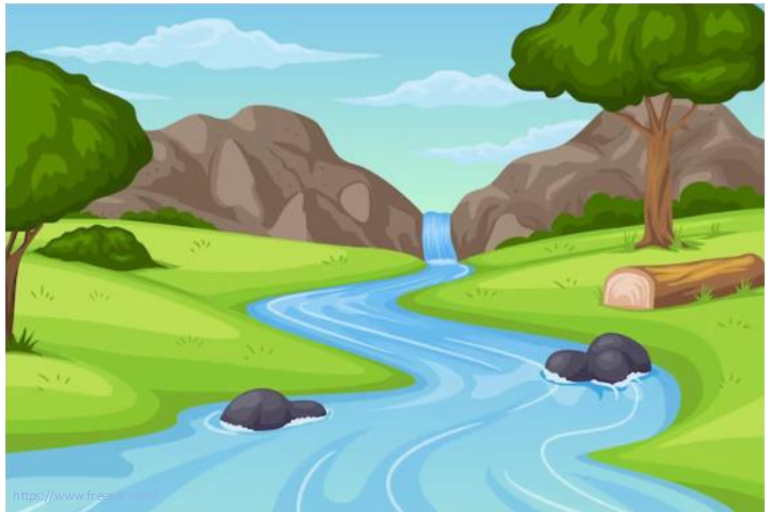
UNEC model: annual surface and groundwater concentrations as a function of input history and estimates of lag-times

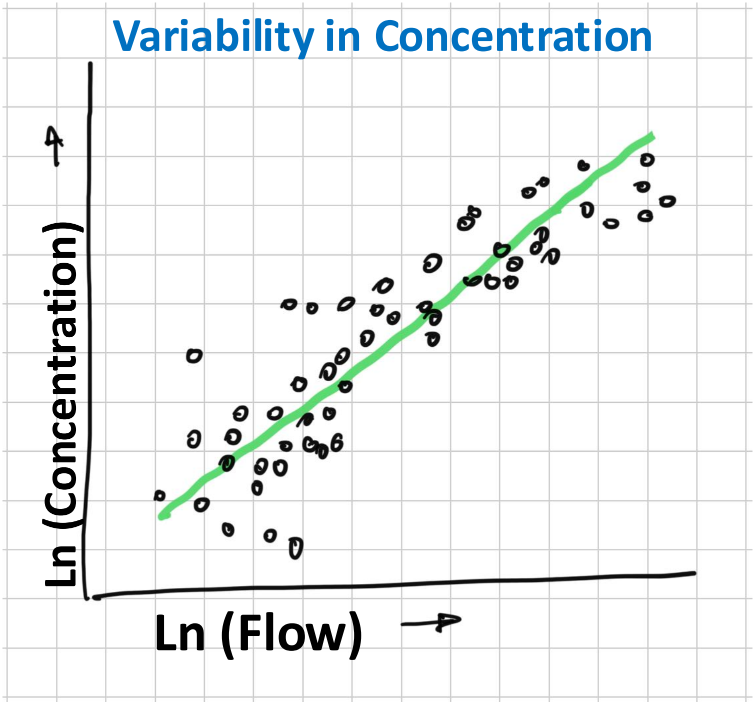
Stream Transport Factor (STF)

agricultural

natural

developed



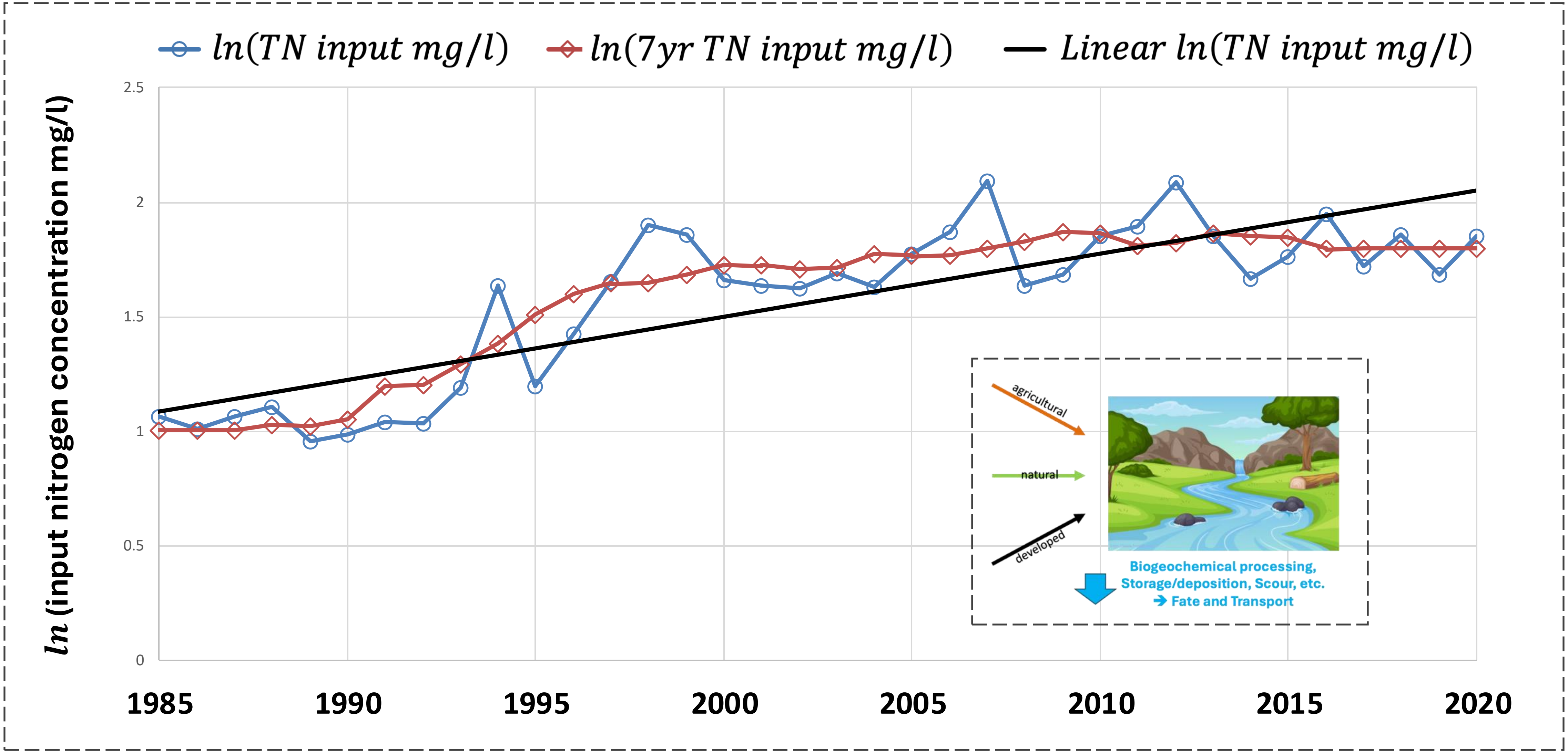


Biogeochemical processing, Storage/deposition, Scour, etc. → Fate and Transport ?

$$ln(c) = \beta_o + ln(c_{in,yr} \times STF) + \beta_2 ln(Q) + \beta_3 sin(2\pi t) + \beta_4 cos(2\pi t) + \varepsilon$$

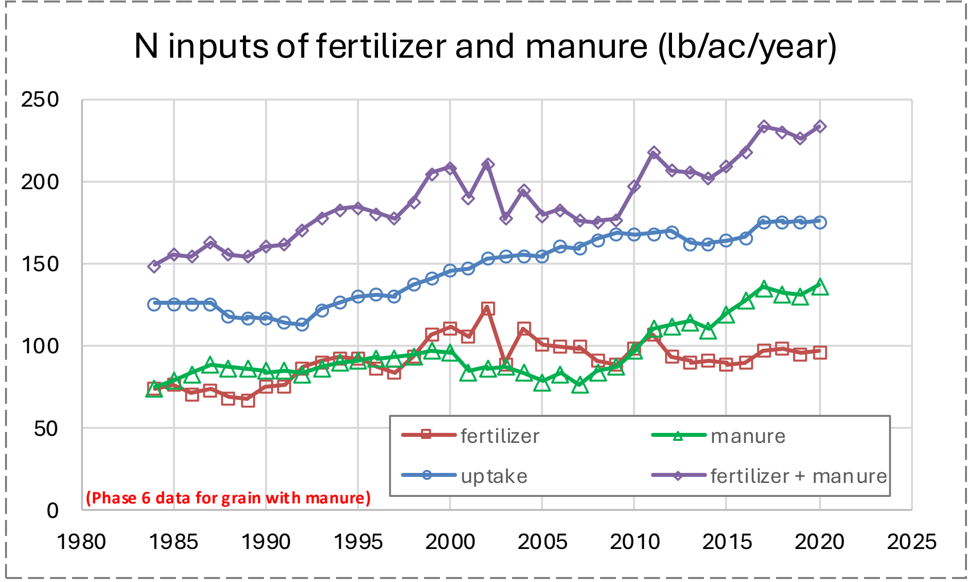
where, $c_{in,yr}$ vary annually, and STF, stream transport factor is provided by CalCAST

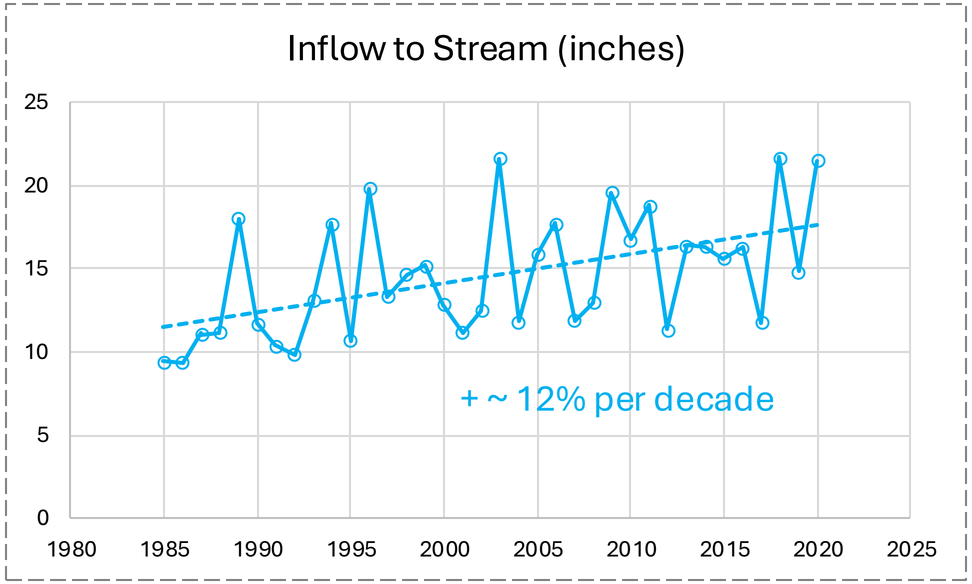
A 1st order NHD MR stream EM2_009405936 (0.6 sq. miles)

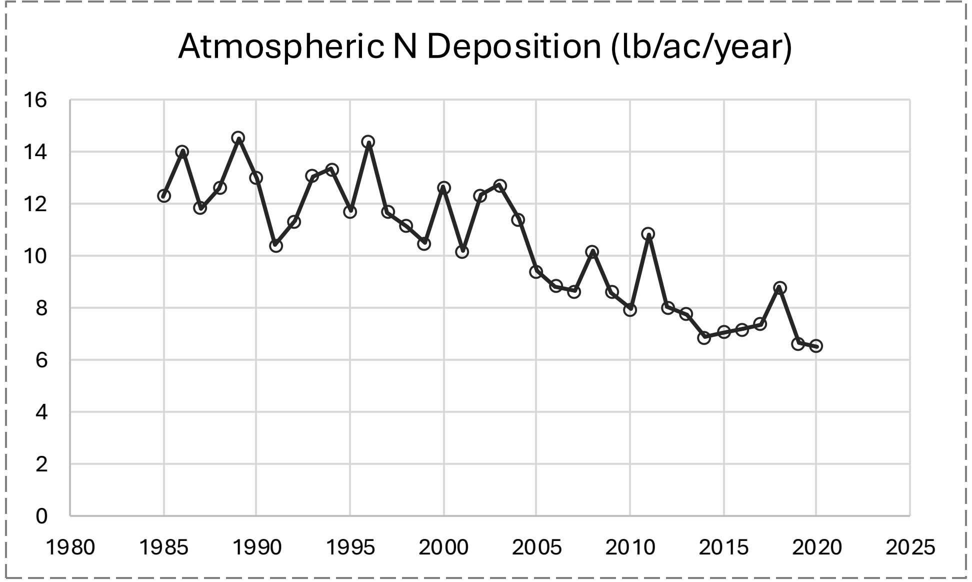


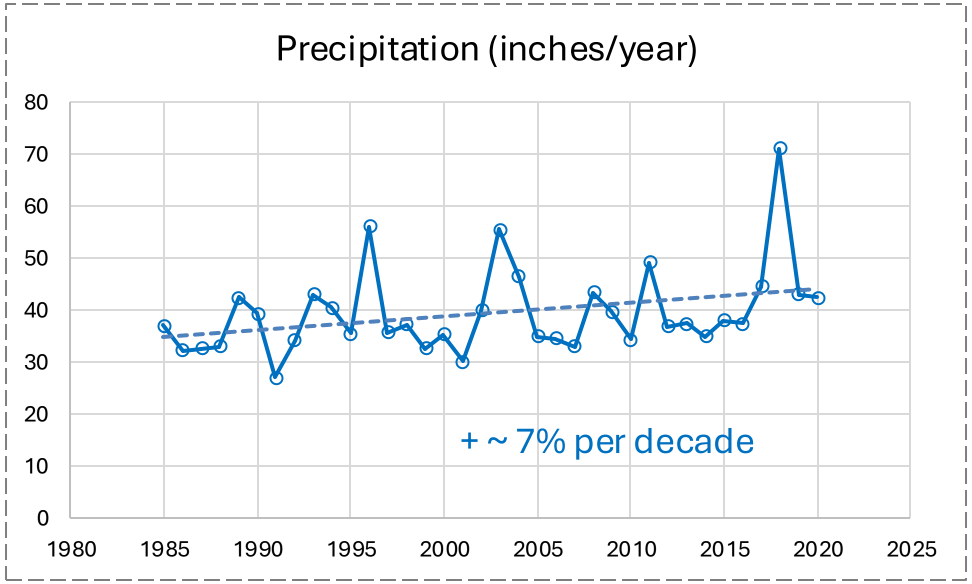
Trend is an integration of history of inputs, sensitivities, lags, land use change, climate/hydrology, BMPs, ...

A 1st order NHD MR stream EM2_009405936 (58% Crops)

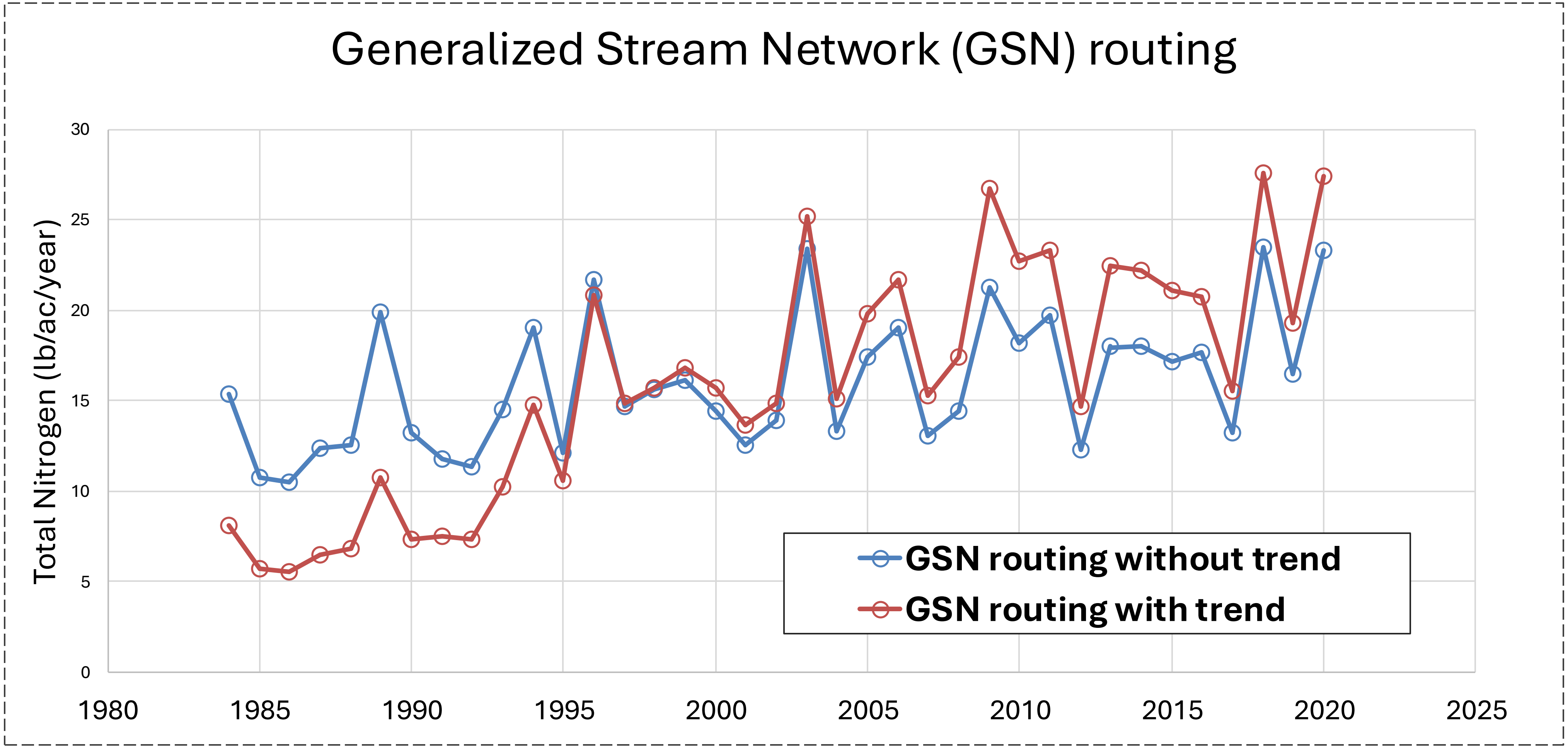








A 1st order NHD MR stream EM2_009405936 (58% Crops)

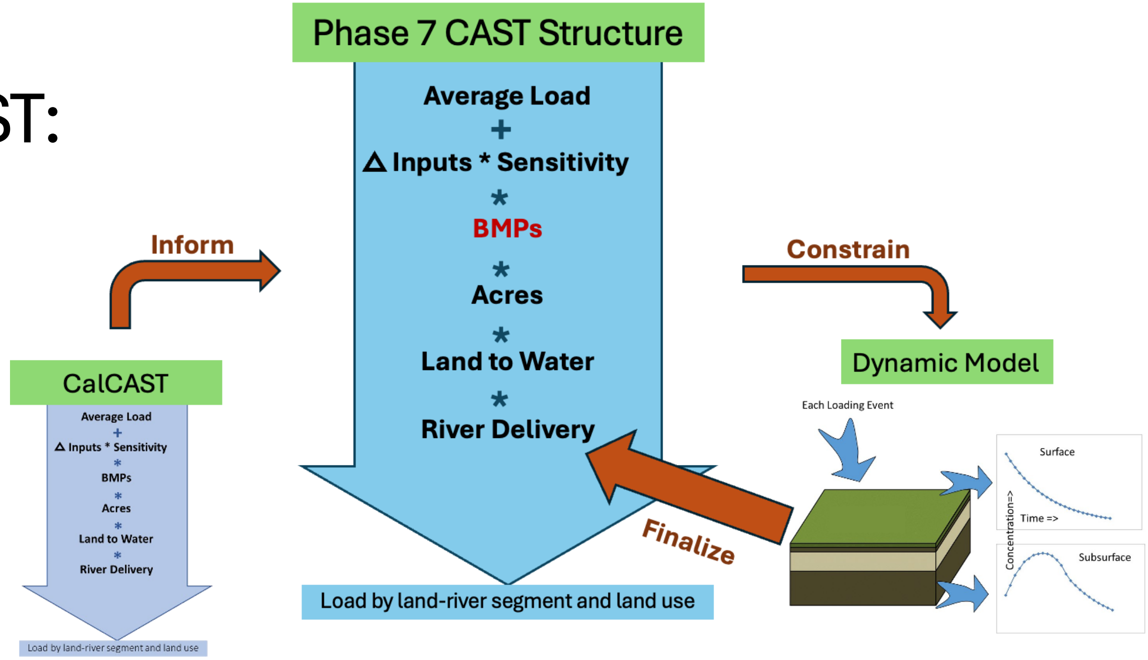


Incorporation of BMPs as aggregated CAST removal efficiencies

We incorporated BMPs in the Phase 7 DWSM

→ Removal efficiencies are provided by CAST:

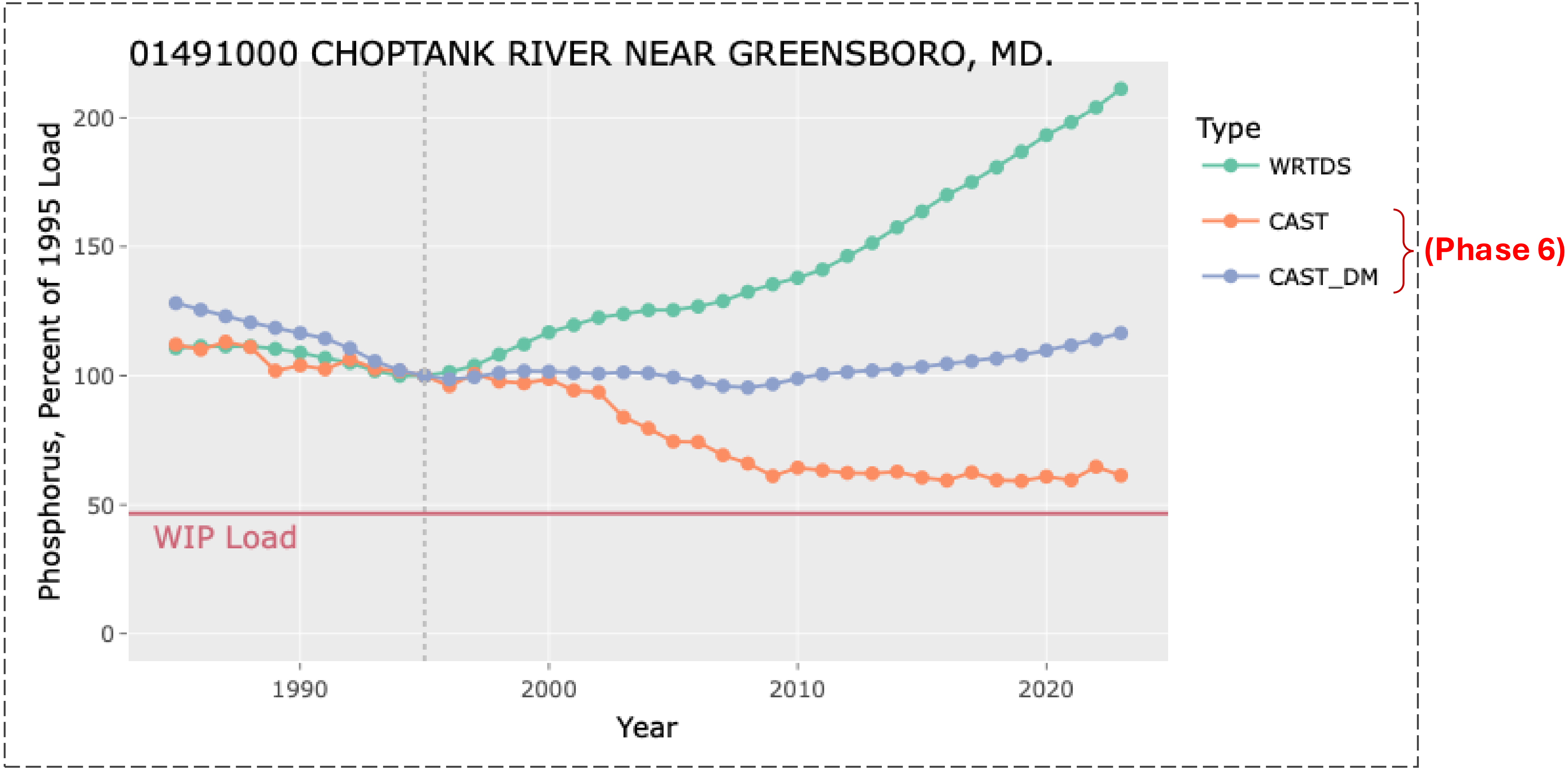
- Annual time step for the model calibration
- Removal factors for TN, TP, and SS
- NHD catchments and land segments
- Aggregated up to key load sources (currently 11)



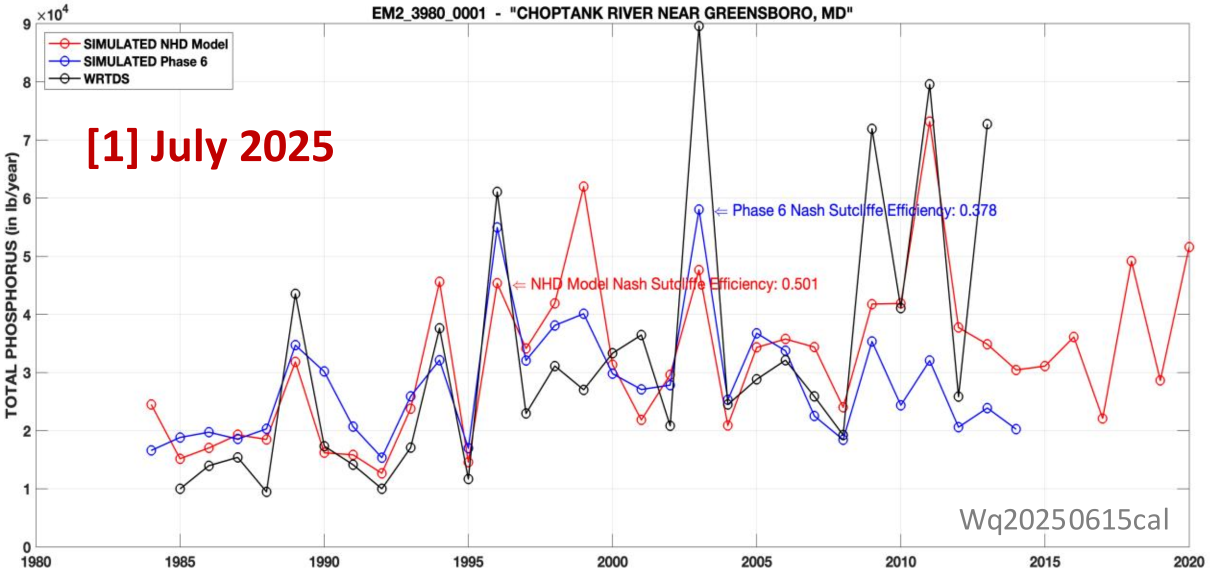
... work in collaboration with Jessica Rigelman (CBPO)

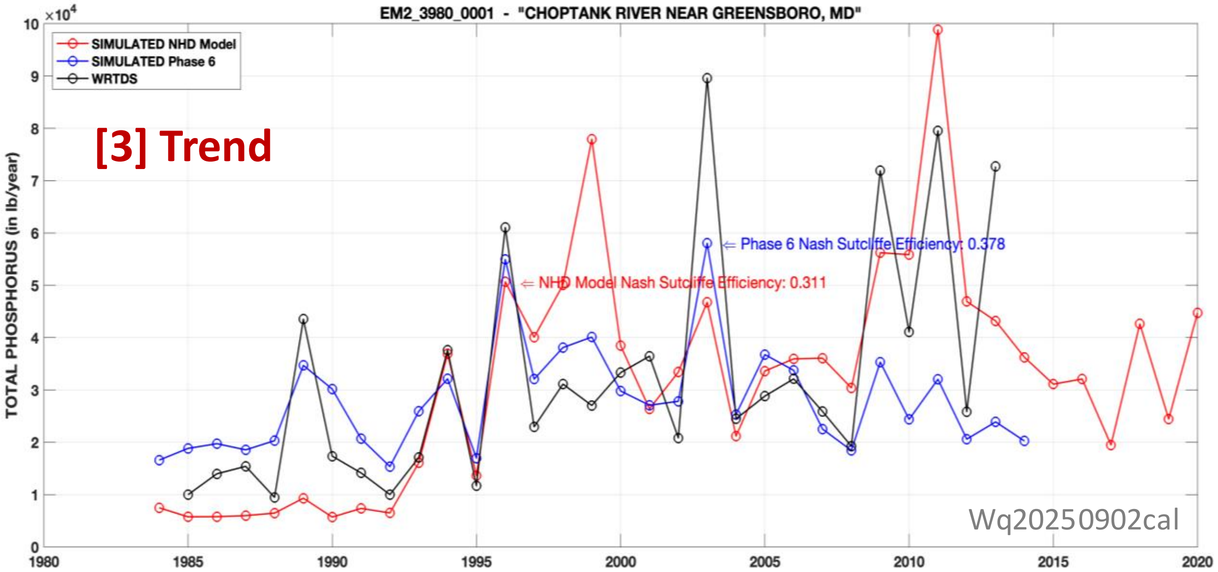
Monitored and Expected Total Reduction Indicator for the Chesapeake (METRIC) https://metric.chesapeakebay.net/metric/

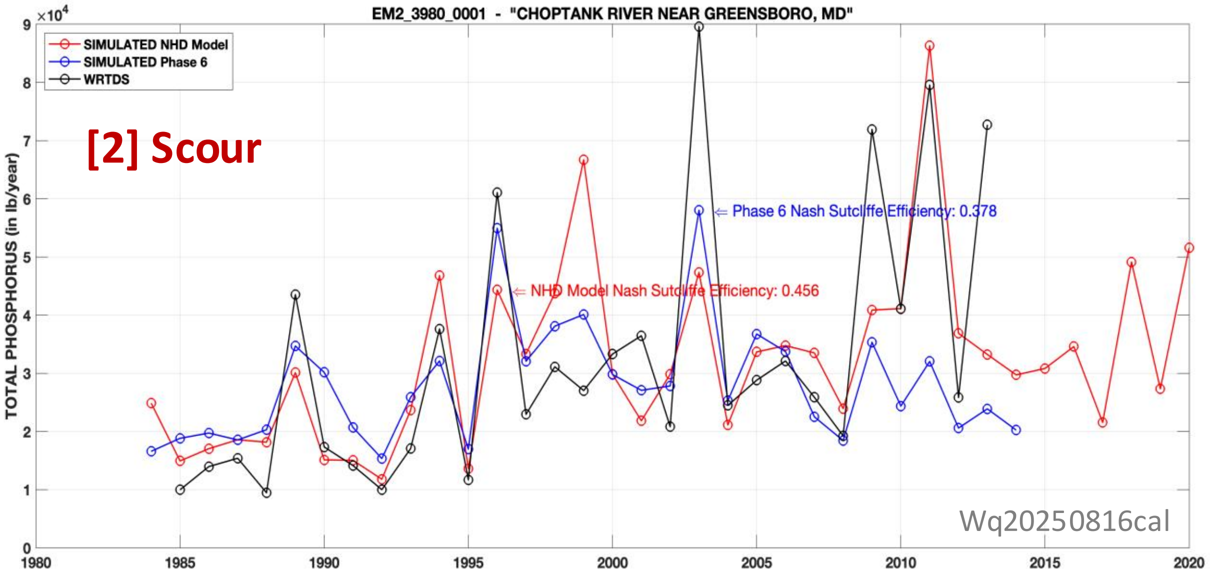
>> for comparing the monitored load trend and CAST-estimated load trend

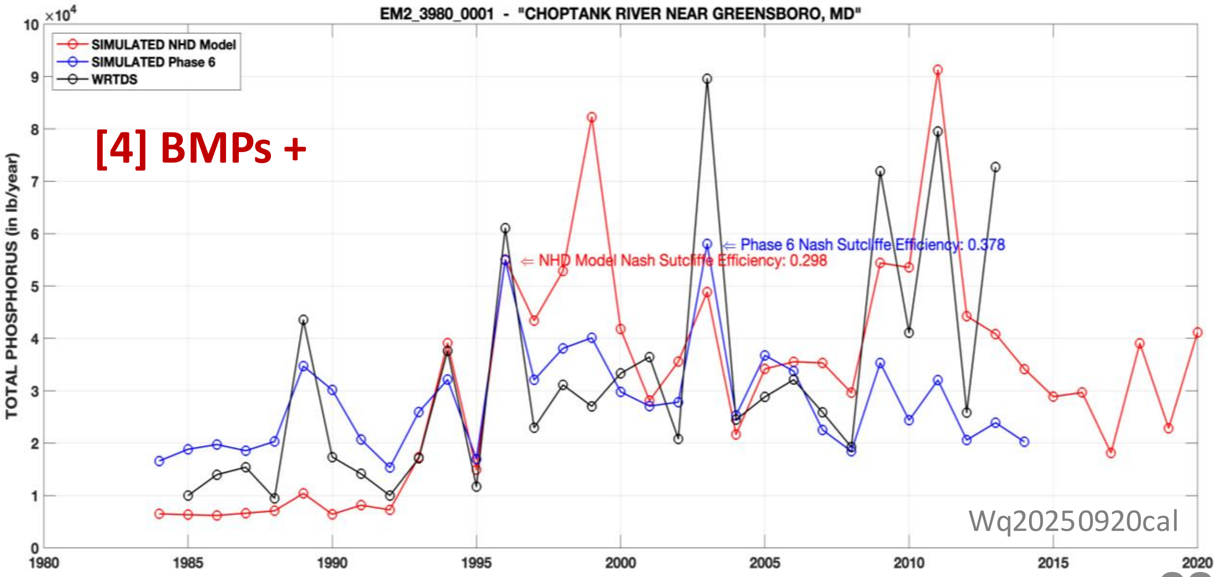


Tracking model performance at Choptank River, TP



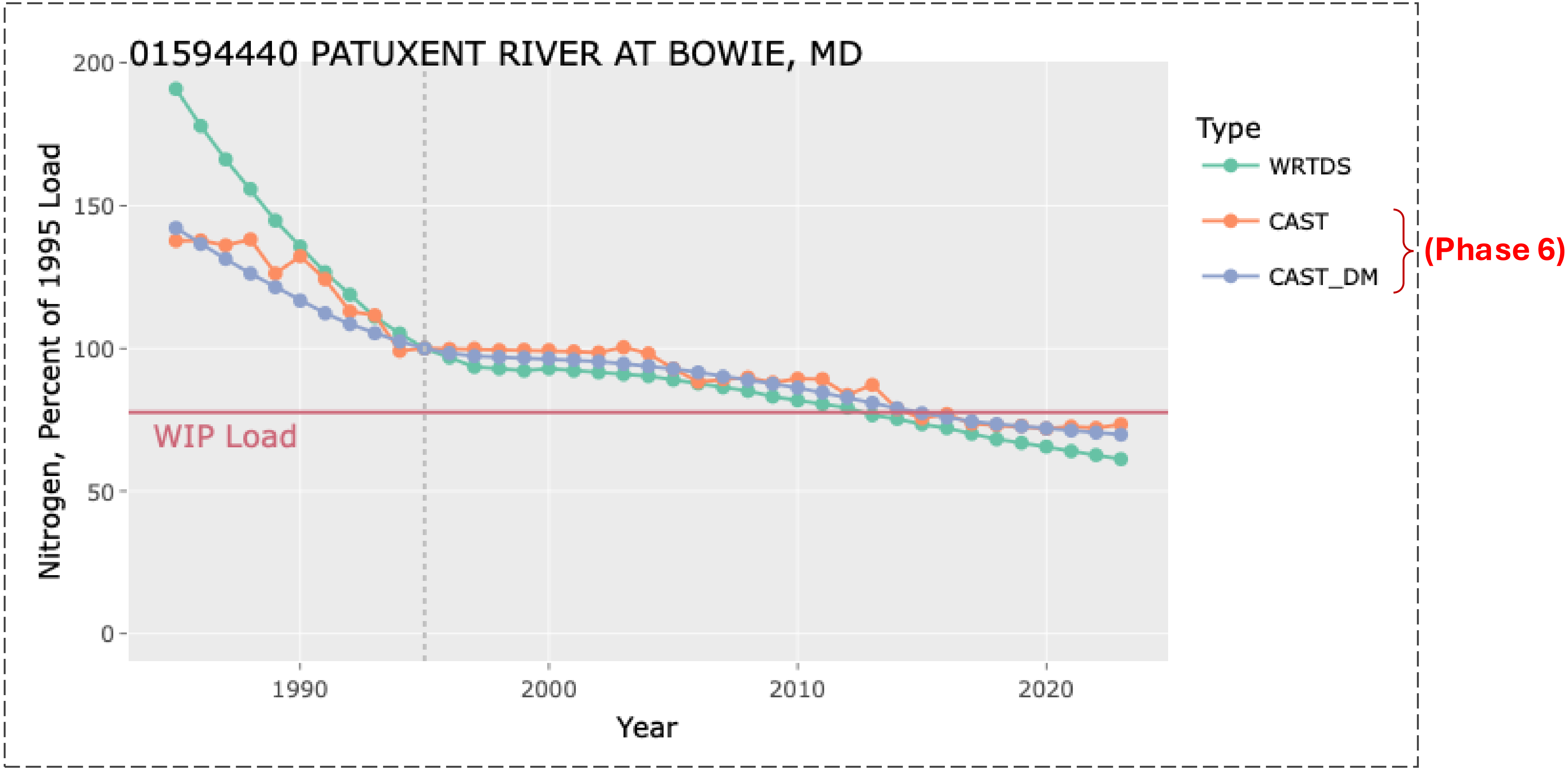




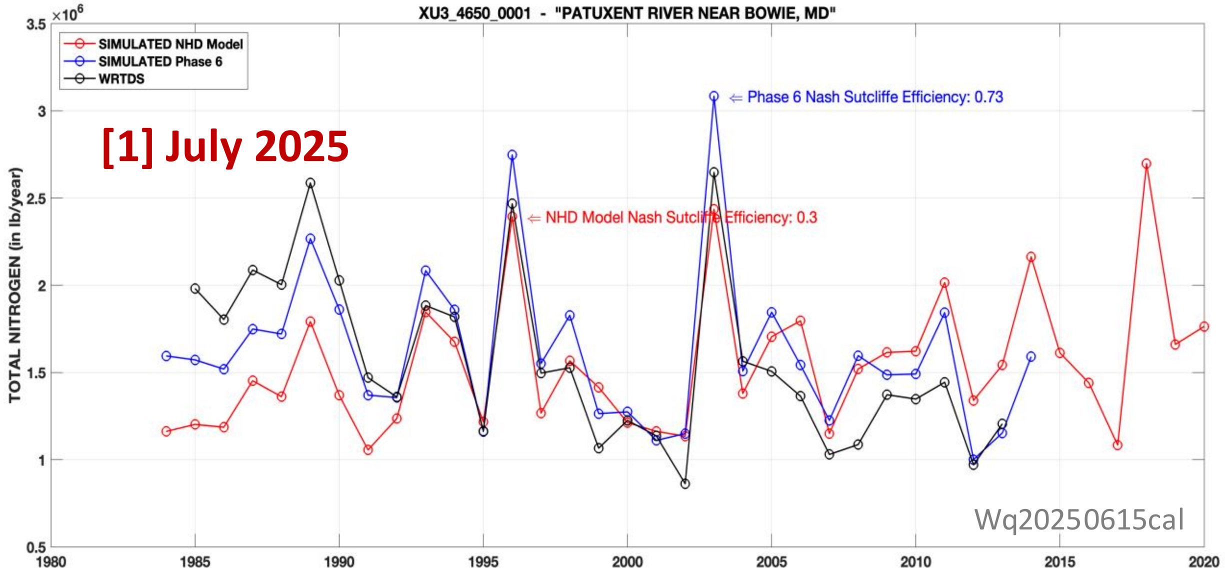


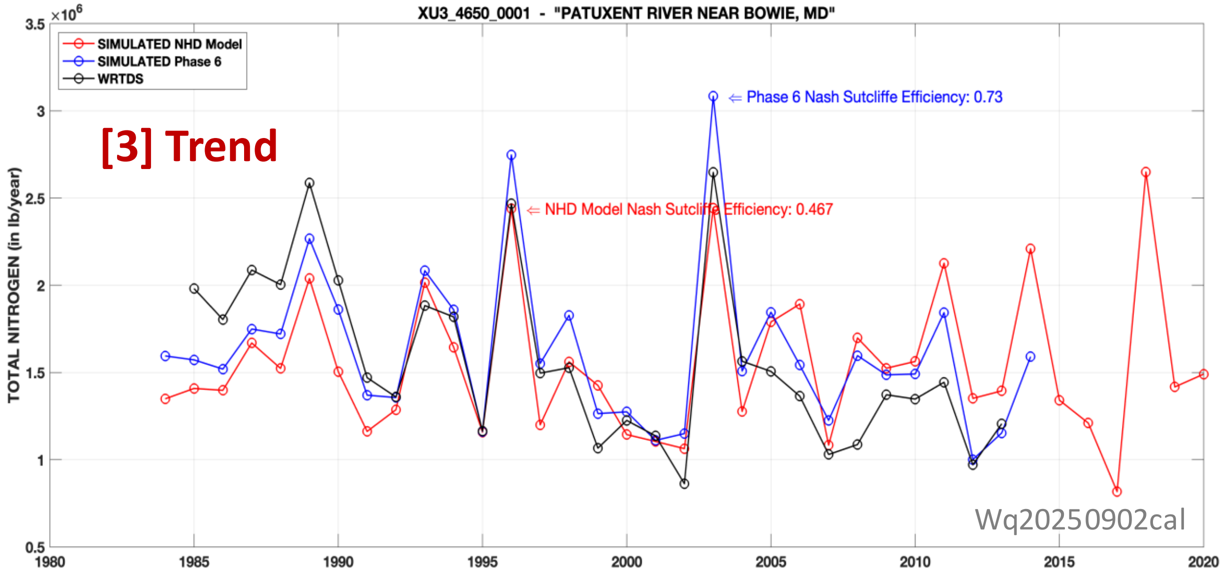
Monitored and Expected Total Reduction Indicator for the Chesapeake (METRIC) https://metric.chesapeakebay.net/metric/

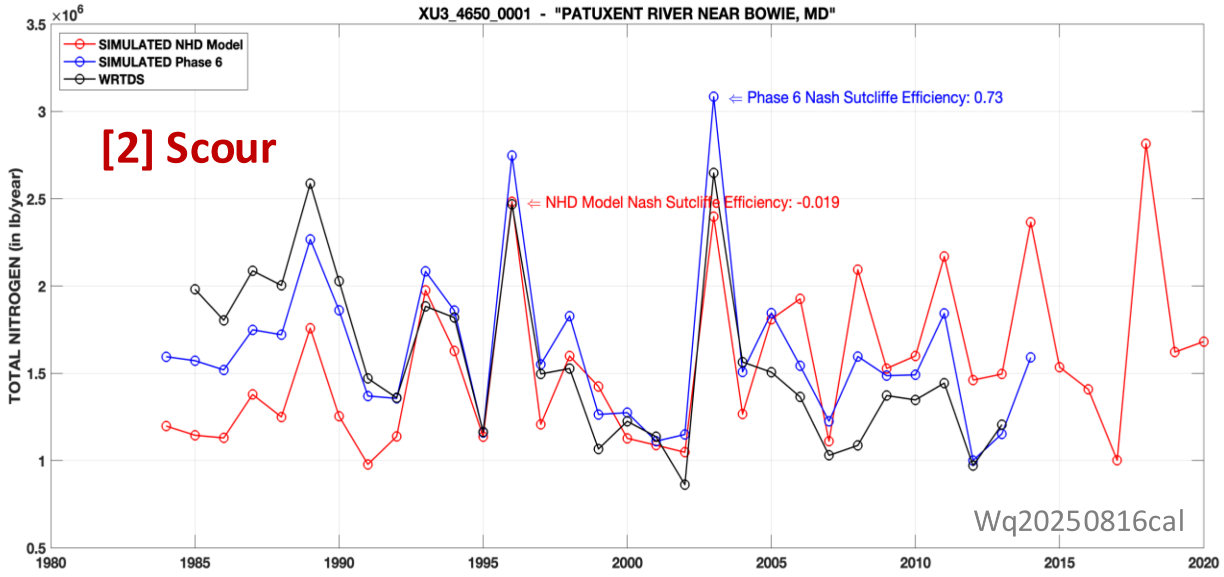
>> for comparing the monitored load trend and CAST-estimated load trend

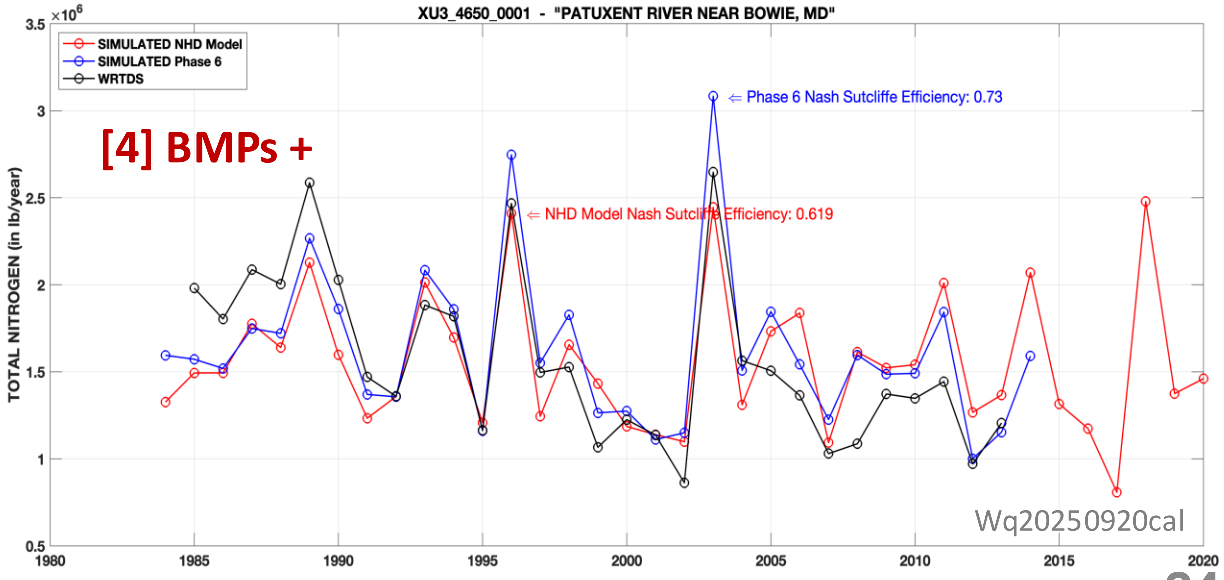


Tracking model performance at Patuxent River, TN

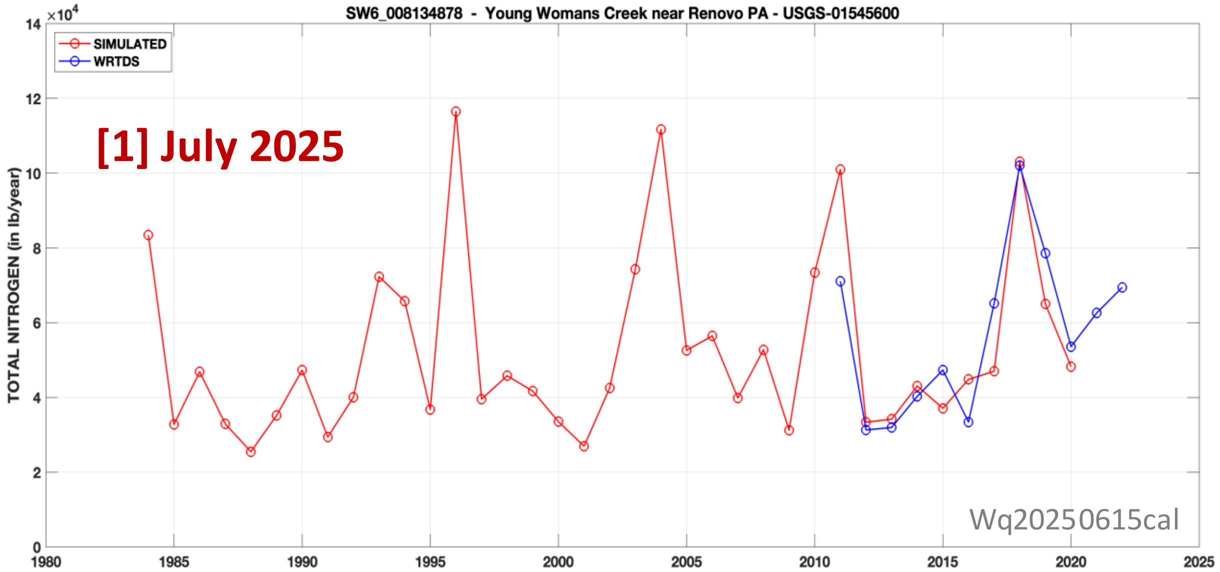


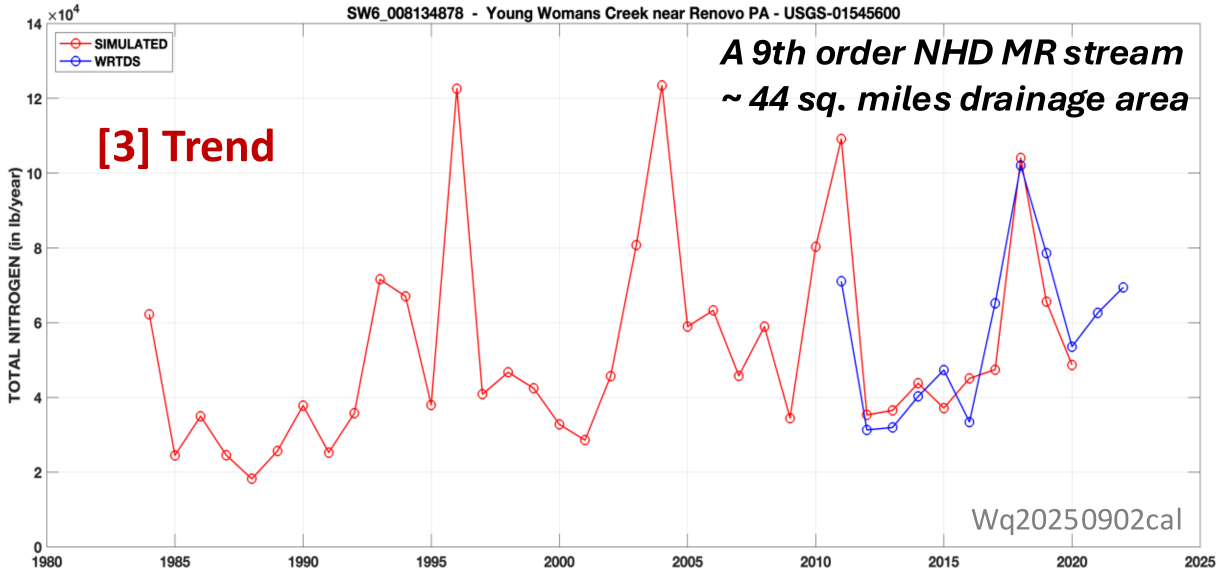


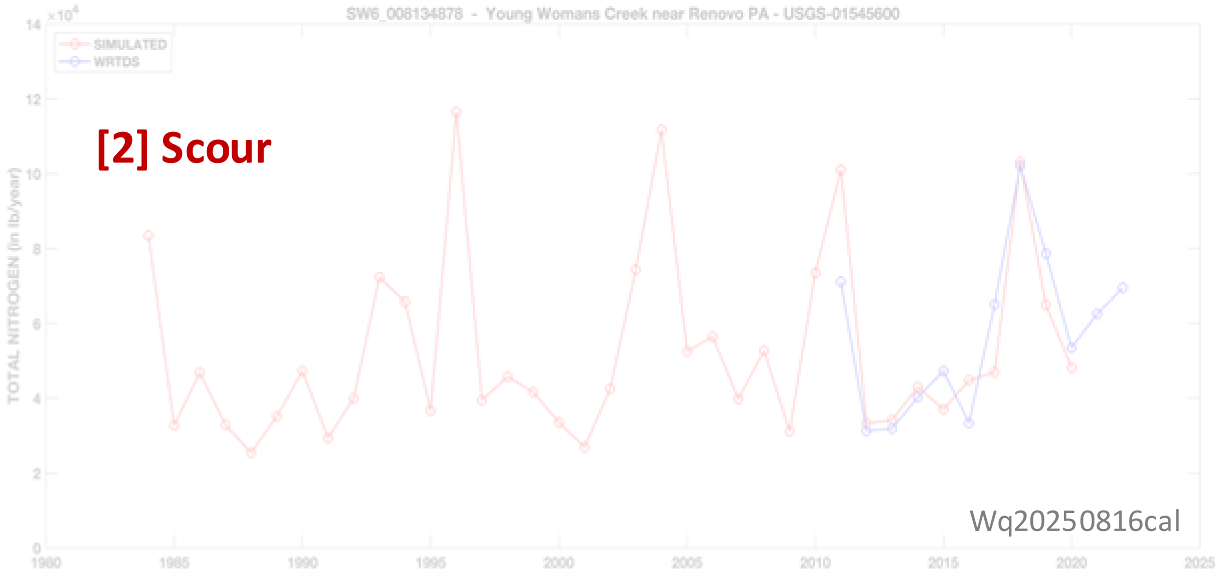


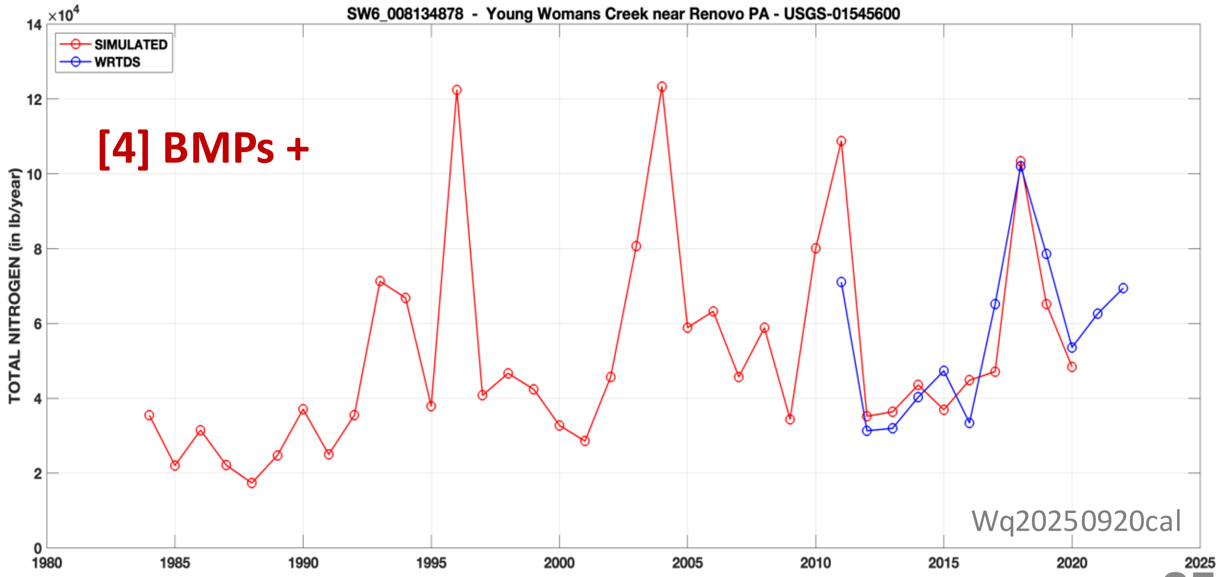


Tracking model performance at Young Womans Creek, TN









RIM stations: Phase 7 Nitrogen loads vs. WRTDS

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	Phase 6	April 2025	July 2025	Scour	Trend	BMPs +
Susquehanna Conowingo MD	-05.0% (+0.836)	-09.2% (+0.665)	-01.1% (+0.723)	-00.8% (+0.727)	-03.1% (+0.537)	-02.5% (+0.548)
Susquehanna Marietta PA	+00.9% (+0.694)	-09.9% (+0.687)	+01.1% (+0.776)	+01.3% (+0.769)	+01.3% (+0.474)	+01.8% (+0.489)
Potomac Washington, DC	-03.1% (+0.797)	-20.9% (+0.670)	-01.6% (+0.817)	-00.9% (+0.764)	-00.9% (+0.789)	+00.2% (+0.693)
James Cartersville, VA	+00.2% (+0.731)	-22.8% (+0.632)	-01.2% (+0.902)	+00.1% (+0.104)	+00.3% (-0.067)	+00.9% (+0.241)
Rappa. Fredericksburg, VA	+01.1% (+0.595)	-05.7% (+0.853)	-05.8% (+0.854)	-05.7% (+0.858)	-07.3% (+0.807)	-06.4% (+0.813)
Appomattox Matoaca, VA	+03.2% (+0.285)	+10.2% (+0.702)	-12.0% (+0.755)	-12.6% (+0.749)	-15.1% (+0.636)	-13.2% (+0.663)
Pamunkey Hanover, VA	+03.1% (+0.338)	+04.9% (+0.786)	-07.4% (+0.771)	-07.4% (+0.735)	-07.2% (+0.648)	-06.8% (+0.670)
Mattaponi Beulahville, VA	+06.8% (+0.511)	+19.9% (+0.378)	-10.2% (+0.655)	-10.7% (+0.628)	-13.8% (+0.245)	-13.0% (+0.270)
Patuxent Bowie, MD	+04.1% (+0.721)	-01.6% (+0.308)	**-04.0% (+0.300)**	-04.1% (-0.019)	**-01.3% (+0.467)**	**+00.1% (+0.619)**
Choptank Greensboro, MD	-04.7% (+0.565)	-03.1% (+0.732)	-04.4% (+0.722)	-04.2% (+0.696)	-07.5% (+0.602)	-04.2% (+0.660)

→ *some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period*

RIM stations: Phase 7 Nitrate loads vs. WRTDS

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	Phase 6	April 2025	July 2025	Scour	Trend	BMPs +
Susquehanna Conowingo MD	+07.1% (+0.496)	-12.6% (+0.528)	+11.3% (+0.501)	+15.1% (+0.361)	+01.5% (+0.183)	+03.7% (+0.183)
Susquehanna Marietta PA	+03.1% (+0.764)	-11.9% (+0.637)	+07.4% (+0.745)	+08.6% (+0.730)	+09.4% (+0.376)	+10.3% (+0.394)
Potomac Washington, DC	-04.6% (+0.846)	-14.7% (+0.700)	+13.7% (+0.771)	+05.9% (+0.817)	+07.5% (+0.805)	+01.2% (+0.856)
James Cartersville, VA	+09.4% (-0.380)	-21.2% (-0.051)	**+36.7% (-0.131)**	-04.6% (+0.531)	-05.8% (+0.336)	+02.4% (+0.427)
Rappa. Fredericksburg, VA	+03.2% (+0.524)	+25.0% (+0.260)	**+32.8% (-0.002)**	+19.8% (+0.441)	+16.7% (+0.384)	+17.1% (+0.385)
Appomattox Matoaca, VA	+10.1% (-0.824)	+130.0% (-11.669)	-07.8% (+0.095)	-24.9% (+0.039)	-21.7% (+0.172)	**-21.1% (+0.252)**
Pamunkey Hanover, VA	+09.0% (+0.067)	+38.7% (-0.418)	**+21.8% (+0.169)**	+11.5% (+0.436)	+11.2% (+0.266)	+11.9% (+0.283)
Mattaponi Beulahville, VA	+11.0% (-1.751)	+93.8% (-8.730)	**+32.7% (-0.751)**	+17.9% (+0.124)	+19.8% (-0.742)	+15.4% (-0.417)
Patuxent Bowie, MD	+00.8% (+0.629)	-08.3% (+0.076)	-03.8% (+0.079)	-15.4% (-0.113)	-10.2% (+0.528)	-07.3% (+0.666)
Choptank Greensboro, MD	-01.9% (+0.437)	+14.2% (+0.613)	+13.6% (+0.637)	+09.6% (+0.707)	+10.1% (+0.555)	+15.0% (+0.487)

→ some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period

RIM stations: Phase 7 Phosphorus loads vs. WRTDS

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	Phase 6	April 2025	July 2025	Scour	Trend	BMPs +
Susquehanna Conowingo MD	+02.0% (+0.944)	+18.2% (+0.763)	+02.2% (+0.783)	+02.1% (+0.796)	+01.8% (+0.868)	+02.4% (+0.853)
Susquehanna Marietta PA	+04.2% (+0.858)	-13.9% (+0.789)	+04.4% (+0.840)	+04.1% (+0.847)	+05.7% (+0.606)	+06.0% (+0.641)
Potomac Washington, DC	+01.0% (+0.877)	-05.5% (+0.541)	+06.9% (+0.226)	+07.0% (+0.197)	+06.0% (+0.306)	+06.4% (+0.336)
James Cartersville, VA	-04.7% (+0.558)	-21.8% (+0.615)	+01.9% (+0.850)	+02.8% (+0.522)	+03.5% (+0.385)	+04.1% (+0.481)
Rappa. Fredericksburg, VA	-03.6% (+0.309)	-11.3% (+0.732)	-03.4% (+0.680)	-03.5% (+0.669)	-05.6% (+0.473)	-05.2% (+0.496)
Appomattox Matoaca, VA	-01.5% (+0.678)	+12.8% (+0.713)	-06.2% (+0.739)	-07.1% (+0.747)	-10.5% (+0.005)	-10.2% (+0.039)
Pamunkey Hanover, VA	+00.0% (+0.622)	+04.2% (+0.506)	-02.0% (+0.243)	-02.4% (+0.305)	+00.3% (+0.180)	-00.1% (+0.275)
Mattaponi Beulahville, VA	+01.6% (+0.214)	+11.2% (-0.035)	-07.3% (+0.237)	-07.2% (+0.237)	-11.4% (-0.256)	-11.2% (-0.234)
Patuxent Bowie, MD	+02.5% (+0.688)	-11.8% (+0.348)	-07.0% (-0.015)	-06.4% (-0.206)	-07.3% (-0.249)	-06.0% (-0.058)
Choptank Greensboro, MD	-01.7% (+0.395)	+06.6% (+0.499)	-02.3% (+0.501)	-01.8% (+0.456)	-00.3% (+0.311)	+01.5% (+0.298)

→ *some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period*

RIM stations: Phase 7 Sediment loads vs. WRTDS

(a) biases in 1985-2014 average loads as compared to WRTDS; (b) NSE of annual loads in parentheses;

Rivers	Phase 6	April 2025	July 2025	Scour	Trend	BMPs +
Susquehanna Conowingo MD	+08.0% (+0.963)	+18.0% (+0.433)	+04.3% (+0.808)	+04.6% (+0.837)	+05.8% (+0.881)	+06.2% (+0.875)
Susquehanna Marietta PA	-00.9% (+0.833)	+02.6% (-0.115)	+07.9% (-0.047)	+07.7% (-0.047)	+11.2% (-0.986)	+11.7% (-0.903)
Potomac Washington, DC	+03.2% (+0.827)	-08.4% (-0.503)	+10.1% (-0.623)	+10.0% (-0.596)	+07.9% (-0.658)	+09.2% (-0.713)
James Cartersville, VA	+01.1% (+0.384)	-36.0% (+0.627)	+08.0% (-2.613)	+07.2% (-2.166)	+06.2% (-2.536)	+02.9% (-0.674)
Rappa. Fredericksburg, VA	+00.1% (-0.356)	-41.9% (-0.750)	-04.1% (+0.474)	-04.1% (+0.476)	-06.2% (+0.411)	-04.9% (+0.329)
Appomattox Matoaca, VA	+13.8% (-0.567)	-32.7% (+0.534)	-06.4% (+0.449)	-11.2% (+0.423)	-12.3% (-0.171)	-12.3% (-0.181)
Pamunkey Hanover, VA	+01.7% (-1.143)	-44.2% (+0.229)	-02.4% (-0.024)	-02.6% (+0.027)	-01.4% (-0.110)	-02.3% (-0.034)
Mattaponi Beulahville, VA	-00.9% (-0.120)	+101.3% (-10.342)	-09.4% (-0.533)	-09.4% (-0.532)	-12.1% (-0.804)	-11.7% (-0.769)
Patuxent Bowie, MD	+10.3% (+0.678)	+28.7% (+0.501)	-11.0% (-0.134)	-11.0% (-0.134)	-15.3% (-0.425)	-14.0% (-0.283)
Choptank Greensboro, MD	+15.9% (+0.424)	-19.4% (+0.116)	+01.5% (-0.805)	+01.5% (-0.803)	+06.1% (-1.995)	+10.0% (-2.118)

→ some differences from CalCAST can be attributed to WRTDS method and DWSM loads for the 1985-2014 averaging period

Summary

1. We updated beta versions and linkage of incrementally refined watershed model flows and loads with the estuarine model.

2. We have shifted towards completeness of the model: (a) model parameters (Beta parameters) and trends; (b) calibration methods (RIM loads); (c) incorporation of inputs (BMPs; afo/cfo loads); (d) linkage with the MBM and MTMs (atmospheric inputs, tracking progress).

>> Next Steps for the Phase 7 Dynamic Watershed Model (DWSM)

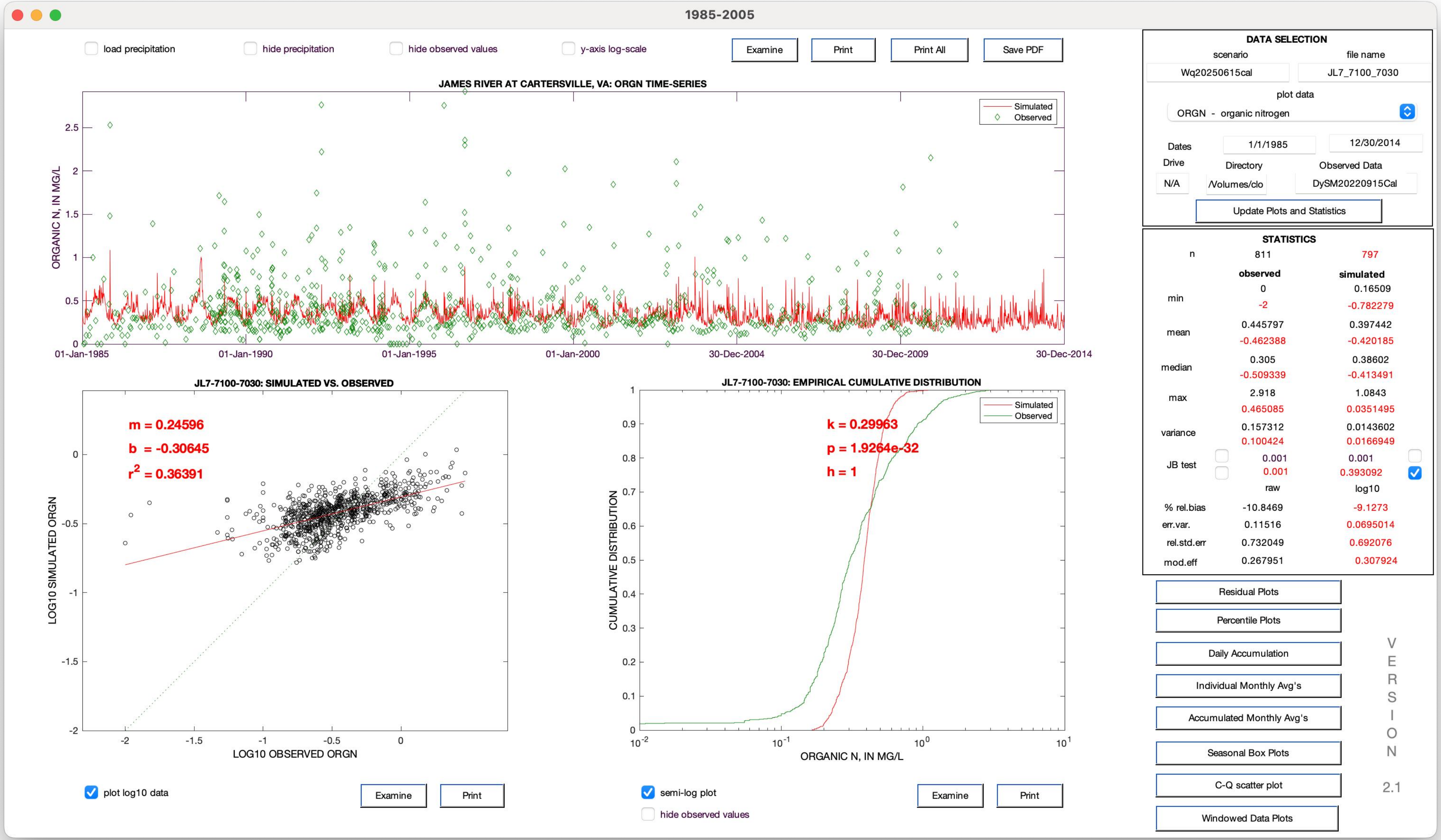
3. (a) deeper/systematic investigation of model calibration to identify opportunities for improving model performance (GSN trends, lags, transport pathways, sensitivities, inputs); (b) Phase 7 land uses including combined sewer system system and feeding operations; (c) surface water withdrawals; and (d) expanded monitoring and WRTDS-K data in model calibration;

Appendices

Riverine simulation without Organic Scour

James River at Cartersville, VA

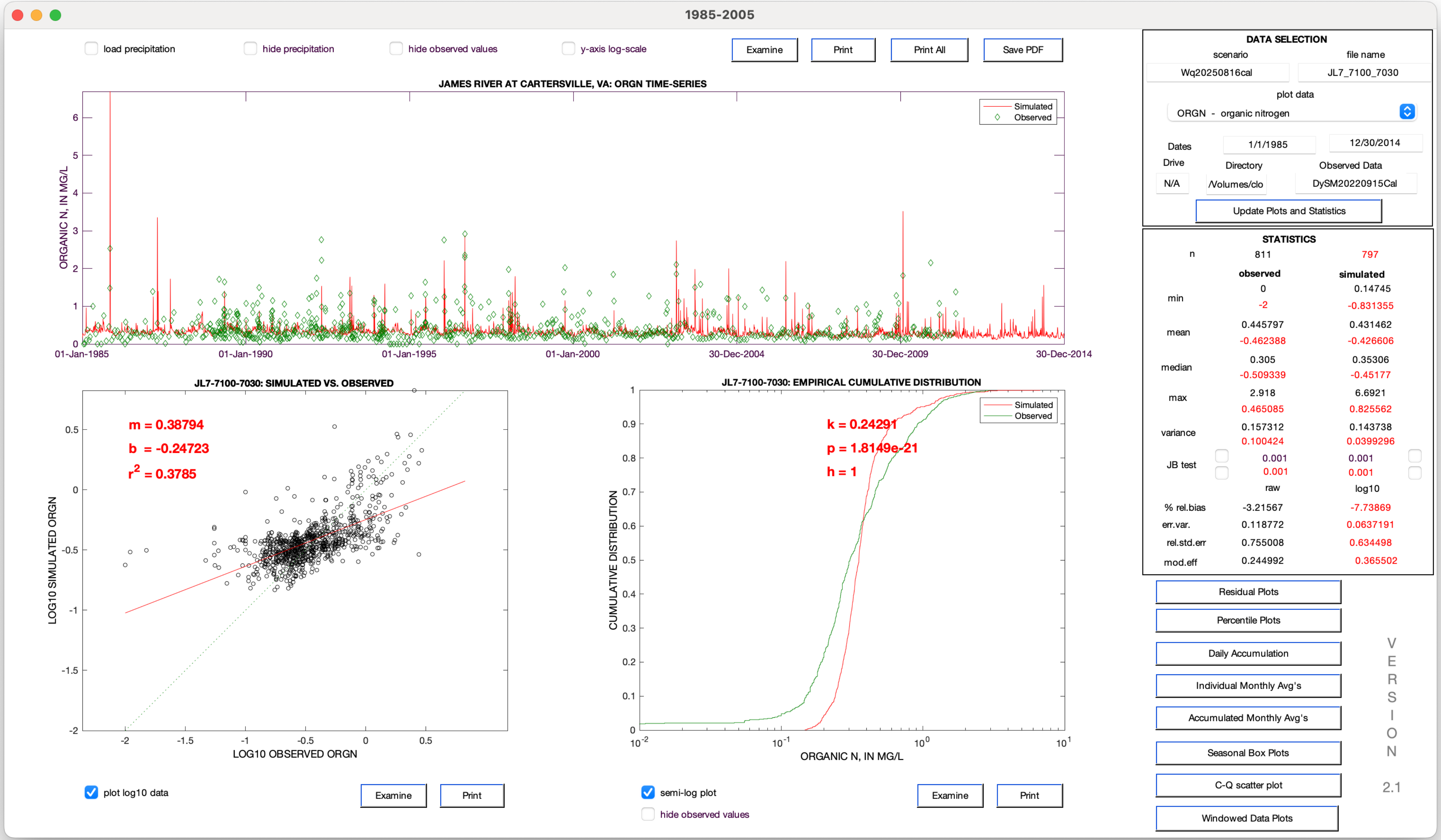
Organic Nitrogen



Riverine simulation without Organic Scour

James River at Cartersville, VA

Organic Nitrogen



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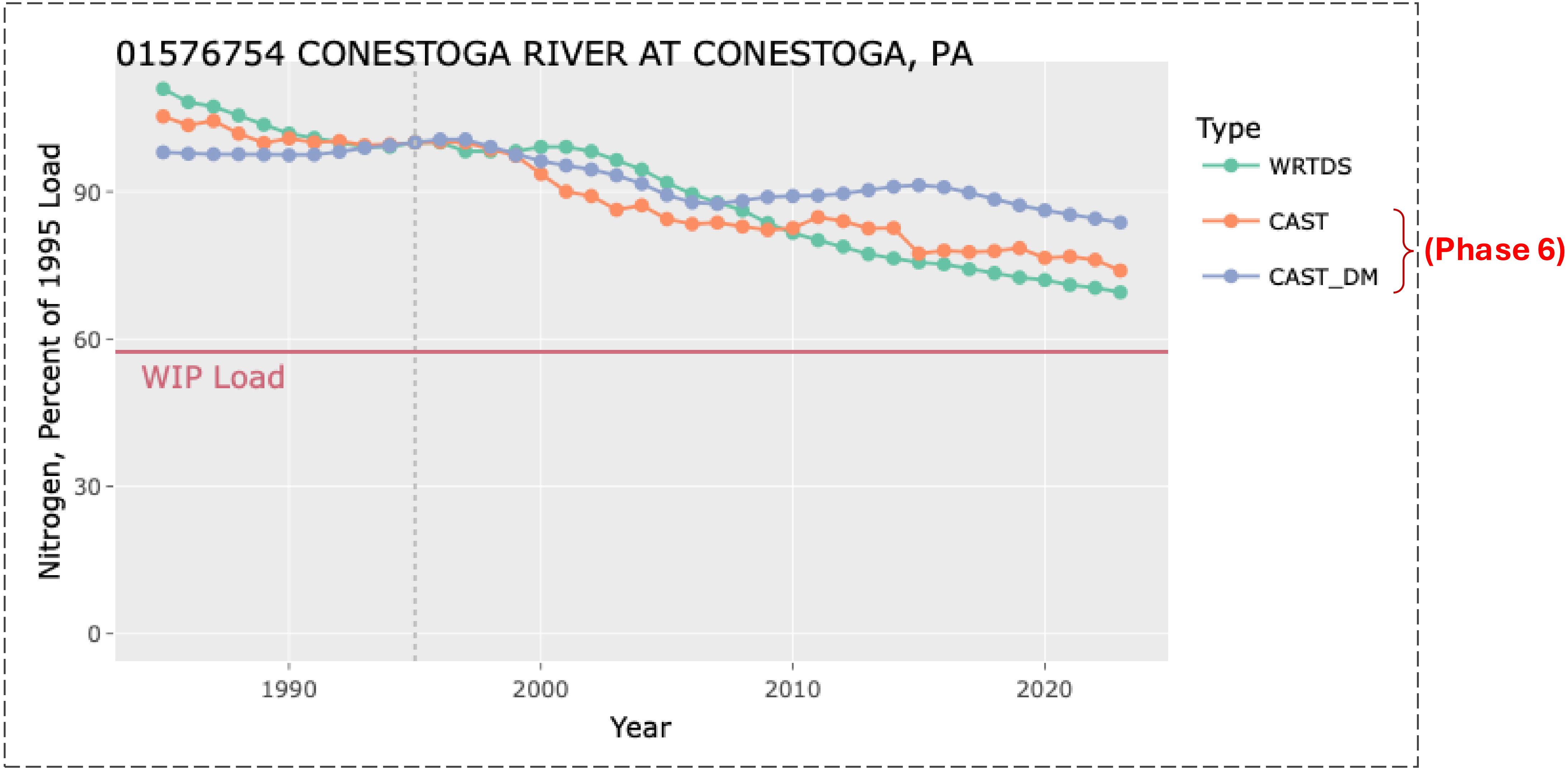
>> for comparing the monitored load trend and CAST-estimated load trend



Tracking model performance at Conestoga River, TN