01/10/2023

Phase 7 WSM Development – Dynamic Model for Nutrients and Sediment

Modeling Workgroup Quarterly Meeting – January 2023

Gopal Bhatt[1], Isabella Bertani[2], Lewis Linker[3], Robert Burgholzer[4]

[1] Penn State, [2] UMCES, [3] US EPA, [4] VA DEQ – Chesapeake Bay Program Office

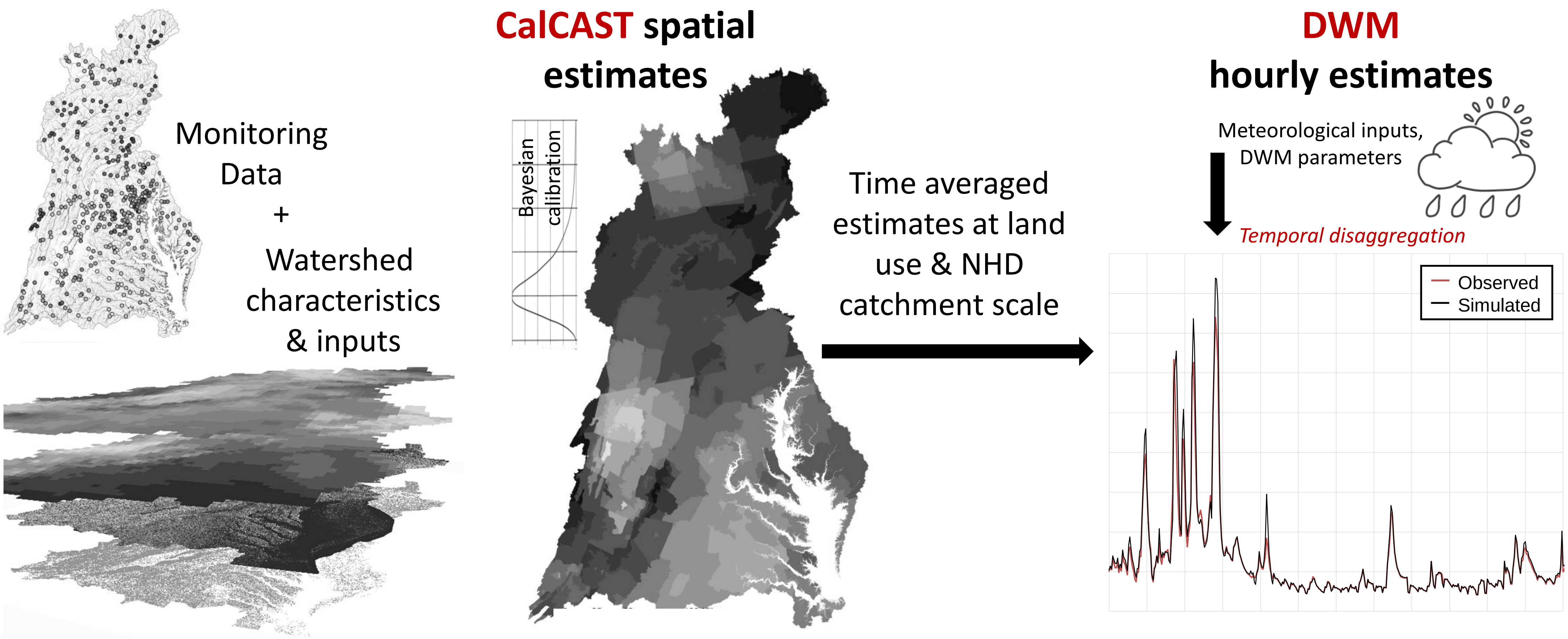
Dynamic Watershed Model (DWM) Development

Calendar Year 2022

CY 2022	Progress/Major Development Elements
1Q	NHD-scale model structure; Hydrology prototype; Expanded simulation period 1985 to 2020; [1][2]
2Q	Hydrology calibration (CalCAST→DWM) method updates; Simple routing (initial testing of numerical simplifications); [3]
3Q	Sediment model; Hydrology model calibration updates with respect to stormflow; [4]
4Q	Nutrient (Nitrogen and Phosphorus) model; Updated sediment model; [5]

[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] this presentation

Framework: Spatial Model (CalCAST) → Dynamic Watershed Model (DWM)



- Data-driven CalCAST informs DWM parameters and responses.
- NHD-scale DWM prototype is now 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.**

Purpose

NHD Scale Dynamic Watershed Model (DWM)

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

Presentation Outline

Dynamic Watershed Model (DWM) for Nutrients & Sediment

1. NHD Model for Nutrients (Nitrogen & Phosphorus)

- Nutrient model structure (CalCAST→DWM)
- Input: CalCAST TN and TP at catchment land use scale
- Model results and performance (WRTDS vs. DWM)

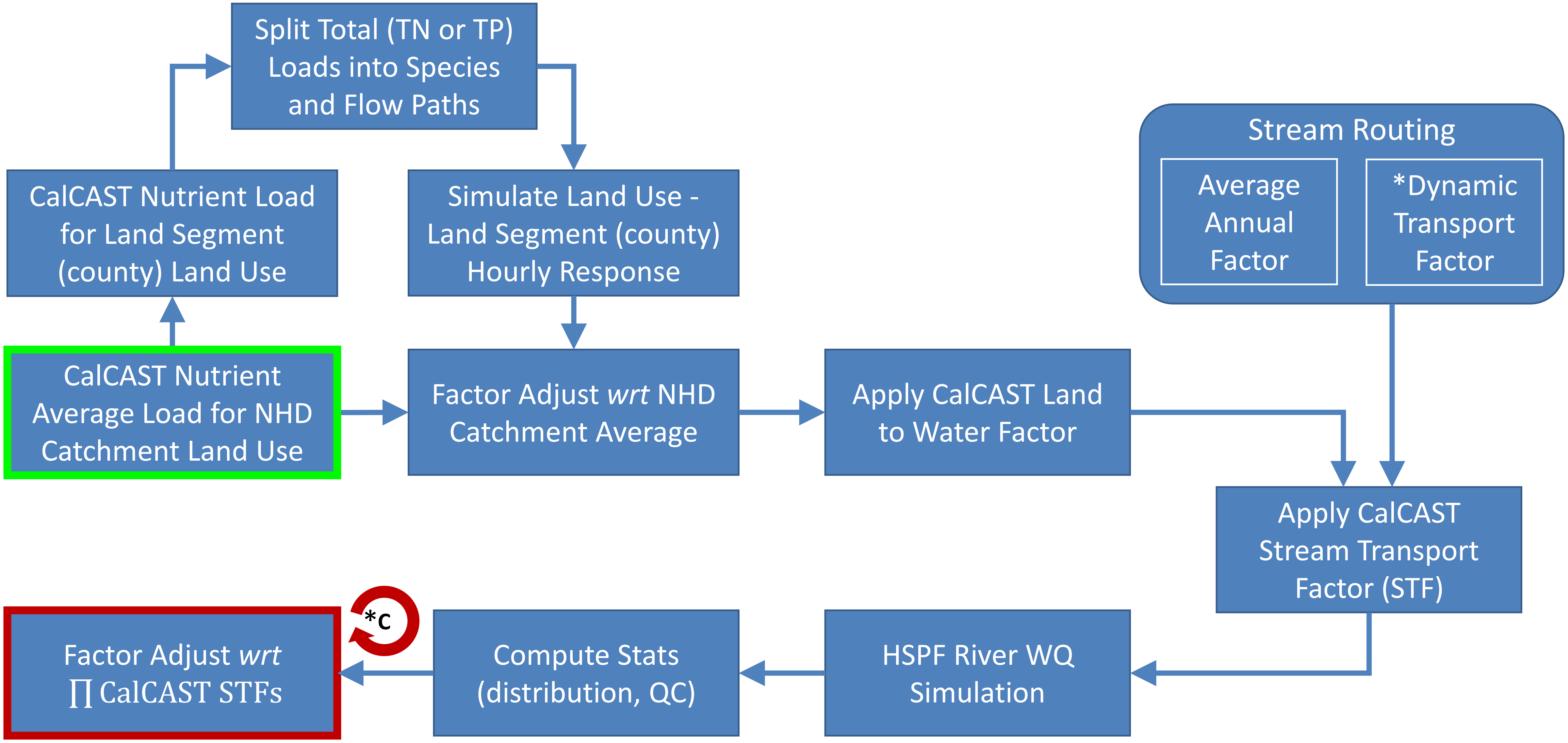
2. Model Verification

- CalCAST vs. DWM

3. Computational Requirements

4. Next Steps

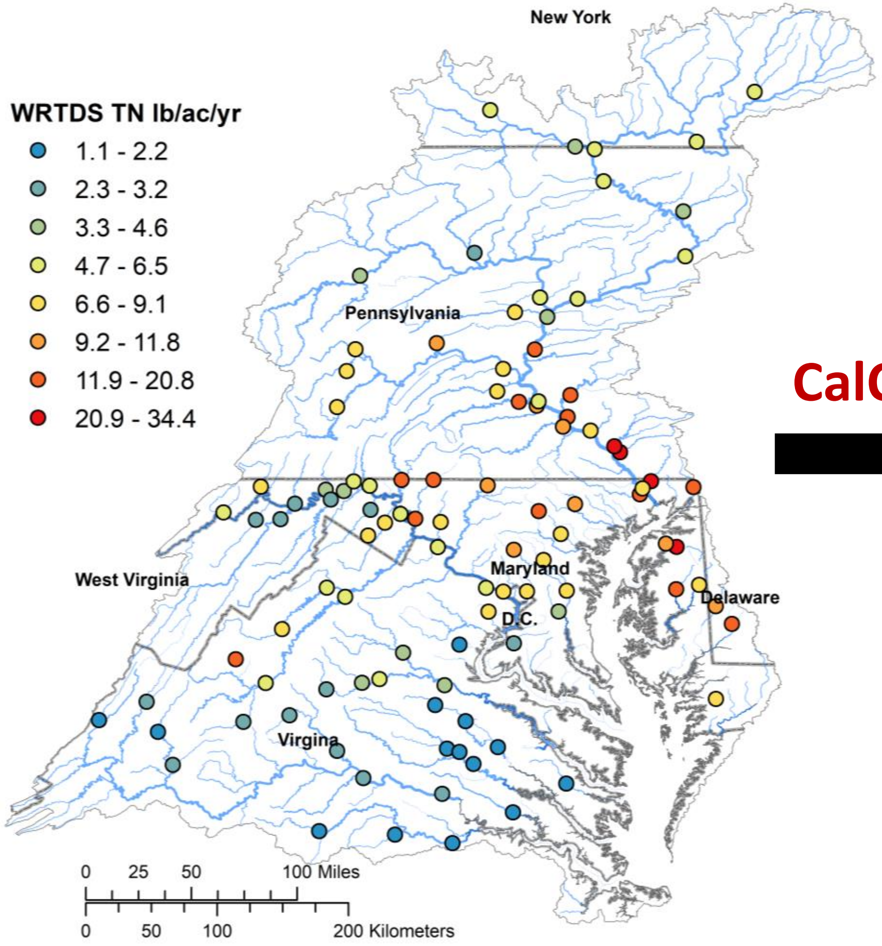
1. NHD Scale Nutrient Model Structure



Modules marked with * are <u>not</u> yet implemented or applied in the prototype we are discussing today.

Average Annual Nitrogen Model

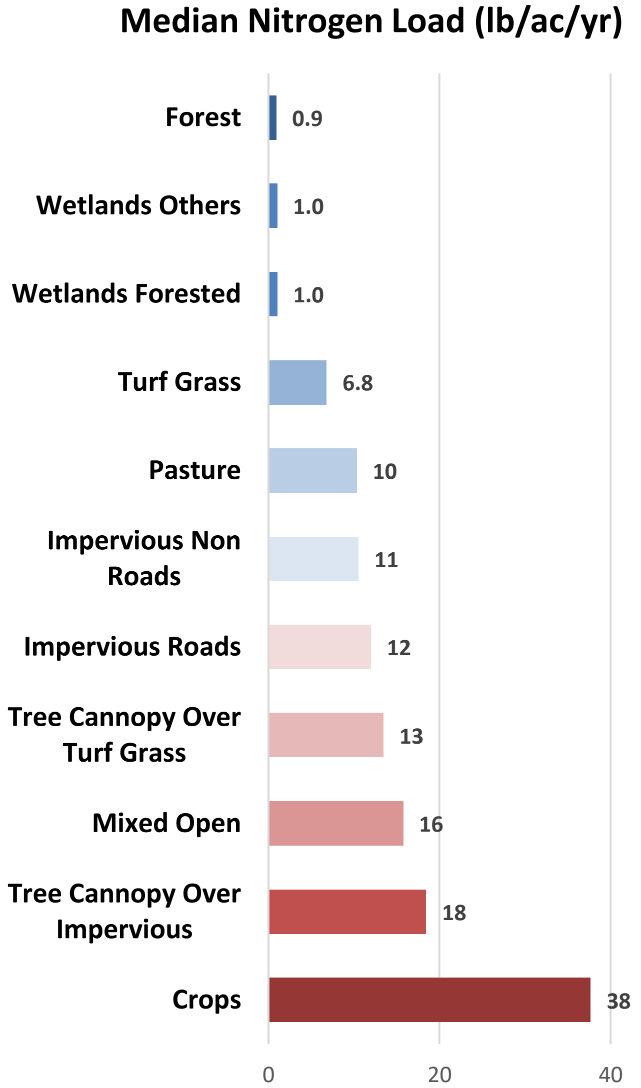
Monitoring

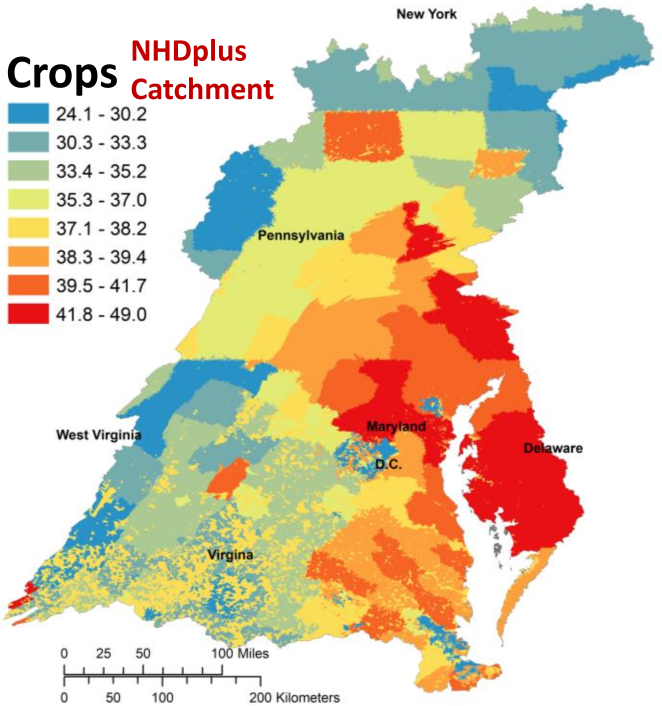


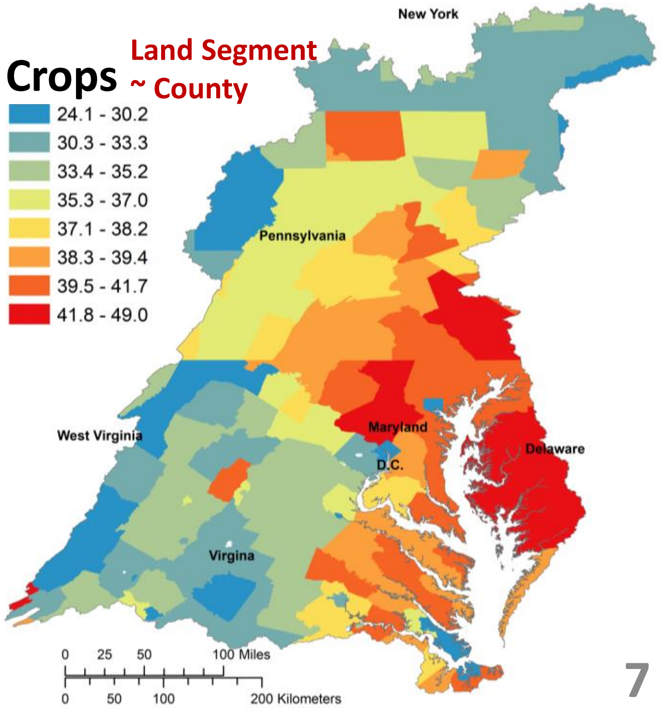
Average Annual Total Nitrogen Estimated using USGS WRTDS

CalCAST

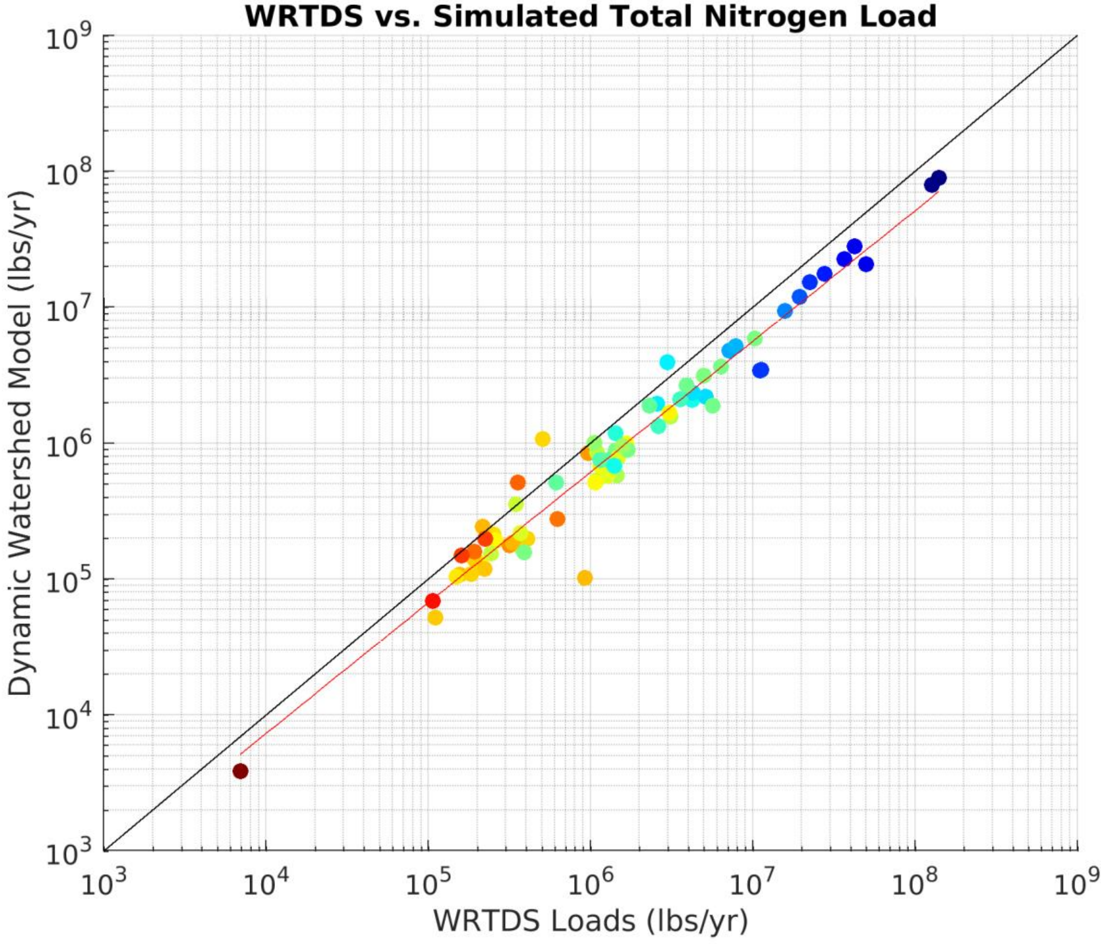
Spatial Prediction

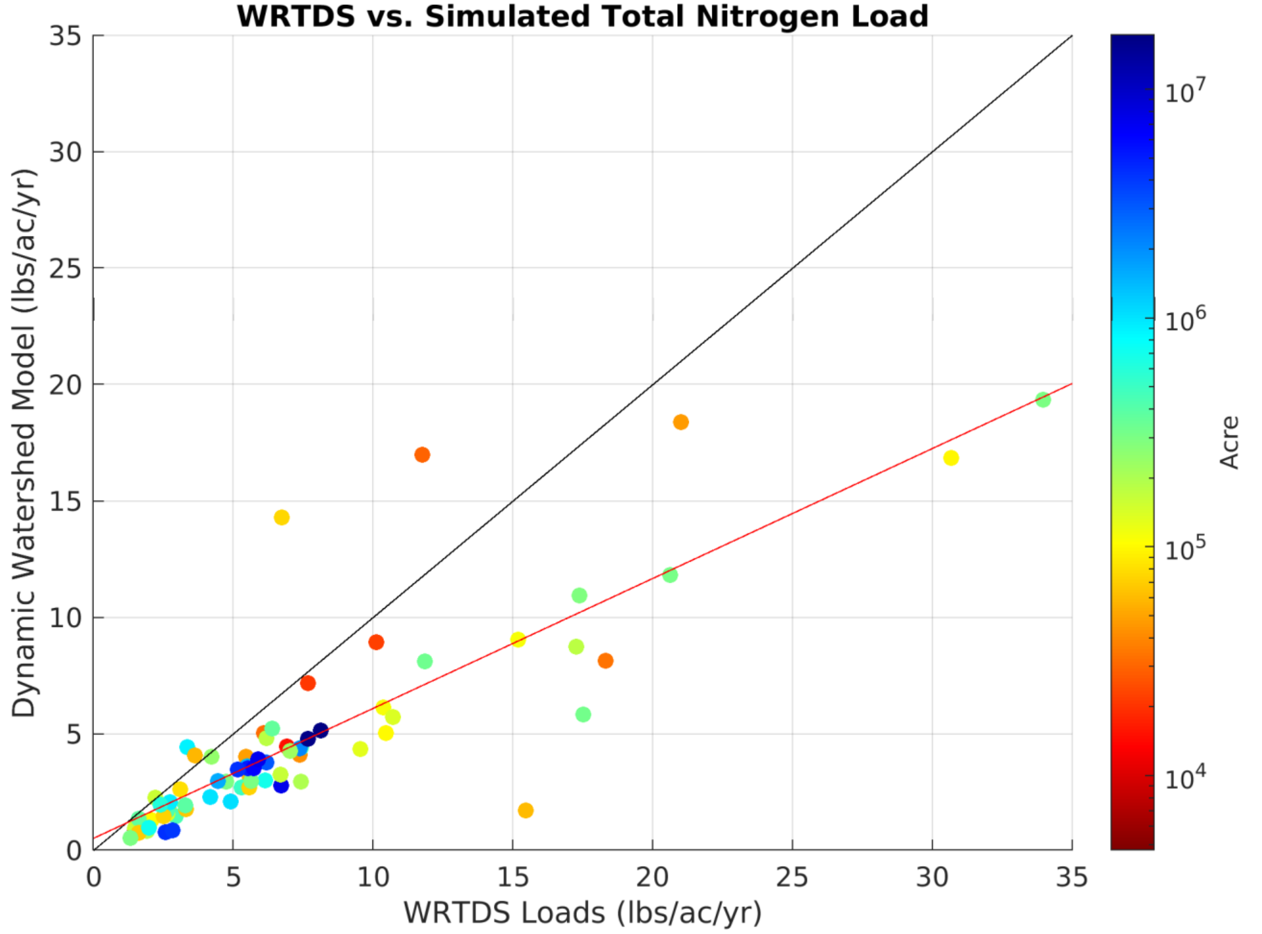






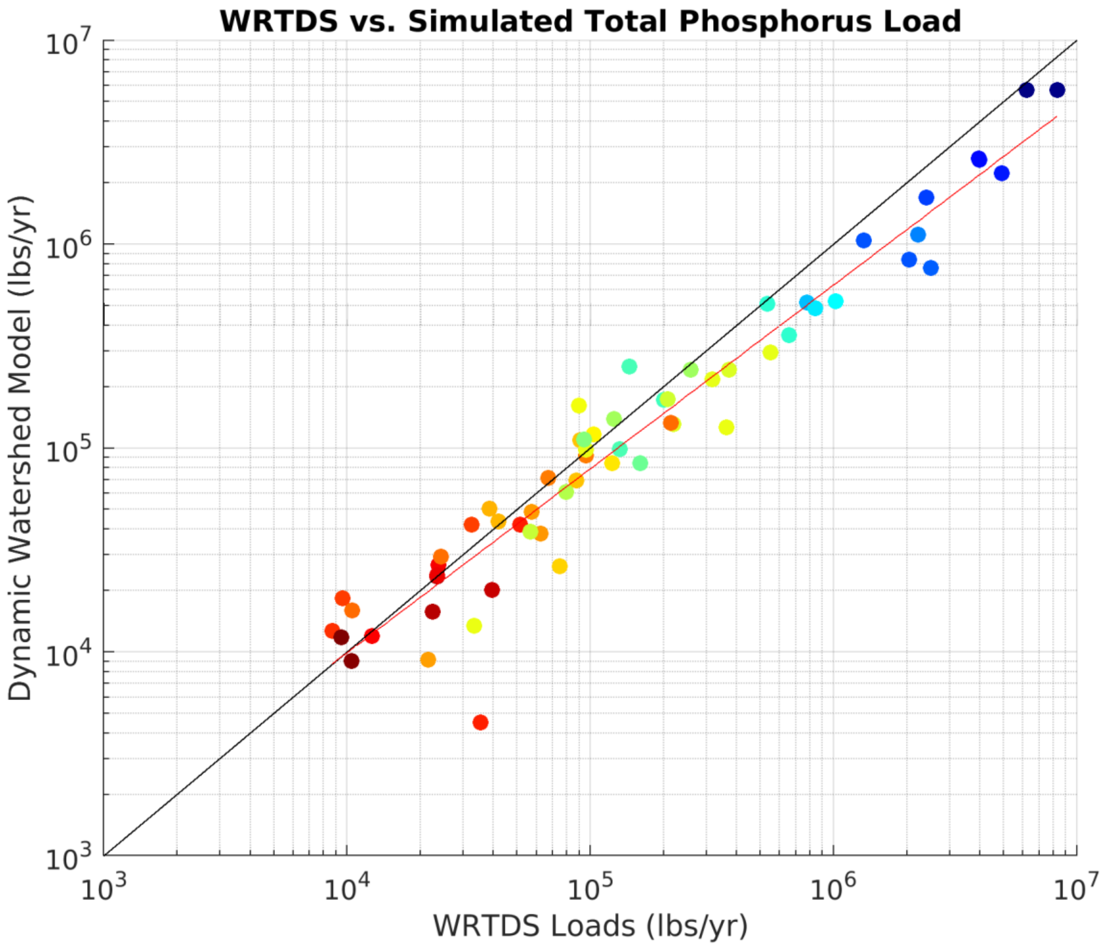
Observed vs. Simulated: Total Nitrogen (TN)

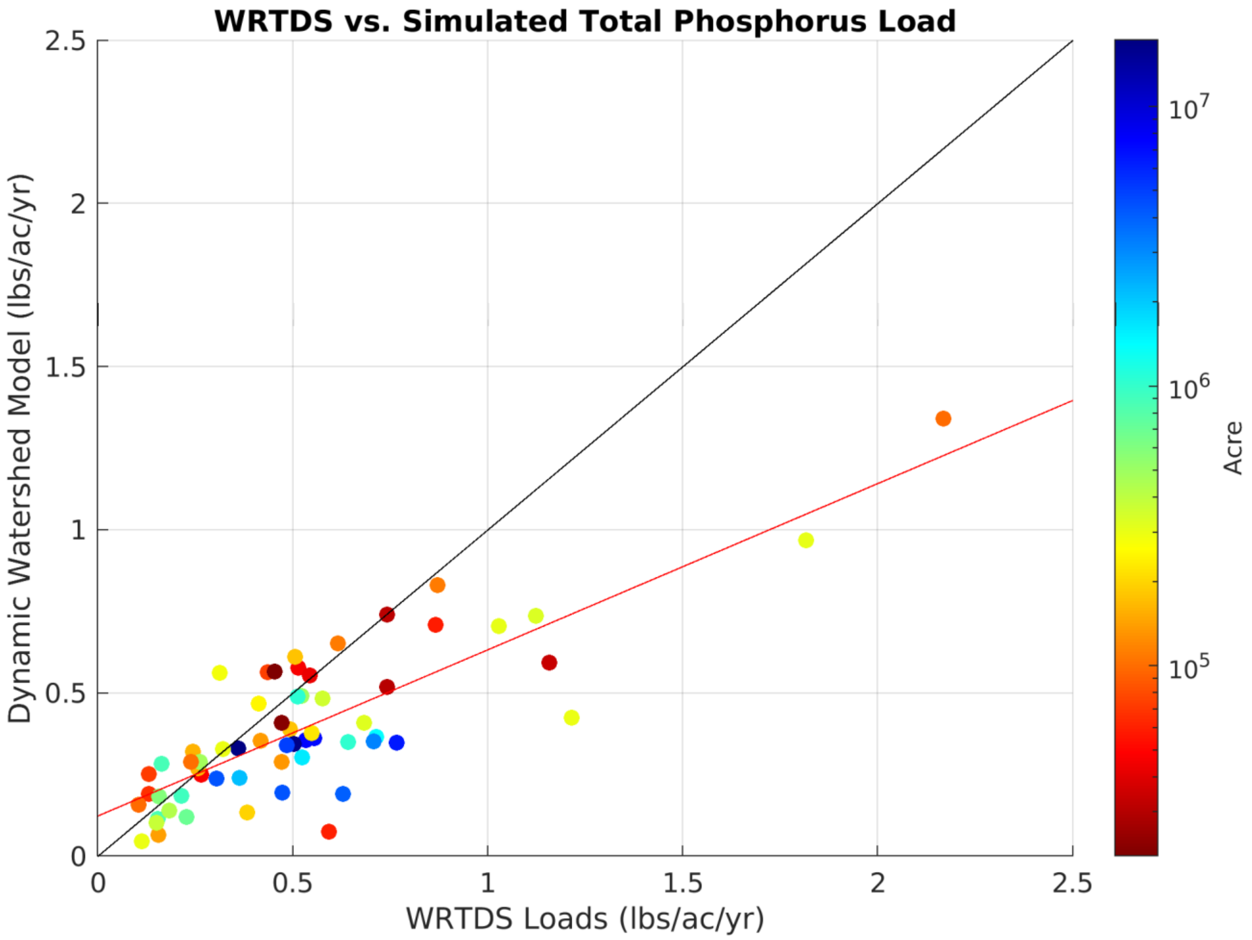




Data points show agreement in average annual load at NTN monitoring stations with WRTDS loads.

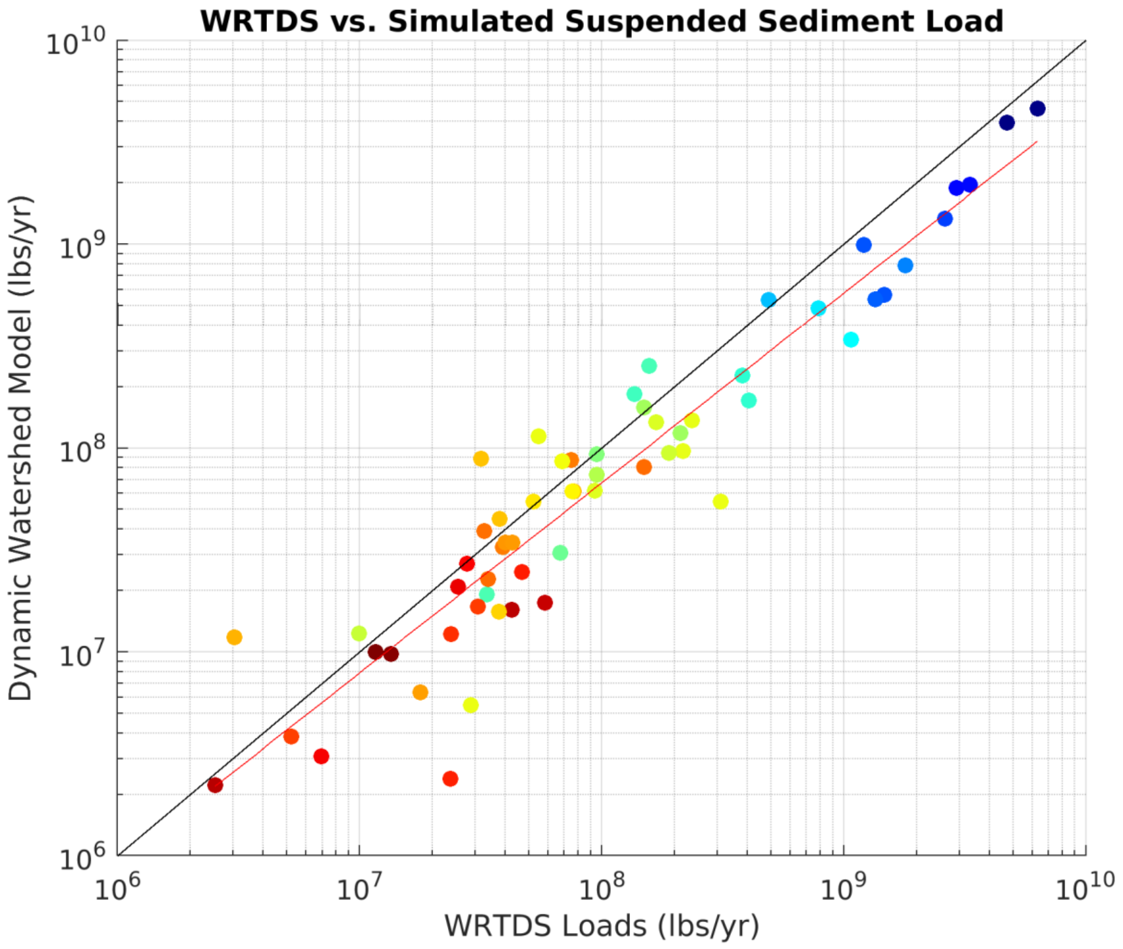
Observed vs. Simulated: Total Phosphorus (TP)

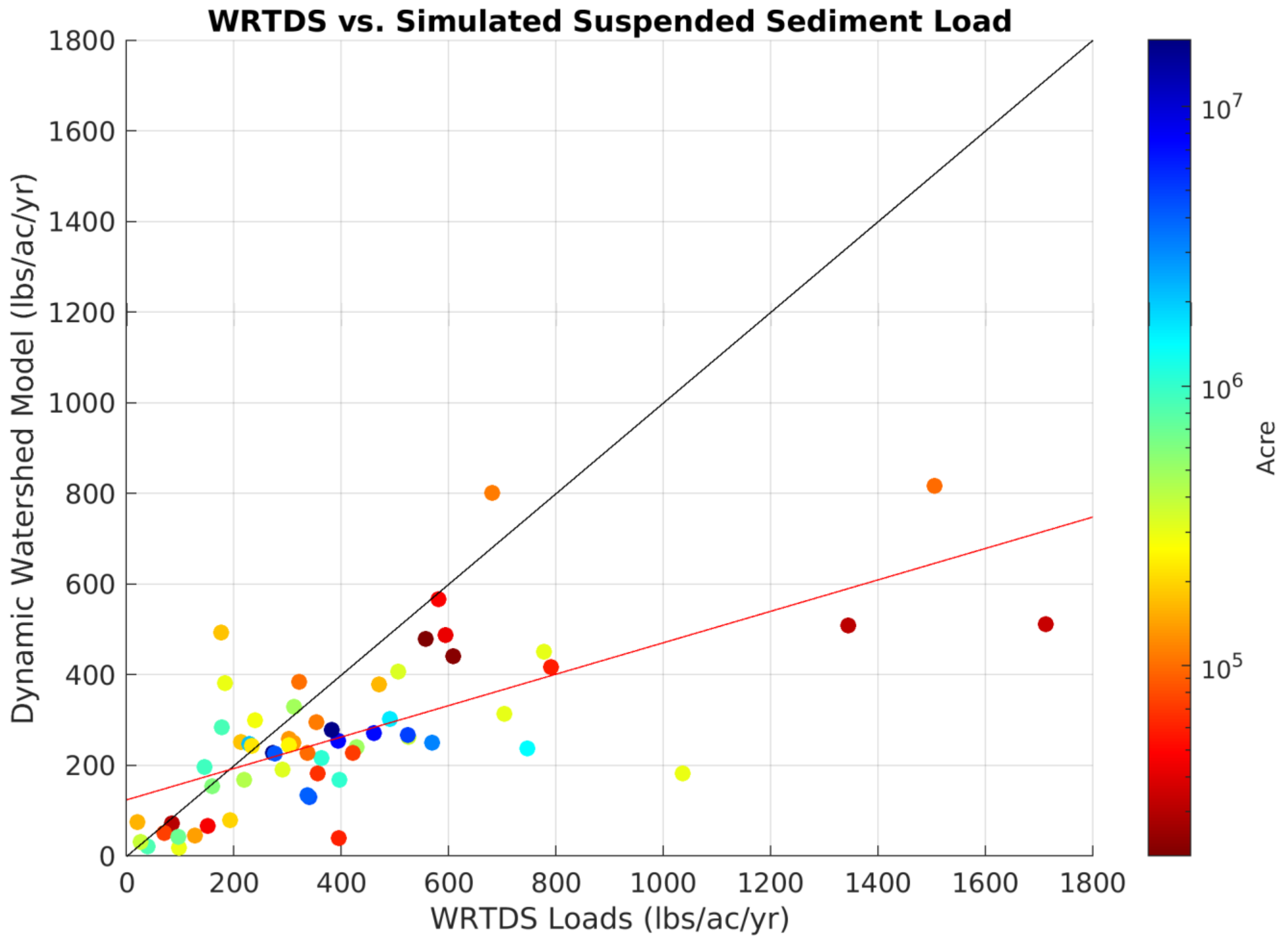




Data points show agreement in average annual load at NTN monitoring stations with WRTDS loads.

Observed vs. Simulated: Suspended Sediment (SS)



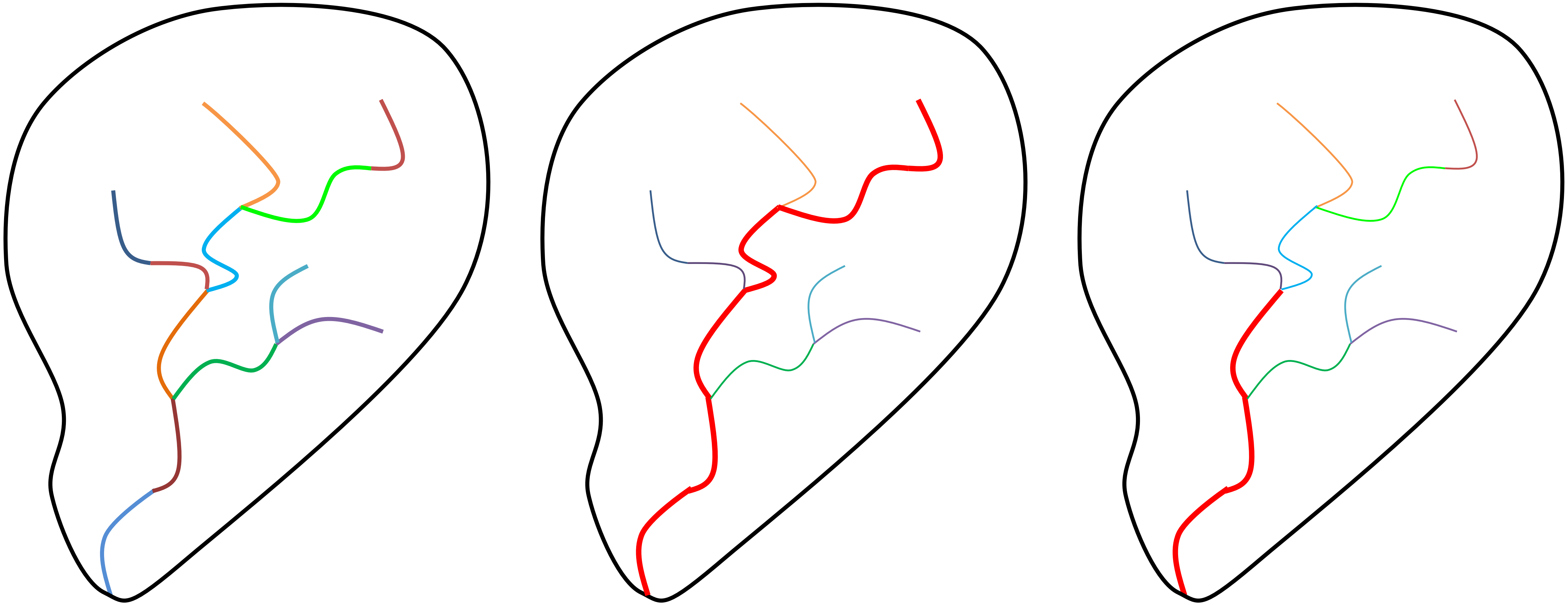


Data points show agreement in average annual load at NTN monitoring stations with WRTDS loads.

2. Model Verification: CalCAST vs. DWM

ISSUE #1

River (main stem) delineation and 'aggregation effect'

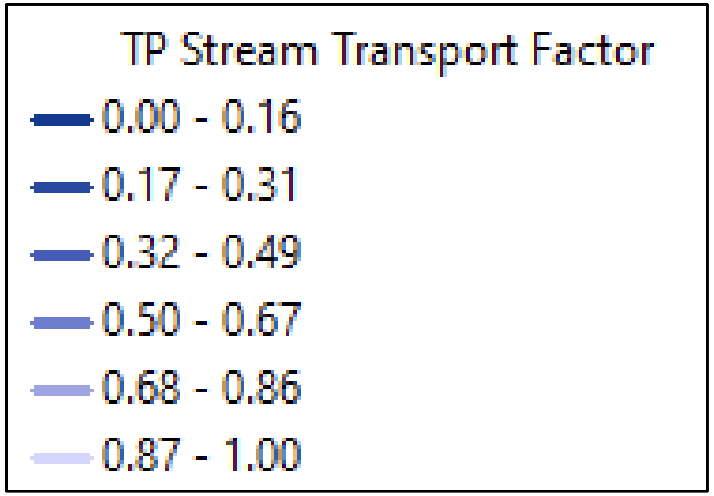


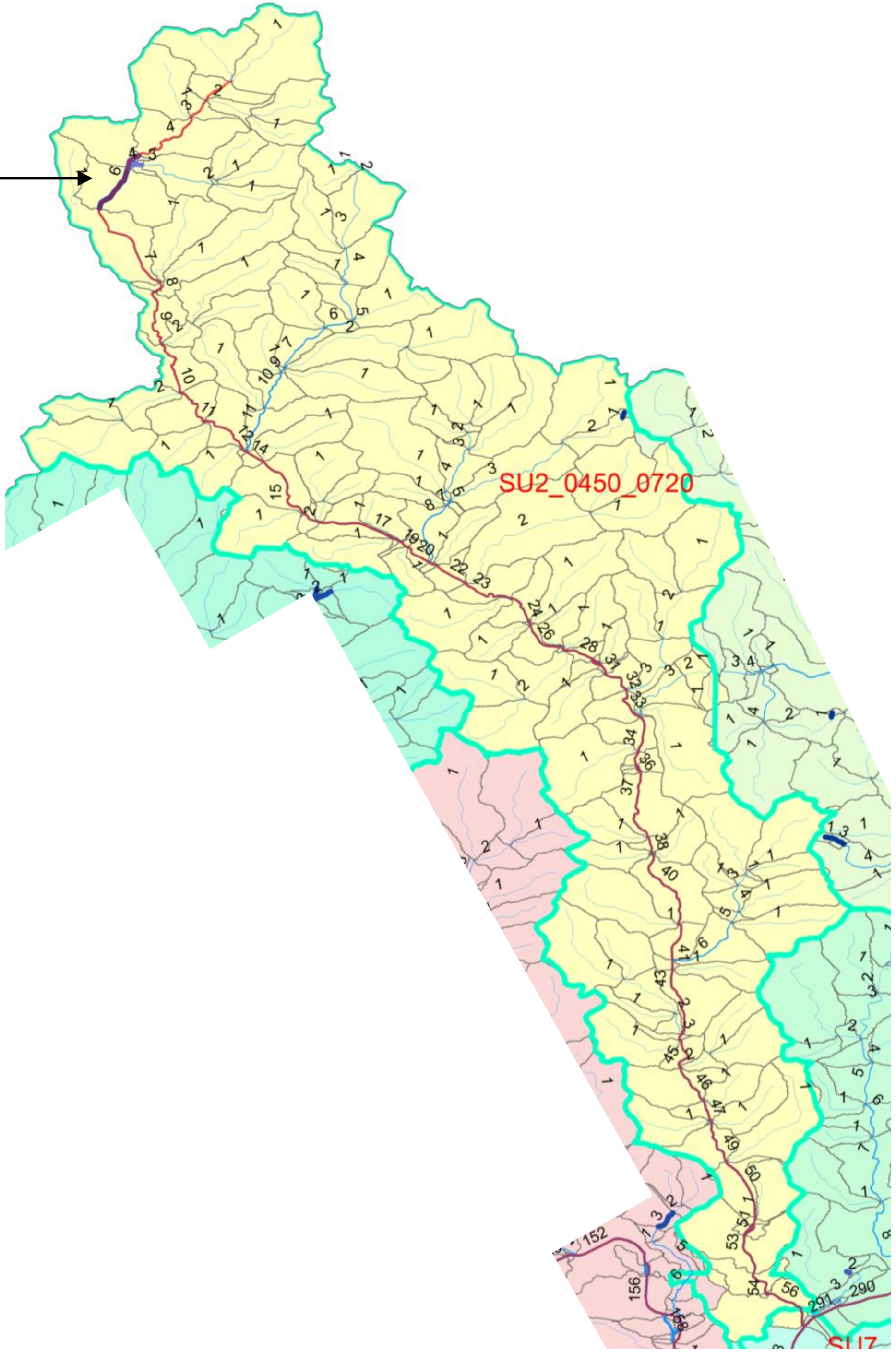
NHD streams

Nested streams & rivers, Hybrid WQ simulation (right now)

Nested streams & rivers, Hybrid WQ simulation (maybe ideal; proposed)

Model Verification: CalCAST vs. DWM



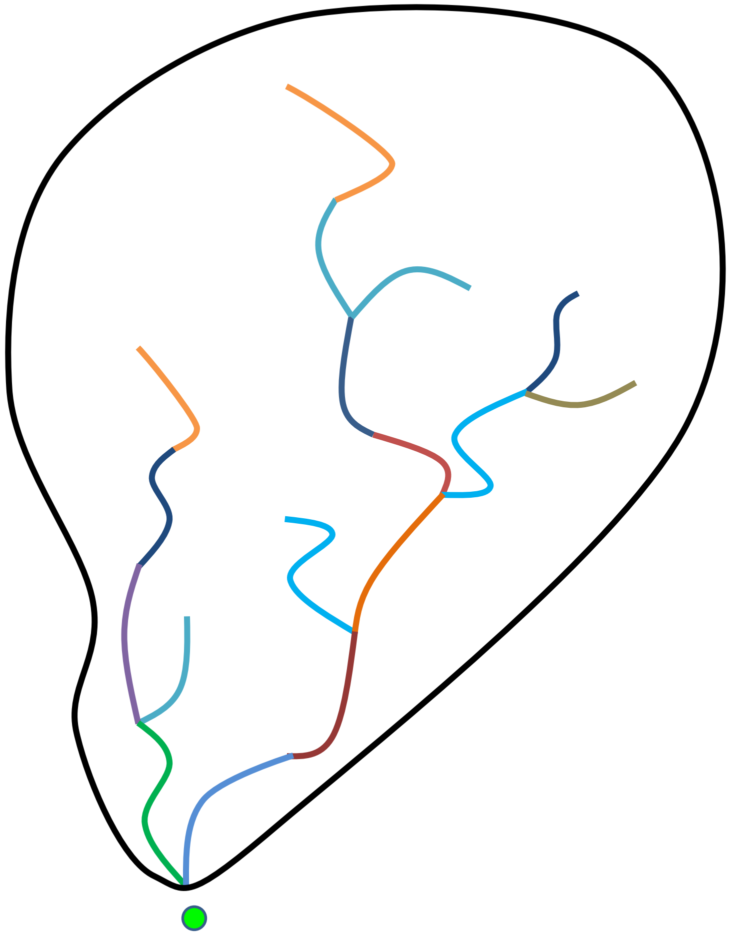


Extended delineation of main stem causes “aggregation effect”

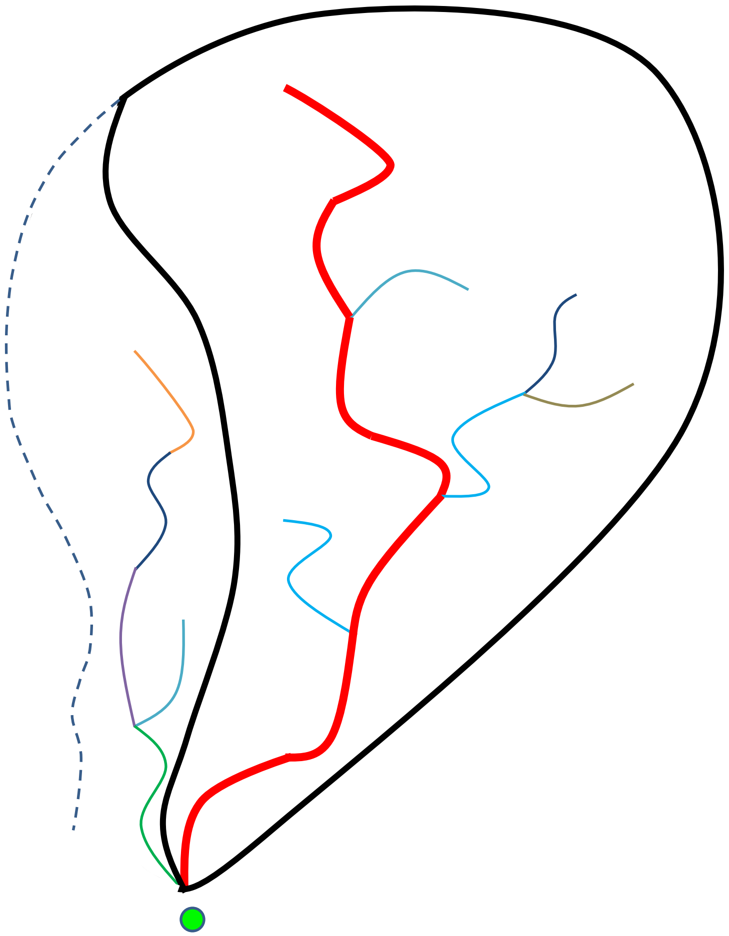
2. Model Verification: CalCAST vs. DWM

ISSUE #2

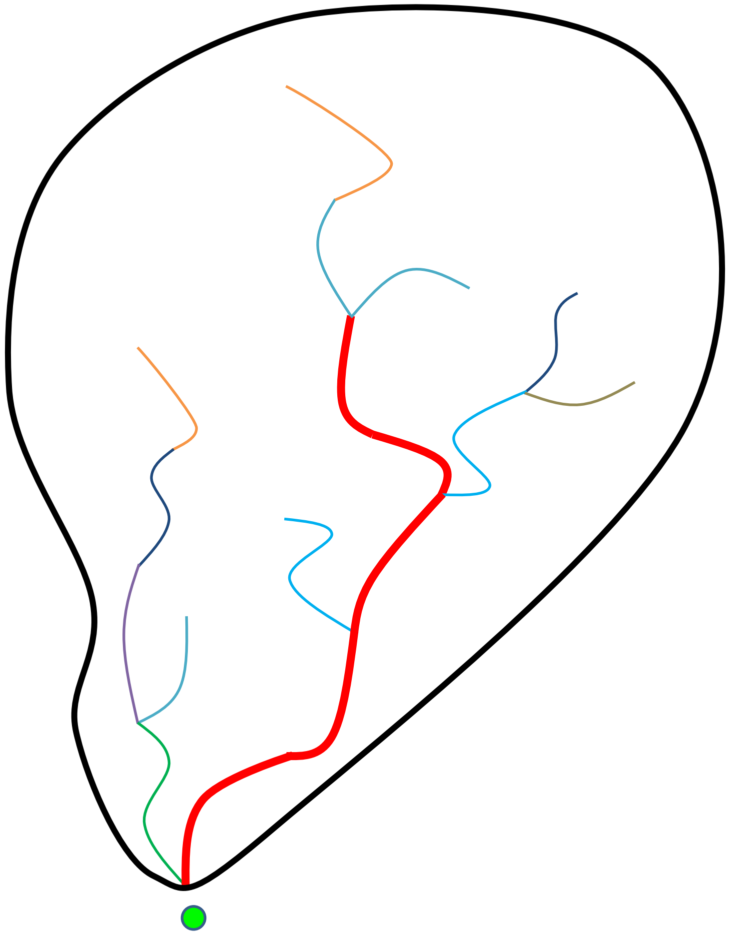
Sub-watershed delineation: DWM vs. CalCAST stats



NHD streams

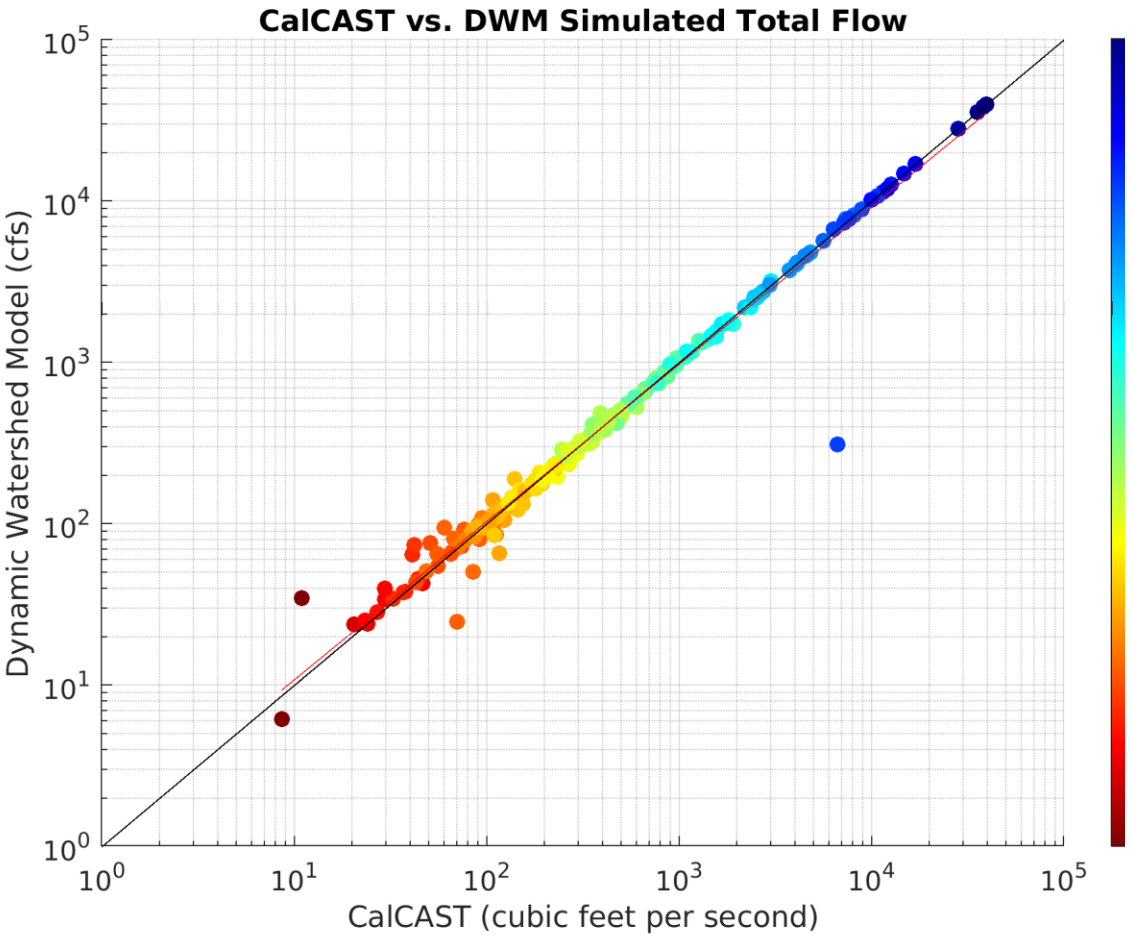


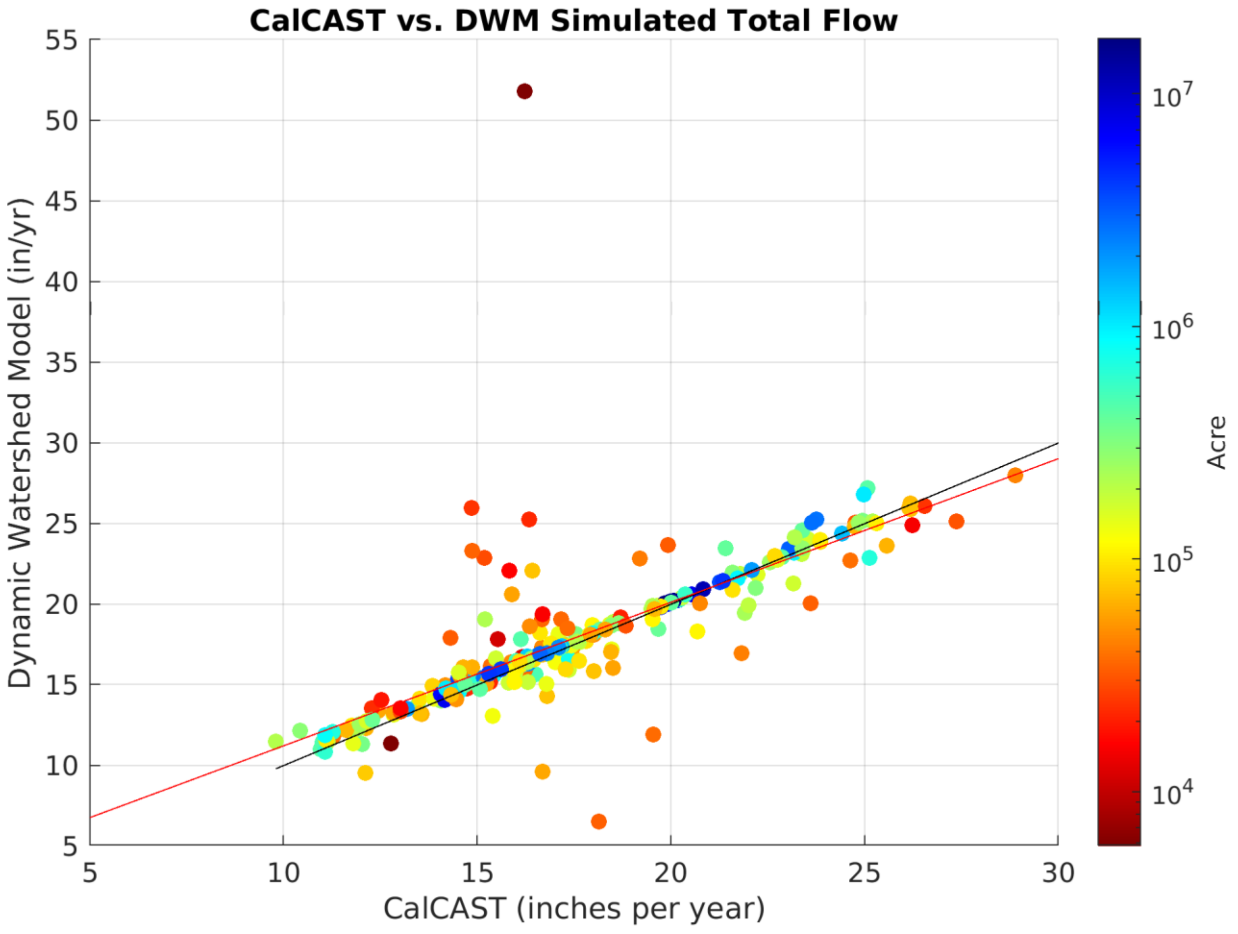
Nested streams & rivers, Hybrid WQ simulation
(right now)



Nested streams & rivers, Hybrid WQ simulation
(maybe ideal; proposed)

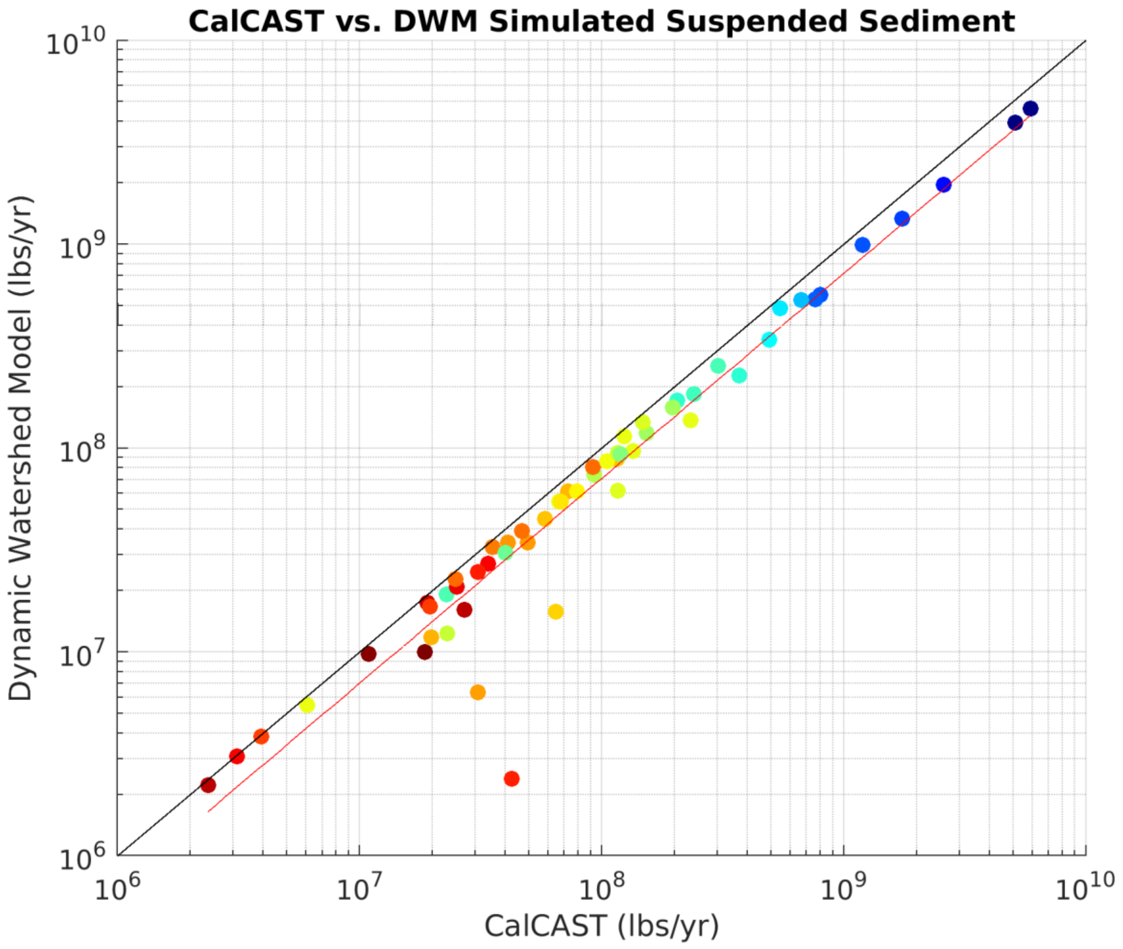
CalCAST vs. DWM: Flow

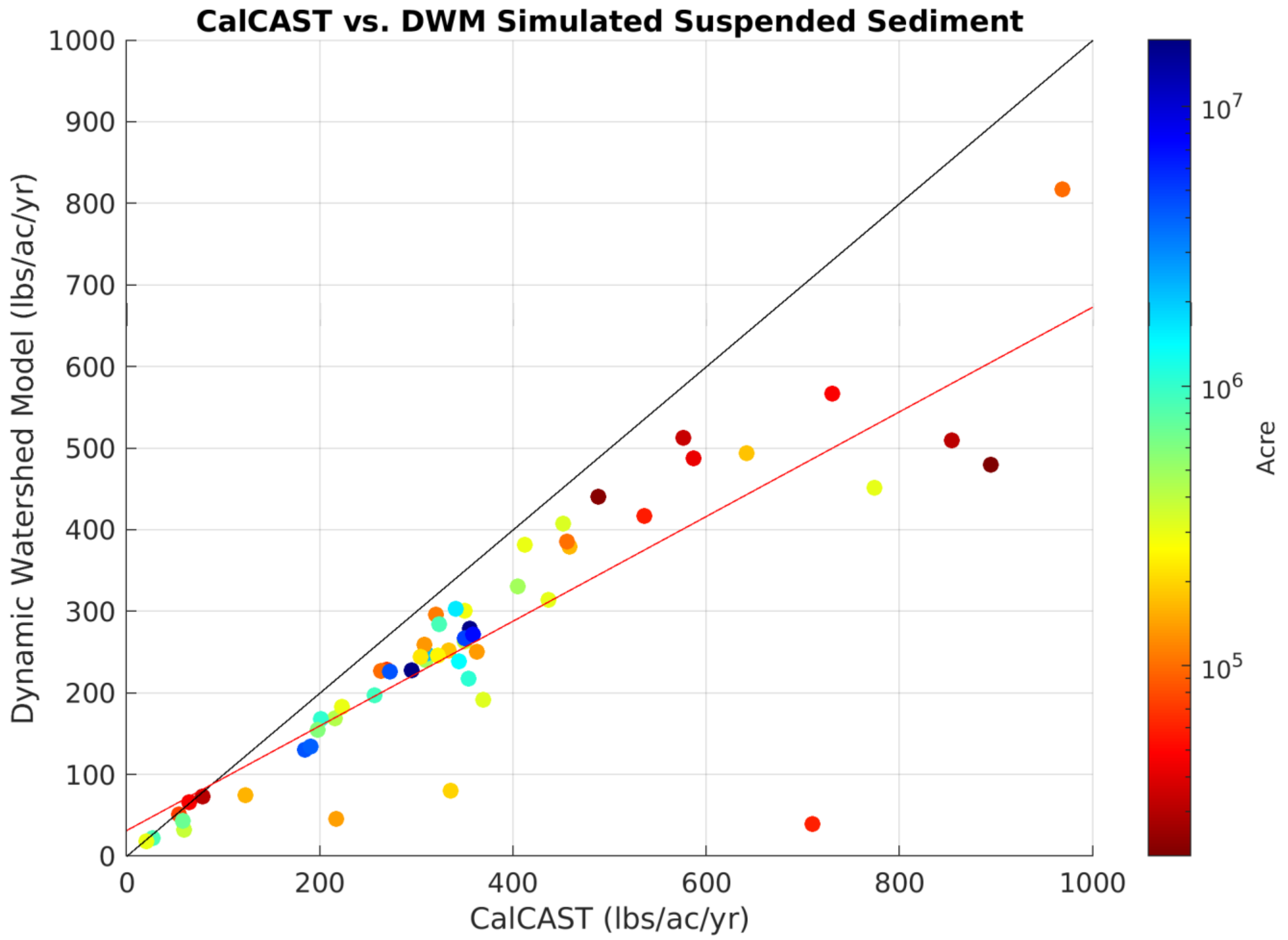




Plot features special CalCAST and DWM model runs without point source of surface water withdrawal.

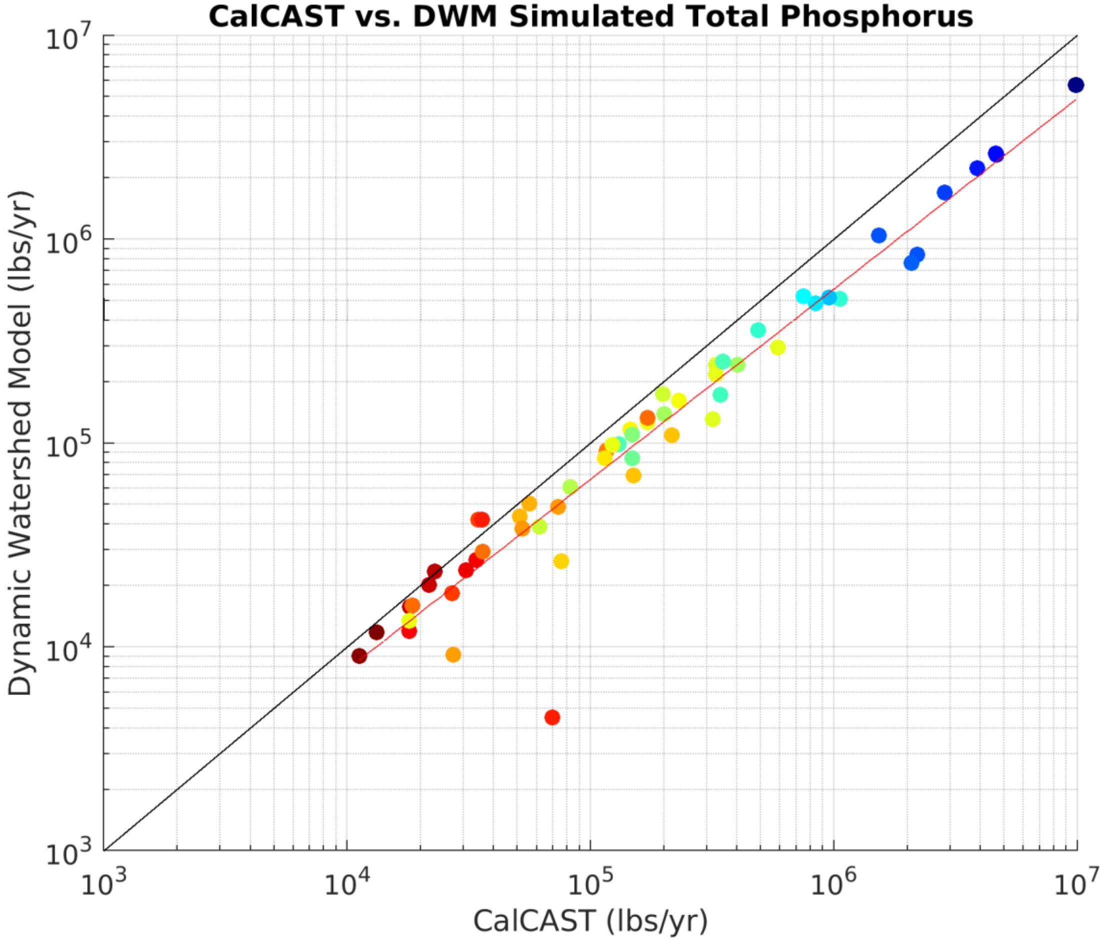
CalCAST vs. DWM: Sediment

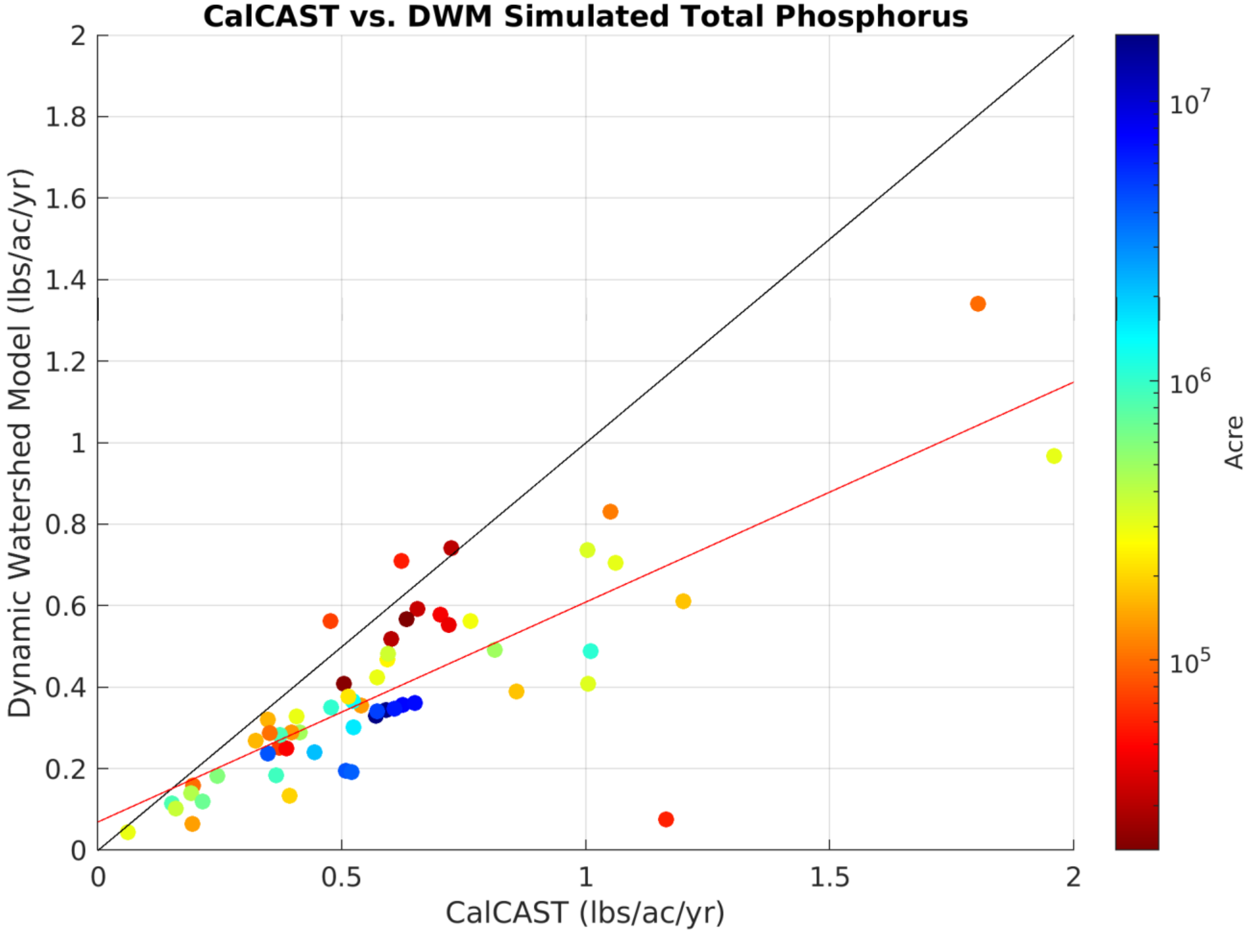




The aggregation effect may explain a certain portion of the differences that we see here.

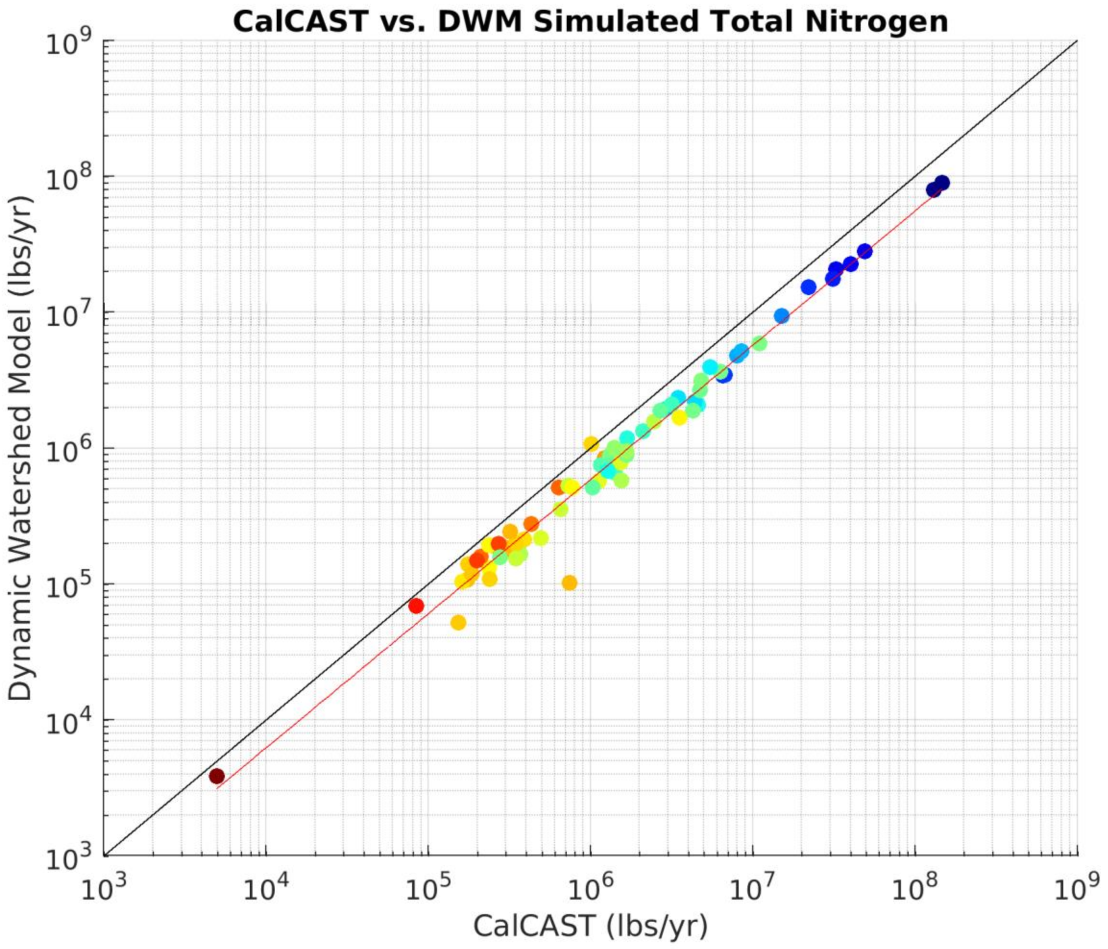
CalCAST vs. DWM: Phosphorus

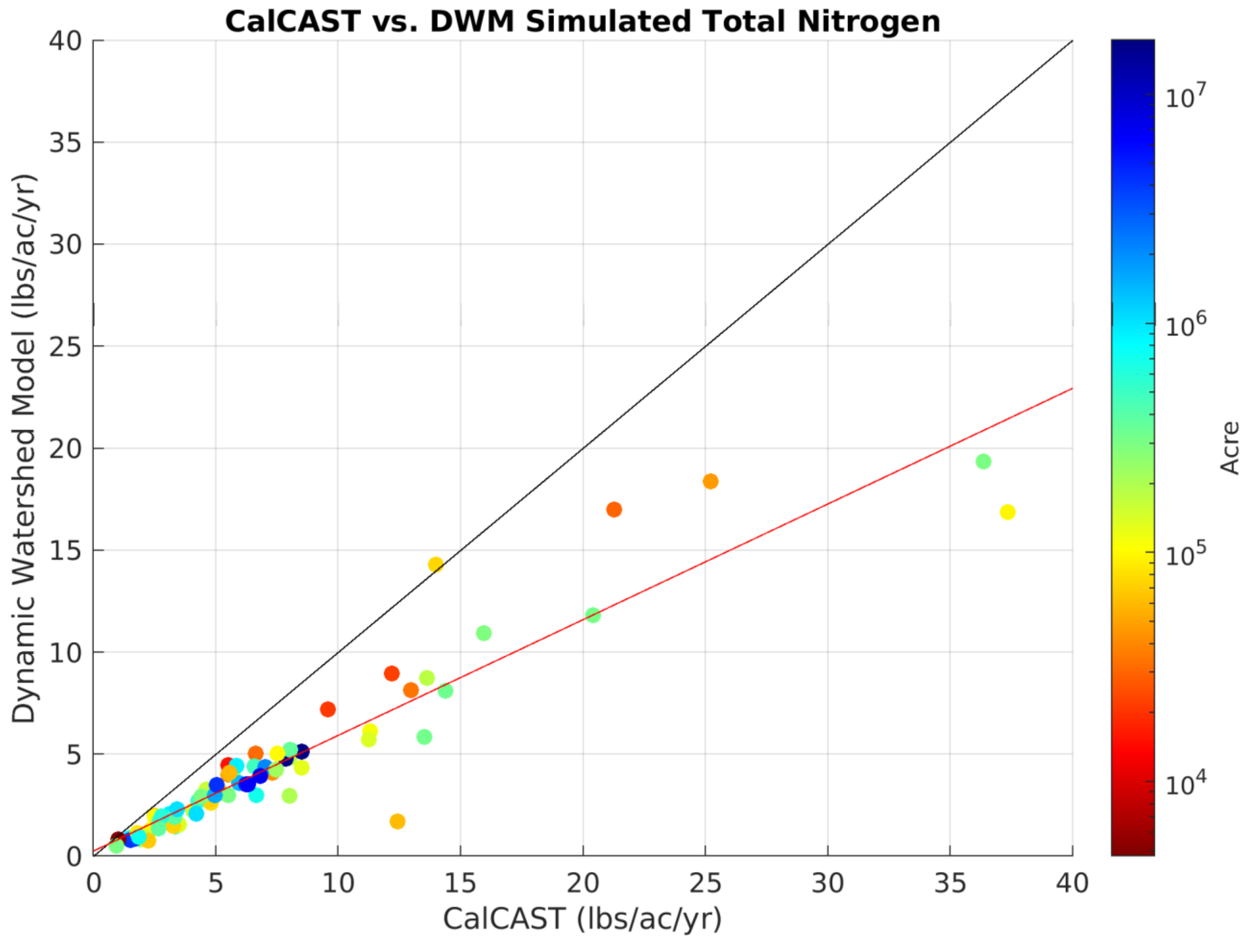




The aggregation effect may explain a certain portion of the differences that we see here.

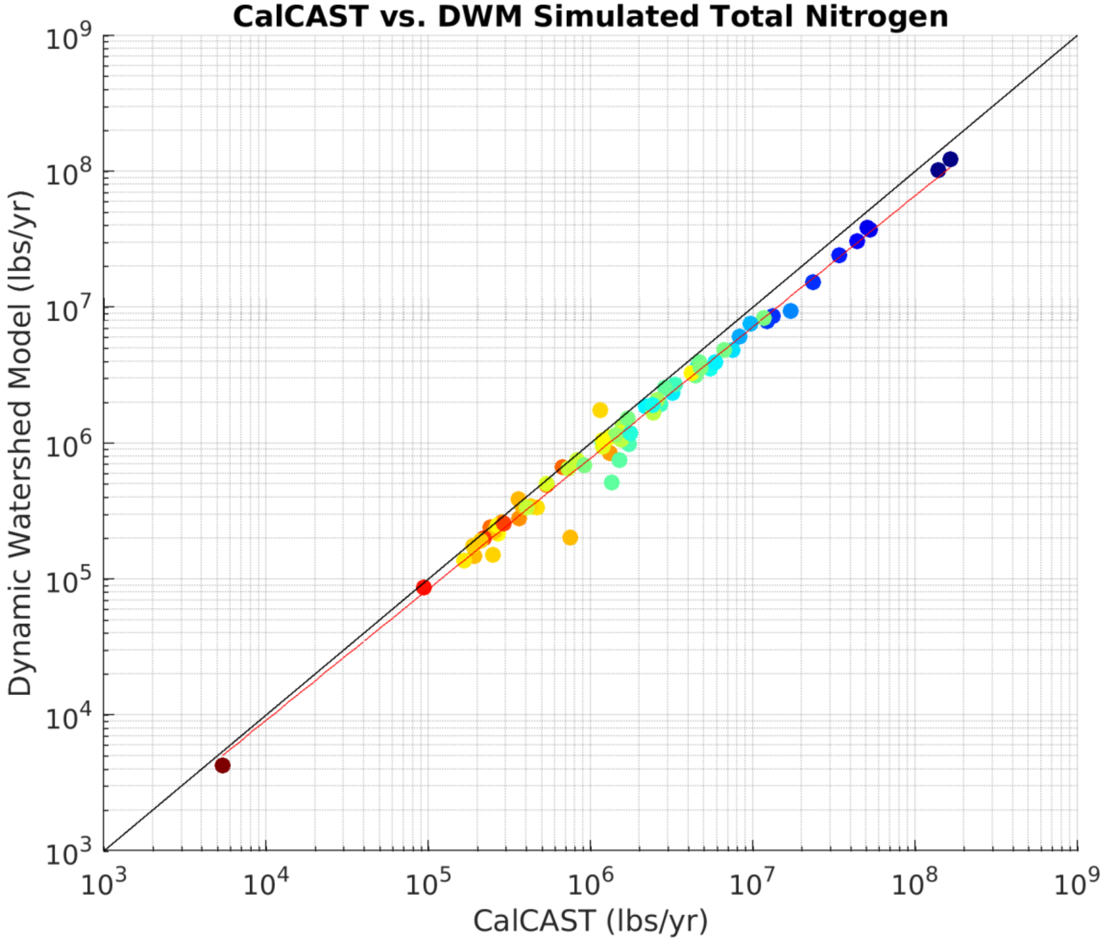
CalCAST vs. DWM: Nitrogen

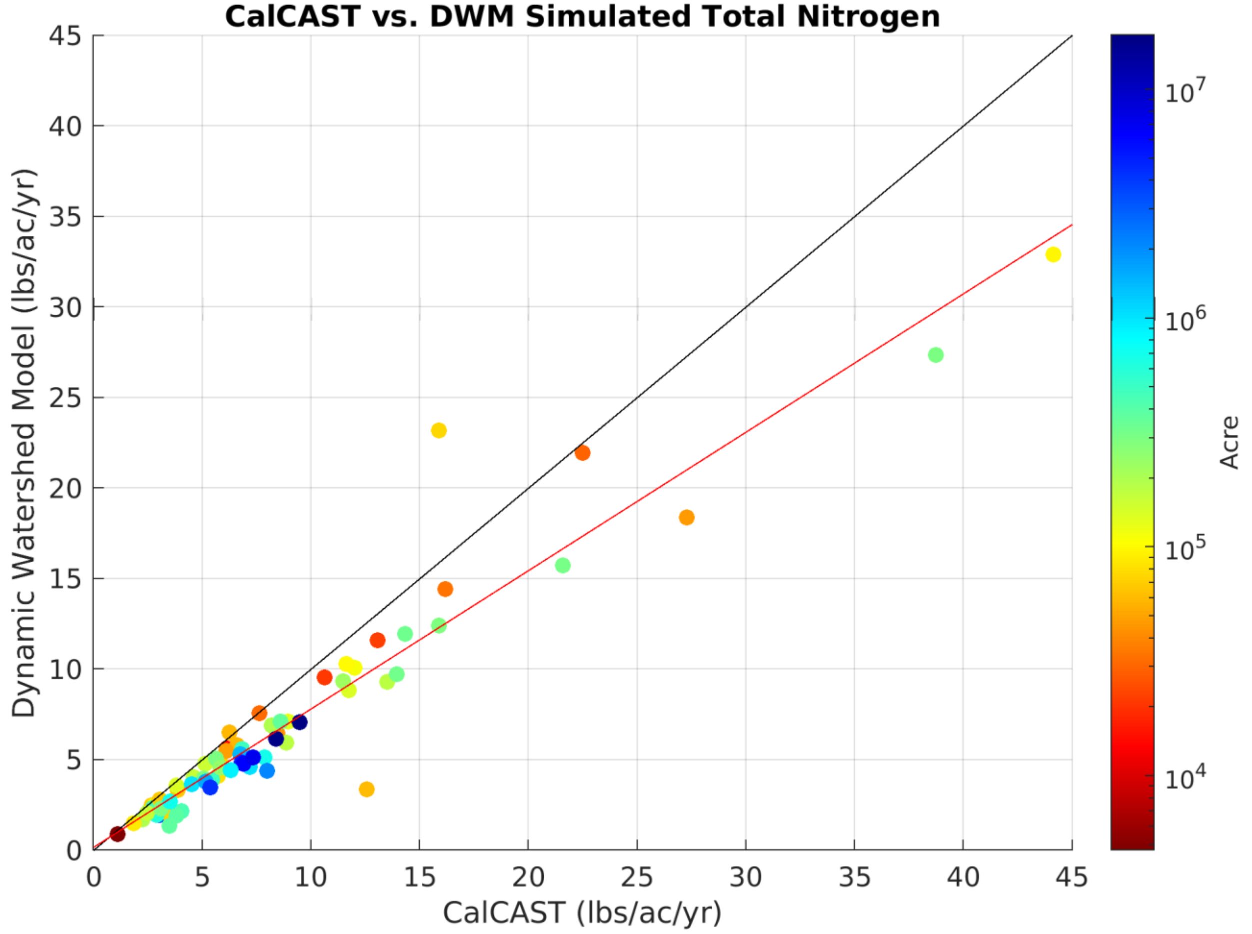




The aggregation effect may explain a certain portion of the differences that we see here.

CalCAST vs. DWM: Nitrogen (without aggregation effect, i.e., TF = 1)





This features special CalCAST and DWM model runs with 100% passthrough or no attenuation in large rivers.

3. Computational Requirements

Model runs are made of AWS Cloud HPC with 144 compute cores

	Model Run	Calibration
Hydrology (CalCAST Flow)	4 Hours	55 Hours
Hydrology (CalCAST Flow and Stormflow)	4.5 Hours	66 Hours
Hydrology & Sediment	11 Hours	?
Hydrology, Sediment, Nutrients, Water Temperature, Dissolved Oxygen, Carbon	288 cores **29 Hours**	?

Aggregation of loads from land-uses took the most time, ~ 8 hours.

~ 3 TB

We expect land use will change from 12 to something else.

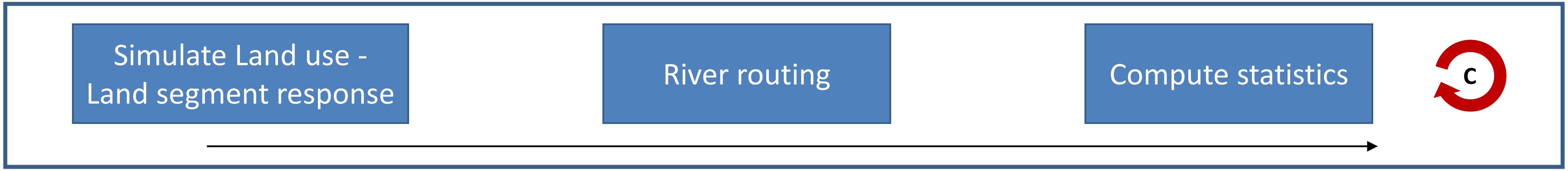
Sediment added 3 model variables (i.e., sand, silt, clay). Now we have a total of 22 variables.

4. Next Steps

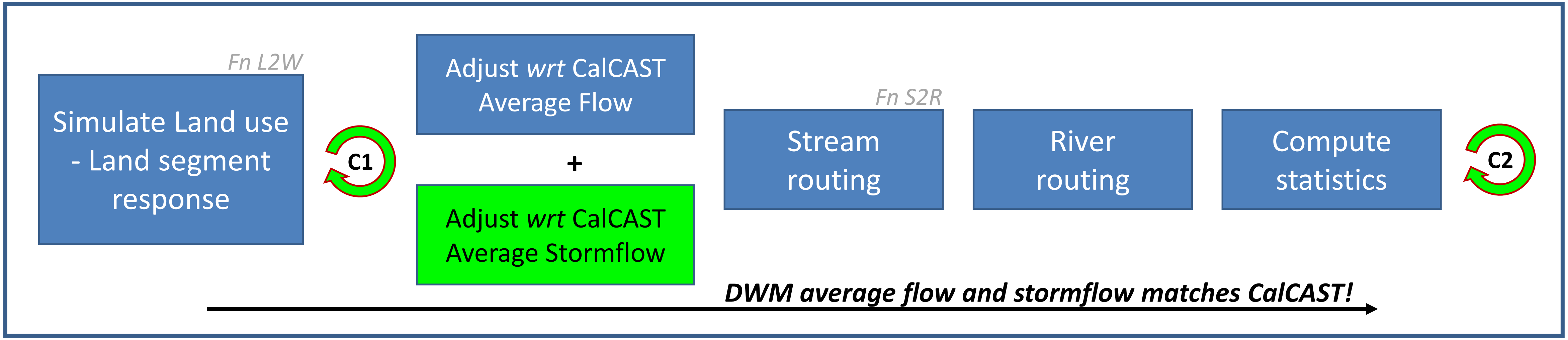
- **An update is needed for the model segmentations**
  - **grouping of the streams for river simulation**
  - **sub-watershed delineation (with new shoreline layer)**
- Refine and implement simple routing for water quality simulation of streams (with draft channel properties)
- Update and expand water quality data inventory
- Revisit and revise water quality calibration methods
- Steps for including additional monitoring stations in the DWM calibration and verification
- considerations of lag times
- aspects of nutrient surface and groundwater split and speciation

Hydrology Calibration Method

PHASE 6: HYDROLOGY CALIBRATION

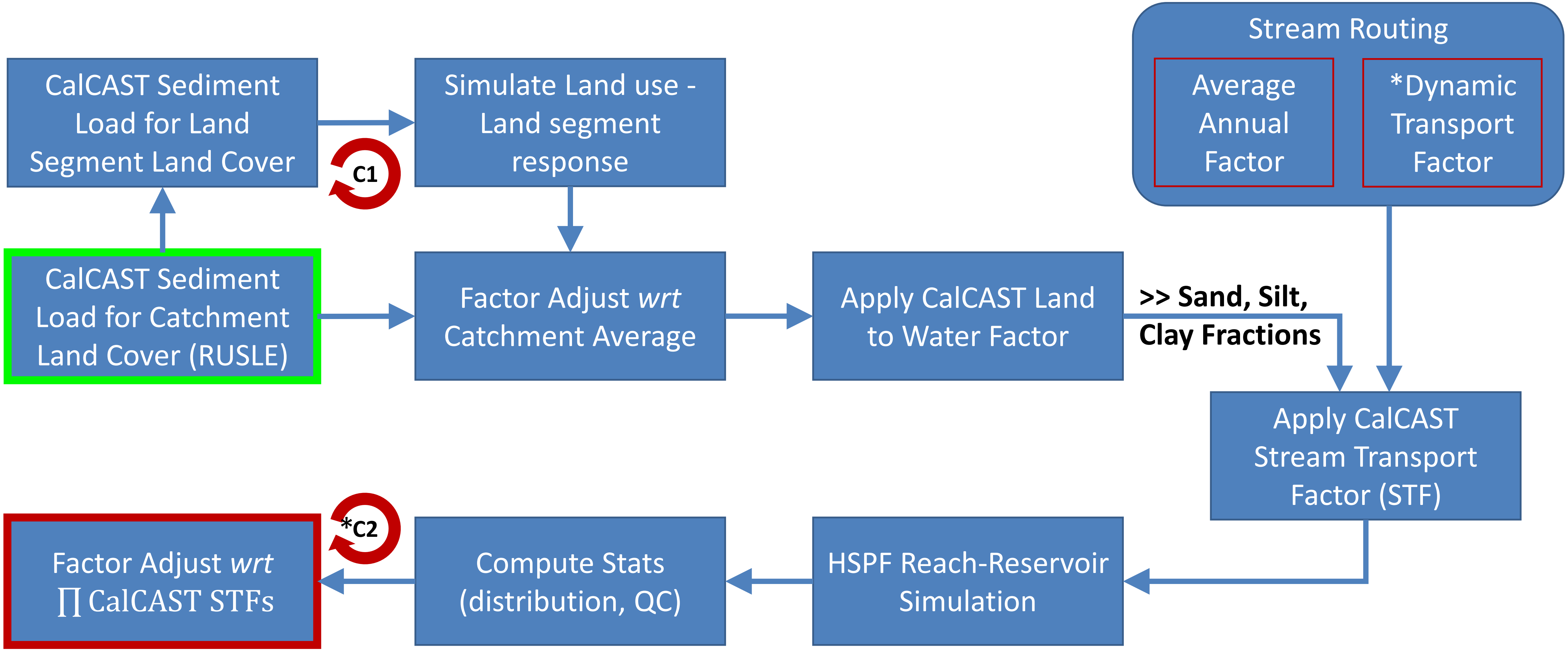


PHASE 7: PROPOSED DWM HYDROLOGY CALIBRATION



Can we improve DWM hydrology in addition to new data from CalCAST?

NHD Scale Sediment Model Structure



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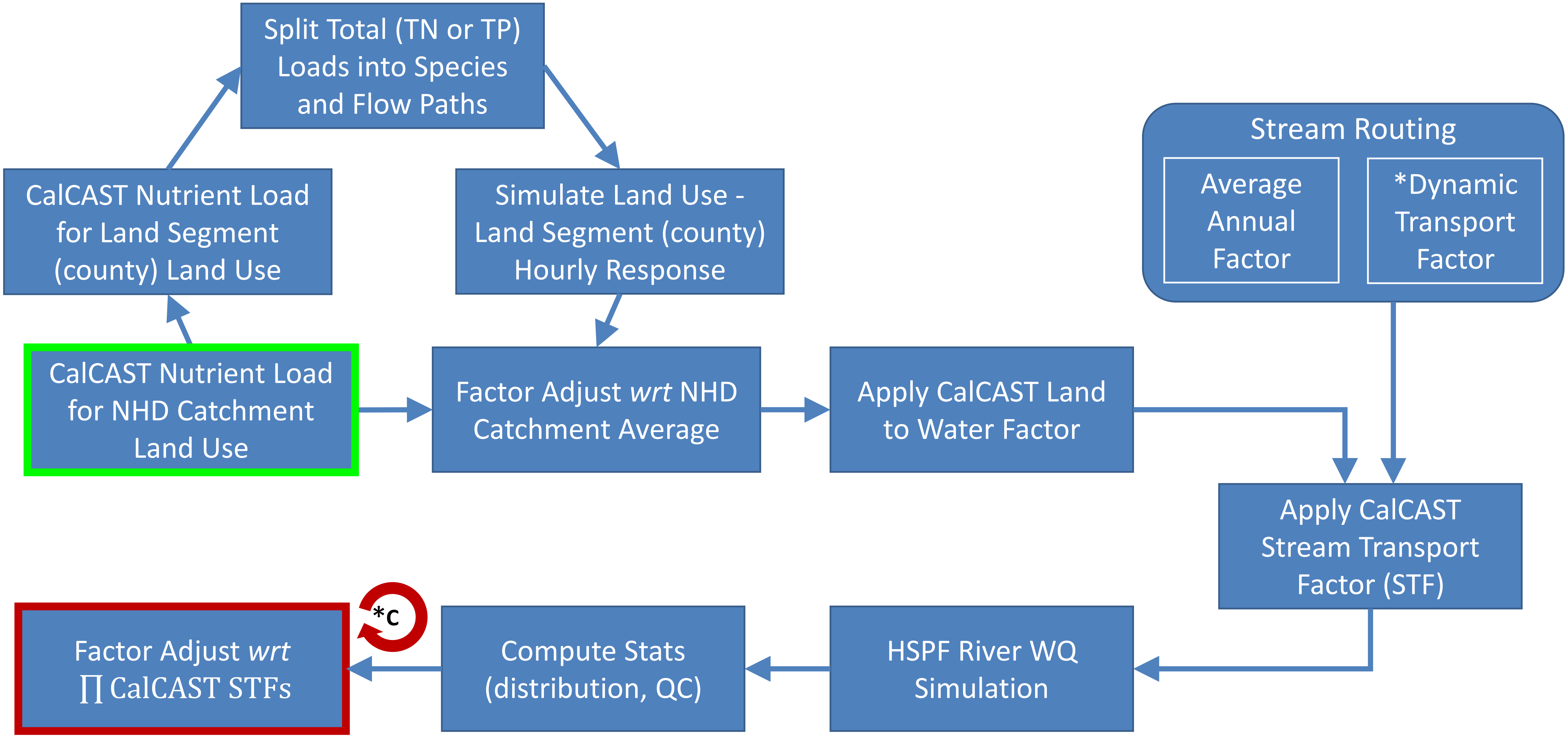
NHD Scale Nutrient Model Structure



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ISSUE #2
Sub-watershed delineation: DWM vs. CalCAST stats