Watershed Modeling Workplan Options

Gary Shenk – CBPO

10/5/2021

MWG

2025

- Midpoint Assessment – Agreed to a reassessment of climate change through 2035
- TMDL – Agreed to full implementation of WIPs that meet planning targets
- TMDL accountability framework – 2024-2025 milestones

New Planning Targets?

- PSC 2018 - “The jurisdictions’ Phase III WIP nitrogen and phosphorus planning targets will remain unchanged through 2025, recognizing that the PSC reserves the right to revisit this decision if necessary.”

- This decision indicates the possibility of planning target changes in 2025, but not the inevitability.

Climate adjustment to planning targets

- Yes, almost certainly

			2018 Planning Targets approved by PSC		2019 Planning Targets with Exchanges and Sediment			2020 Climate Adjustments		2020 Planning Targets with Climate	
Major	State										
Major	State	StateBasin	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Sediment	Nitrogen	Phosphorus	Nitrogen	Phosphorus
Potomac	DC	DC Potomac	2.42	0.130	2.42	0.130	41.9	0.01	0.001	2.42	0.129
Eastern Shore	DE	DE Eastern Shore	4.55	0.108	4.55	0.108	26.7	0.04	0.003	4.51	0.105
Eastern Shore	MD	MD Eastern Shore	15.21	1.286	15.60	1.290	2903.4	0.37	0.032	15.23	1.258
Patuxent	MD	MD Patuxent	3.21	0.301	3.21	0.300	437.7	0.11	0.019	3.09	0.281
Potomac	MD	MD Potomac	15.30	1.092	15.80	1.090	1928.0	0.21	0.033	15.59	1.057
Susquehanna	MD	MD Susquehanna	1.18	0.053	1.60	0.050	113.8	0.14	0.007	1.46	0.043
Western Shore	MD	MD Western Shore	10.89	0.948	9.63	0.950	2959.9	0.31	0.020	9.32	0.929
Susquehanna	NY	NY Susquehanna	11.53	0.587	11.53	0.587	532.7	0.40	0.044	11.13	0.543
Eastern Shore	PA	PA Eastern Shore	0.45	0.025	0.46	0.022	27.4	0.05	0.005	0.41	0.017
Potomac	PA	PA Potomac	6.11	0.357	6.14	0.338	295.5	0.04	0.008	6.11	0.330
Susquehanna	PA	PA Susquehanna	66.59	2.661	66.87	2.544	1838.2	1.72	0.082	65.14	2.462
Western Shore	PA	PA Western Shore	0.02	0.001	0.02	0.001	0.3	0.00	0.000	0.02	0.001
Eastern Shore	VA	VA Eastern Shore	1.43	0.164	1.83	0.152	473.3	0.01	0.000	1.82	0.152
James	VA	VA James	25.92	2.731	21.81	2.241	2015.2	0.30	0.143	21.51	2.097
Potomac	VA	VA Potomac	16.00	1.892	16.51	1.823	1929.7	0.56	0.073	15.95	1.750
Rappahannock	VA	VA Rappahannock	6.85	0.849	7.09	0.819	1505.1	0.54	0.102	6.54	0.717
York	VA	VA York	5.52	0.556	5.71	0.548	949.1	0.17	0.018	5.54	0.530
James	WV	WV James	0.04	0.005	0.05	0.006	13.0	0.00	0.000	0.05	0.006
Potomac	WV	WV Potomac	8.18	0.427	8.18	0.427	595.9	0.00	0.008	8.18	0.418

Completely new planning targets?

- A new watershed model or new calibration of phase 6
- A demonstration by the new estuarine model that the current planning targets are insufficient to meet water quality standards or excessive in their protection
- A change in the equity rules governing the planning target calculation.

All Other
WWTP

TN, p5.3, goal=190, WWTP = 4.5-8 mg/l, other: max=min+20%

Percent reduction from 2010 noBMPs to E3

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%

0 1 2 3 4 5 6 7 8 9 10

Relative Effectiveness

4.5 mg/l

Wastewater Loads

All other sources

8 mg/l

20 percent slope

Allocation Method Agreed to by Majority of Principals' Staff Committee Members

CBP Watershed Modeling Products

	Existing	Long term?
TMDL tracking	CAST6-2017, CAST6-2019… CAST6-2025 CAST is updated for each milestone period. Updates are constrained. 1995 load cannot be changed Modifications can be made that better reflect trends from 1995 through current.	CAST7-2025, CAST7-2027… Phase 7 CAST can incorporate any changes from Phase 6 2-year updates will be similarly constrained
Calibration, Estuarine loading Water supply	P6 Dynamic Model	P7 Dynamic Model

Model Development Schedules

Phase 4
Combined phase 2 and phase 3 functionality
Longer simulation
Recalibration

- 1995 Development
- 1996 Development
- 1997 P4.1 application
- 1998 Development
- 1999 Development
- 2000 P4.3 application

Phase 5
Restructuring,
Resegmentation,
Automated calibration

- 2000 Ideation
- 2001 Development
- 2002-2004 WQS
- 2005 Development
- 2006 Development
- 2007 Development
- 2008 Development
- 2009 Development
- 2010 Review/application

Phase 6
Radical restructuring

- 2011 Ideation
- 2012 Priorities
- 2013 Development
- 2014 Development
- 2015 Development
- 2016 Development
- 2017 Review
- 2018 Apply

Phase 7
???

- 2019 Climate
- 2020 Climate
- 2021 Ideation
- 2022 Development
- 2023 Development
- 2024 Review
- 2025 Apply

2022
Development

2023
Development

2024
Review
Refine

2025
Apply

- WQGIT gives priorities – October 2021

- Modeling team ideas; WQGIT may suggest additional priorities
- Can’t do everything; some may be longer-term projects
- Considered directions, not final decisions
- Will be revisited

2022
Development

2023
Development

2024
Review
Refine

2025
Apply

- WQGIT gives priorities – October 2021
- 2 important questions
  - What are we doing in 2025?
  - What scale
- Four Bins
  - Complete by 2023
  - Continue to work on for a later model
  - Encourage research
  - Partnership does not want this done

Existing Priorities – these are happening

- Land use change 1985-2035
  - Resources in place
  - Use land use directly rather than combining with other data sets
  - Consistent land use from meter-scale through watershed scale
- Estuarine model development (separate document)
  - Much finer scale in shallow water
  - Allow analysis of local influence on water quality
  - Address climate change in the shallows

Potential Areas of Focus	Recommend-ations	Impacts Estuarine Model	Impacts CAST	Level of effort	Benefits
Finer-scale modeling	WQGIT, other GITs, STAC	✓	✓	High	Greater accuracy watershed modeling; Enables fine scale targeting of practices; Needed for some co-benefits
Spatially explicit CAST	Non-CB TMDL partners		✓	Medium	Enables CAST output on a fine scale
Physical process simulation	STAC, WQGIT other GITs, CBPO	✓	✓	Low-High	Greater watershed model accuracy overall
Nutrient Application calculation	CBPO		✓	Medium-High	Increases transparency of CAST scenarios; Reduces unintended consequences of model and data changes
Land use change 1985-2035	CBPO, WQGIT	✓	✓	High	Greater accuracy of land use changes through time. Allows direct use of fine-scale land use data in CAST
Improve climate change modeling	PSC, WQGIT	✓	✓	Low	Directly addresses PSC priorities; improves confidence in 2025 climate decision.
Uncertainty Quantification	WQGIT, STAC			Medium	Helps prioritize model updates; Incorporates trends in monitored data
Co-benefits and ecosystem services	WQGIT, other GITs, STAC		✓	Low-High	Helps partners develop comprehensive plans that benefit local citizens.
WQ standards Assessment	WQGIT, STAC			Low-Medium	Potential to assess all tidal oxygen standards and to delist segments

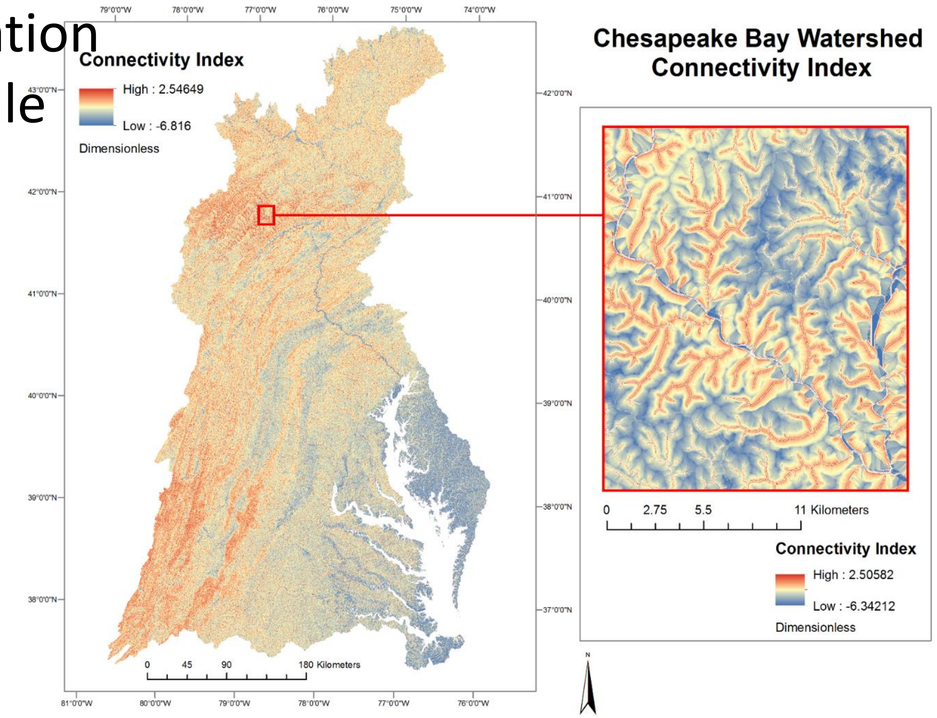
https://www.chesapeakebay.net/channel_files/41830/watershed_modeling_workplan_options_for_2025_v2021_08_26_clean.pdf

To be prioritized

- Scale Topics
  - Finer-scale modeling – changing scale of the underlying model
  - Spatially explicit CAST – Allowing the use of CAST at a user-defined scale
- Process Topics
  - Physical processes – improving the accuracy of nutrient and sediment transport and other important processes.
  - Nutrient applications – improving the process of determining the inputs of fertilizer and manure

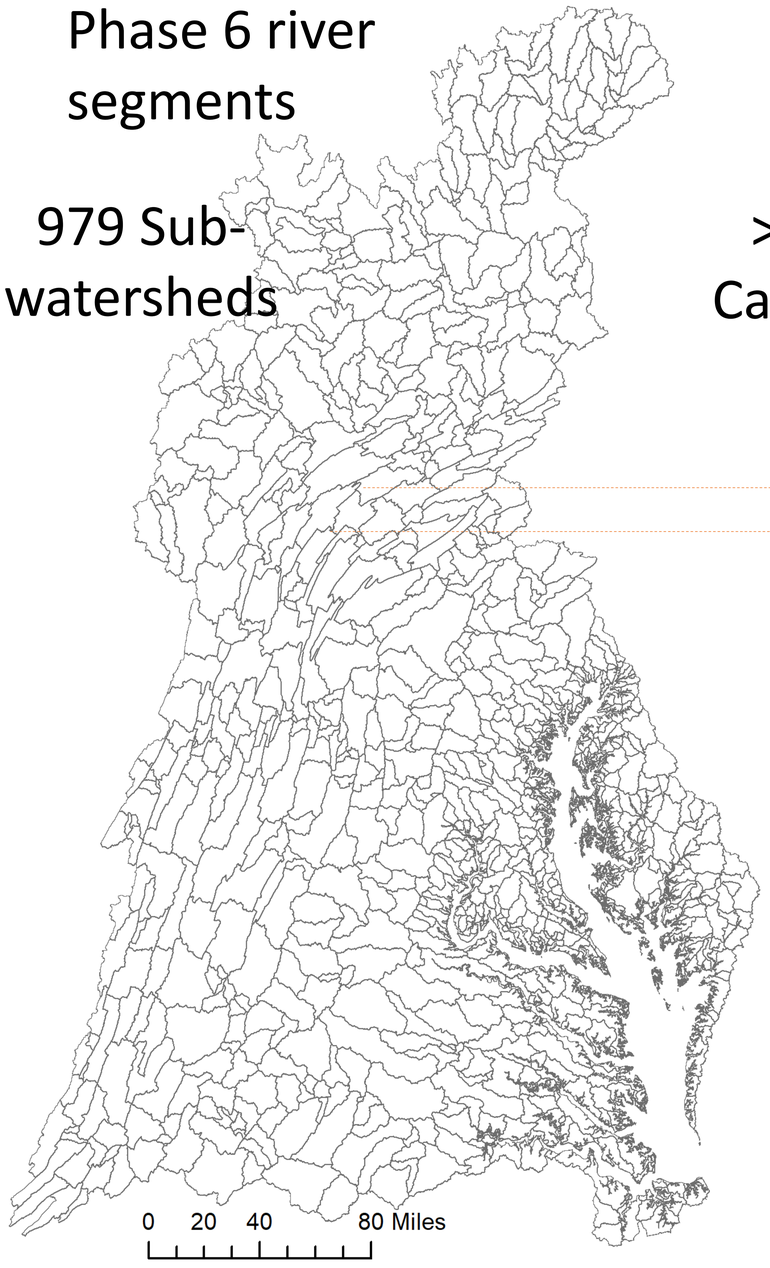
Finer-Scale Modeling

Transport information on a 10-meter scale



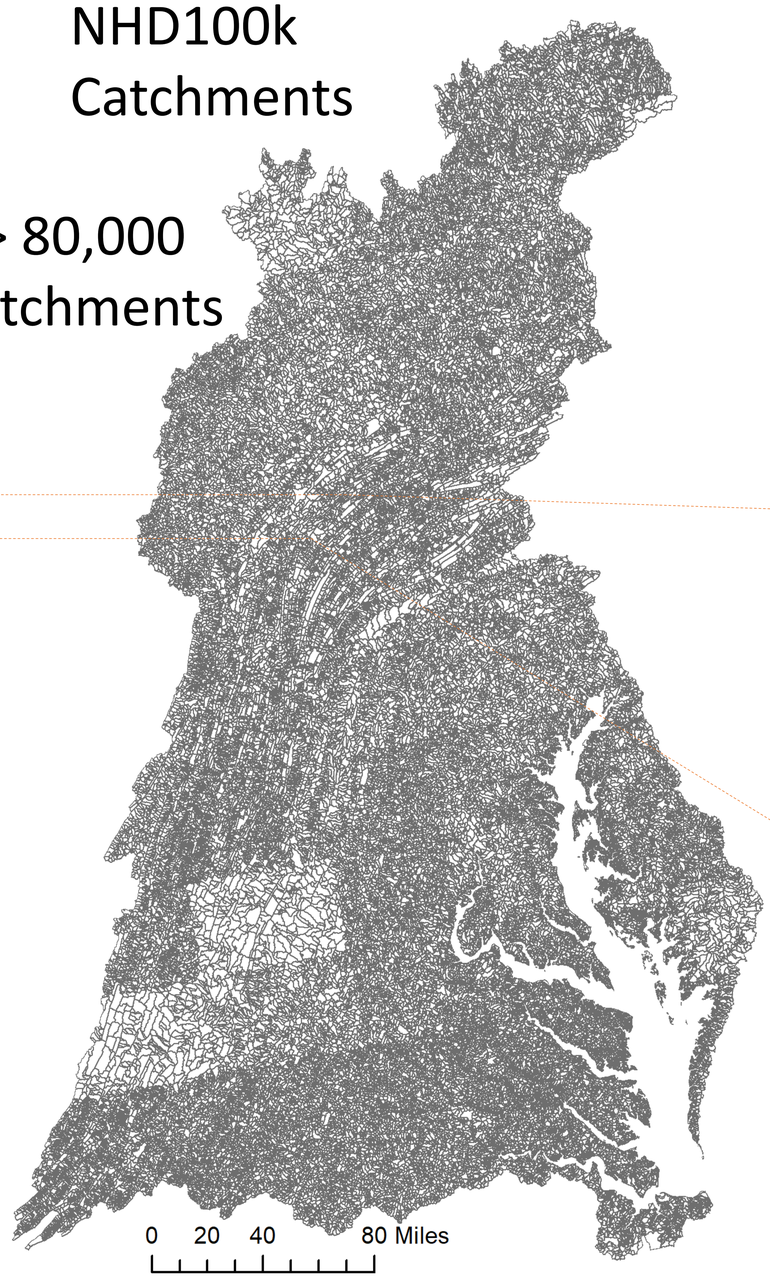
Phase 6 river segments

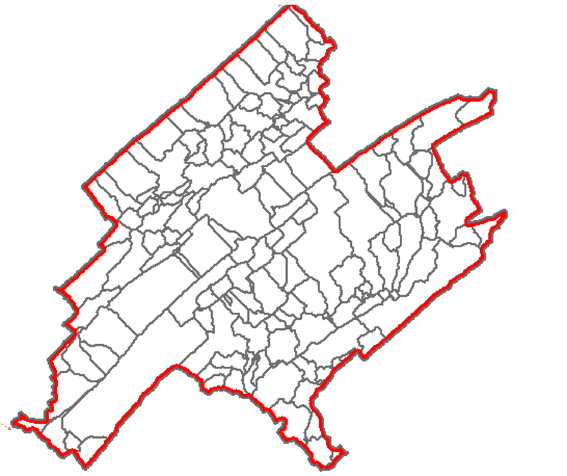
979 Sub-watersheds



NHD100k Catchments

> 80,000 Catchments





0 3.5 7 14 Miles

Greater accuracy watershed modeling; Enables fine scale targeting of practices;
Needed for some co-benefits

To be prioritized

To be prioritized

Full finer-scale proposal

10m Cell

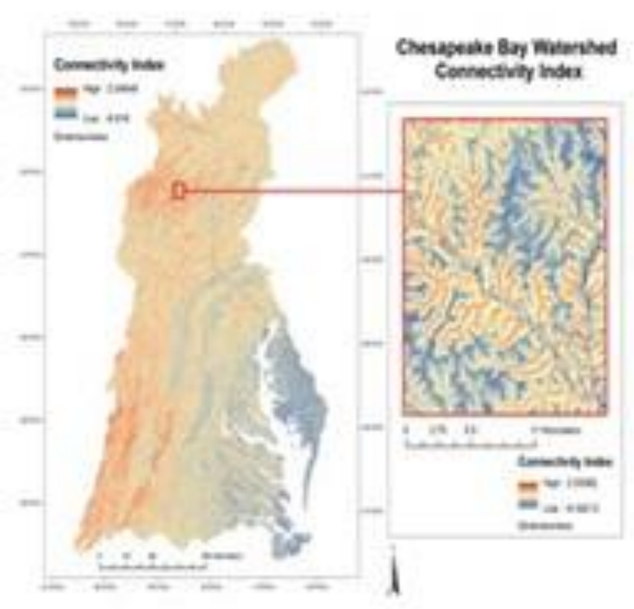
Cellular Model 7

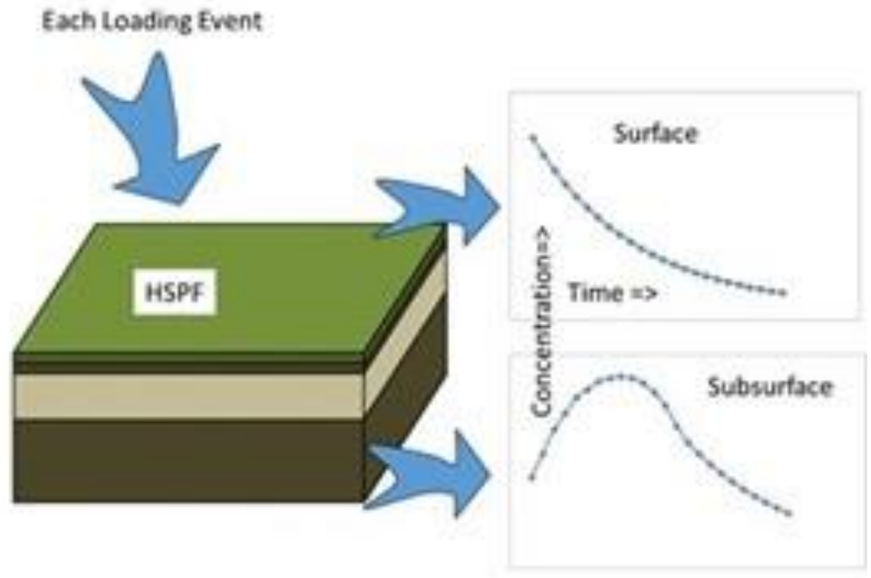
NHD 100k

CAST 7

NHD 100k

Dynamic Model 7





The Cellular model could potentially support BMP targeting

CAST determines CBP official scenario loads

The Dynamic Model temporally downscales CAST results

To be prioritized

Many options

- Watershed delivery factors are already on the NHD100k scale. NHD-scale model could be implemented in CAST with currently available data
- A la carte options
  - Cellular model
  - Dynamic model at the NHD100k scale for hydrology
    - Dynamic model at the NHD100k scale for water quality
    - Gopal Bhatt presentation 10:30am
  - Improvements in calibration
  - Longer simulation time

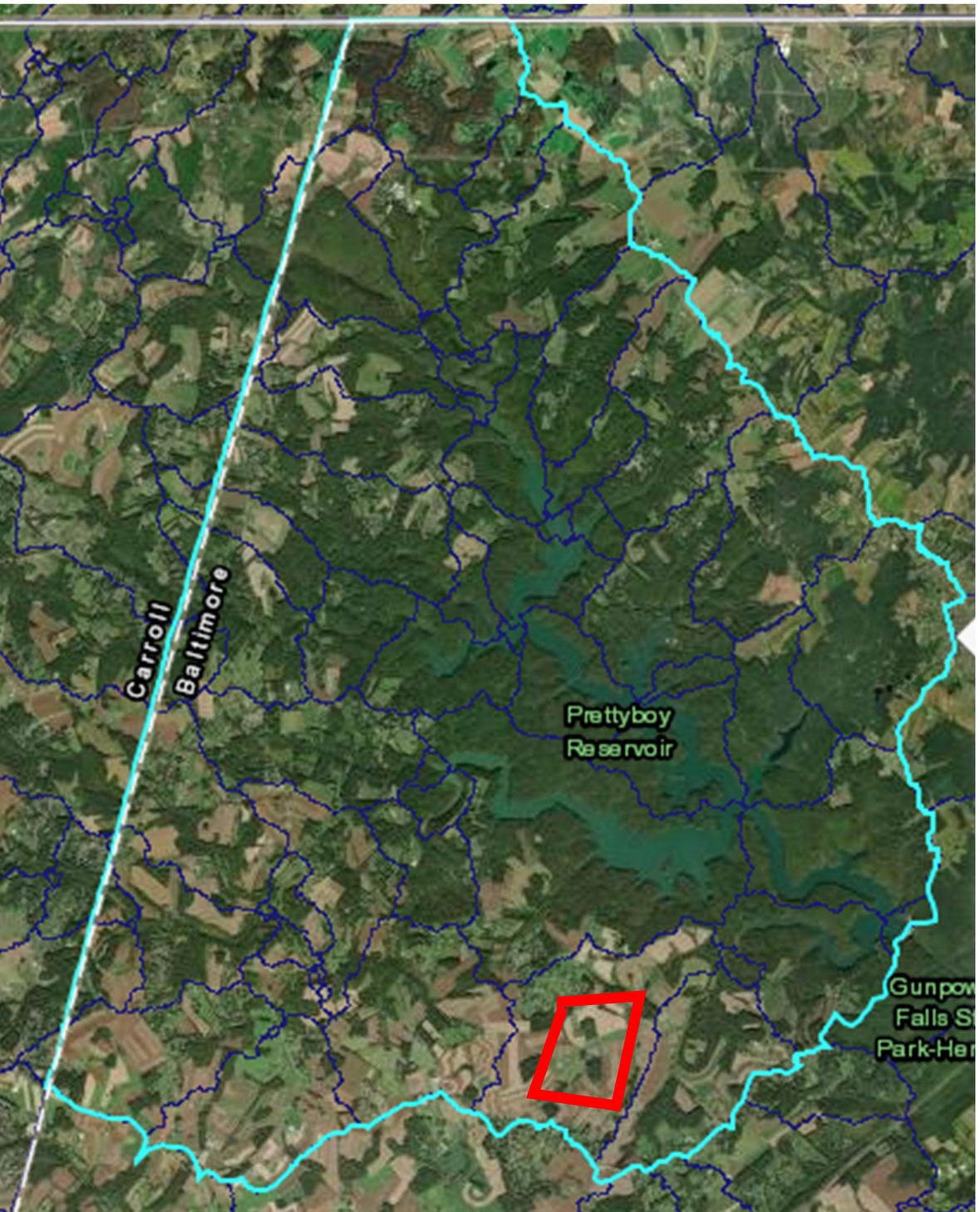
To be prioritized

Fine-Scale modeling – Benefits

- Greater accuracy
  - Increased calibration stations
  - Finer process representation leads to more accuracy at a decision scales
- Enables fine scale targeting of practices for greater management efficiency
- Potentially bring in more local users
- Needed for some co-benefits

To be prioritized

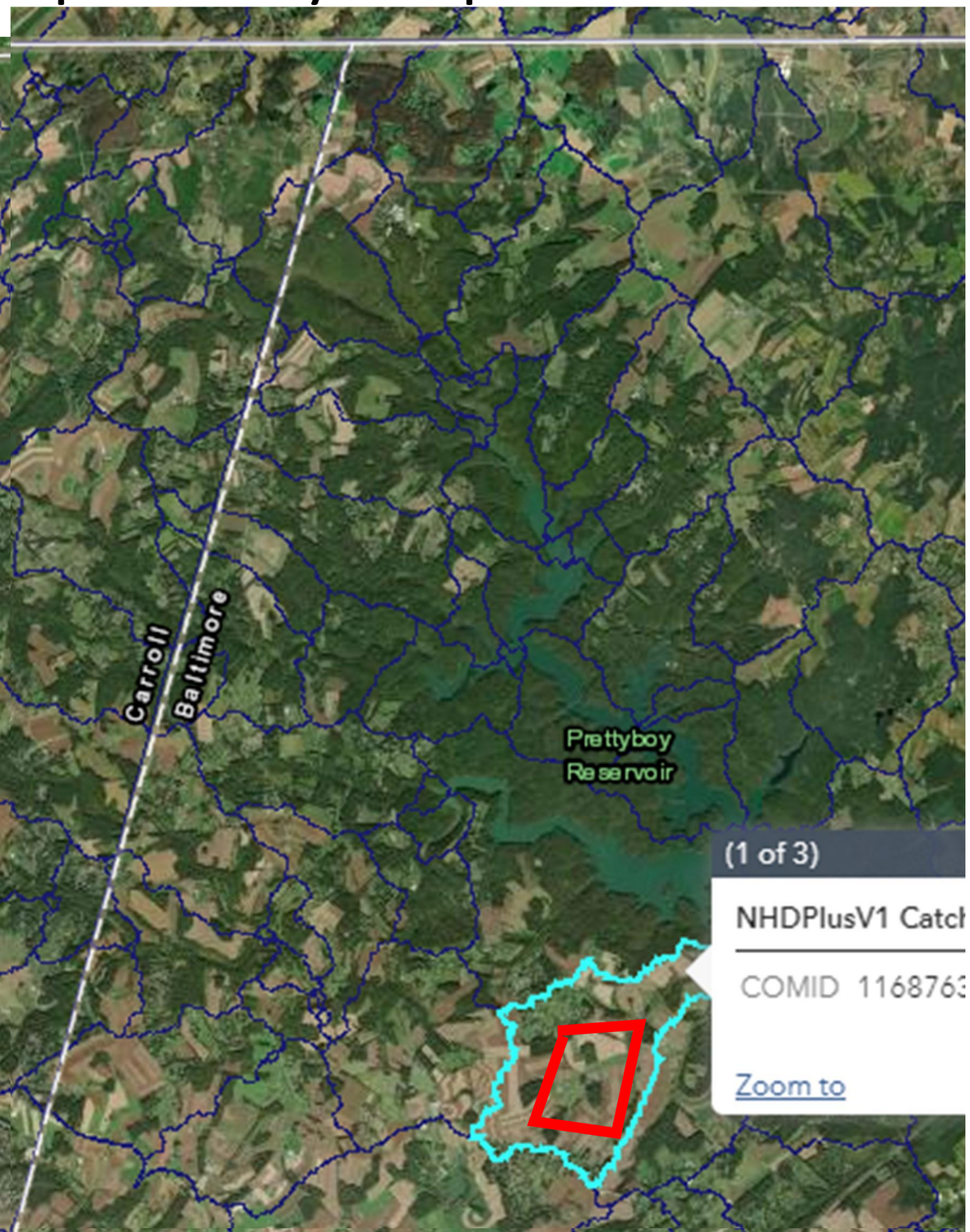
Spatially Explicit CAST



- Allow calculation of load from within user-defined area
- based on **land-river segment** averages applied to the land uses in the area

To be prioritized

Spatially Explicit CAST with Fine-Scale Modeling



- Allow calculation of load from within user-defined area
- based on **NHD or finer segment** averages applied to the land uses in the area

To be prioritized

Physical Process Improvement

- Phosphorus simulation in urban areas
  - Only watershed modeling need identified in the STAR SRS science needs database
- Change in load due to change in input (sensitivities)
- Stream bed and bank loads
  - Partnership wanted them broken out from land use loads for P6
  - Causing some confusion when natural category changes due to management actions in other category.

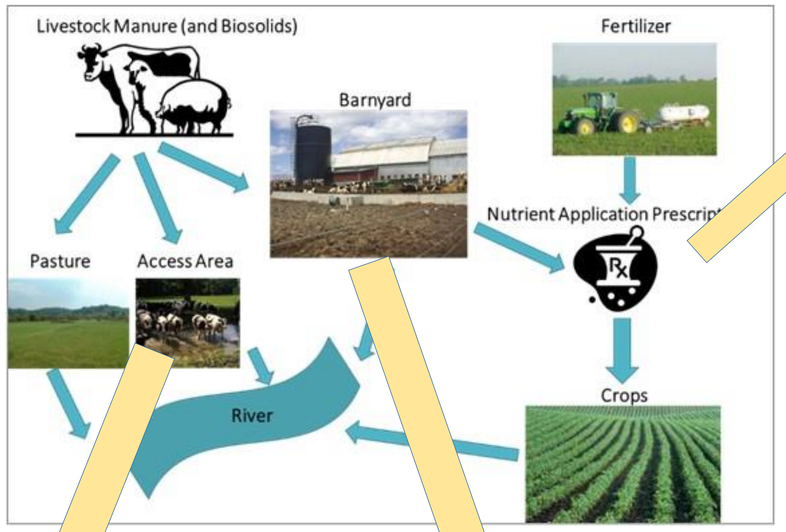
To be prioritized

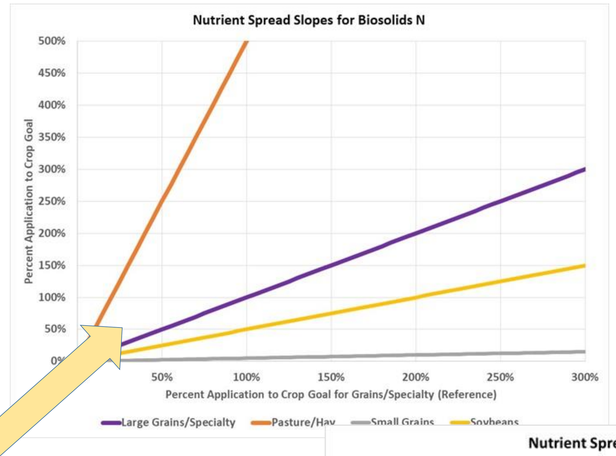
Physical Process Improvement

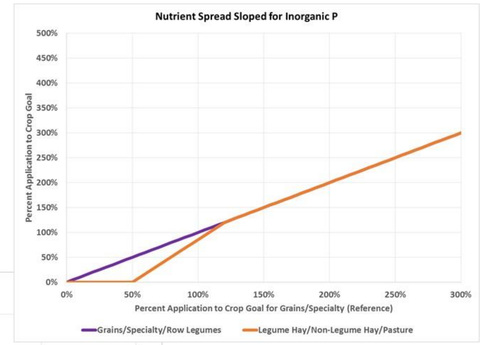
- Temperature simulation at fine scale
  - Impacts co-benefits
- Nutrient speciation
  - Allow for targeting management that reduces inorganics
- Sediment Processes
  - Important for understanding nutrient lag times.
  - Affects health of non-tidal streams

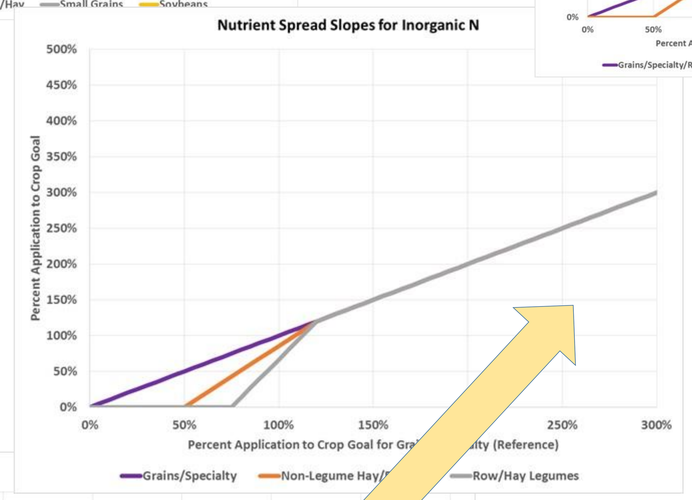
Nutrient Applications

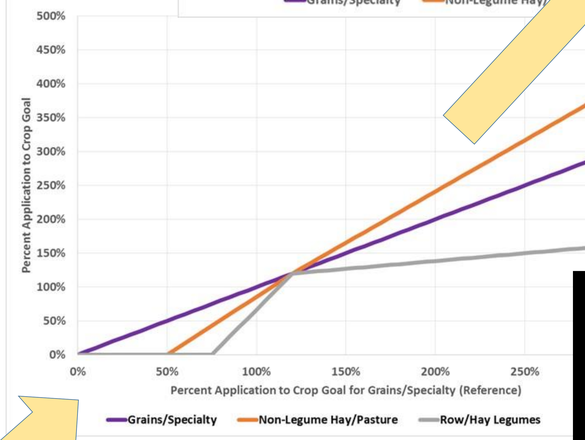
To be prioritized

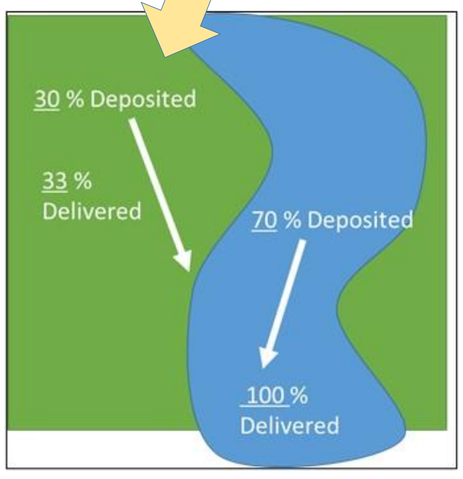


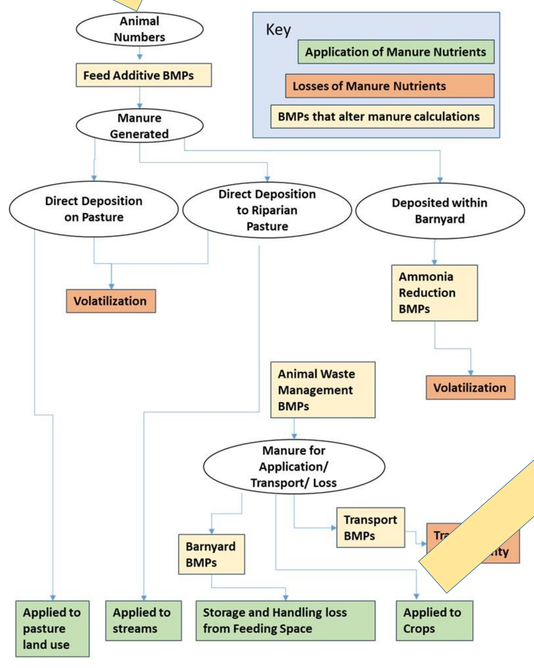


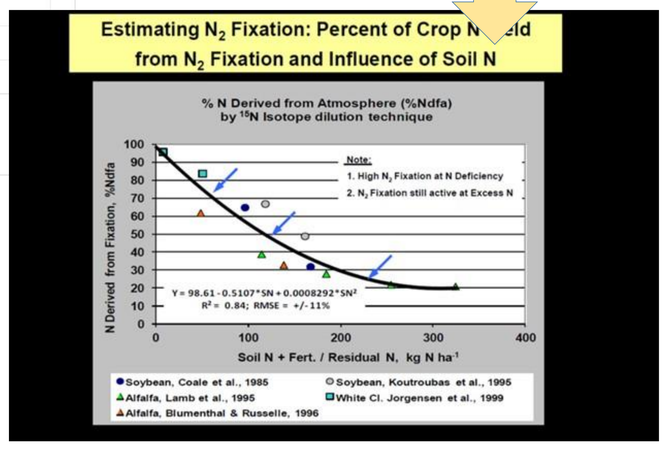












Simulated BMPs vs Percent Reduction

- **Which Description Works Best for Management?**
- **What's my reduction from Nutrient Management?**
  - Well, based on the rules developed by the partnership and the data supplied by national sources and the states, the balance of inputs and outputs for your land use is such that there is an overabundance of manure in your county, as opposed to the next county over where nutrient management has almost no effect. Now when you apply nutrient management, that will attract manure to the nutrient management land use, so it will have a higher load, but since it's pulling manure from other land uses, the total segment load will usually decrease, however in some circumstances when nutrient management is applied to pasture, it can push so much manure back on to other land uses, that the marginal effect …
- **What's my reduction from Cover Crops?**
  - Based on the Cover Crop Panel, who based their decision on multiple referenced data sources and models, your reduction for Early Drilled Barley in the Valley and Ridge Carbonate region is 38%

Slide from 2012 – discussing the building of P6

To be prioritized

Phase 6 Model Structure

Average Load + △ Inputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Land to Water

*

Stream Delivery

*

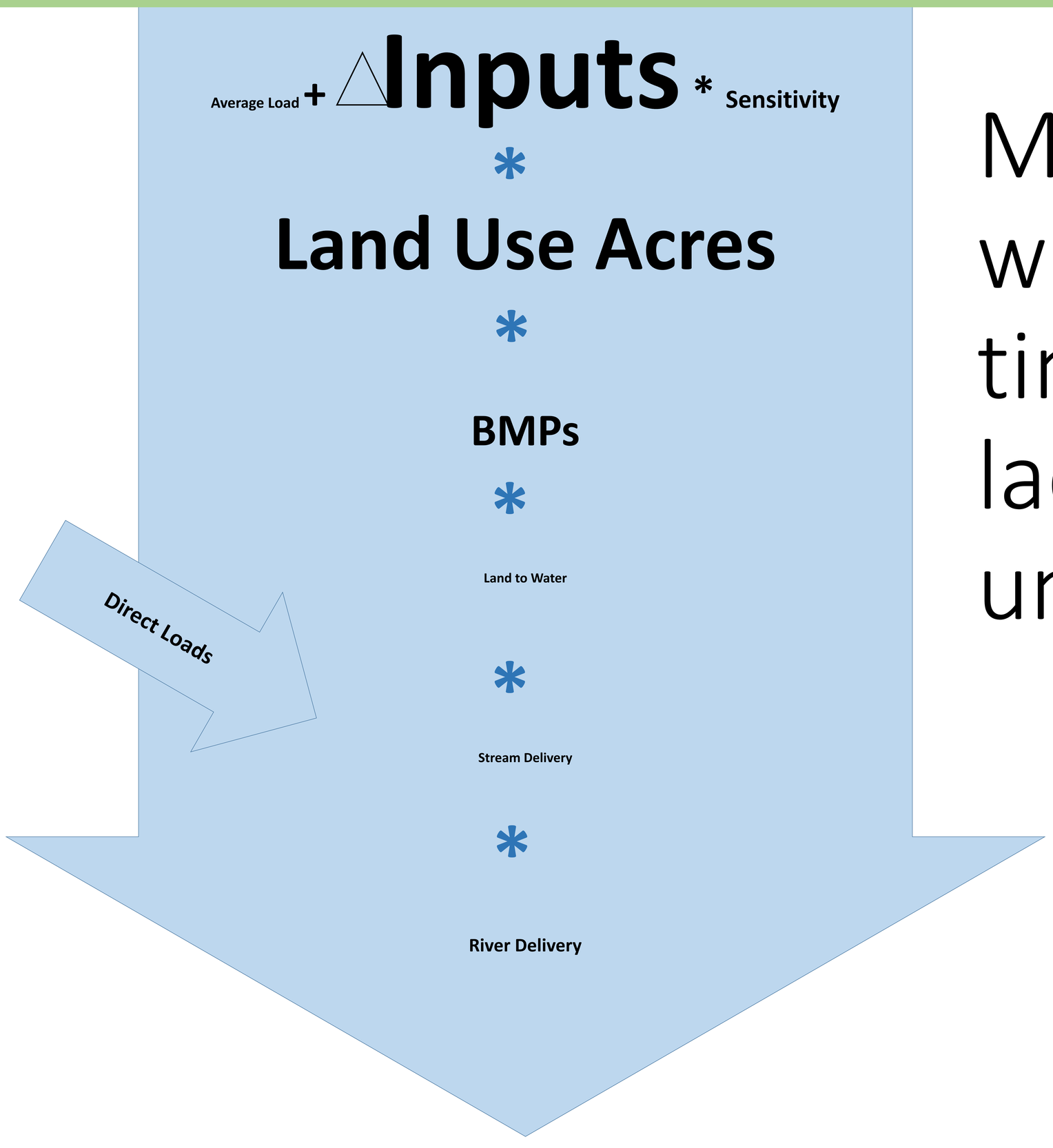
River Delivery

Direct Loads

Where do we struggle to understand the model?

Phase 6 Model Structure

To be prioritized



My impression of where partnership time is spent for lack of understanding

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Finer-scale modeling	WQGIT, other GITs, STAC	✓	✓	High	Greater accuracy watershed modeling; Enables fine scale targeting of practices; Needed for some co-benefits
Spatially explicit CAST	Non-CB TMDL partners		✓	Medium	Enables CAST output on a fine scale
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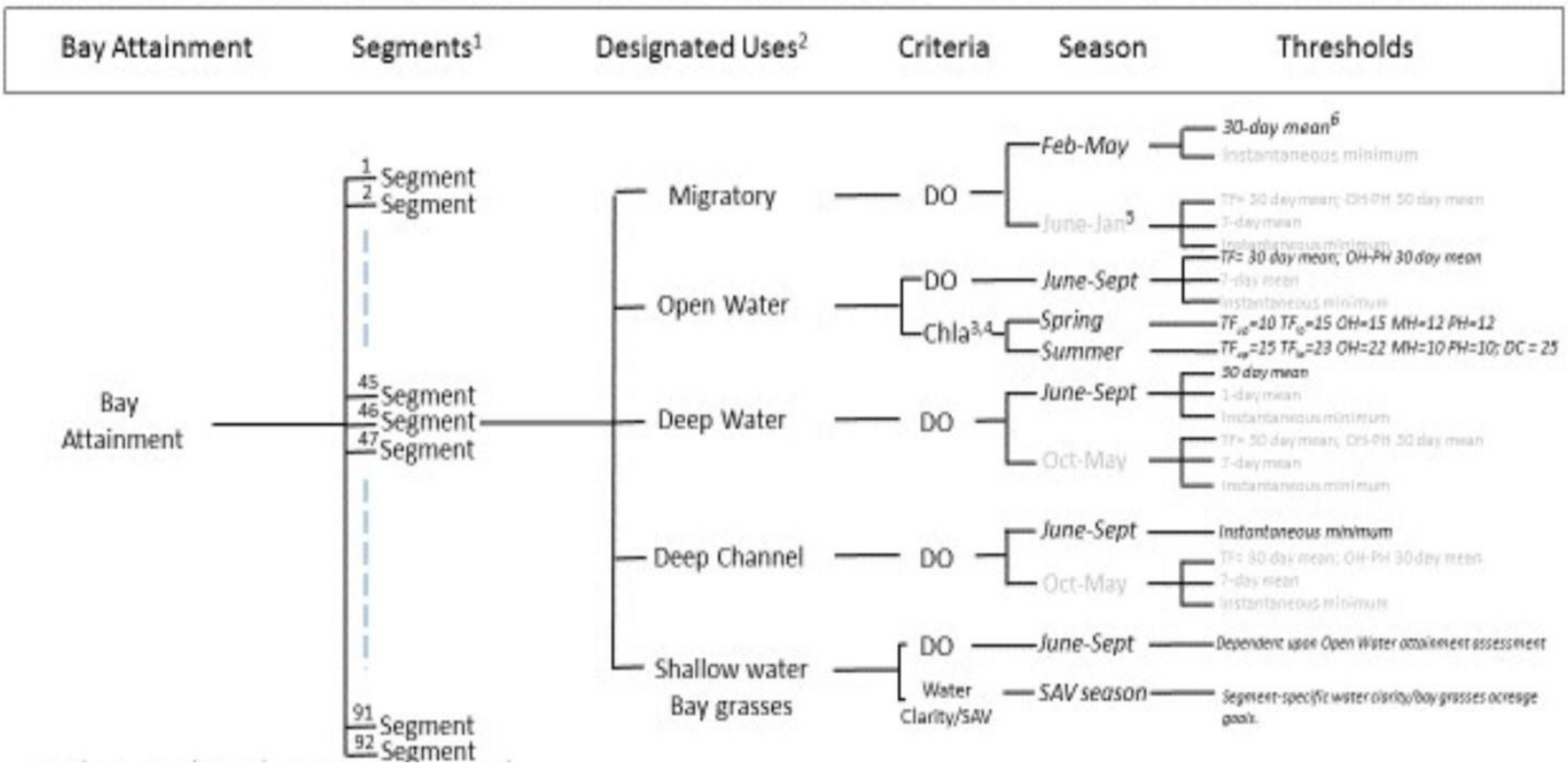
To be prioritized

WQ Standards Assessment

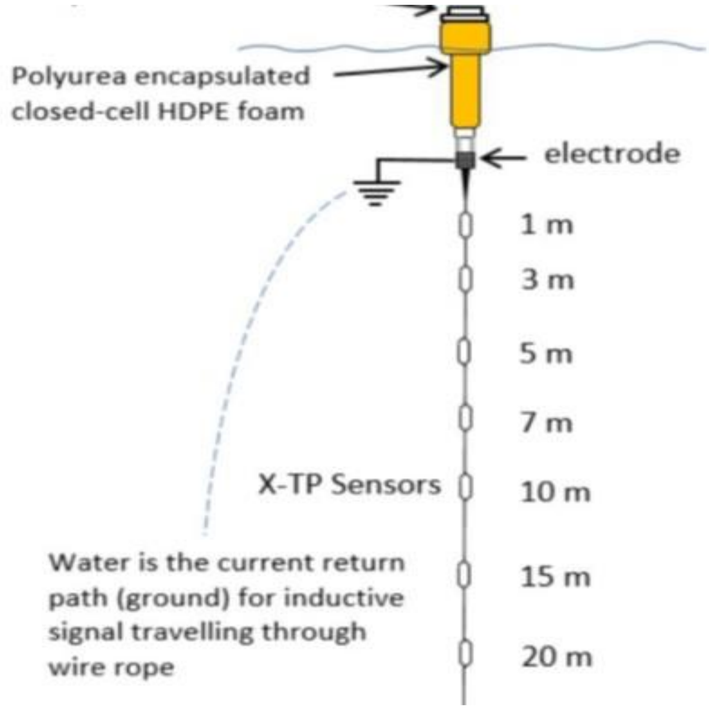
INDICATOR Water Quality Standards Attainment Assessment for Chesapeake Bay DO, Water Clarity and Chlorophyll a

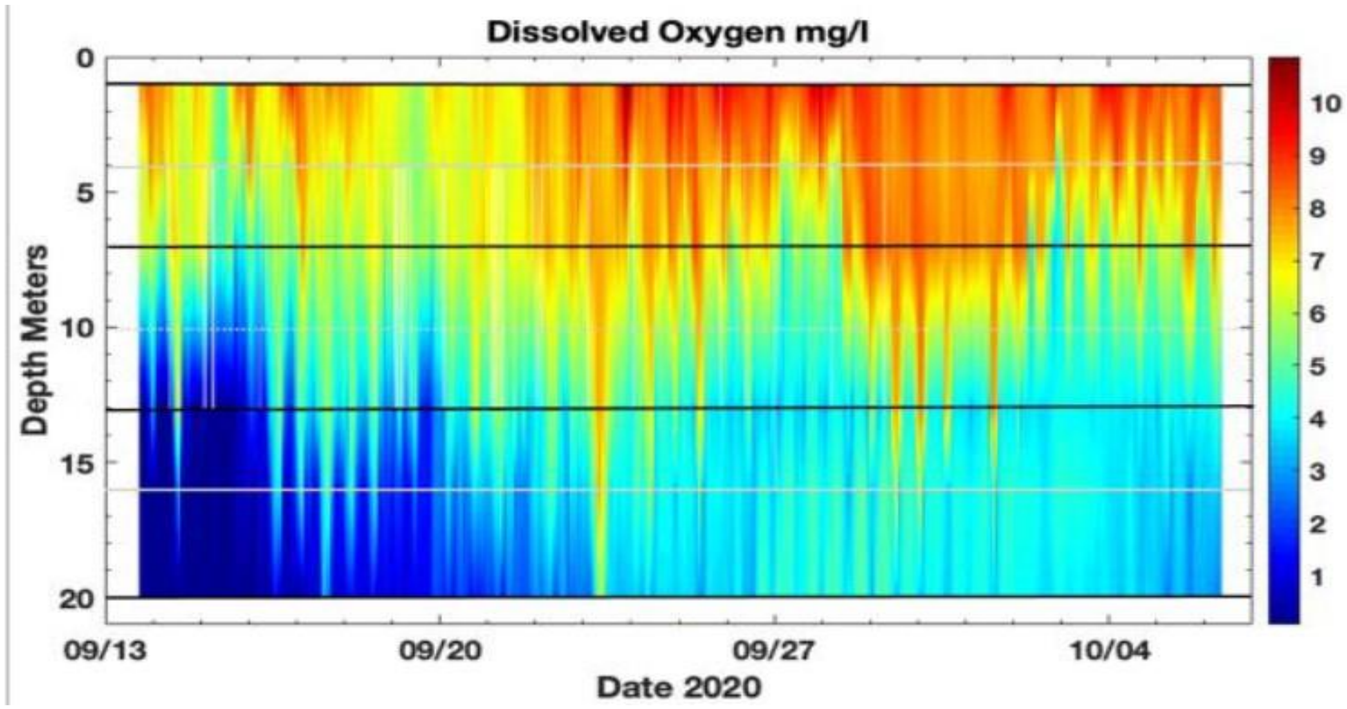


Currently only able to assess 8 of 22 standards

No segment can currently be taken off the TMDL 303d list

WQ Standards Assessment





- Need monitoring and modeling team working together on developing replacement for CBP interpolator
- Represent spatial and temporal variance
- Expand to shallow areas
- Integrate with models

To be prioritized

Co-Benefits and Ecosystem Services

- CAST currently generates N, P, S, and cost based on land use, management actions and wastewater loads.
- Co-Benefits are other CBP outcomes that could be affected by BMP implementation
  - Fish Habitat
  - Brook Trout
  - Tree canopy …
- Ecosystem Services are anything that have a value to people
  - Carbon sequestration
  - Scenic Views …
- Adding Co-Benefits would account for non-TMDL incentives to implementation

Co-Benefits and Ecosystem Services

- Develop and integrate models of living resource response
  - Literature reviews
  - Coordination with academic and federal researchers
- Examples
  - Models of striped bass habitat squeeze
  - Vibrio
  - Harmful algal blooms

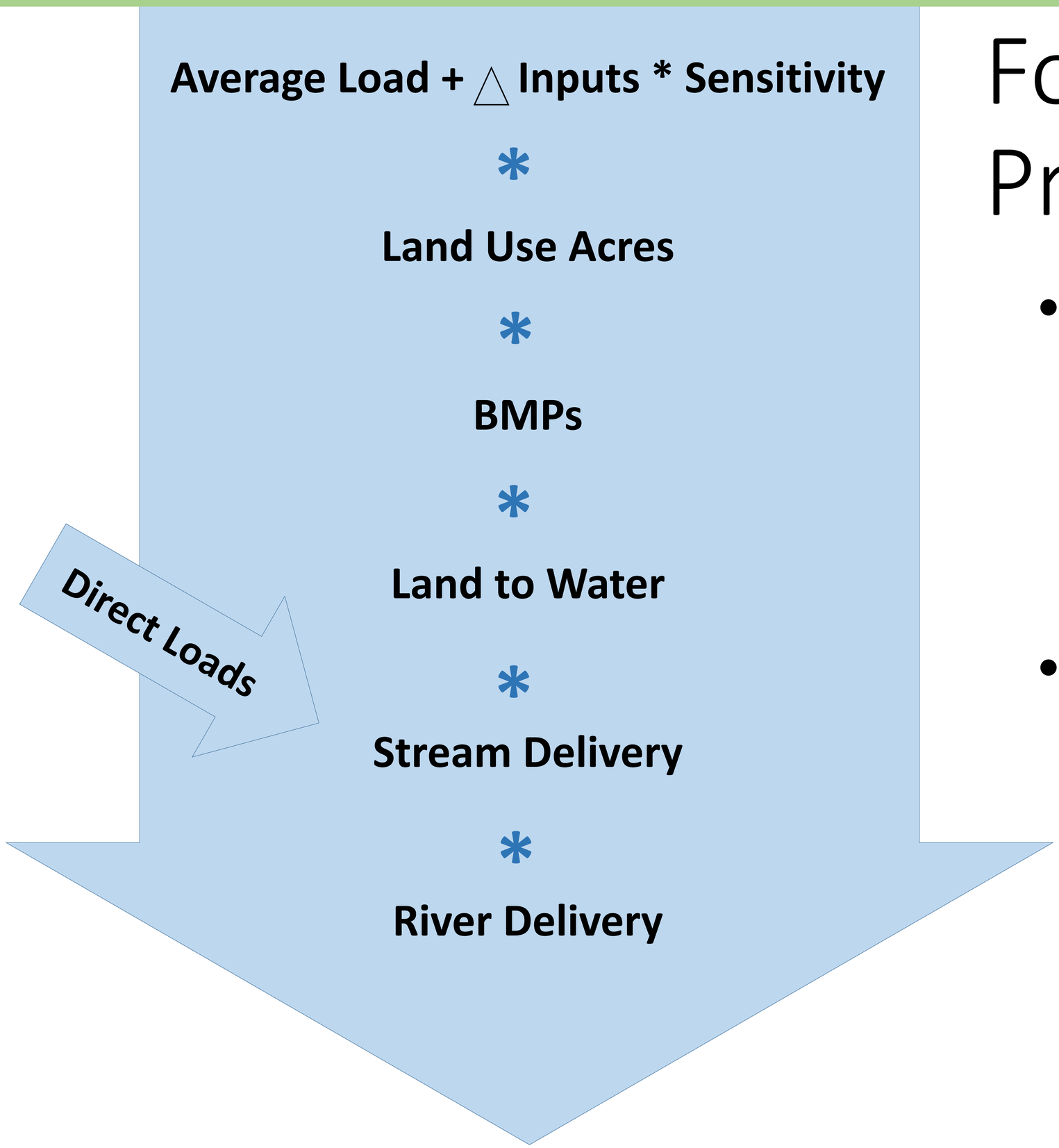
To be prioritized

Uncertainty Quantification

- Answers to the questions
  - How certain are we that we are getting the reductions we estimate?
  - What parts of the model have the largest impact on the nutrient load estimation?
- AgWG requested uncertainty quantification in Phase 6 review

Phase 6 Model Structure

To be prioritized

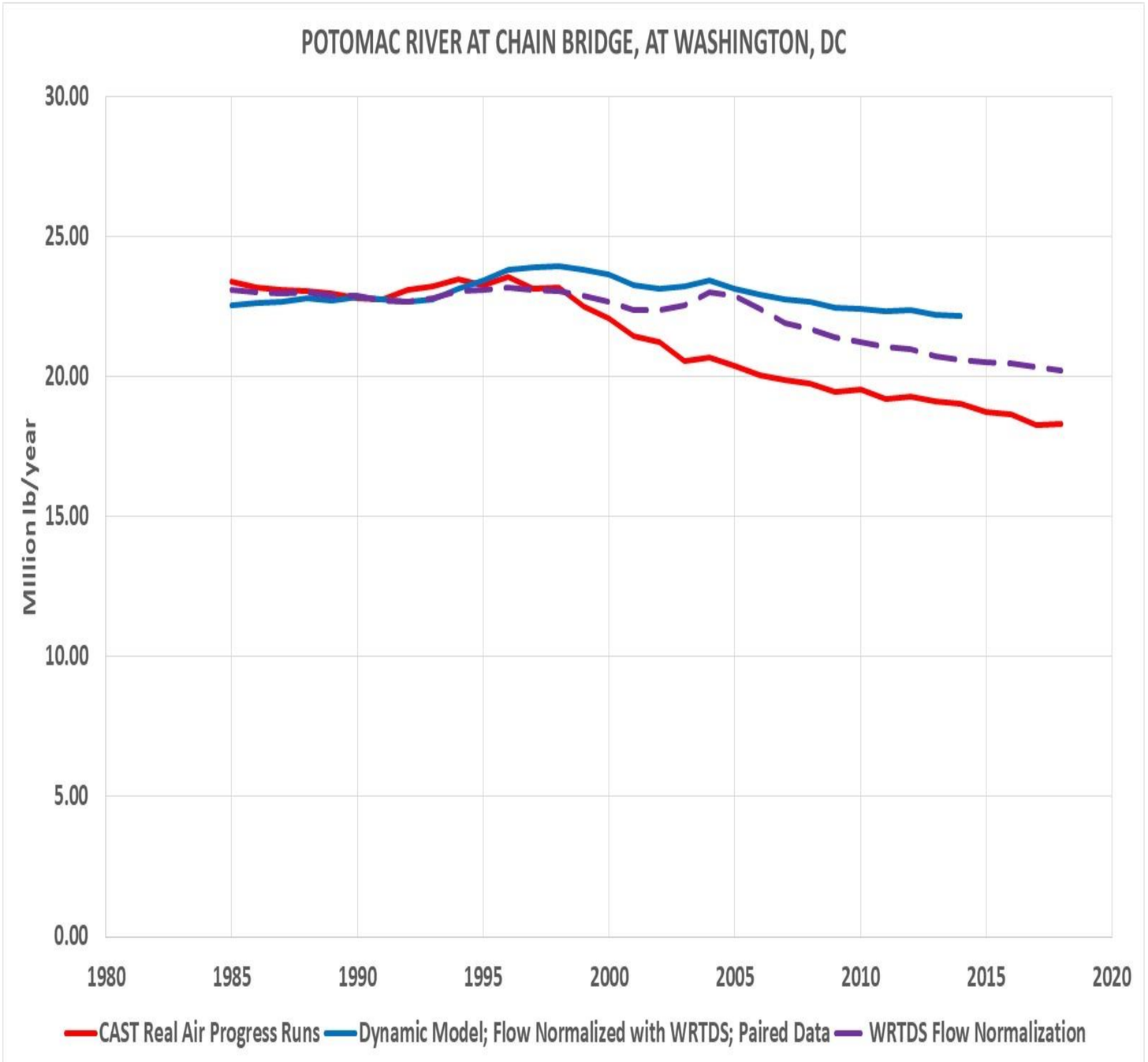


Forward Propagation

- Method:
  - Estimate the uncertainty of all the inputs
  - Run many iterations
- Output
  - estimate overall uncertainty
  - Determine leverage of each parameter in final estimation

To be prioritized

Inverse quantification



- Statistical comparison of the model with observation
- Outputs
  - Direct measure of model prediction success
  - More difficult to understand the reasons
- Isabella Bertani 11am presentation

To be prioritized

Improve Climate Change Modeling

- Only task specifically given by PSC
- Thoroughly dealt with in the watershed model in 2019
- Do we want to spend a lot of time on the final 10% that we didn’t get to or revisiting decisions from 2019?

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