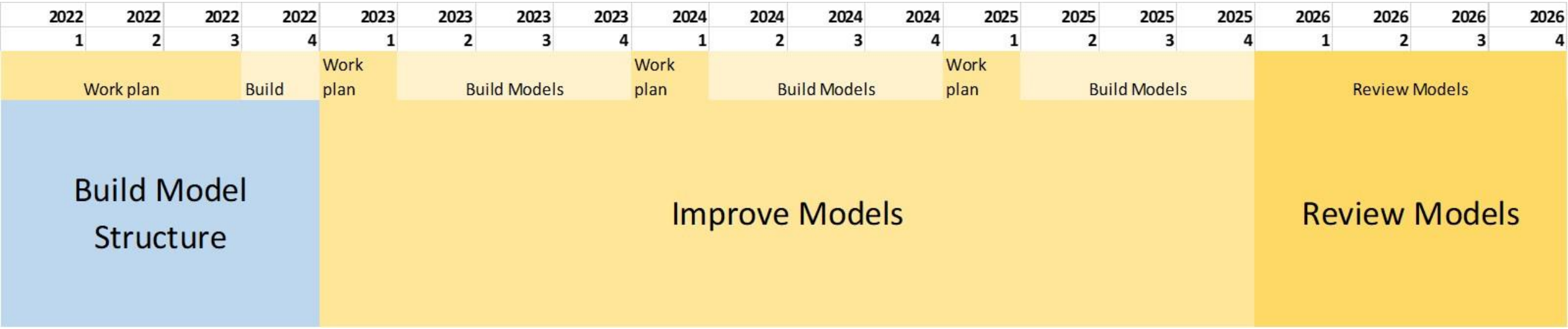
P7 Watershed Model Development

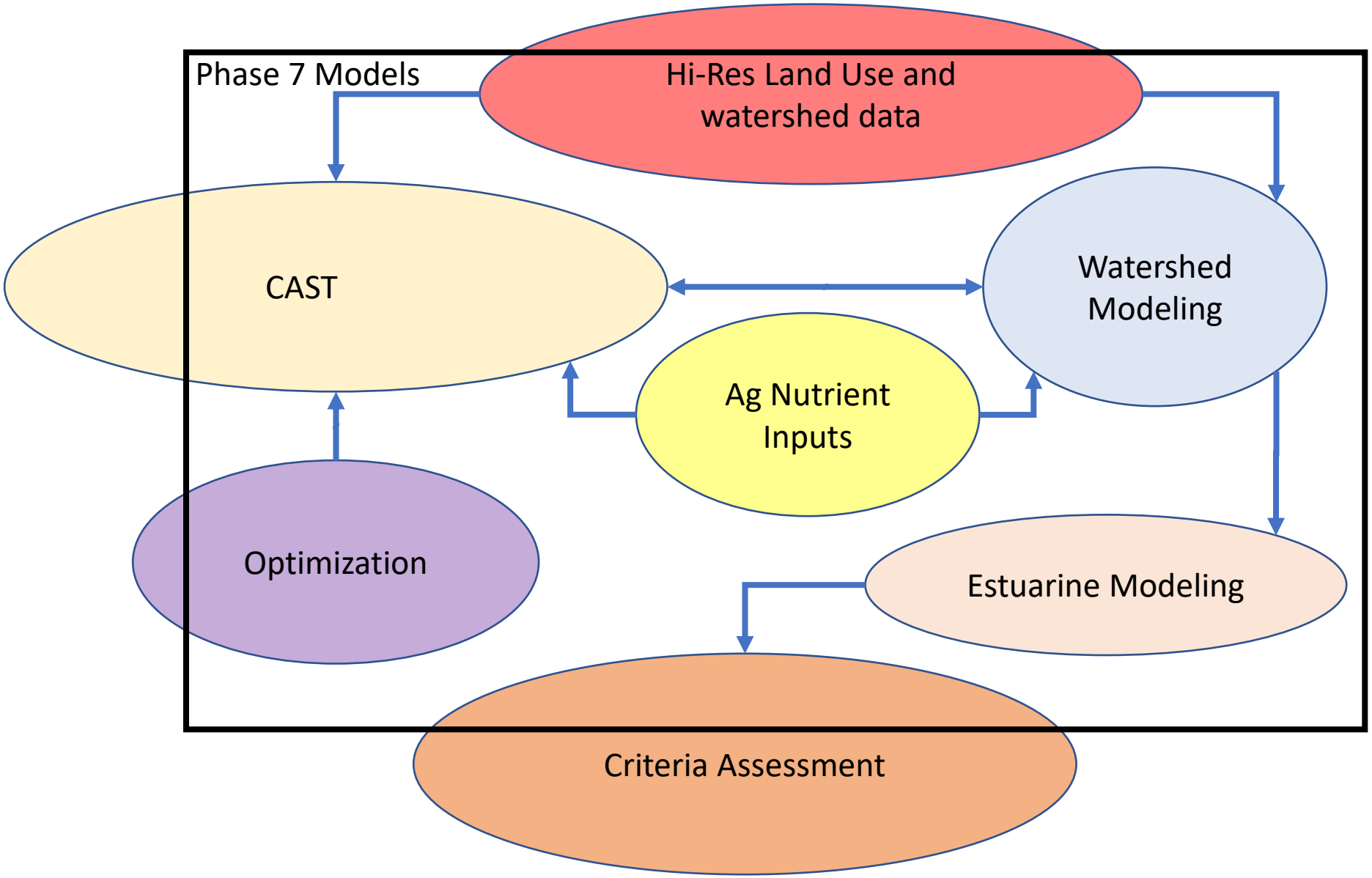
Urban Stormwater Workgroup

1/5/2024

Watershed Model Plan – Big Picture



Phase 7 Development Tracks



Web page

- Overview
- Seven Projects
  - Descriptions
  - Documents
- Linked from
  - Modeling Workgroup
  - WQGIT
  - Many WQGIT WGs

Phase 7 Model Development | Ch

chesapeakebay.net/what/programs/modeling/phase_7_model_development

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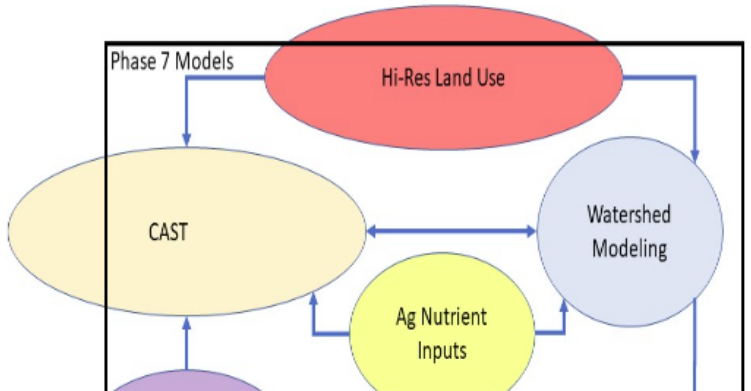
WHAT WE DO > PROGRAMS & PROJECTS > PHASE 7 MODEL DEVELOPMENT

Phase 7 Model Development

The Chesapeake Bay Program is updating its modeling and analysis tools used in the Chesapeake Bay TMDL.

Currently in development, the Phase 7 Modeling Tools will be used by the partnership to inform decisions related to nutrient and sediment reduction goals outlined in the Chesapeake Bay Watershed Agreement. Integral to this updated suite of tools is the ability to project climate change effect through 2035. The model, which will be ready for use by 2027, consists of six interrelated projects:

1. High Resolution Land Use
2. Chesapeake Assessment Scenario Tool (CAST)
3. Optimization
4. Agricultural Inputs
5. Watershed Modeling
6. Estuarine Modeling
7. Criteria Assessment



Modeling

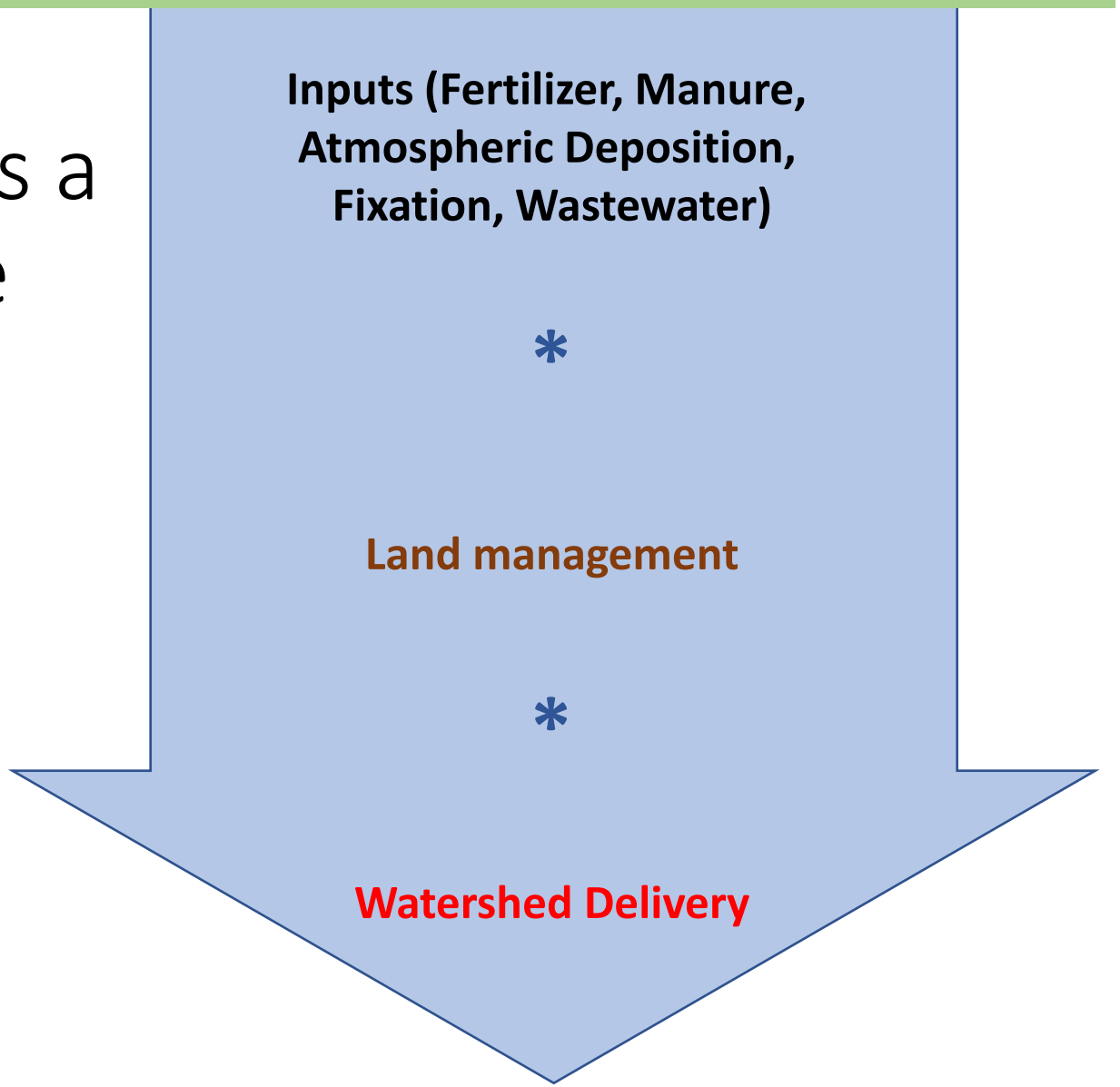
Phase 7 Model Development

Programs & Projects

Modeling
Monitoring
Quality Assurance
Resource Lands Assessment
Chesapeake Bay TMDL
Watershed Implementation Plans
BMP Verification

CAST Structure

CAST is a simple model



Load by land-river segment and land use

CAST is a simple model

CAST Structure

Inputs (Fertilizer, Manure, Atmospheric Deposition, Fixation, Wastewater)

*

Land management

*

Watershed Delivery

Load by land-river segment and land use

CAST Structure

Average Load

+

△ Inputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

*

River Delivery

Load by land-river segment and land use

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

Average nitrogen load to stream for turf grass watershed wide is 11 pounds per acre

Load by land-river segment and land use

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

Load by land-river segment and land use

Your area applies 25 pounds of fertilizer while the watershed-wide average is 20.

Each additional pound of fertilizer results in 0.21 lbs of runoff

11 + (25-20) * 0.21 = 12 lbs/acre

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

BMPs are applied which give, in aggregate, a 1/3 reduction

12 * (1-.33) = 8 lbs/acre

Load by land-river segment and land use

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

There are 100 acres of turf grass in this segment

8 lbs/acre * 100 acres = 800 lbs

Load by land-river segment and land use

CAST Structure

Illustrative example

Average Load

+

△ Inputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

The land here is 50% leaker than average due to high groundwater recharge in the piedmont carbonate

The river system reduces loads by 10%

800 lbs * 1.5 * (1-.10) = 1080 lbs
Delivered to the Bay from this land use and segment

Load by land-river segment and land use

Phase 7 CAST Structure

Average Load
+
Δ Inputs * Sensitivity
*****
BMPs
*****
Acres
*****
Land to Water
*****
River Delivery

Load by land-river segment and land use

Inform

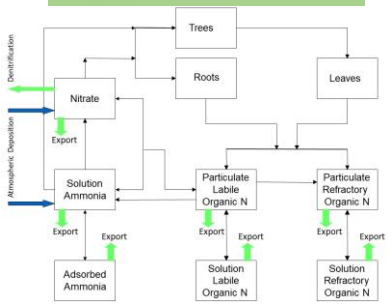
Constrain

CalCAST

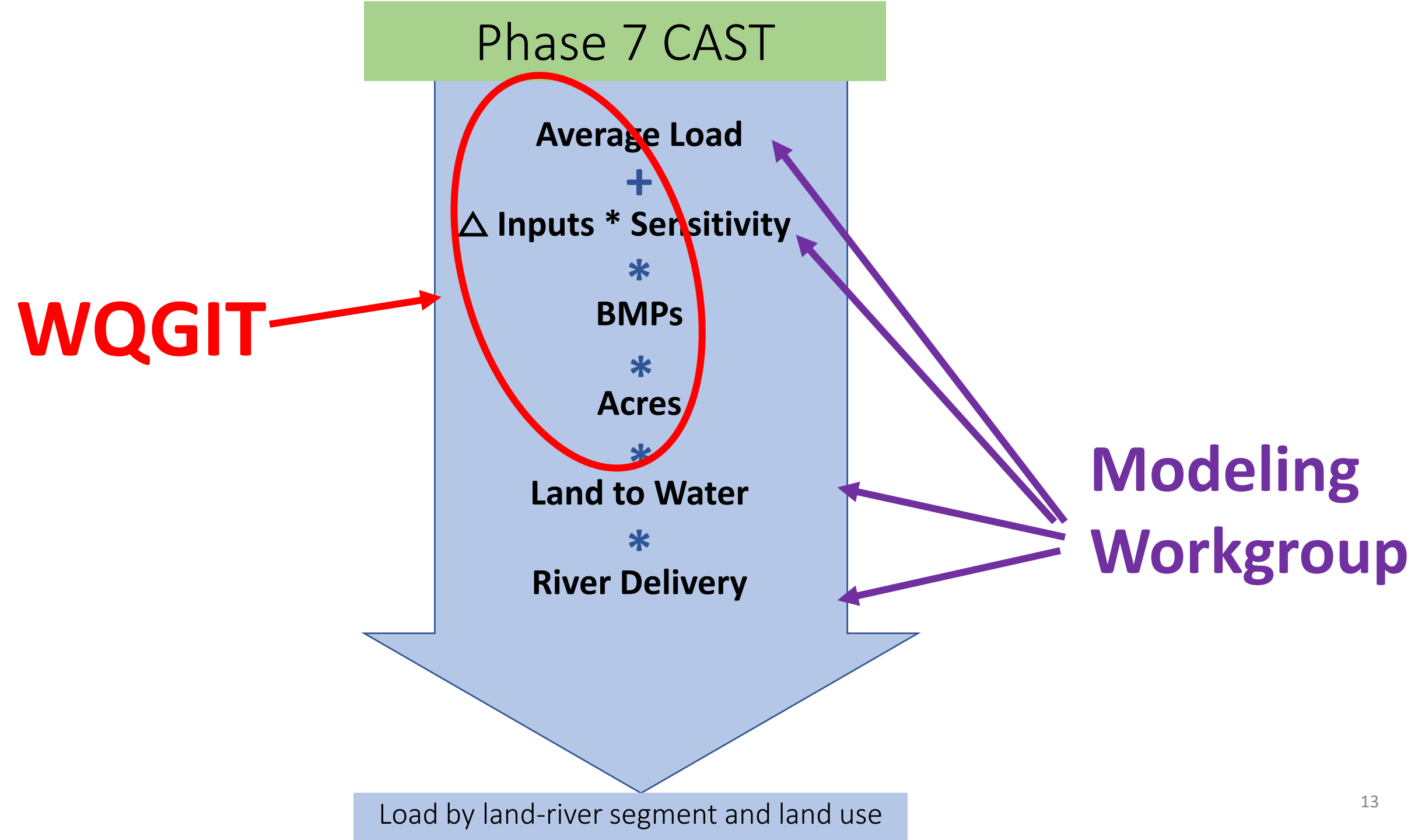
Average Load
+
Δ Inputs * Sensitivity
*****
BMPs
*****
Acres
*****
Land to Water
*****
River Delivery

Load by land-river segment and land use

Temporal downscaling model



CAST model documentation; section 1
https://cast.chesapeakebay.net/Documentation/ModelDocumentation


Phase 7 CAST
Average Load
+
△ Inputs * Sensitivity
*
BMPs
*
Acres
*
Land to Water
*
River Delivery
WQGIT
Modeling Workgroup
Load by land-river segment and land use

P6 Land uses

6 Types

- Buildings and Other
- Construction
- Roads
- Tree Canopy over Impervious
- Tree Canopy over Turfgrass
- Turf Grass

P6 Land uses

6 Types

- Buildings and Other
- Construction
- Roads
- Tree Canopy over Impervious
- Tree Canopy over Turfgrass
- Turf Grass

X

3 Locations

- MS4
- Combined Sewer System
- Non-regulated

P7 Mapped land uses

Impervious

- Roads
- Structures
- Other Impervious (Parking lots, driveways)
- Tree Canopy over Roads
- Tree Canopy over Structures
- Tree Canopy over Other Impervious
- Extractive Impervious
- Solar Field Panel Arrays

Pervious

- Tree Canopy over Turf Grass
- Turf Grass
- Bare Developed
- Extractive Barren
- Solar Field Barren
- Solar Field Herbaceous
- Solar Field Shrubland
- Suspended Succession Barren
- Suspended Succession Herbaceous
- Suspended Succession Shrubland

P6 Land use Loading Rates compared to Roads

6 Types	**Relative Loading Rates**	
	• TN	TP
• Buildings and Other	• 0.79	0.80
• Construction	• 1.17	3.74
• Roads	• 1.00	1.00
• Tree Canopy over Impervious	• 0.89	0.88
• Tree Canopy over Turfgrass	• 0.37	0.76
• Turf Grass	• 0.49	1.00

Sensitivities – P6

TN	Fertilizer	AtmDep	Uptake	CropCov
Roads - Impervious		0.48	0.00	
Turf Grass - Pervious	0.05	0.08	0.00	-0.23
TP	Fertilizer			
Turf Grass - Pervious	0.21			

- Other pervious land uses share the turf grass sensitivities at the same ratio as the loading
- Same for impervious and roads

Sensitivities – P6

TN	Fertilizer	AtmDep	Uptake	CropCov
Roads - Impervious		0.48	0.00	
Turf Grass - Pervious	0.05	0.08	0.00	-0.23
TP	Fertilizer			
Turf Grass - Pervious	0.21			

- Multiplication factors for inputs
  - 100 lbs N in fertilizer causes 5 lbs N runoff
  - 100 lbs P in fertilizer causes 21 lbs P runoff
- Uptake has coefficients, but they are very small
- Crop Cover is the fraction of space that is not bare. This does not vary and so it has not effect

Sensitivities – P6

TN	Fertilizer	AtmDep	Uptake	CropCov
Roads - Impervious		0.48	0.00	
Turf Grass - Pervious	0.05	0.08	0.00	-0.23
TP	Fertilizer			
Turf Grass - Pervious	0.21			

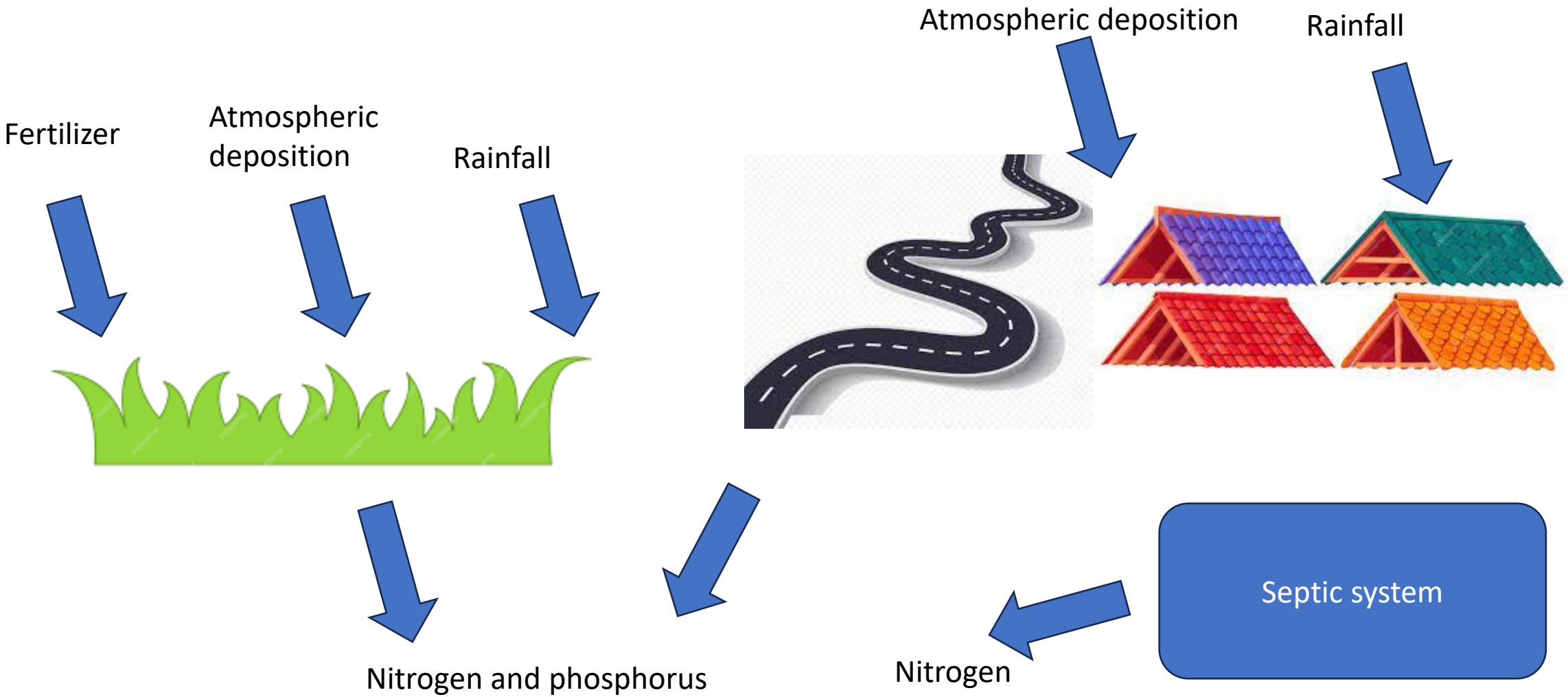
- Additional sensitivity was added for climate change.
- Climate change was assumed to not change concentration (based on an extensive literature survey) and so load change was proportional to total runoff change

Sensitivities – P6

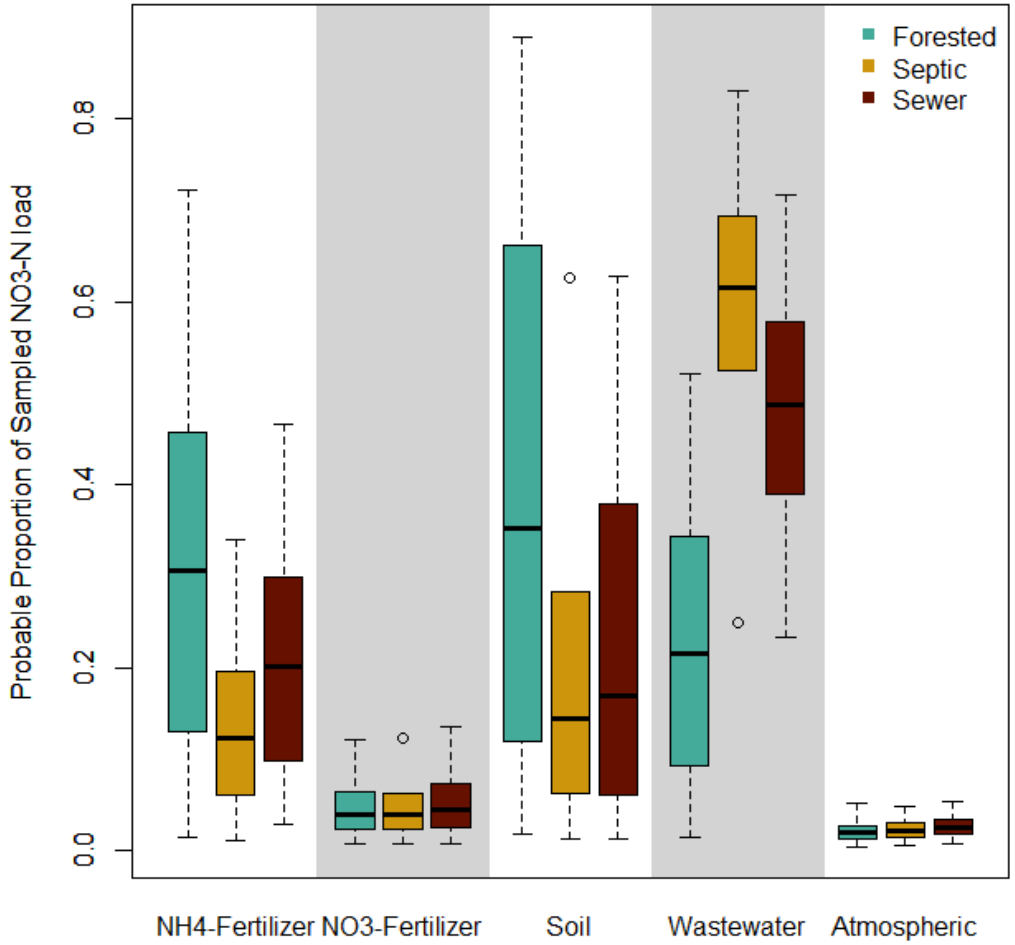
TN	Fertilizer	AtmDep	Uptake	CropCov
Roads - Impervious		0.48	0.00	
Turf Grass - Pervious	0.05	0.08	0.00	-0.23
TP	Fertilizer			
Turf Grass - Pervious	0.21			

- Data
  - Fertilizer – USWG
  - Atmospheric Deposition – MWG
  - Uptake and Cover don’t change and perhaps should be dropped

Lends itself to this mental model



STAC workshop on local monitoring



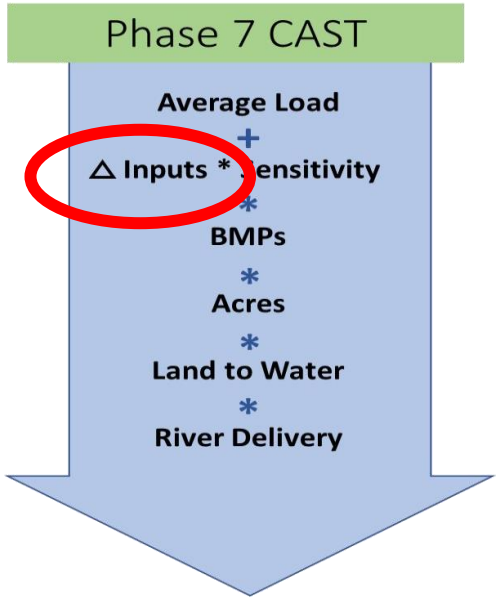
Delesantro, et al., 2021

- Recommendation 2.D.
- Conduct further research to identify and quantify potential new pollutant loading sources or new components of existing pollutant loading sources in the Phase 7 CBWM such as:
  - wastewater exfiltration from sewer pipes,
  - illicit discharges
  - waterfowl and domesticated pets.

USWG can re-examine

- Land use types
- Relative Loading Rates
- Sensitivities – types and numbers – advise MWG
- Inputs
- BMPs

Consistency > Accuracy

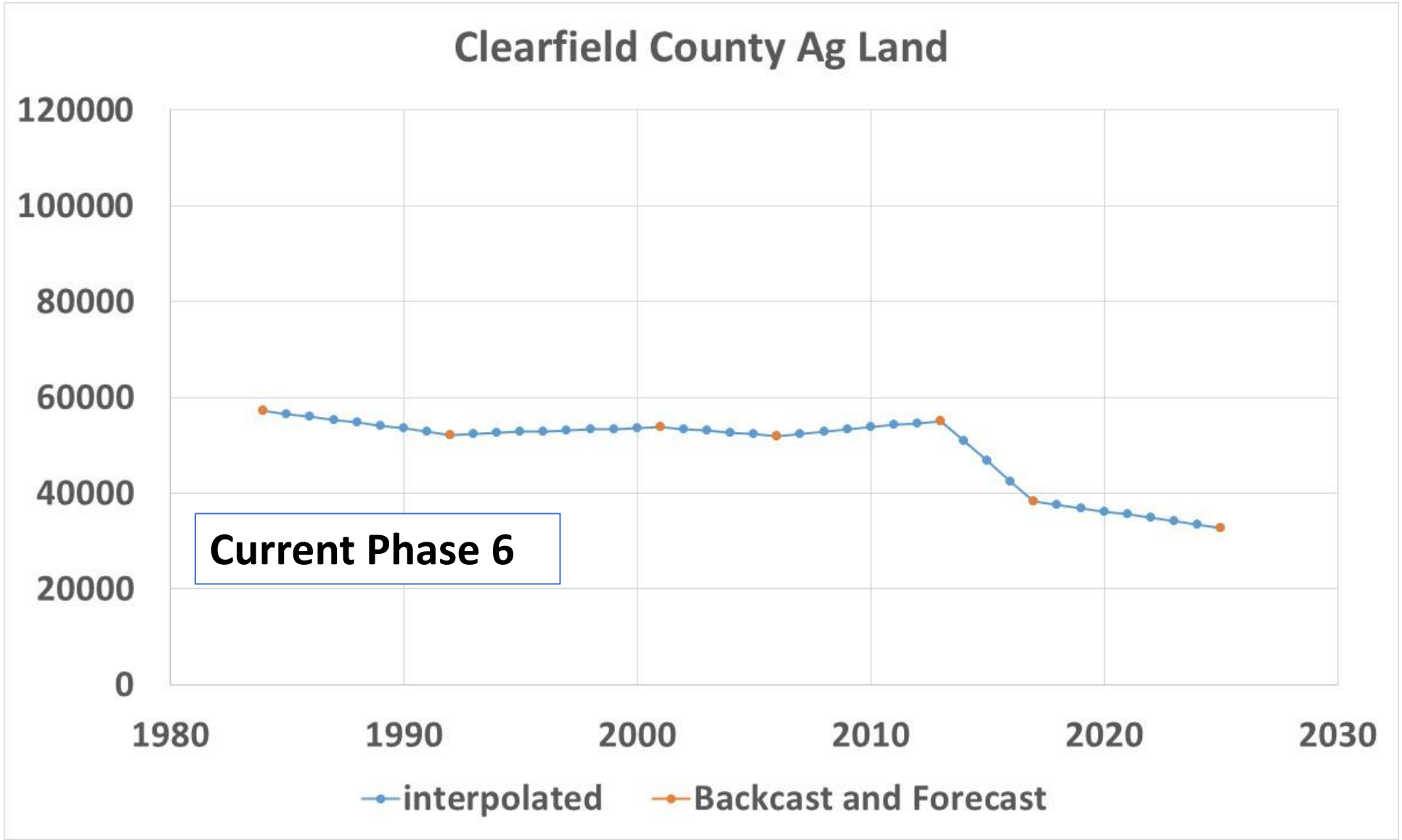


Accuracy of the spatial and temporal trends is more important that the absolute value

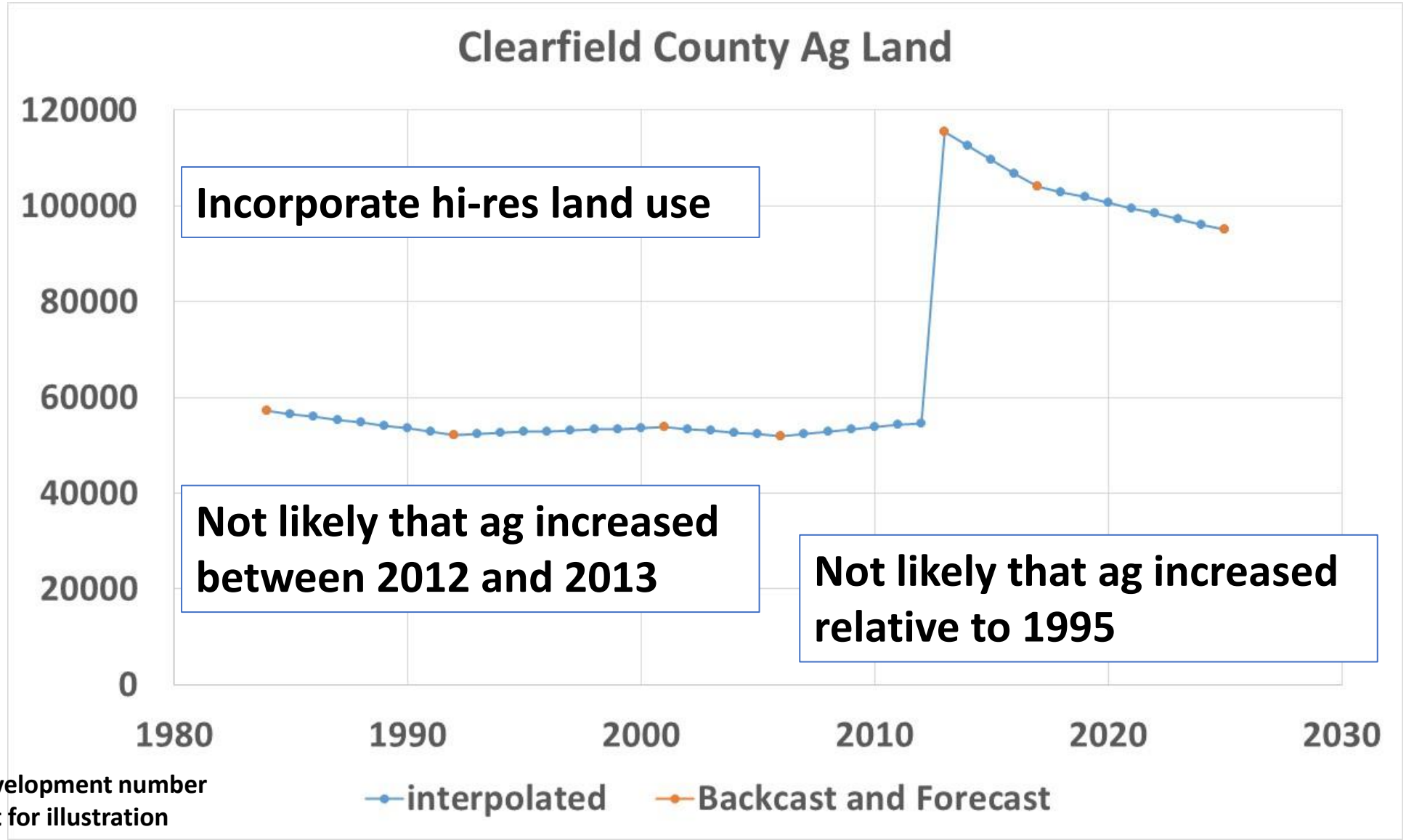
Spatial - Model used to allocate responsibility between jurisdictions

Temporal - Model used to track TMDL, based on changes since 1995

Consistency example



Consistency example



2013 is current development number
2017 and 2025 just for illustration

Watershed Model Plan – Big Picture

2022	2022	2022	2022	2023	2023	2023	2023	2024	2024	2024	2024	2025	2025	2025	2025	2026	2026	2026	2026
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Work plan			Build	Work plan	Build Models			Work plan	Build Models			Work plan	Build Models			Review Models			

Build Model Structure

Improve Models

Review Models