Climate Change Assessment – CBPO Watershed Modeling Update

CHAMP Meeting – May 2019

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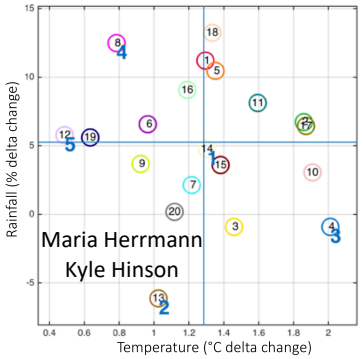
Presentation outline

1. **A brief progress update on the 2019 CBP climate change assessment – (a) land cover land use change impacts; (b) 2025, 2035, 2045, 2055**

   It was presented to the Modeling Workgroup in April

2. **3 new scenarios for CHAMP – based on updated metric for KKZ Ranking analyses (i.e. Nov-Jun rainfall, May-Oct temperature)**

   FMA rainfall, JJA temperature was previously used

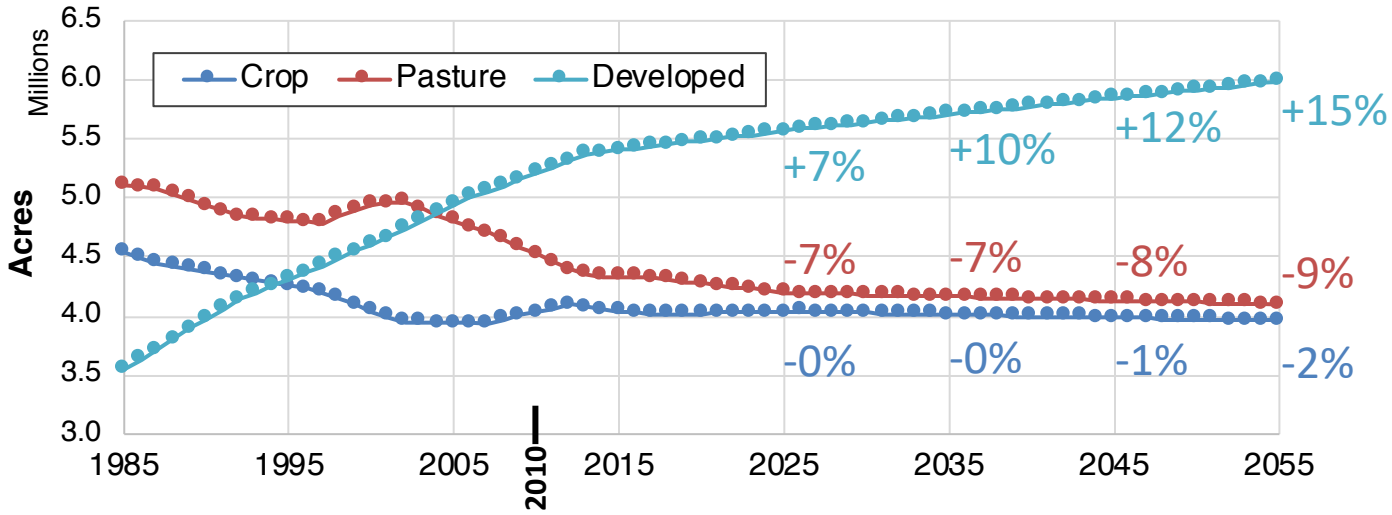


1. Evaluation of land cover land use change impacts on climate change assessment

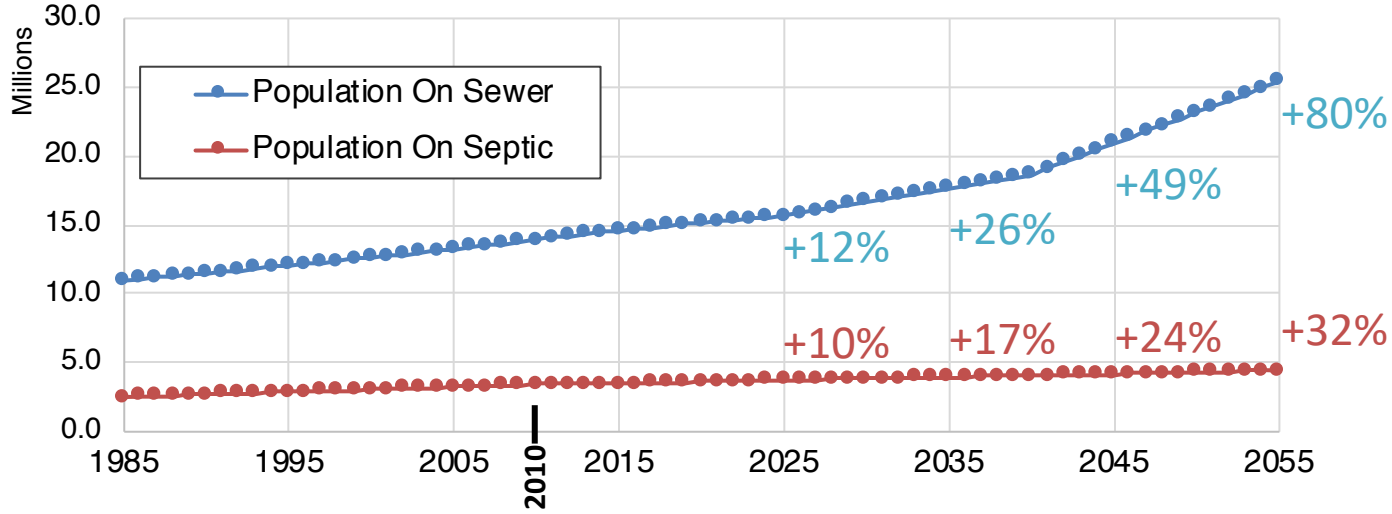
- Land use effects the baseline nutrients and sediment loads, and therefore the marginal differences in loads with climate change.
- The future projections of land use and populations on sewer and septic systems were estimated using Chesapeake Bay Land Change Model (CBLCM Version 4 – *Claggett, P., et al.*)

County-level demographic population projections for 2020, 2030, and 2040 were downloaded from each jurisdiction's official projection provider. Projections beyond 2040 were developed by the CBPO through linearly extrapolating trends from 2010 – 2040.

Land use acres - Chesapeake Bay Watershed

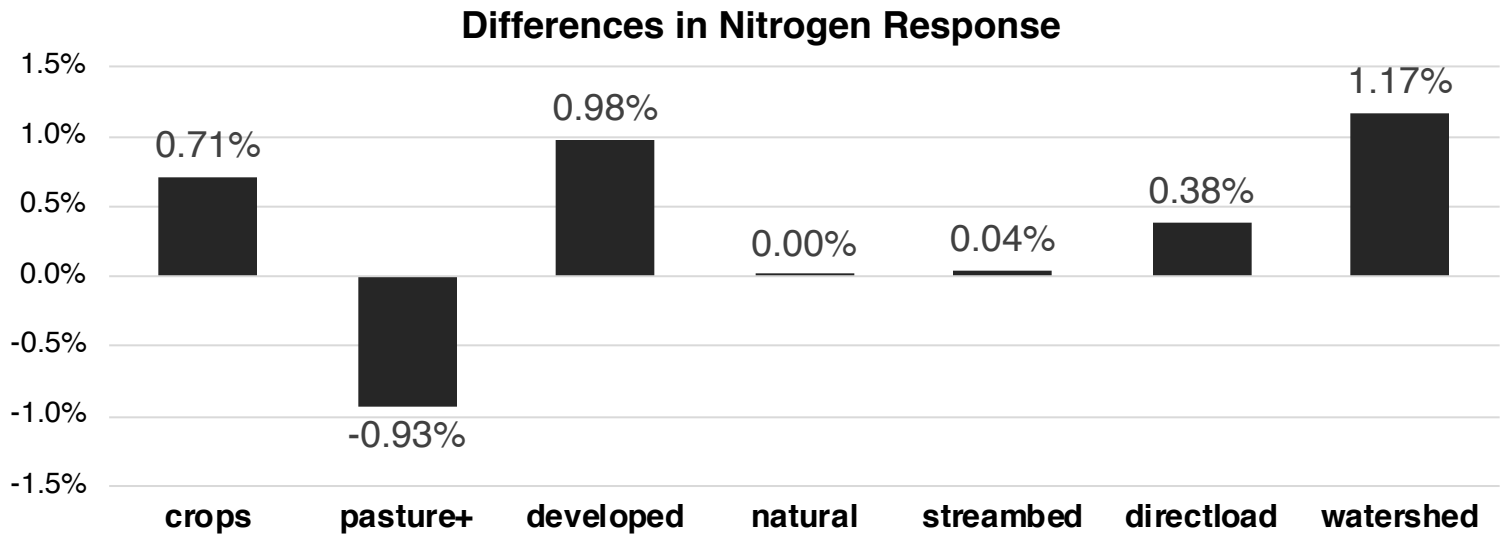


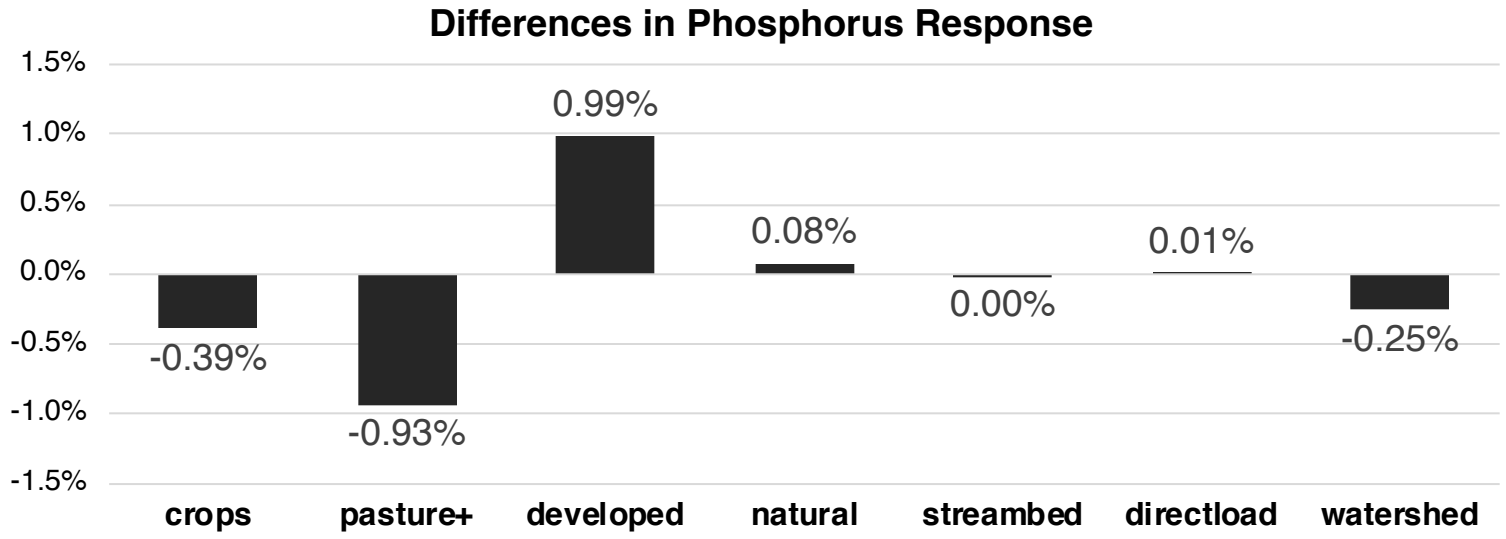
Population - Chesapeake Bay Watershed



Pre-BMP land use acres are shown.
Percent changes are shown with respect to 2010 (with WIP2 level of effort)

WIP2 level of effort on 2025 vs. 2010 land use

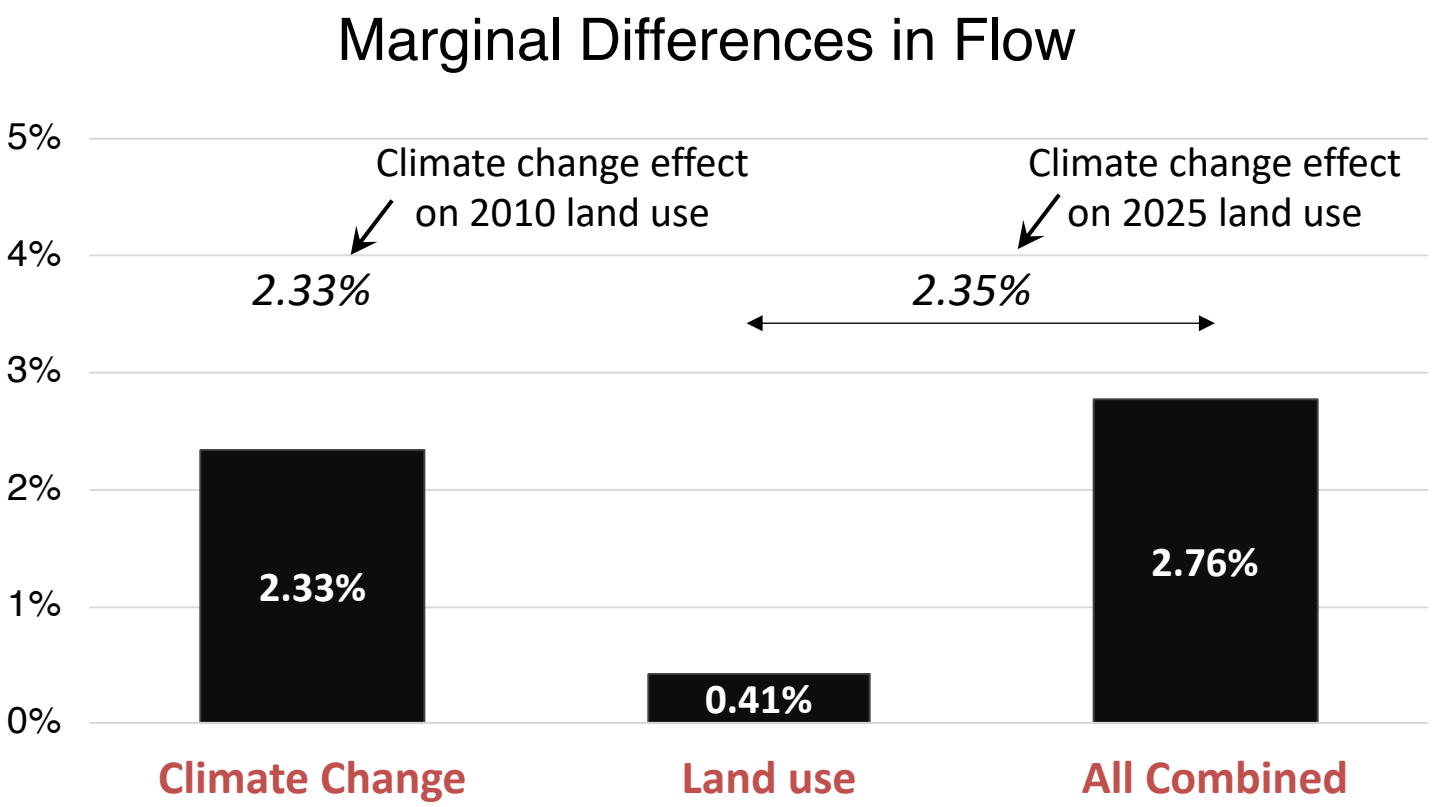




Figures show load sources contributing to the differences in nitrogen and phosphorus loads with changes in land use

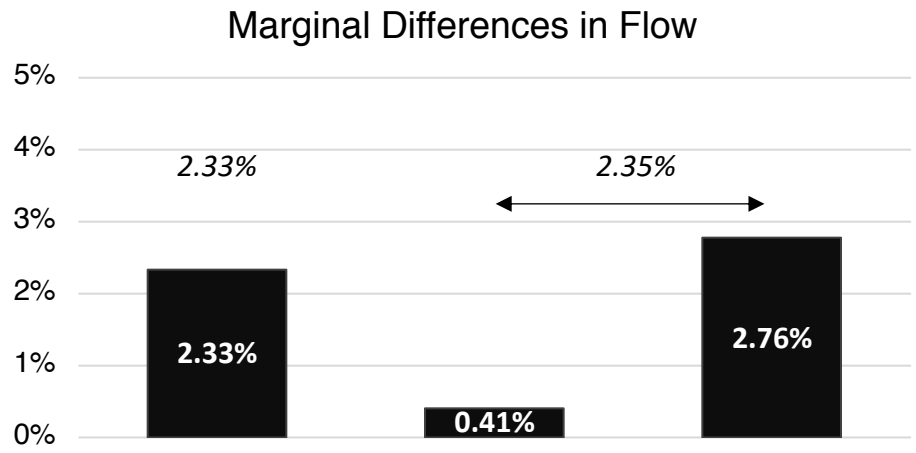
Differences are shown with respect to WIP2 on 2010 land use

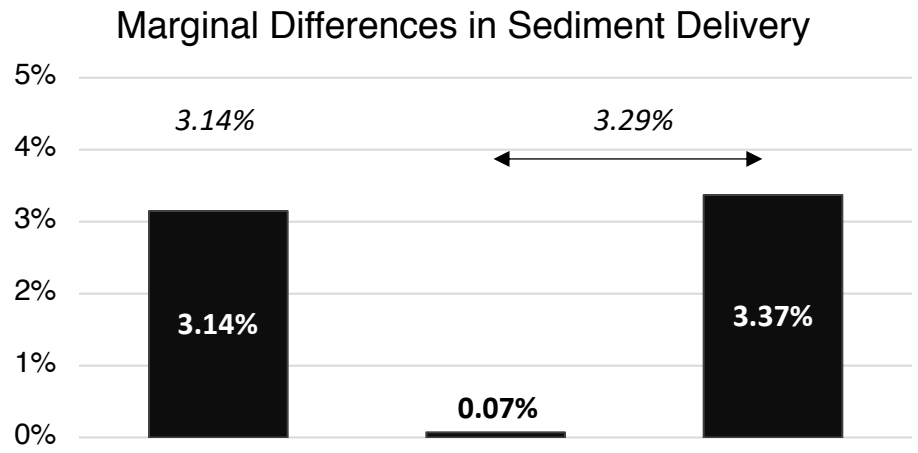
2025 sensitivity scenarios

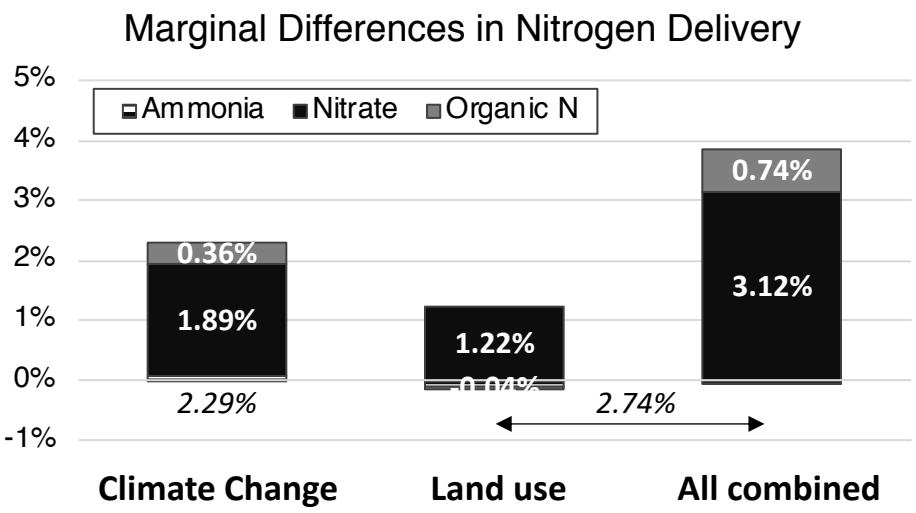


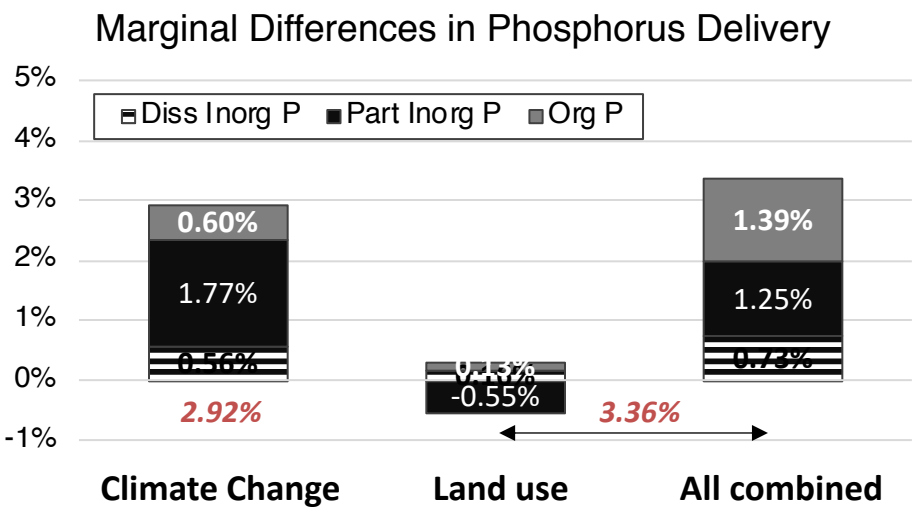
Differences are shown with respect to WIP2 on 2010 land use

2025 sensitivity scenarios





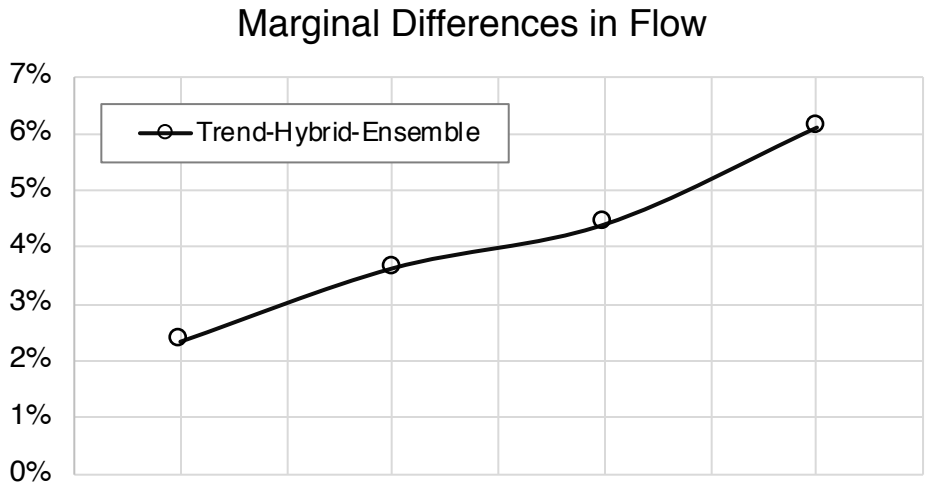


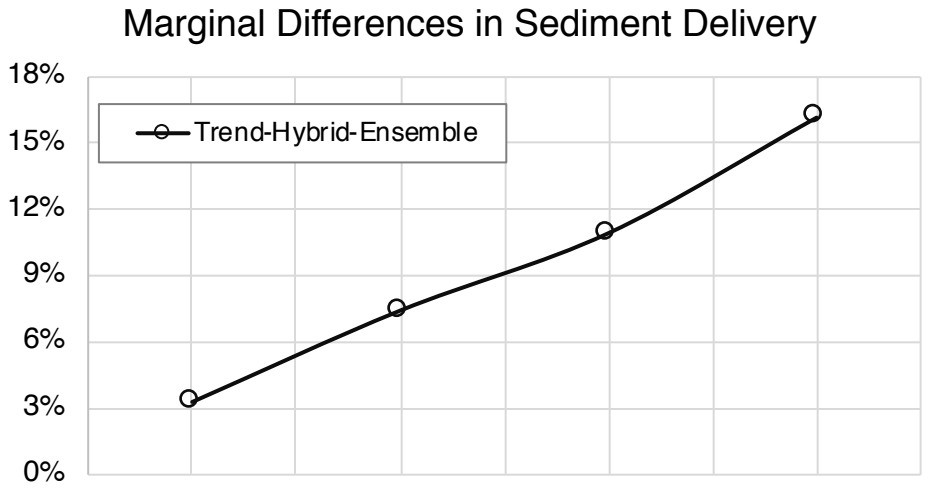


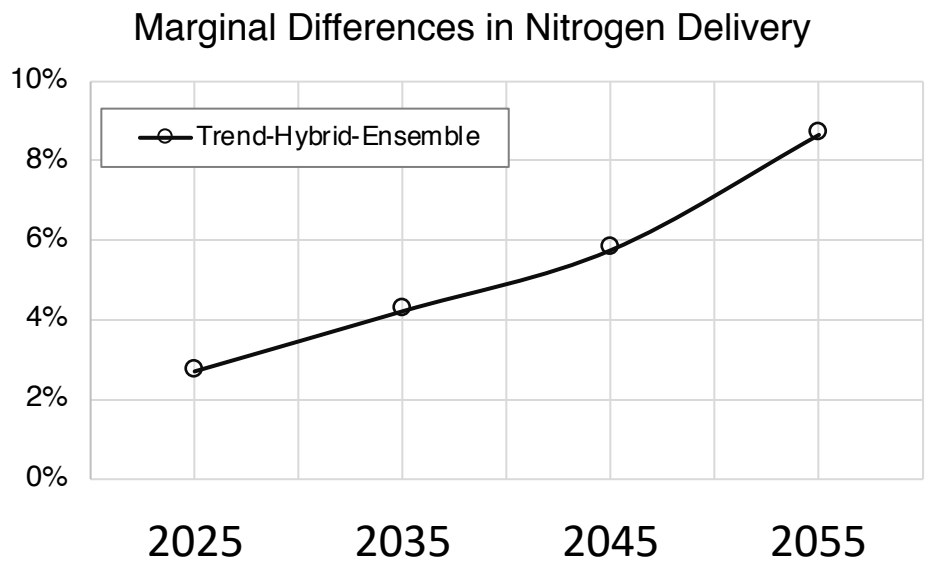
Going forward use WIP2 on 2025 land use for climate change assessments until WIP3 is available.

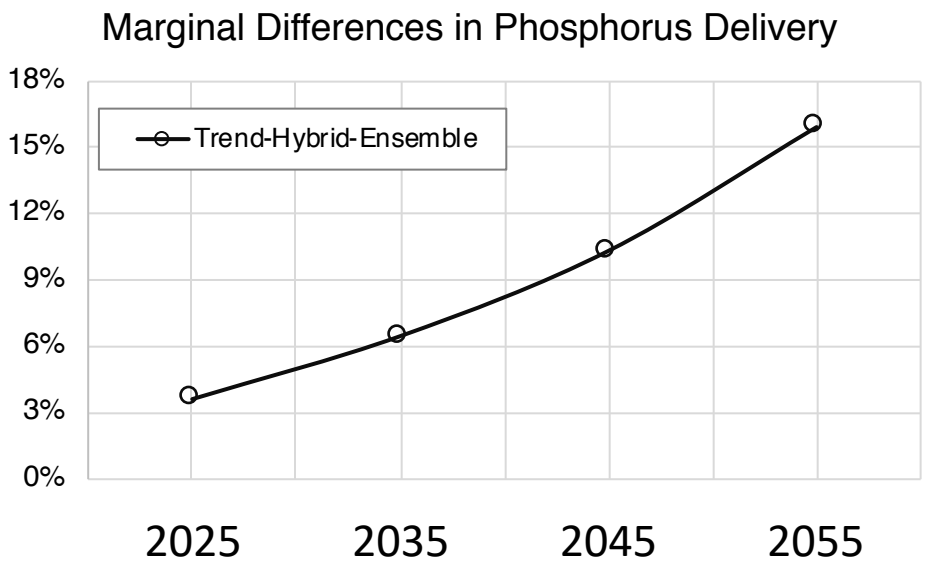
Differences are shown with respect to WIP2 on 2025 land use

2025, 2035, 2045, & 2055 Summary - Climate









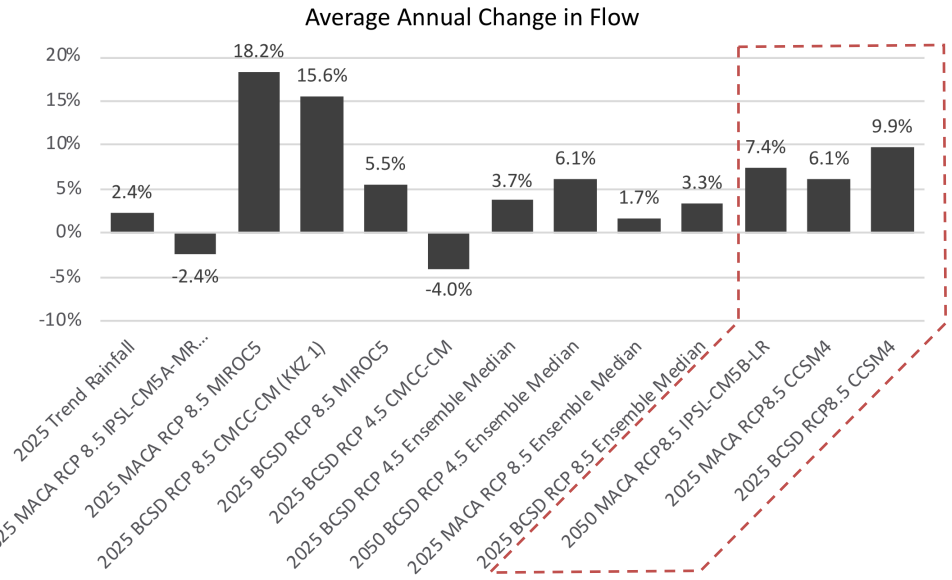
2. CHAMP Climate Change Scenarios

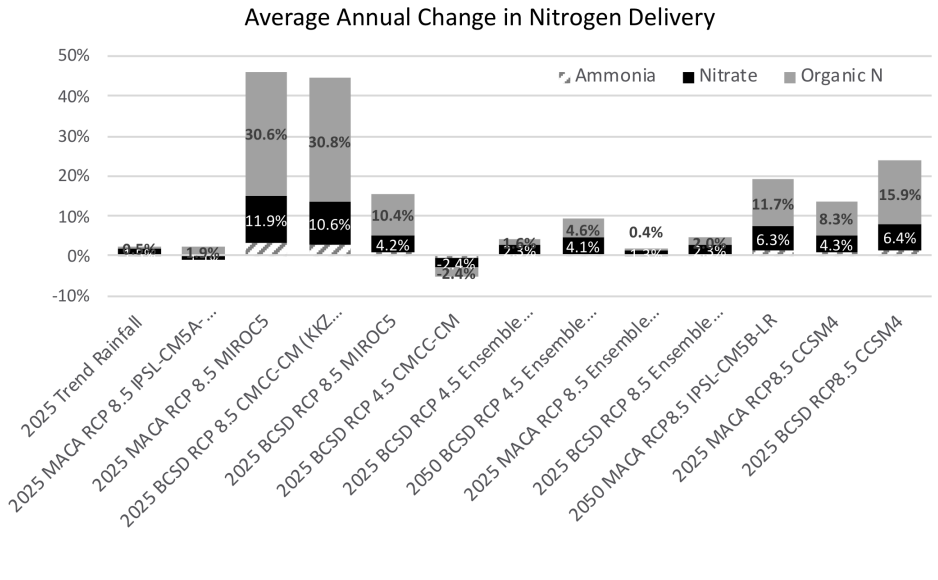
List of scenarios for CHAMP climate change assessment to investigate the impact of downscaling, and watershed model responses

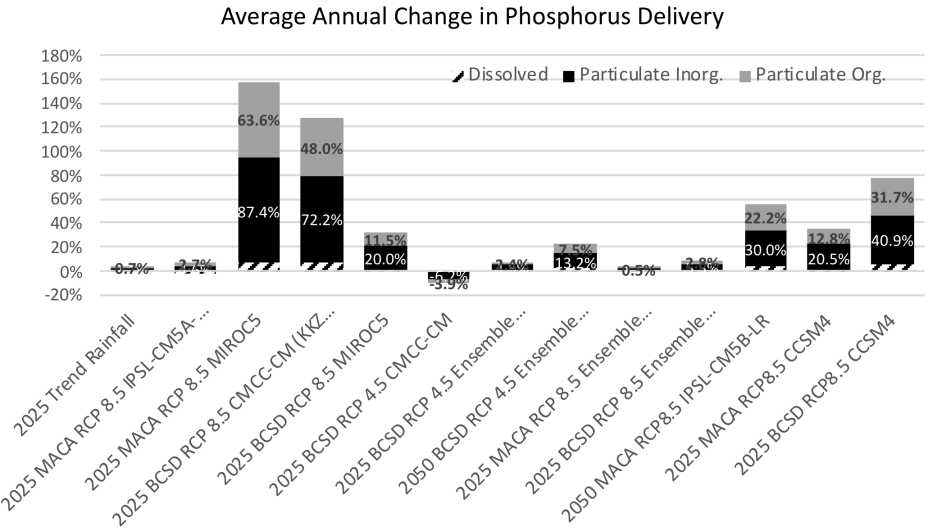
SNo.	SCENARIO NAME	SCENARIO DESCRIPTION
01	MFBASE1808CXXNONERXXMXX	**Baseline representing calibration 1991-2000 condition**
02	MFBASE1808C25T88YR45P50	**2025 Trend Rainfall, BCSD RCP 4.5 Ensemble Median temperature**
03	MFBASE1808C25MACAR85M27	**2025 MACA RCP 8.5 IPSL-CM5A-MR (KKZ Rank = 1)**
04	MFBASE1808C25MACAR85M31	**2025 MACA RCP 8.5 MIROC5**
05	MFBASE1808C25BCSDR85M09	**2025 BCSD RCP 8.5 CMCC-CM (KKZ Rank = 1)**
06	MFBASE1808C25BCSDR85M31	**2025 BCSD RCP 8.5 MIROC5**
07	MFBASE1808C25BCSDR45M09	**2025 BCSD RCP 4.5 CMCC-CM**
08	MFBASE1808C25BCSDR45P50	**2025 BCSD RCP 4.5 Ensemble Median**
09	MFBASE1808C50BCSDR45P50	***2050* BCSD RCP 4.5 Ensemble Median**
10	MFBASE1808C25MACAR85P50	**2025 MACA RCP 8.5 Ensemble Median**
11	MFBASE1808C25BCSDR85P50	**2025 BCSD RCP 8.5 Ensemble Median**
12	MFBASE1808C50MACAR85M28	***2050* MACA RCP8.5 IPSL-CM5B-LR (KKZ# Rank = 1)**
13	MFBASE1808C25MACAR85M06	**2025 MACA RCP8.5 CCSM4 (KKZ# Rank = 1)**
14	MFBASE1808C50MACAR85M28	**2025 BCSD RCP8.5 CCSM4 (KKZ# Rank = 1)**

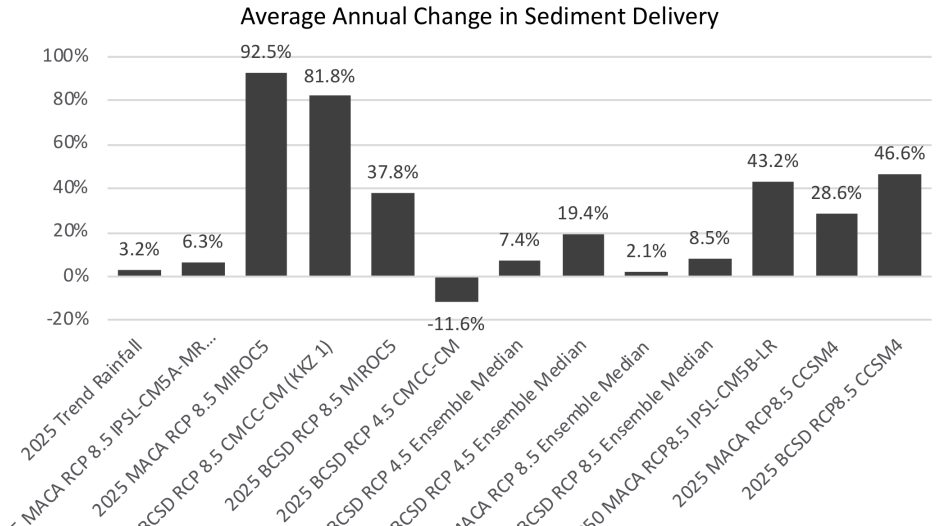
 # revised for Nov-June rainfall and May-Oct temperature

CBP Watershed Model results – Average Annual



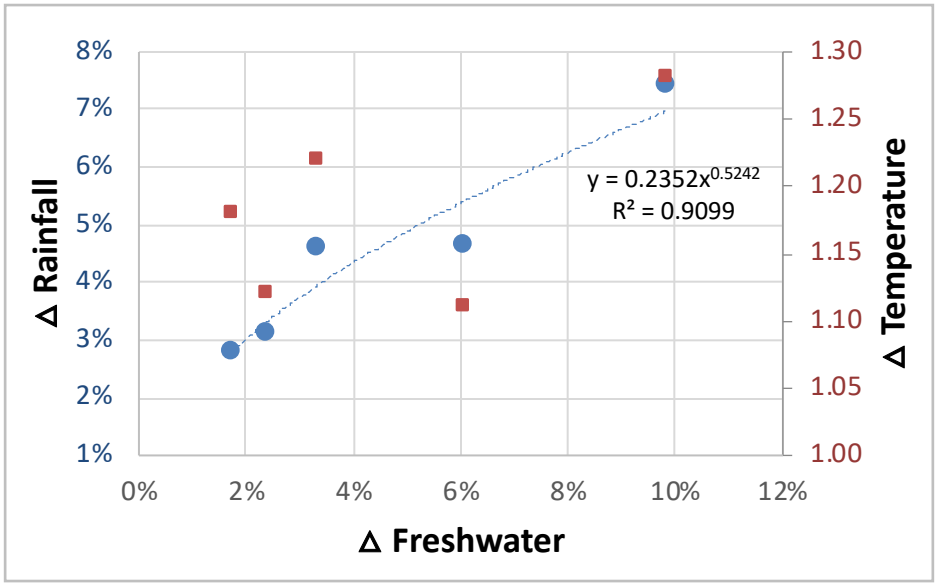


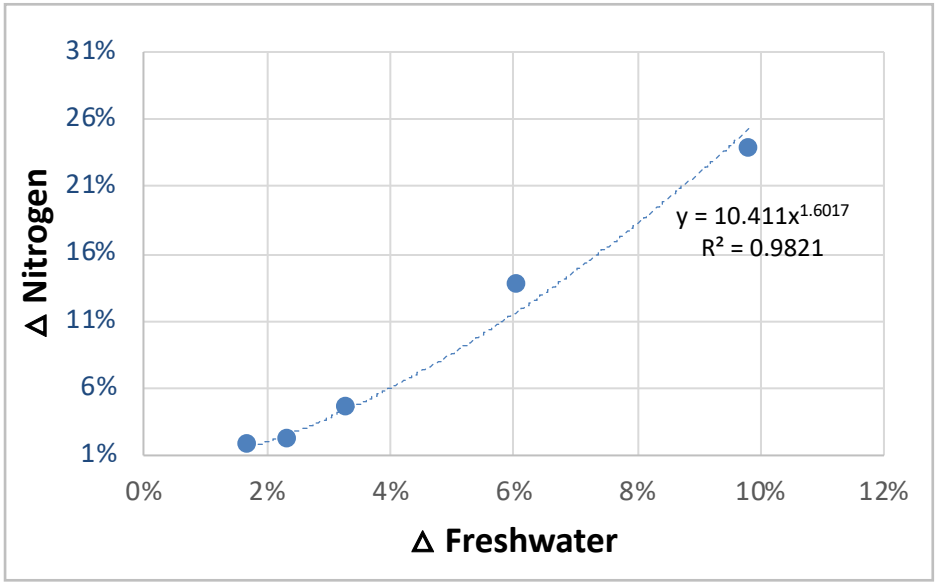




2025: Annual Responses

Simulation	Δ Rainfall	Δ Freshwater	Δ Nitrogen
Rainfall Trend	3.11%	2.38%	2.10%
BCSD RCP8.5 Ensemble Median	4.61%	3.34%	4.50%
MACA RCP8.5 Ensemble Median	2.80%	1.73%	1.80%
BCSD RCP8.5 CCSM4 (KKZ #1)	7.43%	9.85%	23.80%
MACA RCP8.5 CCSM4 (KKZ #1)	4.66%	6.08%	13.60%

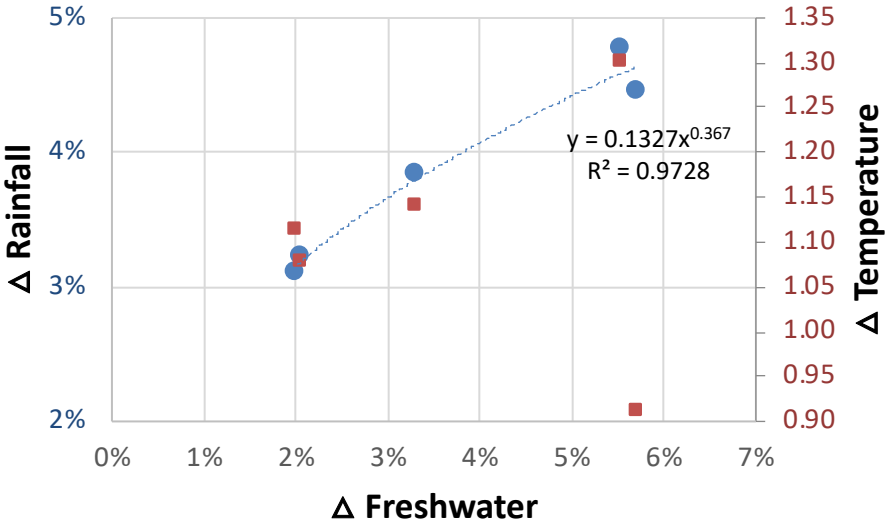


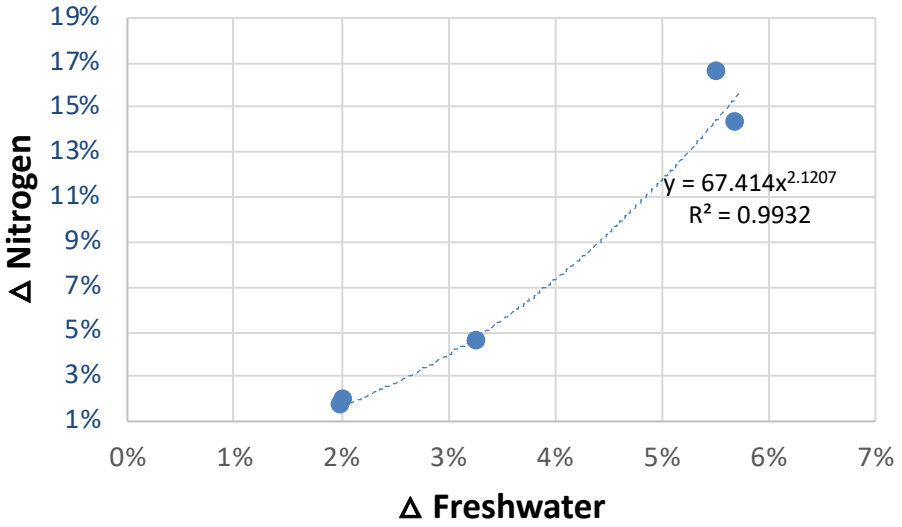


For these scenarios, rainfall change had higher variability and impacted the flow responses the most but temperature change was important as well.

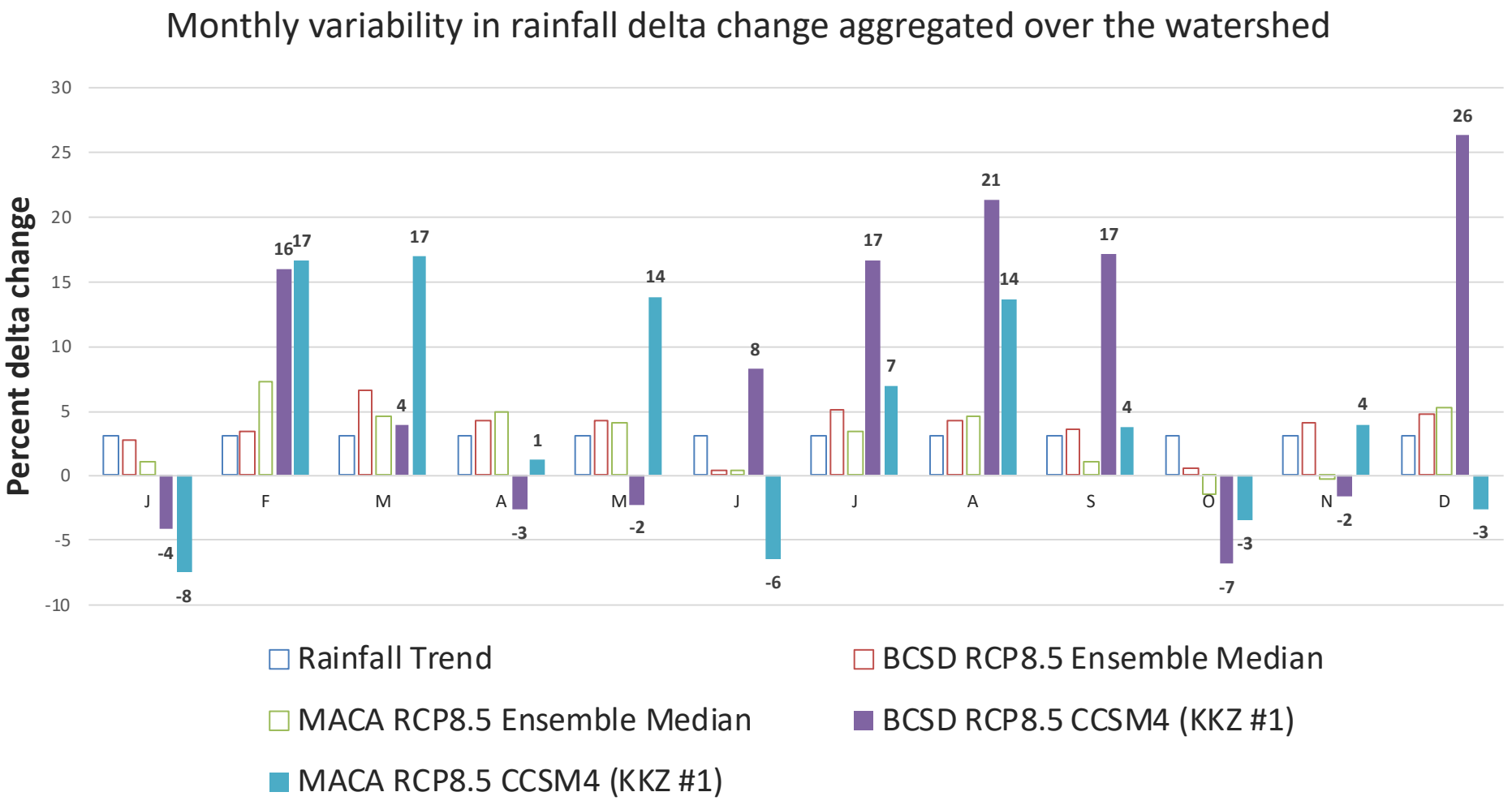
2025: Nov-Jun Responses

Simulation	Δ Rainfall	Δ Freshwater	Δ Nitrogen
Rainfall Trend	3.11%	2.02%	1.67%
BCSD RCP8.5 Ensemble Median	3.84%	3.30%	4.56%
MACA RCP8.5 Ensemble Median	3.23%	2.06%	1.90%
BCSD RCP8.5 CCSM4 (KKZ #1)	4.77%	5.55%	16.56%
MACA RCP8.5 CCSM4 (KKZ #1)	4.45%	5.72%	14.27%





Rainfall inputs for the scenarios



The ensemble medians are estimated distinctly at Phase 6 land segment (~county) and month space-time scales.

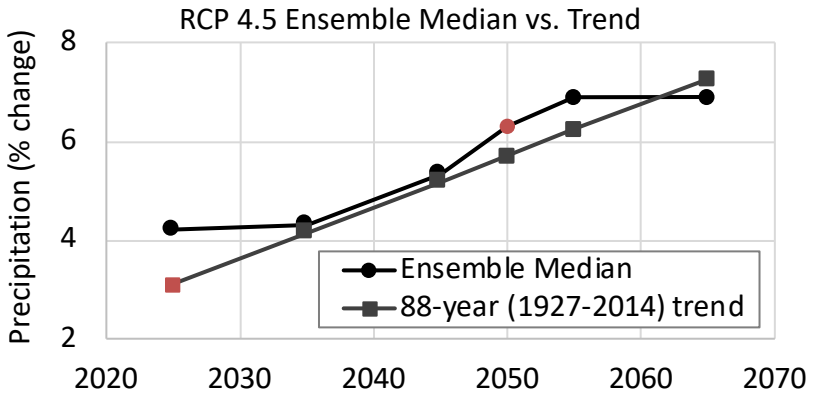
Summary

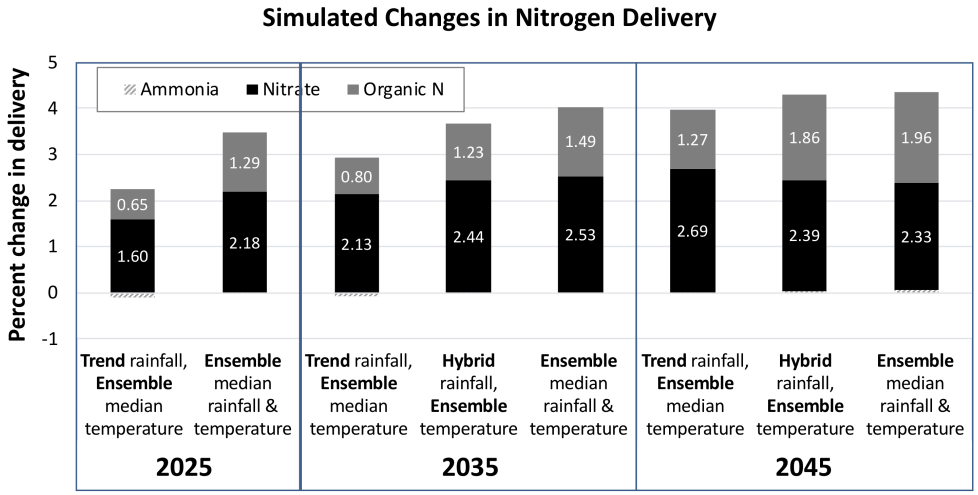
- Results of climate change assessments for 2025, 2035, 2045, and 2055 were shown.
- Including land use change slightly compounded the climate change effects.
- 3 new scenarios based on updated metric for KKZ Ranking analyses were processed and analyzed.
- Simulation results showed that watershed model responses are sensitive to how space and time scales are factored in the processing of delta changes in rainfall and temperature inputs.

- Trend-based rainfall projections (estimated from annual rainfall data) did not have any monthly/seasonal component.
- Analysis did not include changes in socio-economic responses, crop yields, growing degree days, atmospheric deposition, and best management practices (BMPs) etc.

?. How rainfall volume delta change is estimated for climate change scenarios beyond Year 2025

- They form a source of discontinuity. Modeling workgroup in September 2018[1] recommended combining two data sources using weighted averages for the periods between 2025 and 2050.
- Model results were presented in October 2018[2].





***Trend**: projection of extrapolation of long-term trends*
***Ensemble**: 31-member ensemble of RCP4.5 GCMs*
***Hybrid**: weighted average of trend and ensemble*

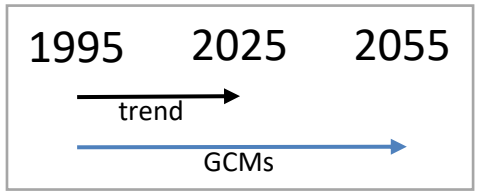
[1] https://www.chesapeakebay.net/channel_files/26032/20180911b_-_bhatt_-_mwcc_-_application_of_phase_6_watershed_model_to_climate_change_assessment.pdf
[2] https://www.chesapeakebay.net/channel_files/25923/20181016_-_bhatt_-_mwqm_-_application_of_phase_6_watershed_model_to_climate_change_assessment.pdf

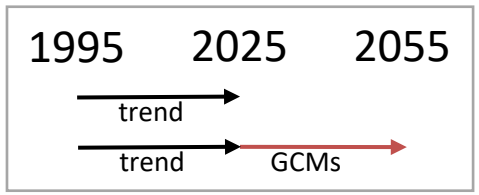
?. How rainfall volume delta change is estimated for climate change scenarios beyond Year 2025

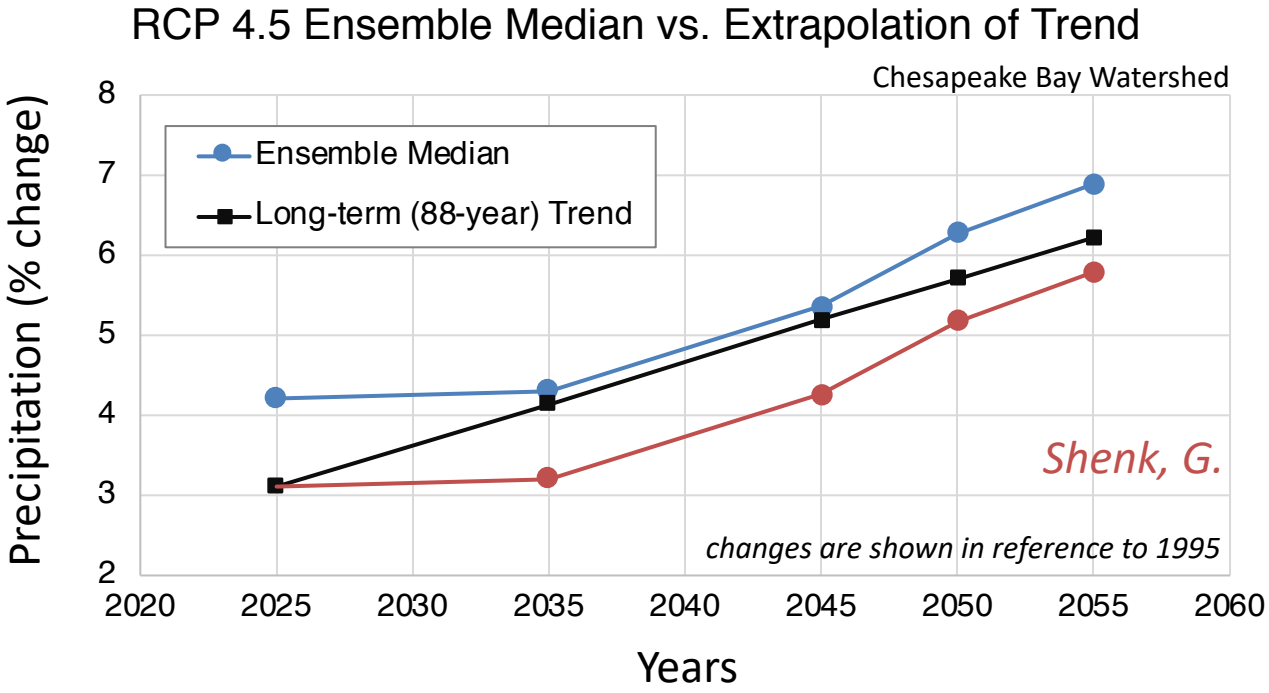
- An alternative would be to estimate delta change for the periods beyond 2025 by adding GCM delta for a future year and 2025 to the trend-based delta for 2025.

Hybrid vs. **Proposed**

(delta change for GCMs *wrt* 2025)



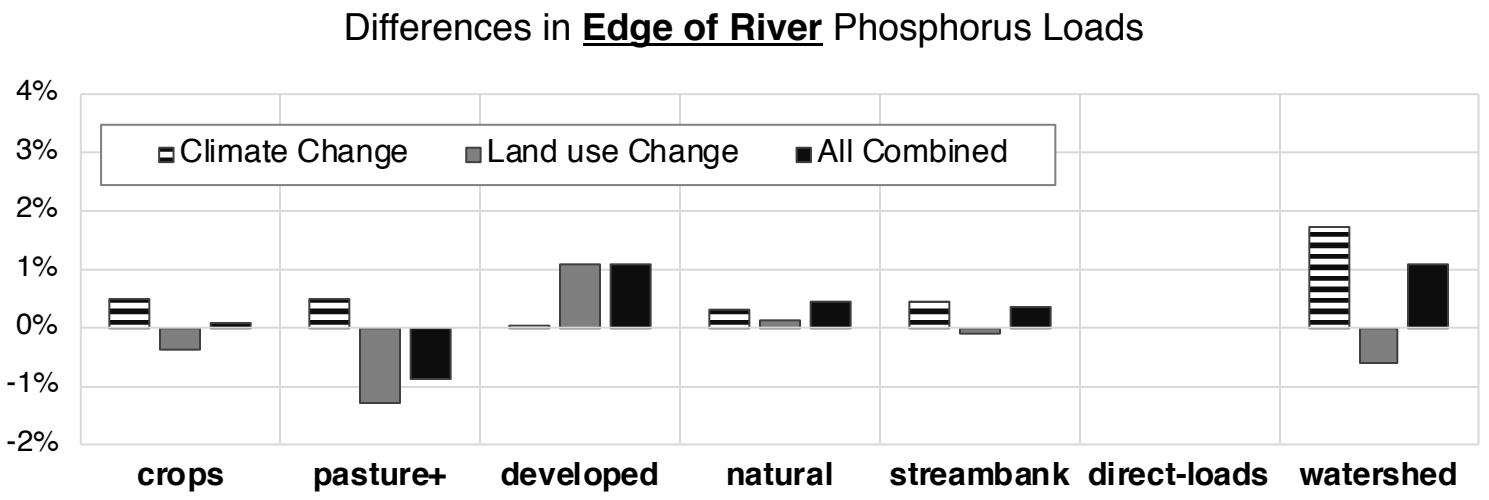


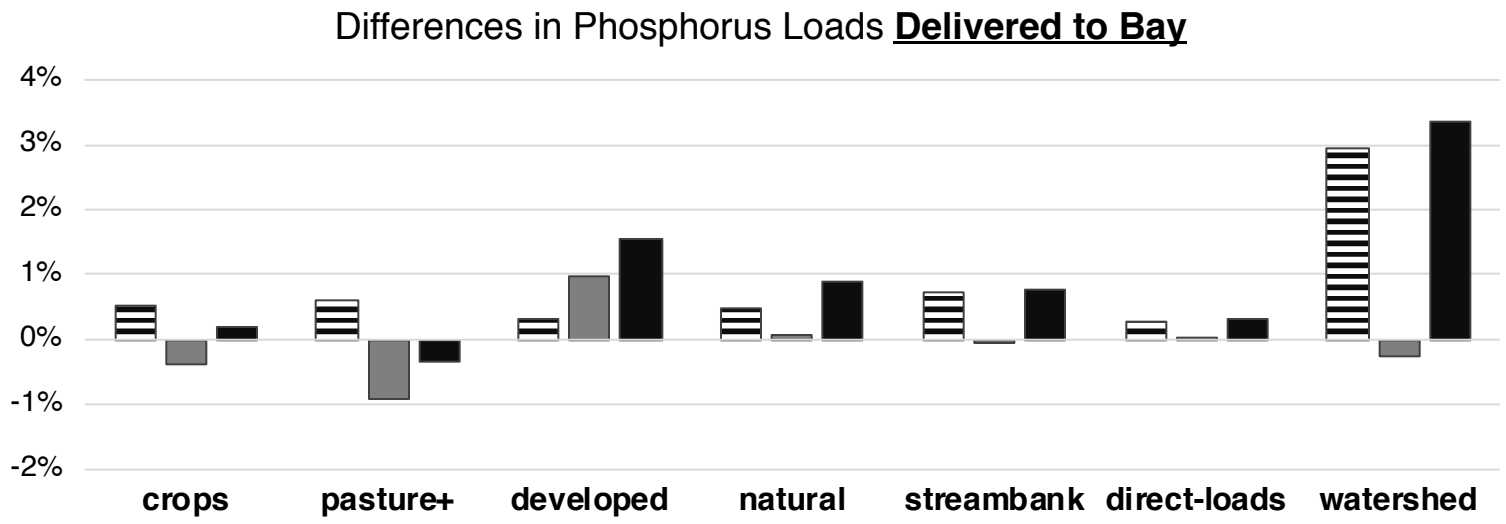


***Ensemble**: 31-member ensemble of RCP4.5 GCMs; **Trend**: extrapolation of long-term (1927-2014) trends;*

Differences are shown with respect to WIP2 delivery on 2010 land use

2025 Phosphorus delivery

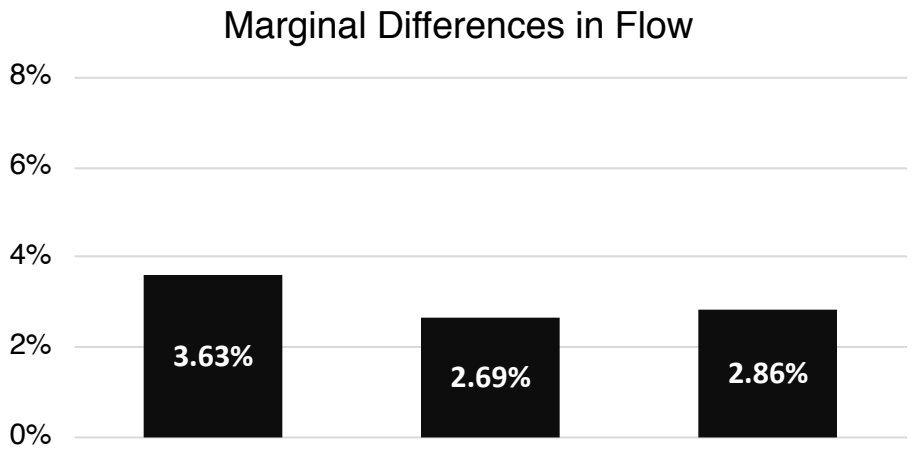


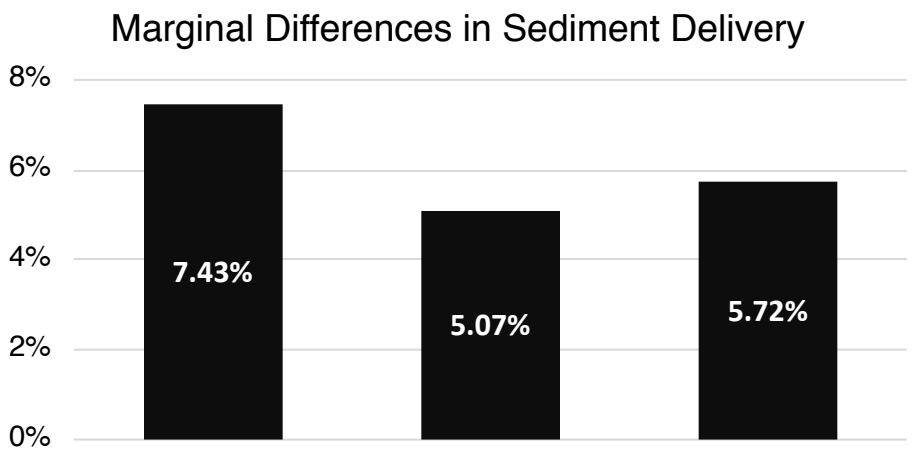


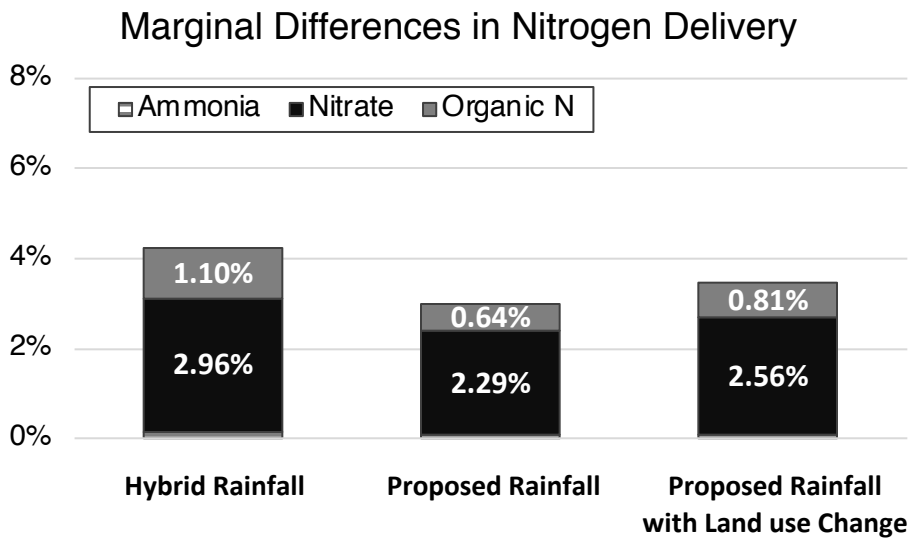
Climate change on 2025 land use had higher riverine response, particularly due to larger developed footprint.

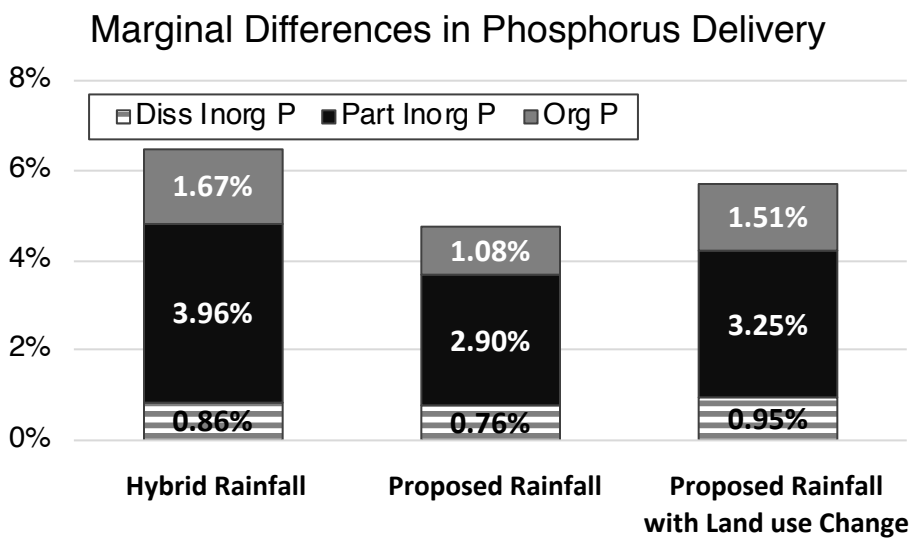
Differences are shown with respect to WIP2 on 2025 land use

2035 sensitivity scenarios



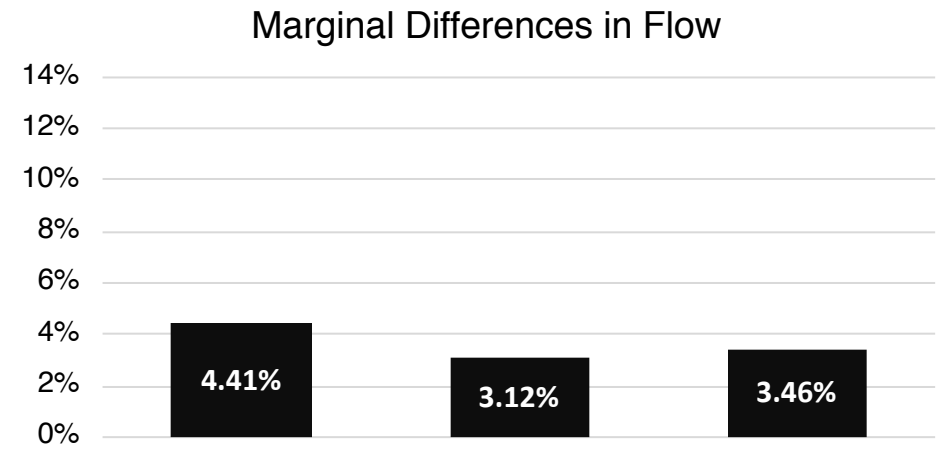


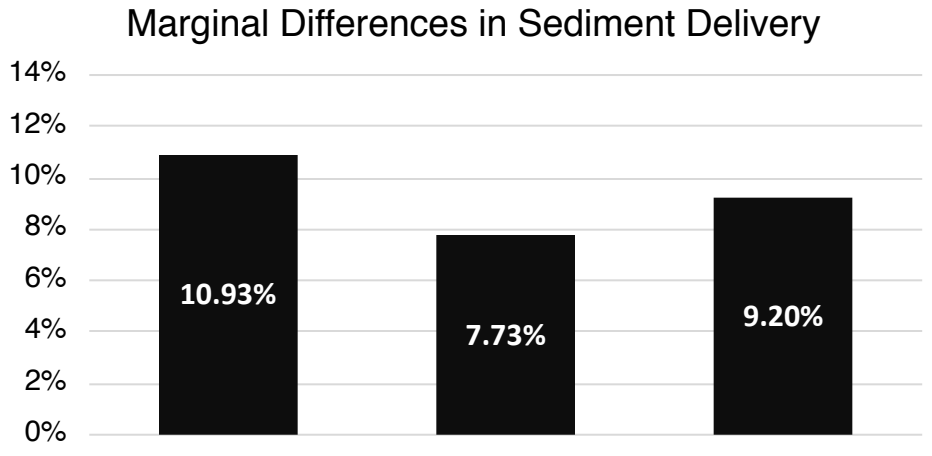


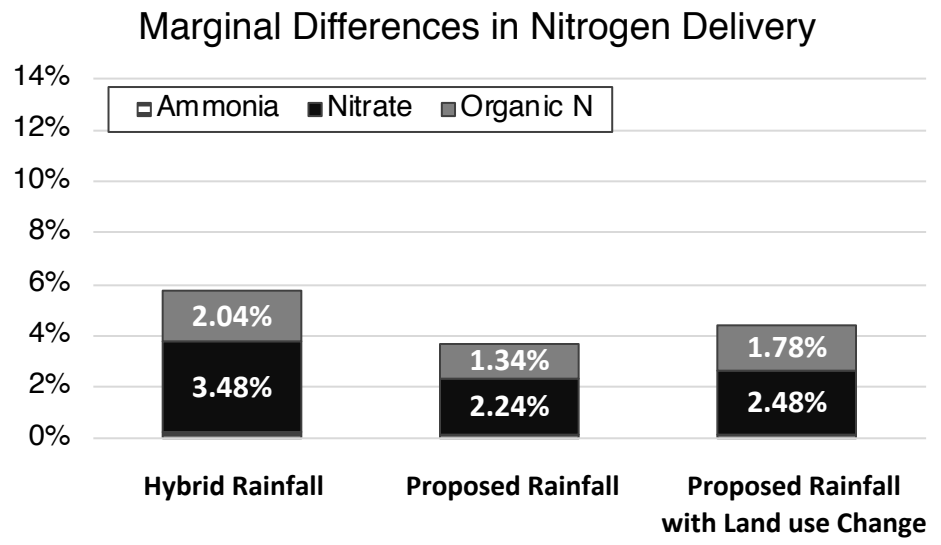


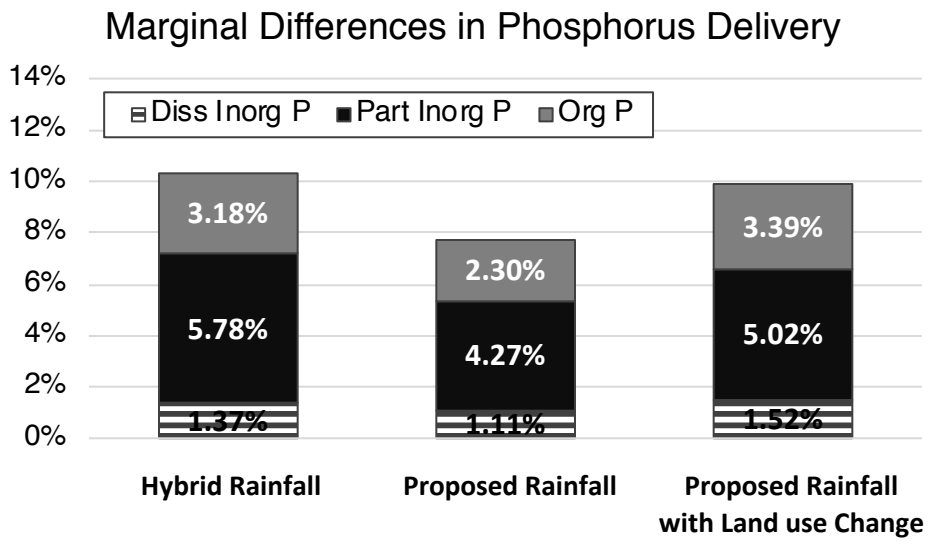
Differences are shown with respect to WIP2 on 2025 land use

2045 sensitivity scenarios



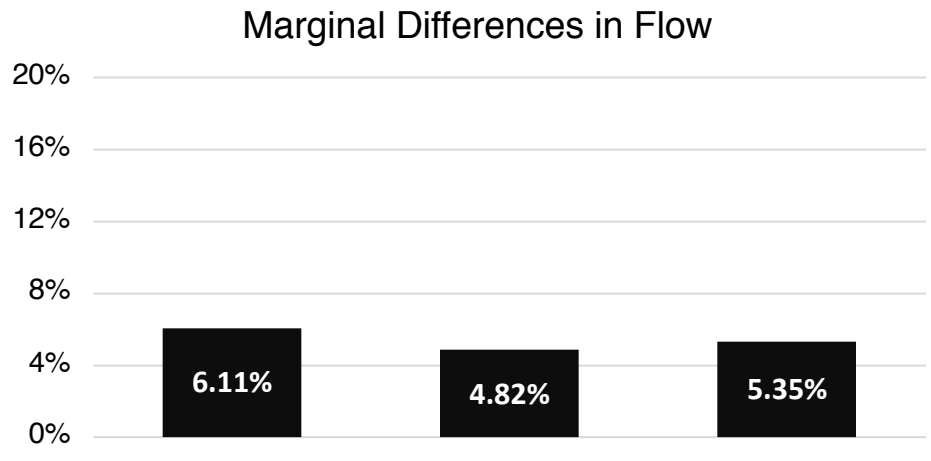


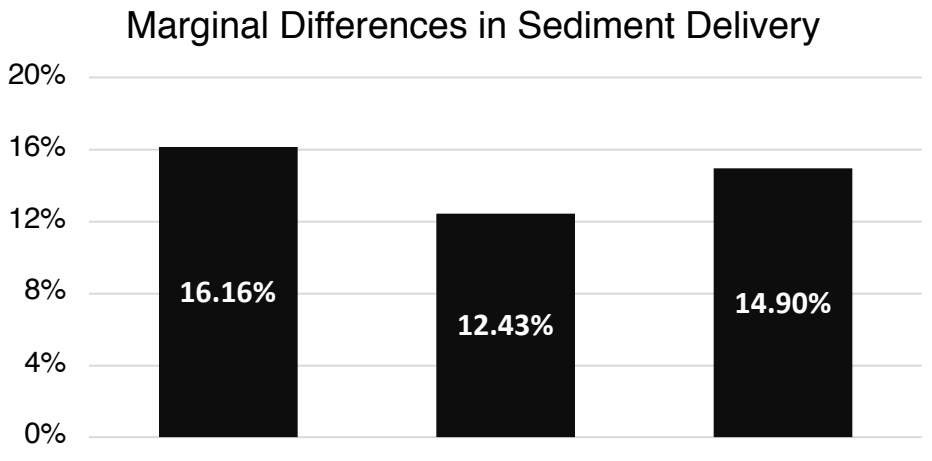


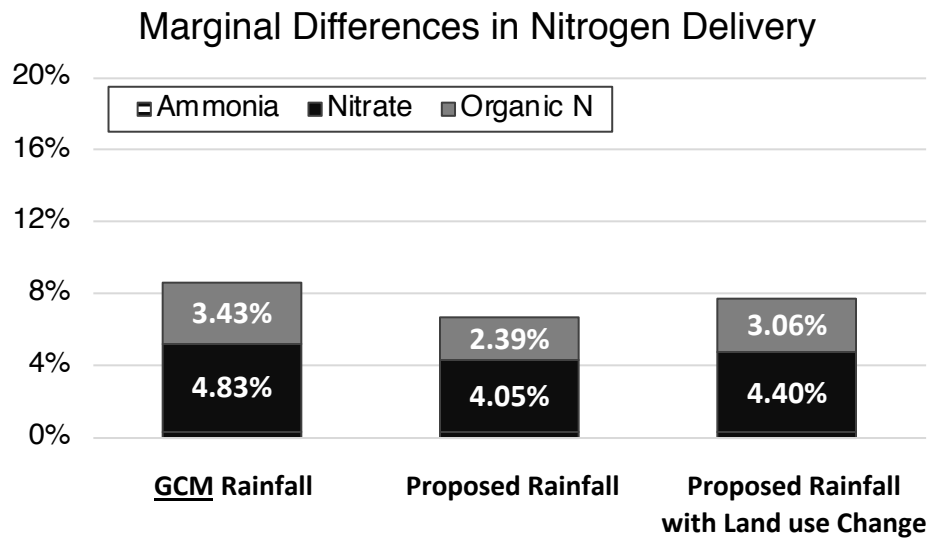


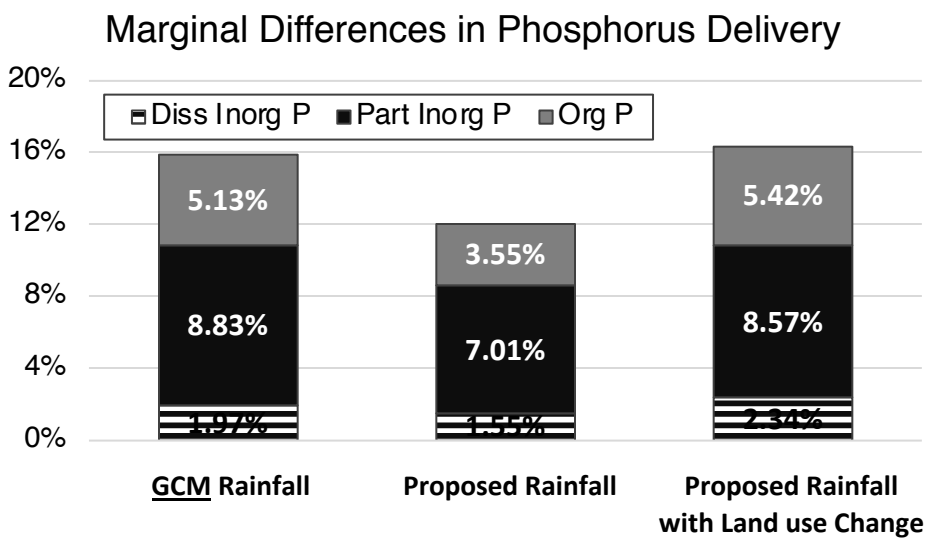
Differences are shown with respect to WIP2 on 2025 land use

2055 sensitivity scenarios

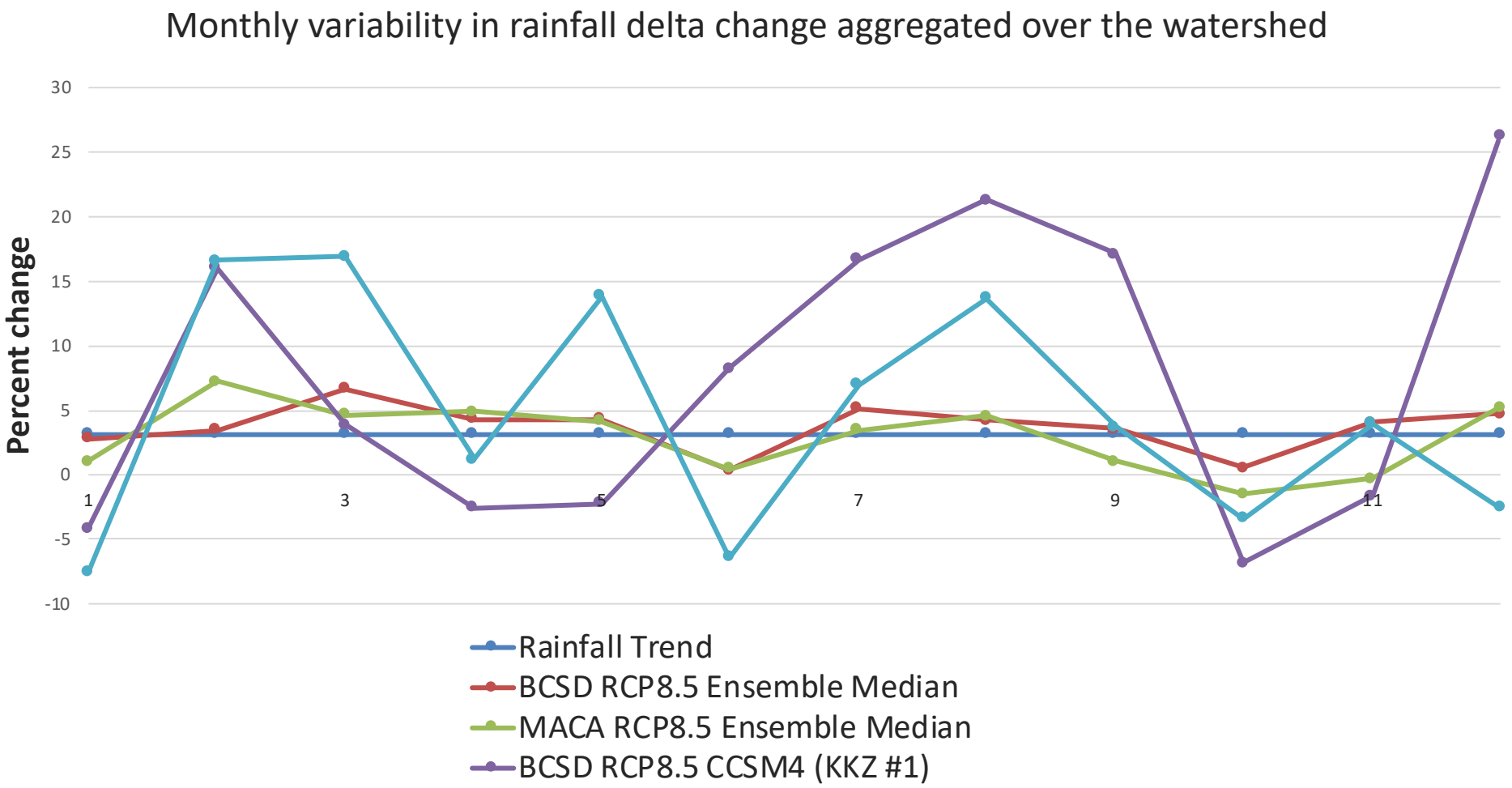








Rainfall inputs for the scenarios



The ensemble medians are estimated distinctly at Phase 6 land segment (~county) and month space-time scales.