UTAH LAKE C, N, AND P PROJECT UPDATE

ULWQS Science Panel Meeting

2021-06-10

Presented by Kateri Salk, Tetra Tech

GOALS

1. Present completed analyses for the external budget and SedFlux modeling
2. Solicit any feedback from the SP on approach and results
3. Initiate SP sub-group to review report

EXTERNAL MASS BALANCE MODEL

RECAP OF DECISIONS MADE AT LAST SP MEETING: FLOW

- Differing methodologies between DWQ and WFWQC
  - DWQ used USGS methodology
  - WFWQC used USGS methodology but with fewer partial sections than best practices
- Monitored sub-catchments
  - DWQ: 16
  - WFWQC: 13
- Distributions of flow were similar across 11 of 13 sub-catchments
- Lindon Drain & Spanish Fork River had wider distribution for DWQ than WFWQC

→ **Decision**: retain both entities' flow values for 11 sub-catchments, but DWQ only for these 2

FLOW

TN - total

DWQ	552
WFWQC	111

TN – Lindon Drain

DWQ	38
WFWQC	17

TN – Spanish Fork

DWQ	31
WFWQC	7

TP - total

DWQ	550
WFWQC	168

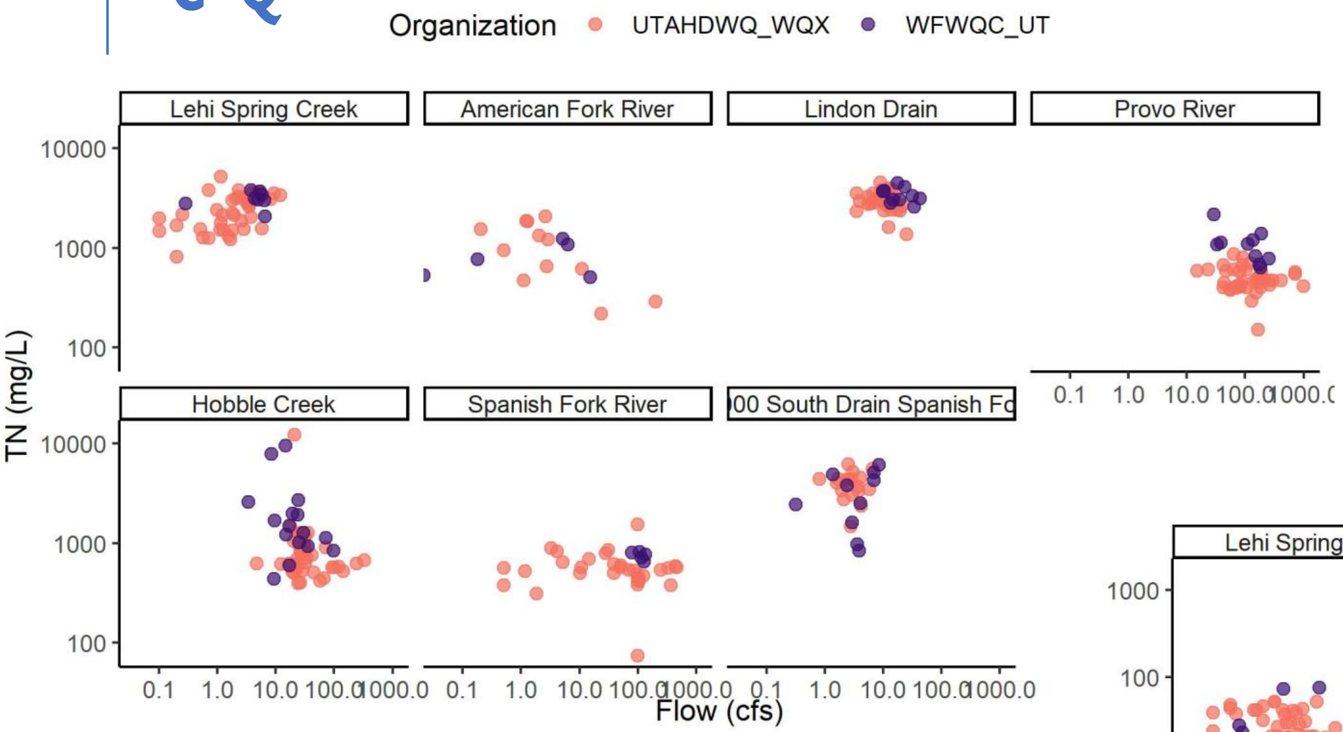
TP – Lindon Drain

DWQ	38
WFWQC	10

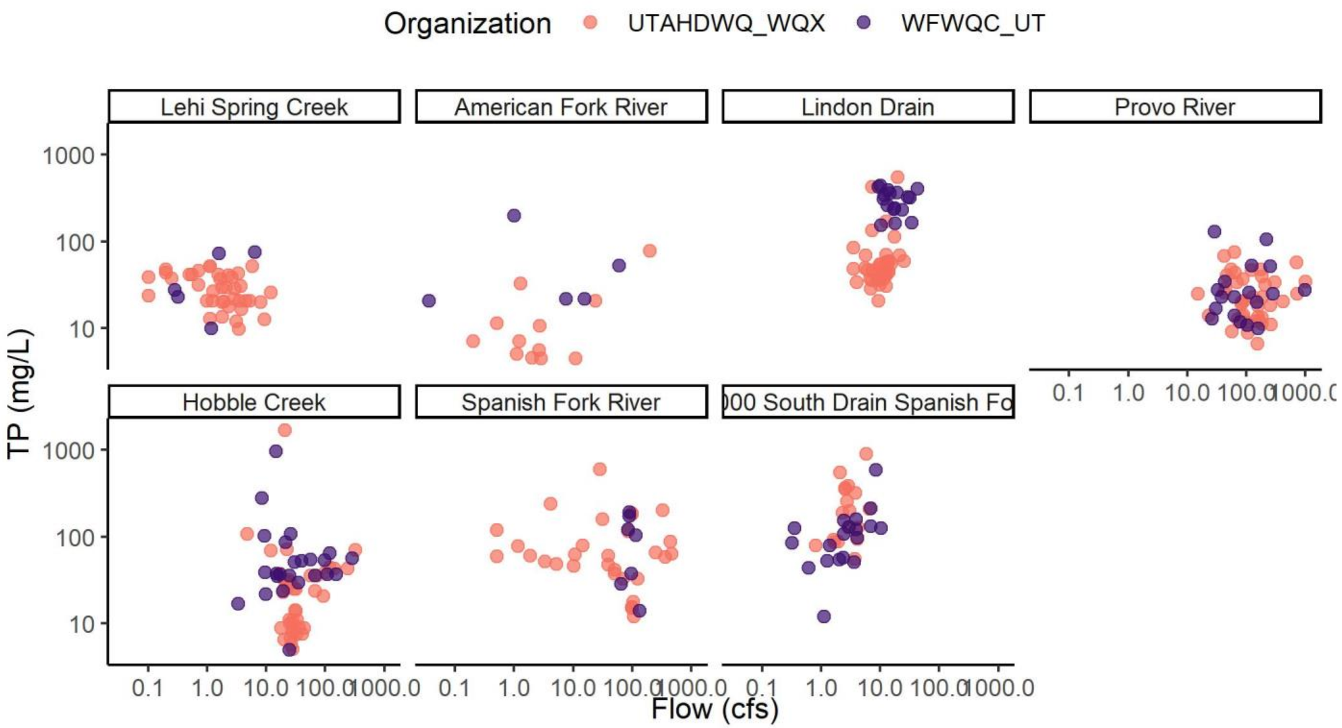
TP – Spanish Fork

DWQ	31
WFWQC	5

C-Q



Organization UTAHDWQ_WQX WFWQC_UT
Lehi Spring Creek
American Fork River
Lindon Drain
Provo River
Hobble Creek
Spanish Fork River
)00 South Drain Spanish Fo
TN (mg/L)
10000
1000
100
0.1 1.0 10.0 100.0 1000.0
Flow (cfs)



Organization UTAHDWQ_WQX WFWQC_UT
Lehi Spring Creek
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Lindon Drain
Provo River
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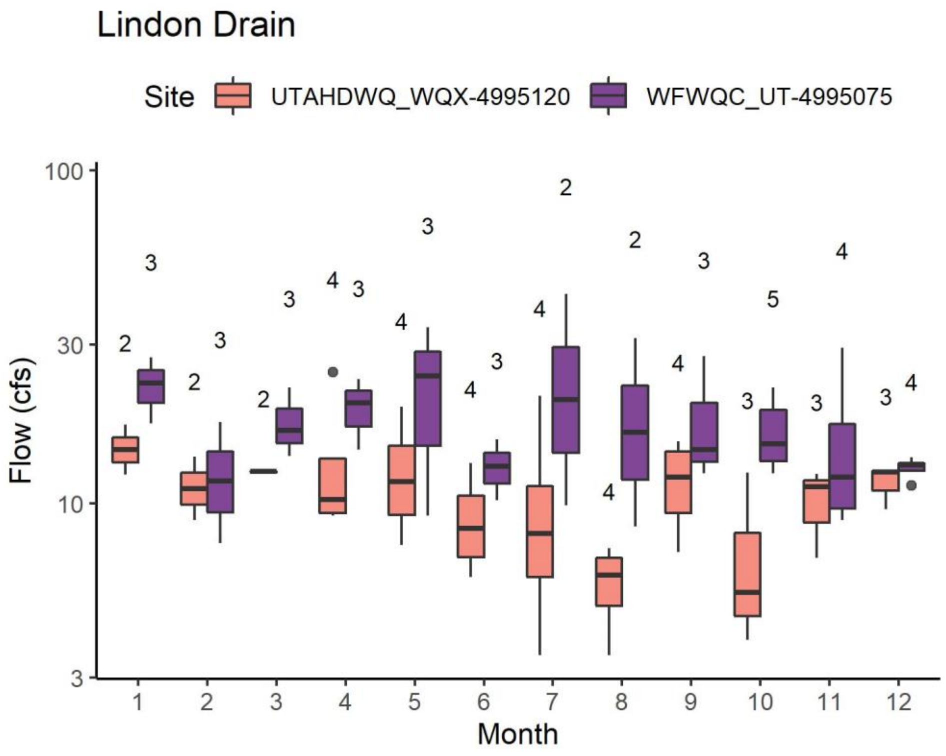
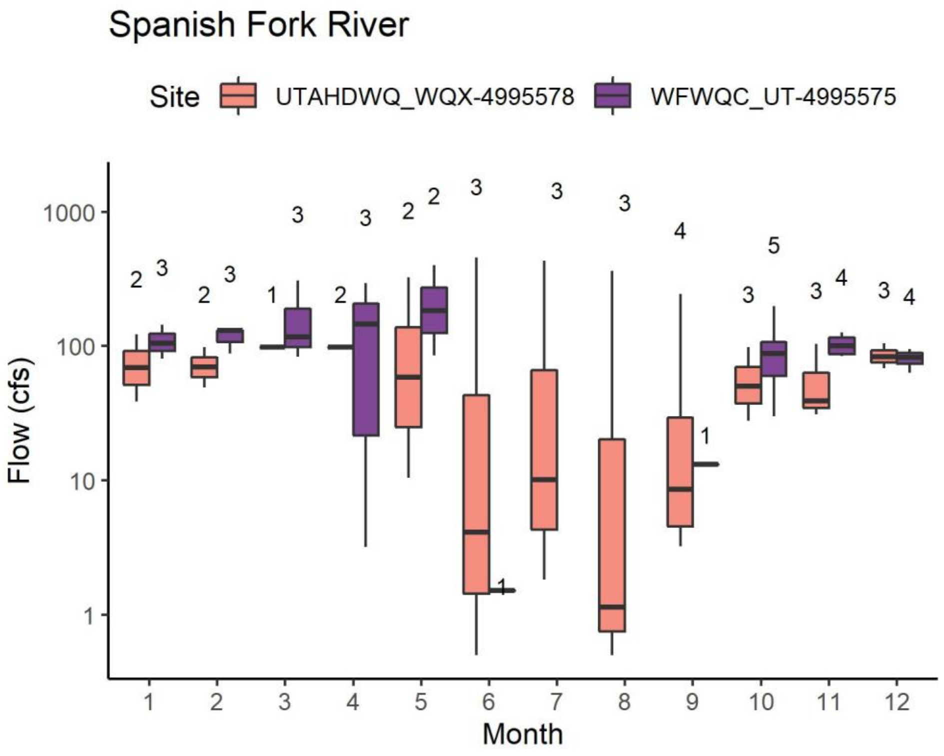
)00 South Drain Spanish Fo
TP (mg/L)
1000
100
10
0.1 1.0 10.0 100.0 1000.0
Flow (cfs)

FLOW


Lindon Drain
Site
UTAHDWQ_WQX-4995120
WFWQC_UT-4995075
Flow (cfs)
100
30
10
3
1
2
3
4
5
6
7
8
9
10
11
12
Month


Spanish Fork River
Site
UTAHDWQ_WQX-4995578
WFWQC_UT-4995575
Flow (cfs)
1000
100
10
1
1
2
3
4
5
6
7
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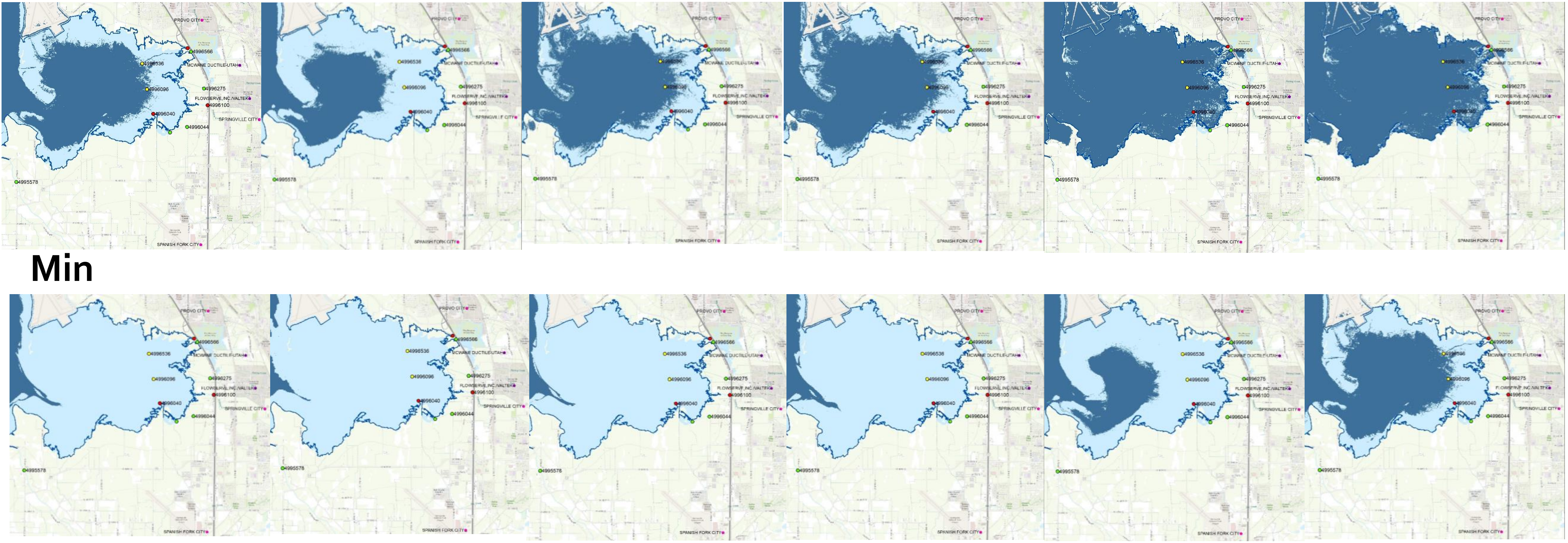
9
10
11
12
Month

PROVO BAY: VARIATION IN ELEVATION

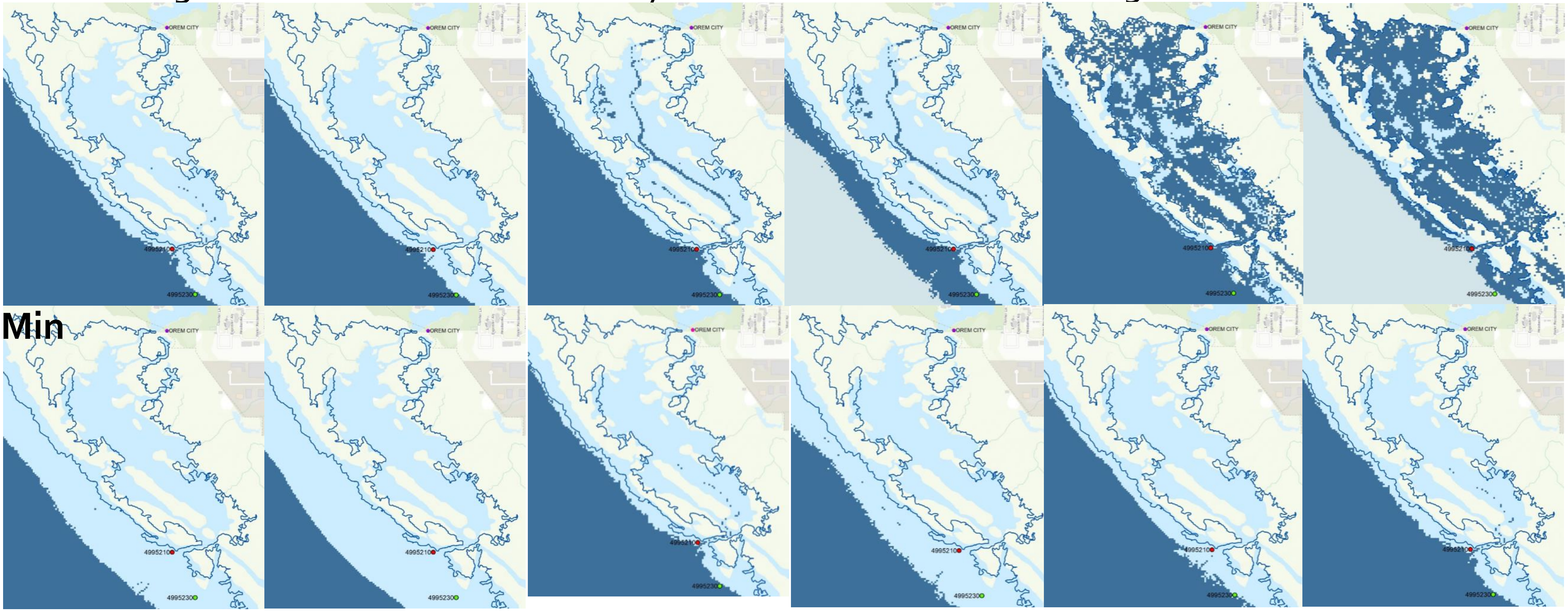
Max 2015 2016 2017 2018 2019 2020

Min



POWELL SLOUGH: VARIATION IN ELEVATION

Max 2015 2016 2017 2018 2019 2020



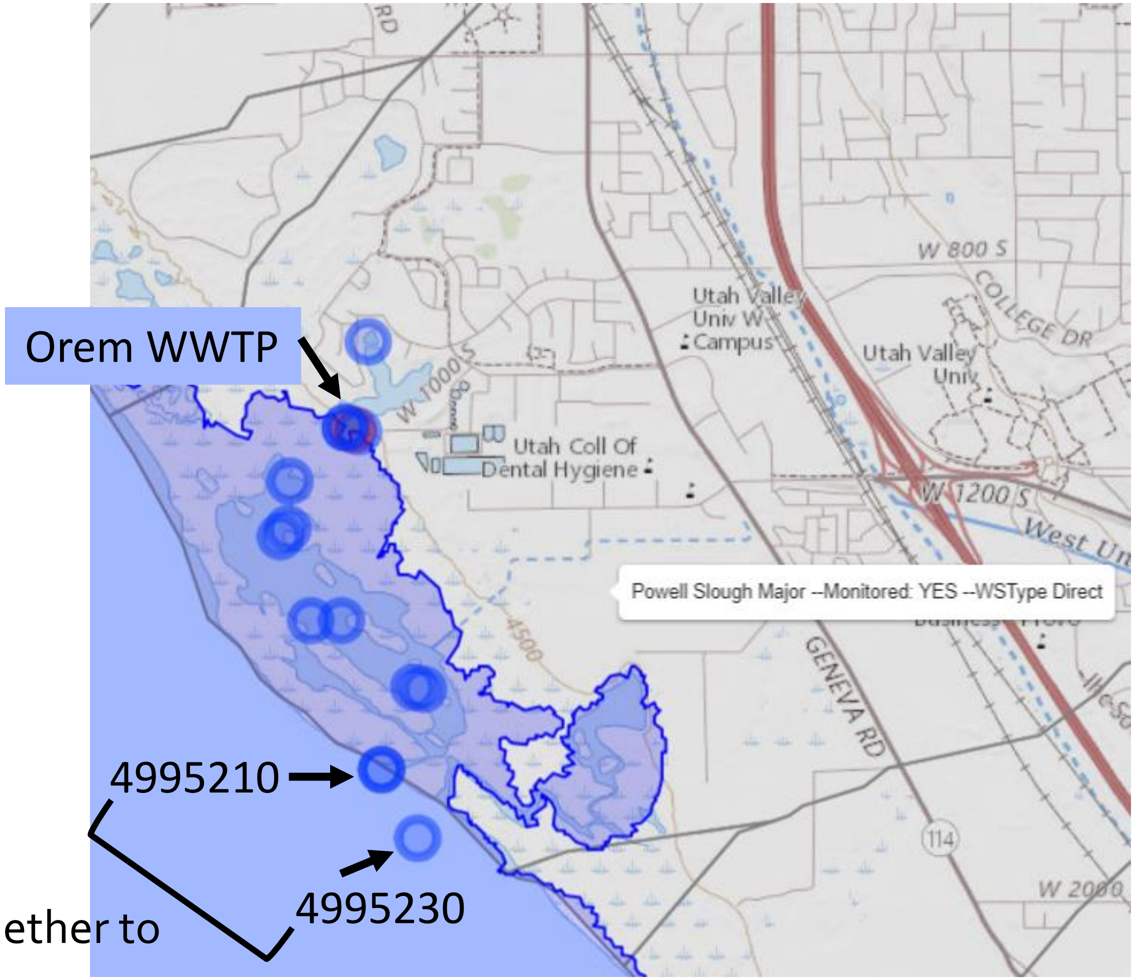
RECAP OF DECISIONS MADE AT LAST SP MEETING

- Lake boundary
  - If lake boundary = compromise elevation → generate loads from location directly upstream of compromise
  - If lake boundary = inundated area at time of sampling → generate loads from downstream location
  - Intermediate boundary is not possible to calculate (data limitations)
  - **Decision**: For Powell Slough and Mill Race, try both options
- Tributary monitoring data vs. DMR data
  - Monitored flows > DMR flows when WWTP is farther from the lake monitoring site
  - **Decision**:

  1. Use DMR data when WWTP is near tributary outflow (Timp SSD, Powell Slough, Mill Race)
  2. Use tributary data when WWTP is far from tributary outflow (Spring Creek – Springville, Dry Creek – Spanish Fork, Benjamin Slough)

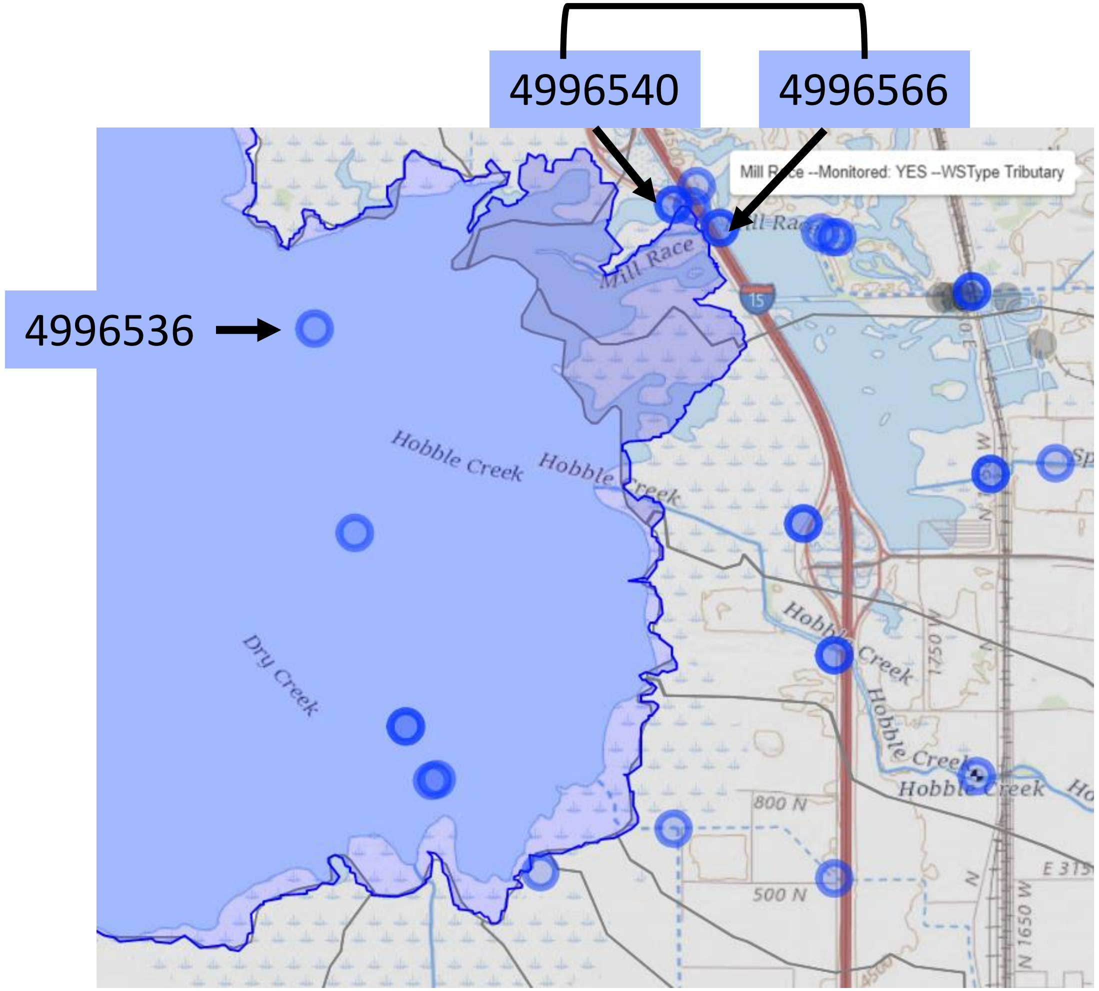
POWELL SLOUGH EXPLORATION

- Calculated load from Orem WWTP DMR data and tributary monitoring sites
- TN (metric tons/yr)
  - DMR: 279.52
  - Tributary: 294.86
- TP (metric tons/yr)
  - DMR: 45.92
  - Tributary: 32.87
- According to SP recommendation, used DMR data from Orem WWTP for final loading estimates



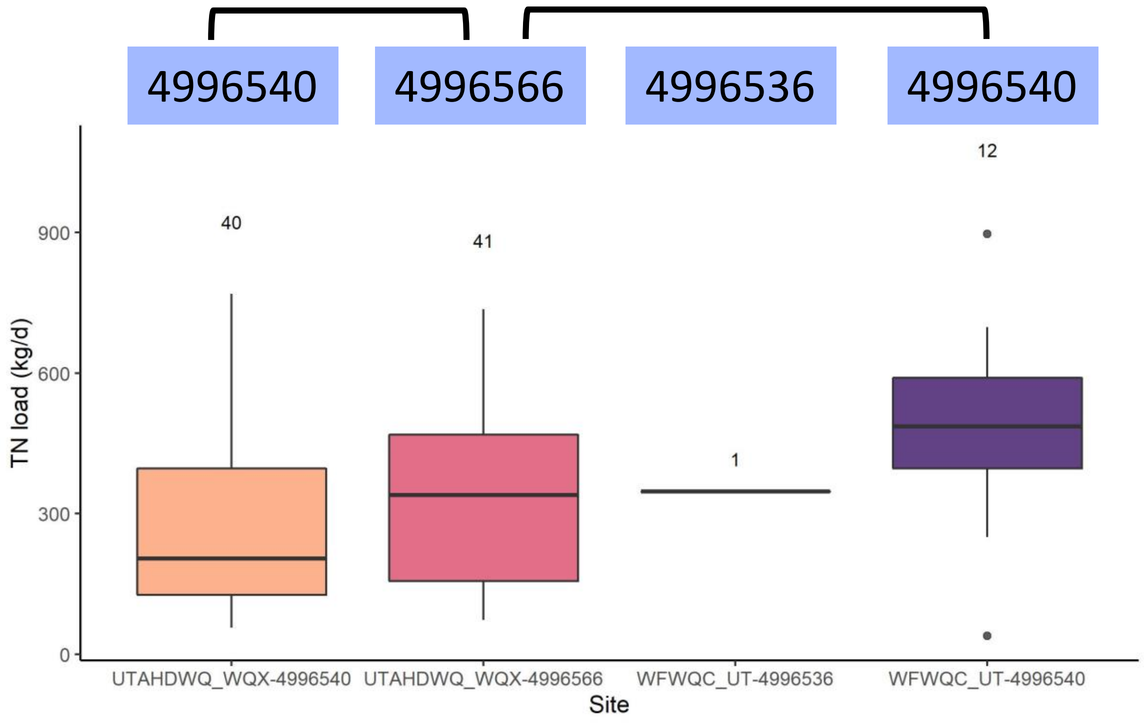
MILL RACE EXPLORATION

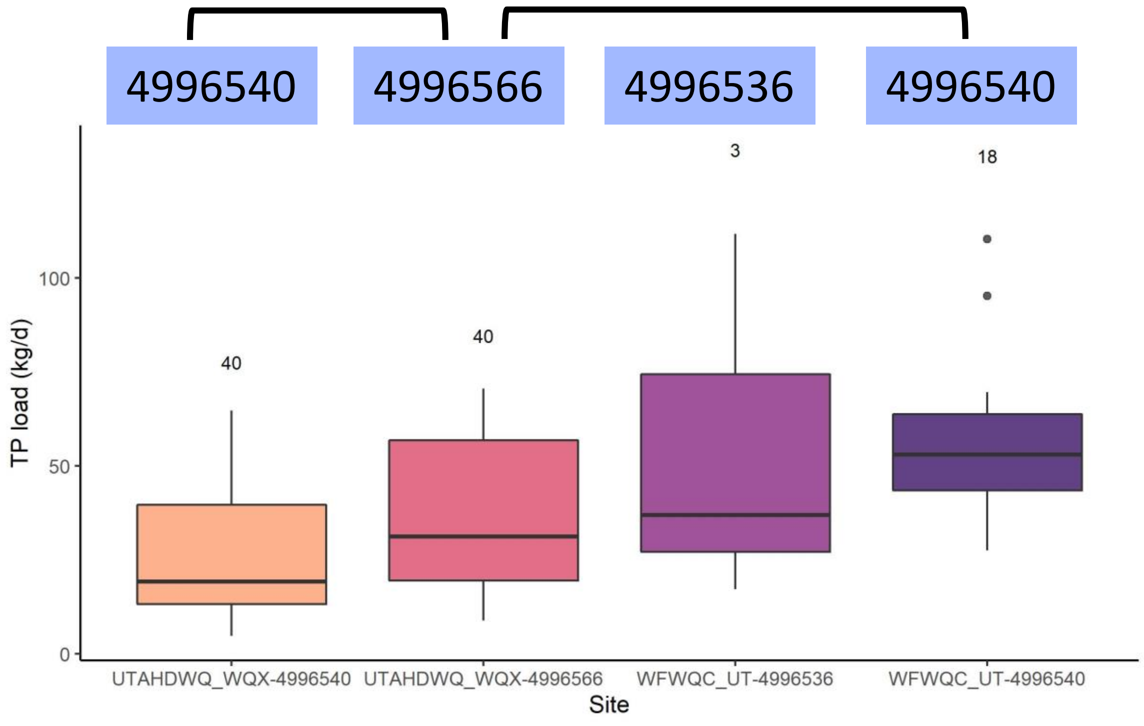
Sum together to calculate total load



MILL RACE EXPLORATION

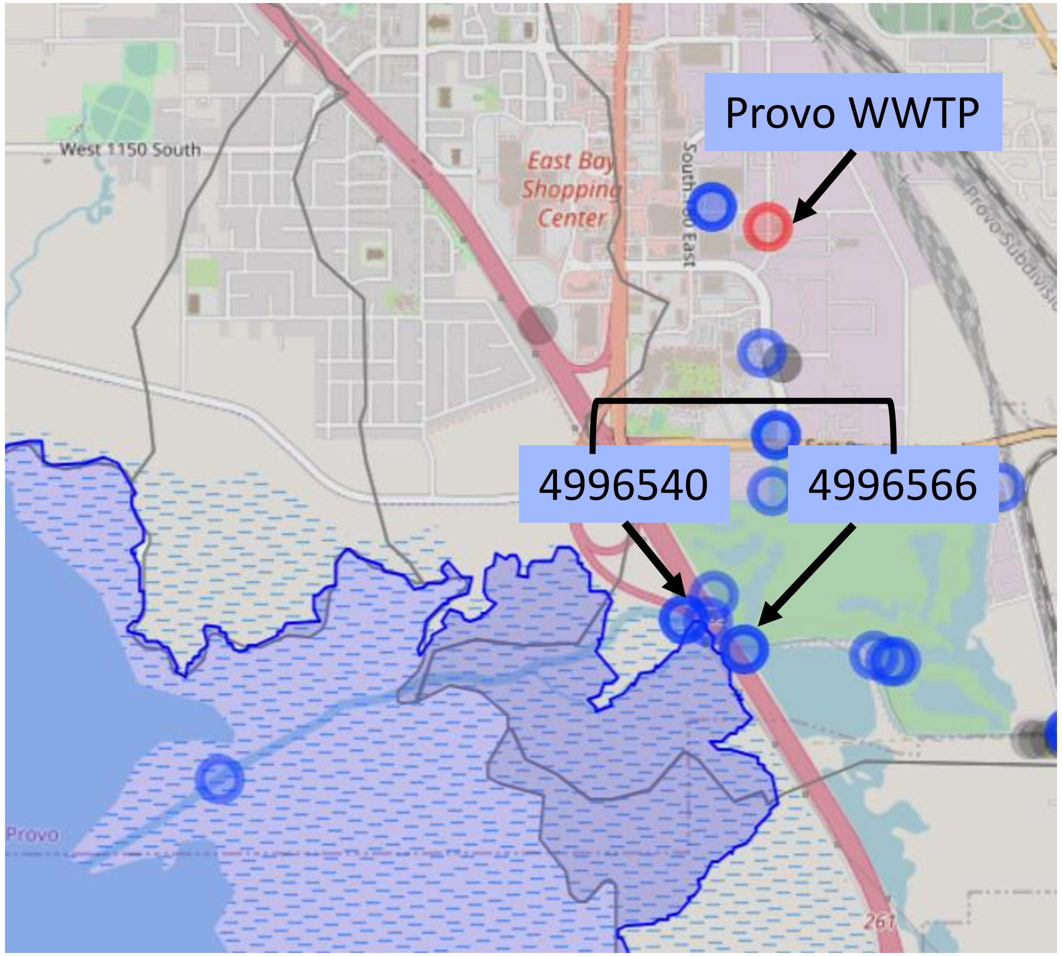
Insufficient samples at the most downstream sampling point to generate a load at that location



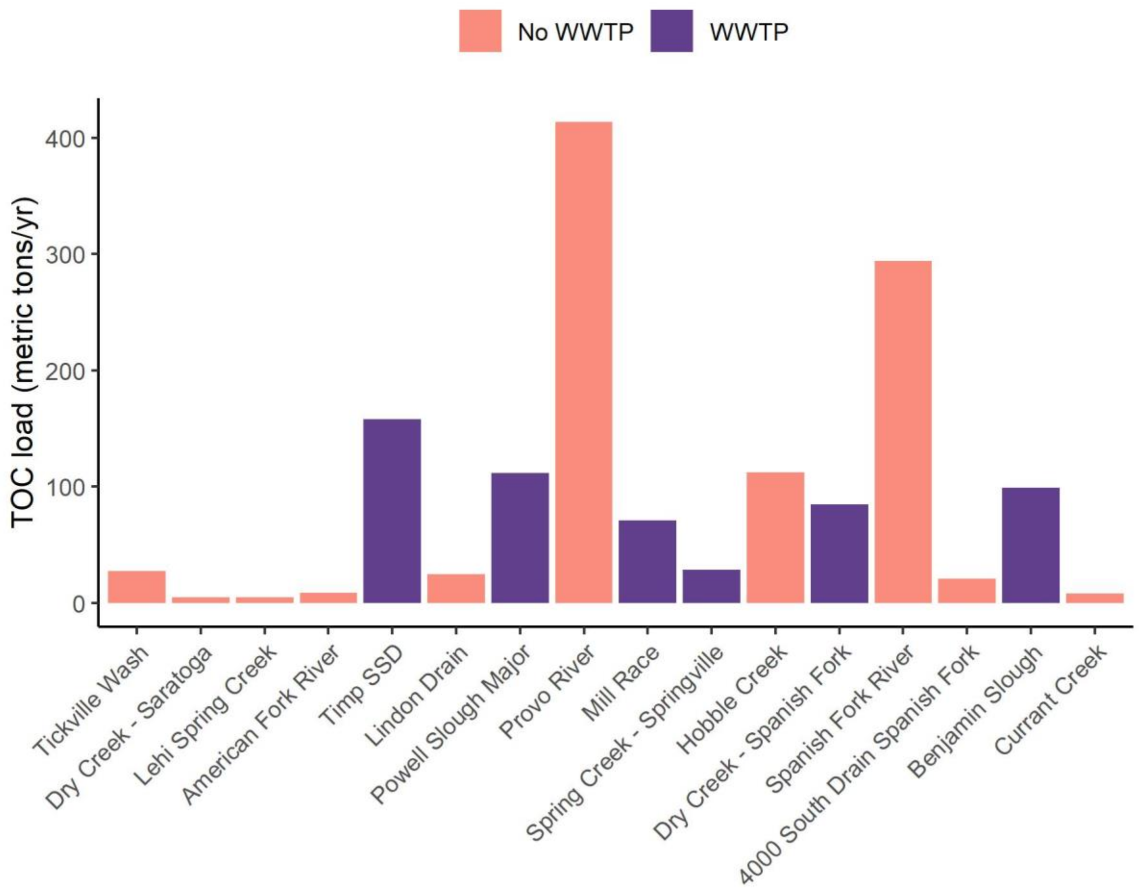


MILL RACE EXPLORATION

- Calculated load from Provo WWTP DMR data and tributary monitoring sites
- TN (metric tons/yr)
  - DMR: 318.31
  - Tributary: 257.41
- TP (metric tons/yr)
  - DMR: 51.88
  - Tributary: 27.27
- According to SP recommendation, used DMR data from Provo WWTP for final loading estimates



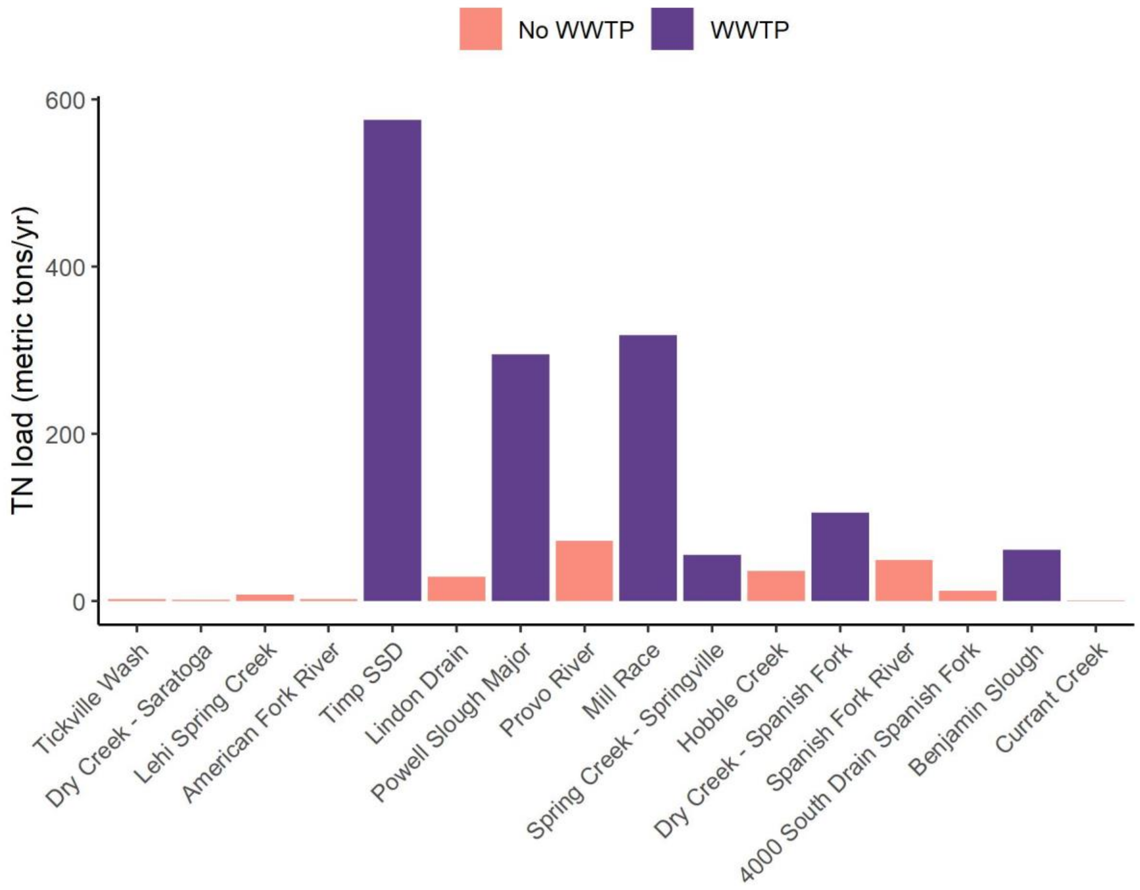
C, N, AND P BUDGETS: MONTIORED SUB-CATCHMENTS



TOC loads highest for Provo River and Spanish Fork River

- High flows
- Large watershed area
- No WWTPs

C, N, AND P BUDGETS: MONTIORED SUB-CATCHMENTS

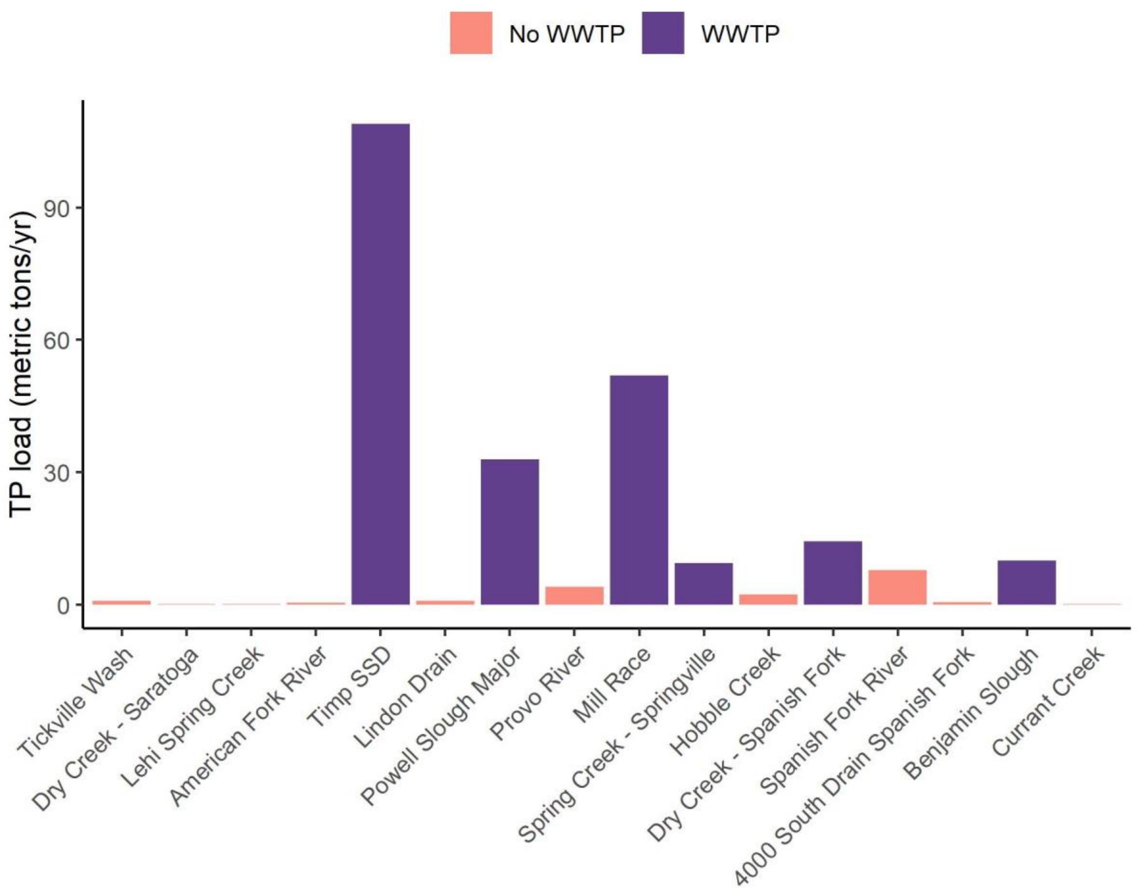


TN loads highest for Timp SSD, Powell Slough, and Mill Race

- WWTPs
- Differing flow and watershed size
- Note: derived from DMR data

Provo River and Spanish Fork highest among non-WWTP sub-catchments

C, N, AND P BUDGETS: MONTIORED SUB-CATCHMENTS

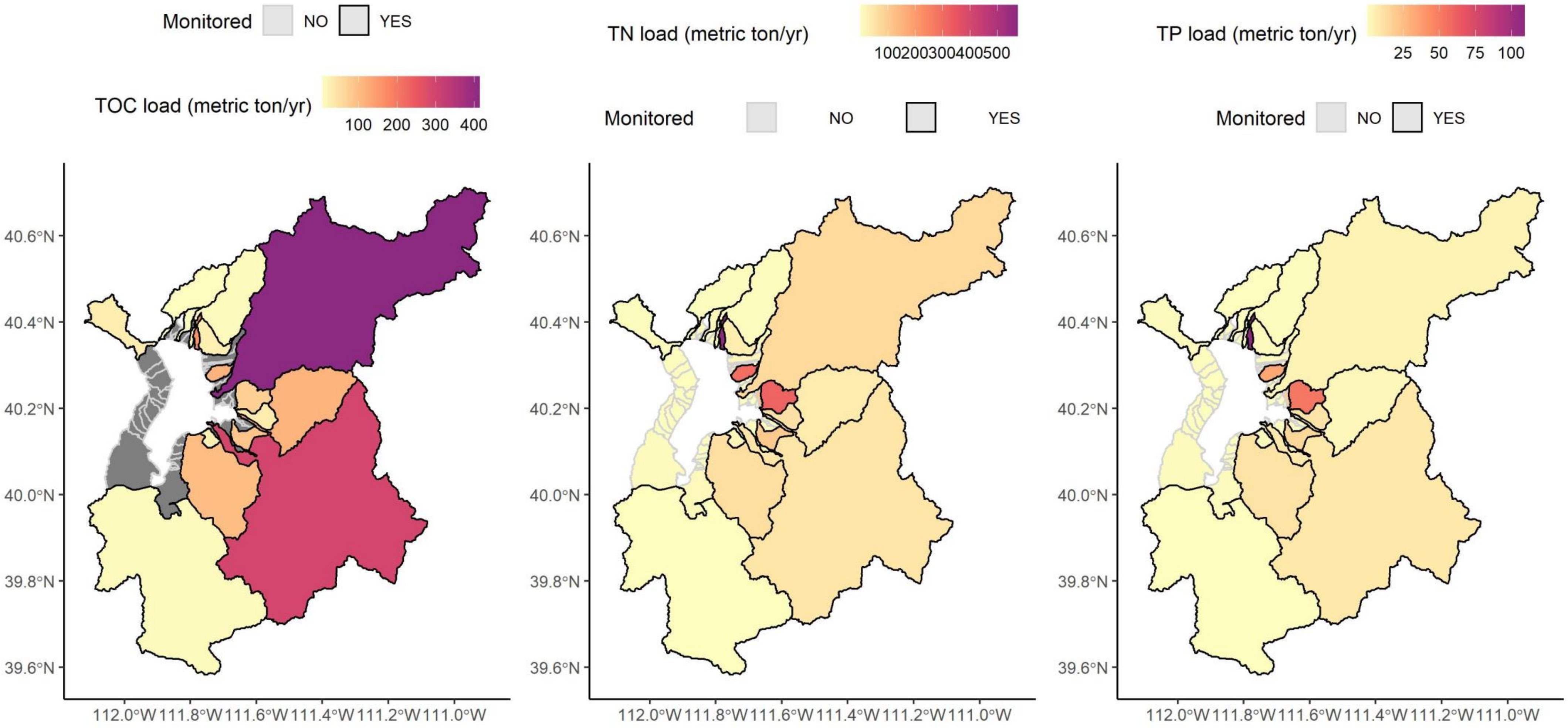


TP loads highest for Timp SSD, Powell Slough, and Mill Race

- WWTPs
- Differing flow and watershed size
- Note: derived from DMR data

Spanish Fork and Provo River highest among non-WWTP sub-catchments

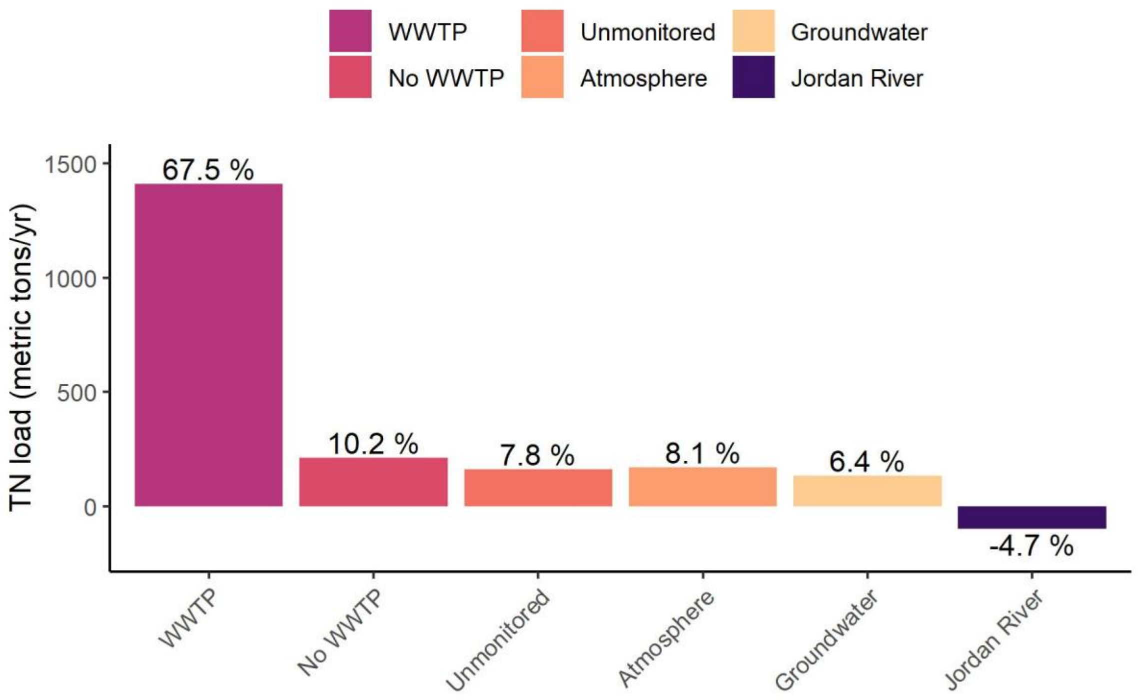
C, N, AND P BUDGETS: ALL SUB-CATCHMENTS

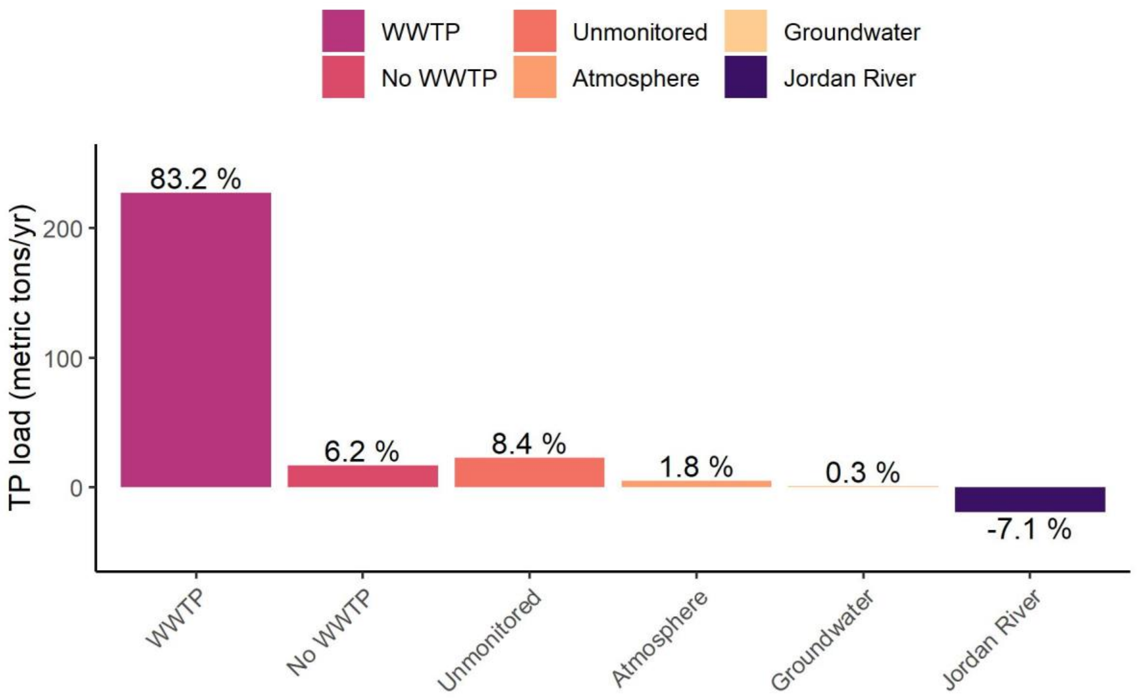


C, N, AND P BUDGETS: ALL SUB-CATCHMENTS

- Additional analysis: calculate load per unit area
- Additional data/visualizations for individual sub-catchments
  - Flow
  - Concentration
  - Load

NUTRIENT BUDGETS



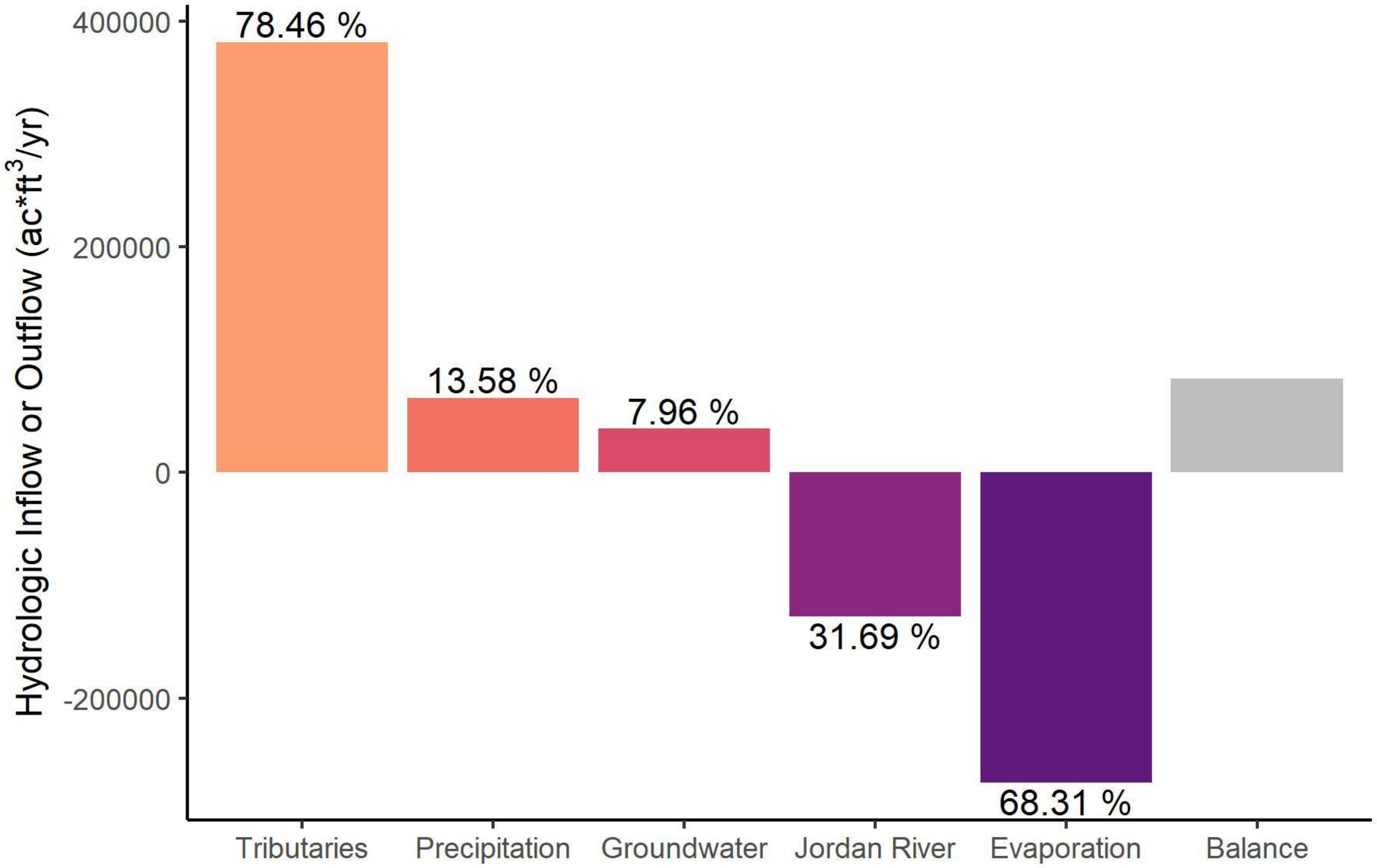


NUTRIENT BUDGETS: COMPARISONS TO OTHER STUDIES

	This Study	Merritt and Miller 2016	PSOMAS and SWCA 2007
Years	2015-2020	2009-2013	1980-2003
TN (metric tons/yr)	2,091	1,946	
TP (metric tons/yr)	273	247	270

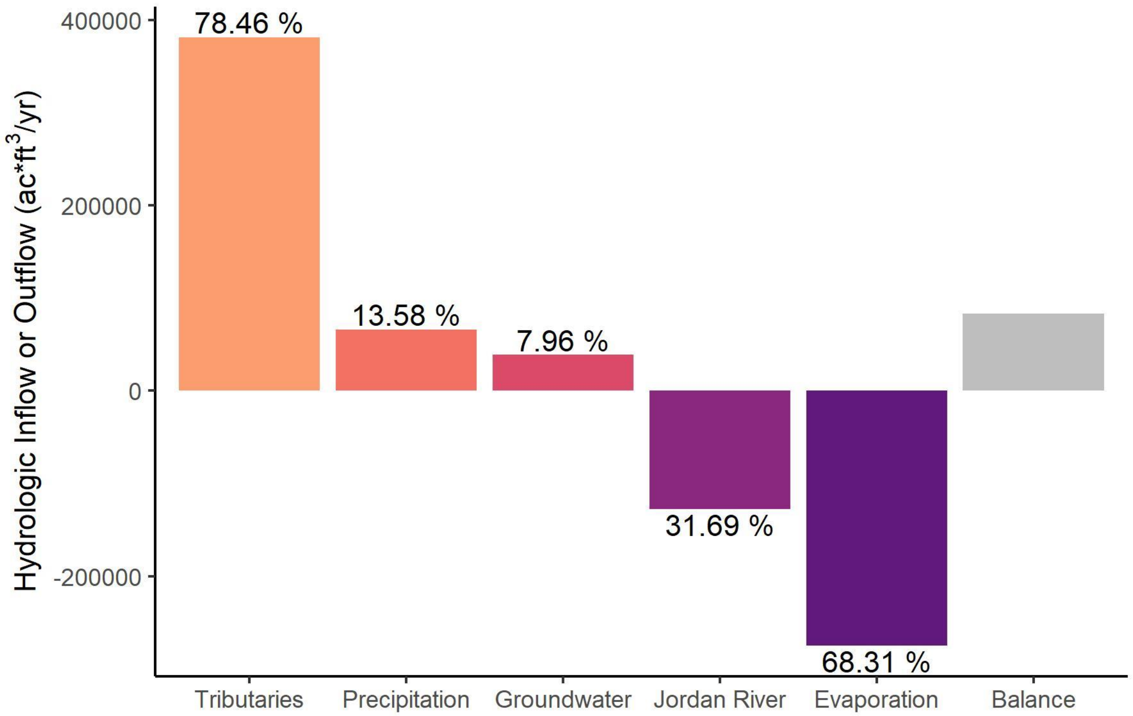
HYDROLOGIC BUDGET

- Monitored sub-catchments: 92 % of tributary inflow
- Net positive storage of 83,500 ac*ft/yr (17 % of total inflow)
- Comparisons to other studies
  - Tributary and overland flow: within range of previous studies
  - Jordan River outflow: lower than previous studies (dry years)

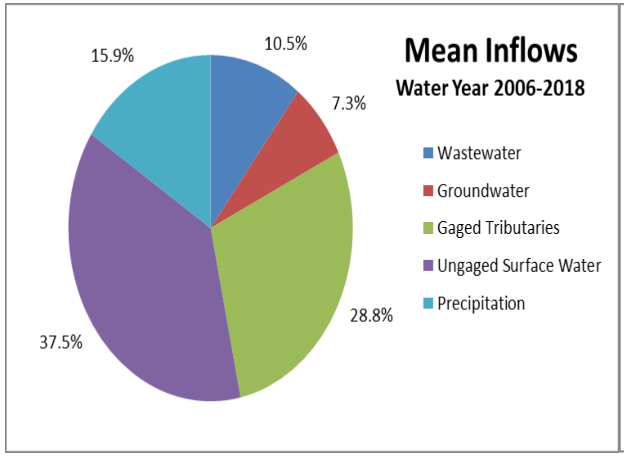


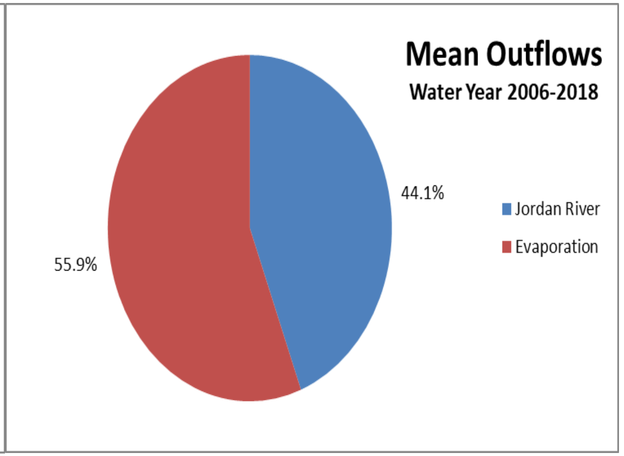
HYDROLOGIC BUDGET

This Study

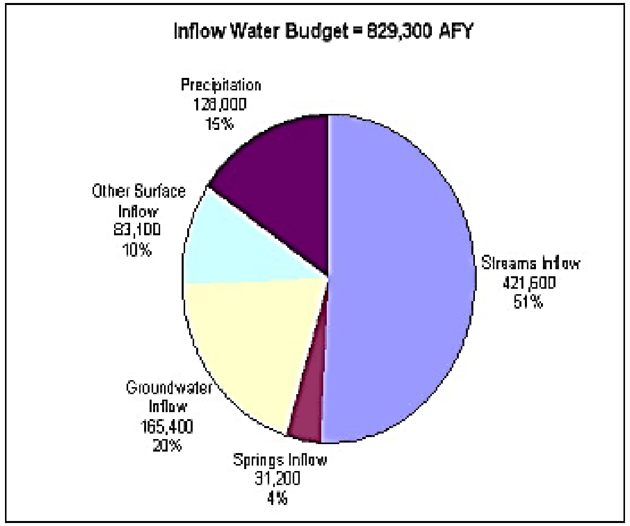


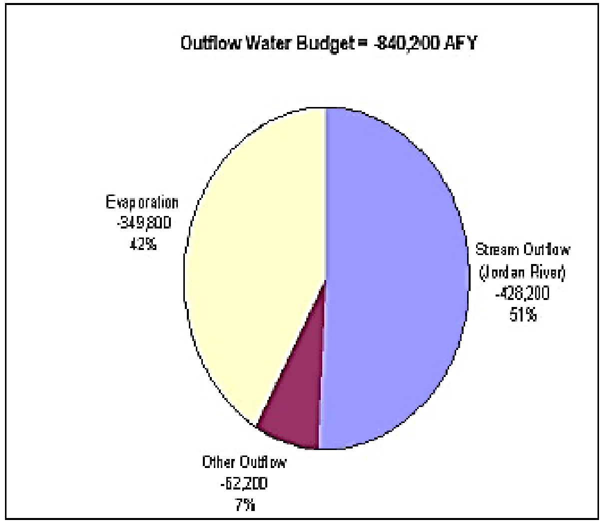
Su and von Stackelberg (2020) – EFDC/WASP





PSOMAS and SWCA (2007) – LKSIM





SEDFLUX MODEL

SEDFLUX MODELING

- Organic matter settling rates
  - Data exist for Utah Lake for sediment content & accumulation
  - UL data lack density needed to generate areal input rates
  - UL data are for sediment, not sinking OM
  - → estimate from literature, run several scenarios across probable range

- Water column depth
  - Main basin observed: 1.9-3.5 m
  - Main basin scenario: 2.0 m ("shallow")
  - Provo Bay observed: 0.2 m
  - Provo Bay scenario: 1.5 m ("deep")

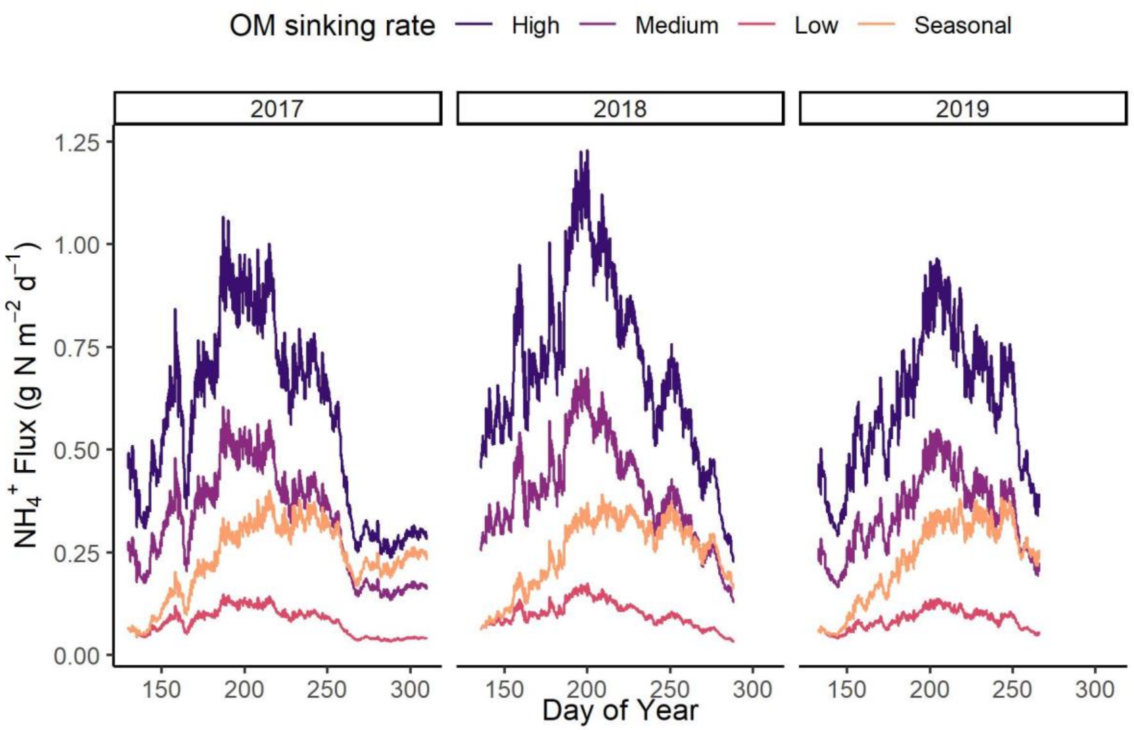
SEDFLUX COMPARISONS TO OTHER STUDIES

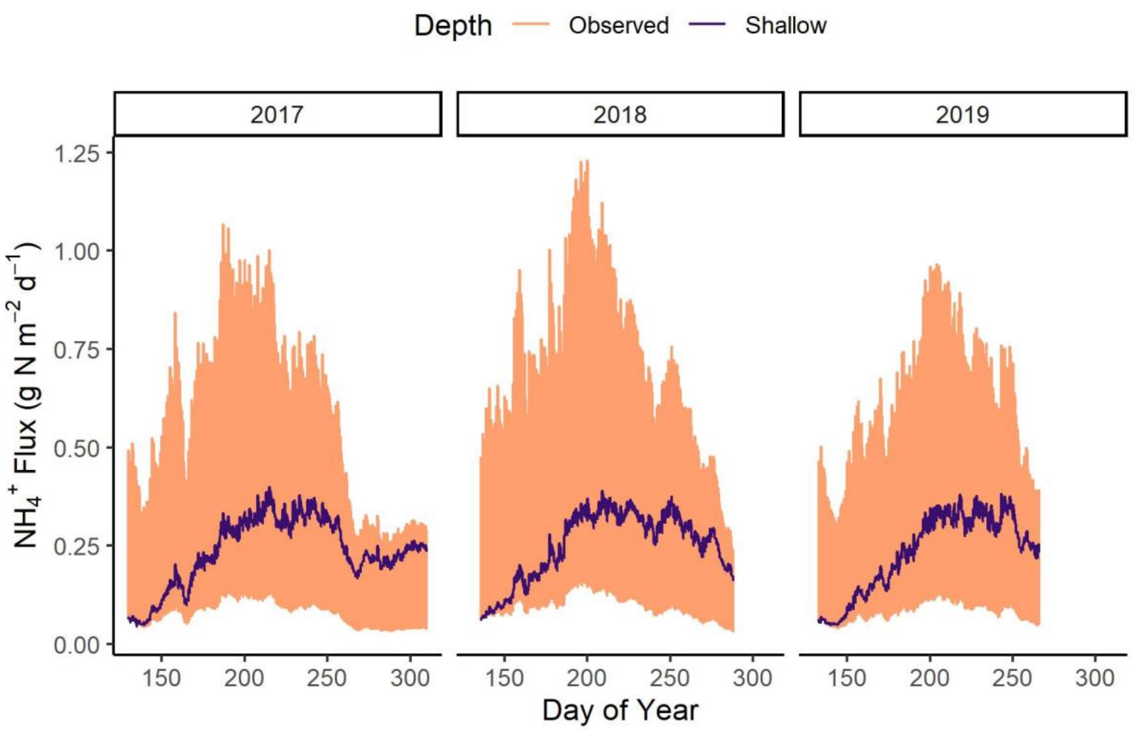
- SRP, NH_4^+, NO_3^- comparable to other studies
- SOD higher than other studies

Rate ($g\ m^{-2}\ d^{-1}$)	Main Basin This Study	Hogsett et al. 2019	Goel et al. 2020	Provo Bay This Study	Hogsett et al. 2019	Goel et al. 2020
SRP Flux	0.006-0.20	-0.004-0.071	-0.0024 ± 0.0042	0.005-0.17	0.01	-0.012 ± 0.0097
NH_4^+ Flux	0.03-1.23	-0.033-0.141	-0.0098 ± 0.0034	0.005-0.89	1.442	-0.017 ± 0.01
NO_3^- Flux	-0.01-0.01	-0.008-0.08	--	-0.13-0.009	0	--
SOD	4.90-14.38	0.9-2.04	2.97	1.91-14.58	4.61	0.05

NH_4^+ FLUX

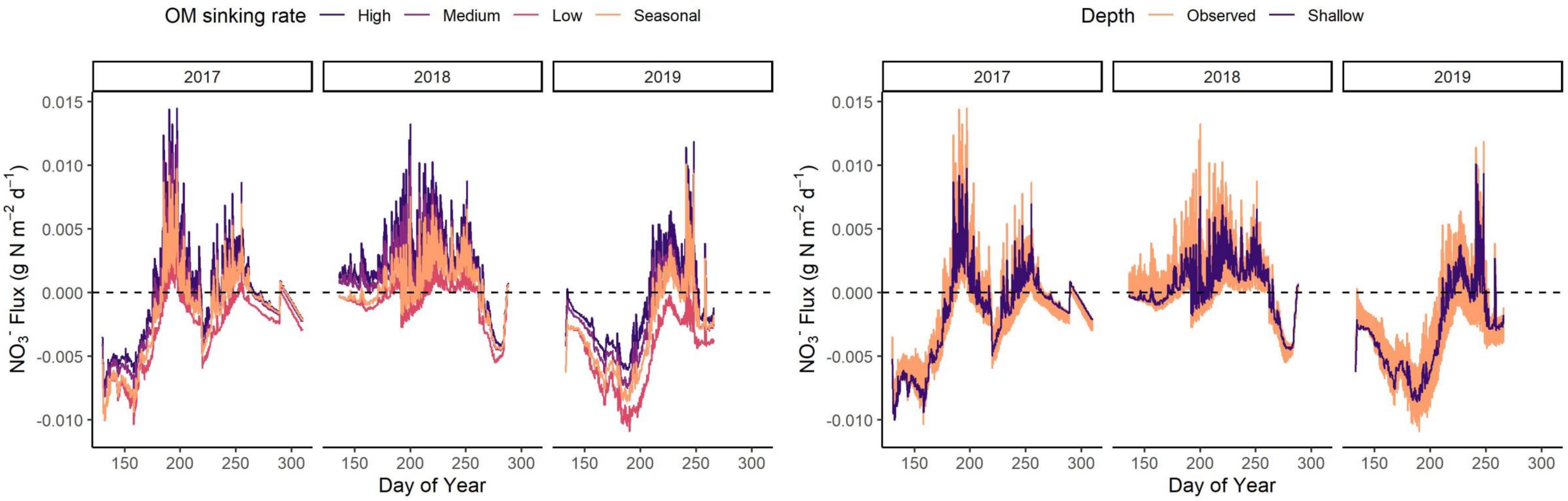
- Flux to water column (+)
- Highest under high OM sinking rate
- Variability: observed > shallow depth





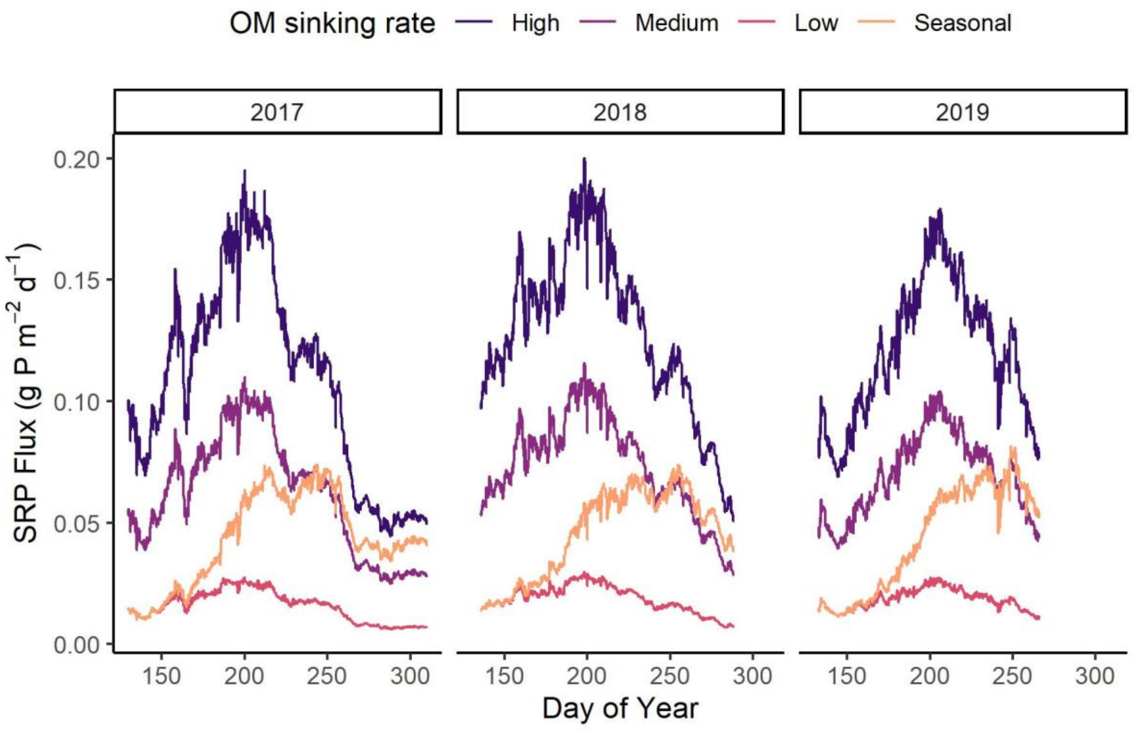
NO_3^- FLUX

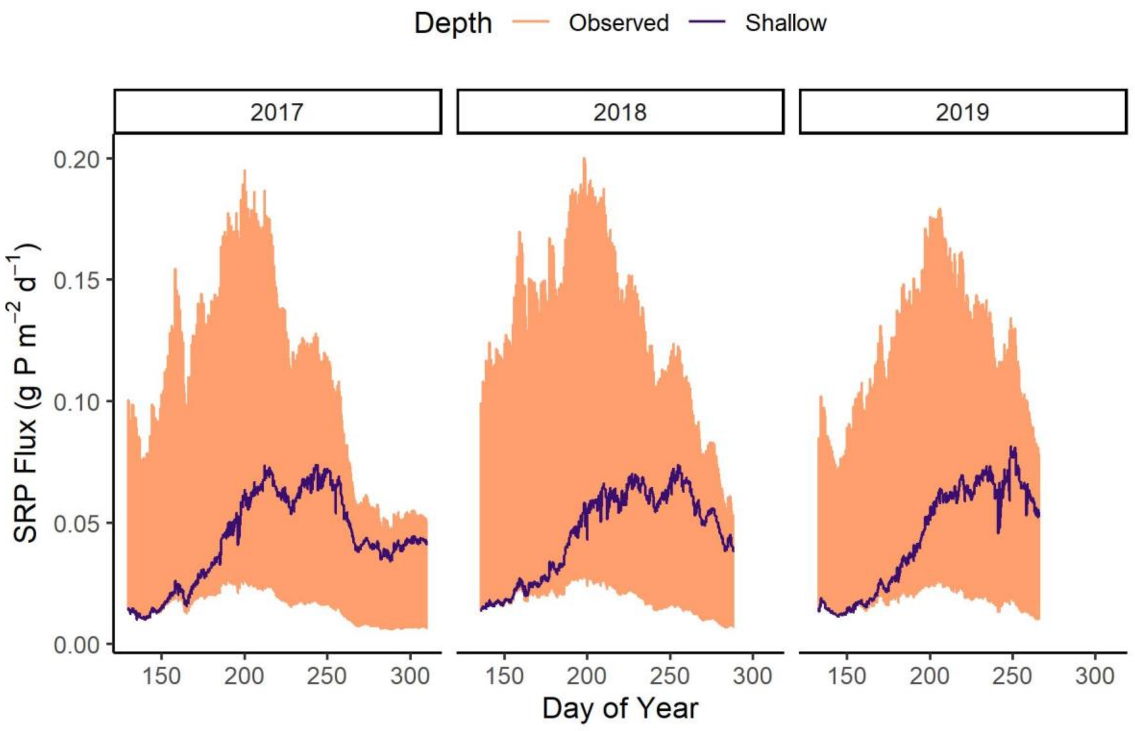
- Flux to water column in summer (+), to the sediment in spring & fall (-)
- Highest under high OM sinking rate
- Variability: observed > shallow depth



SRP FLUX

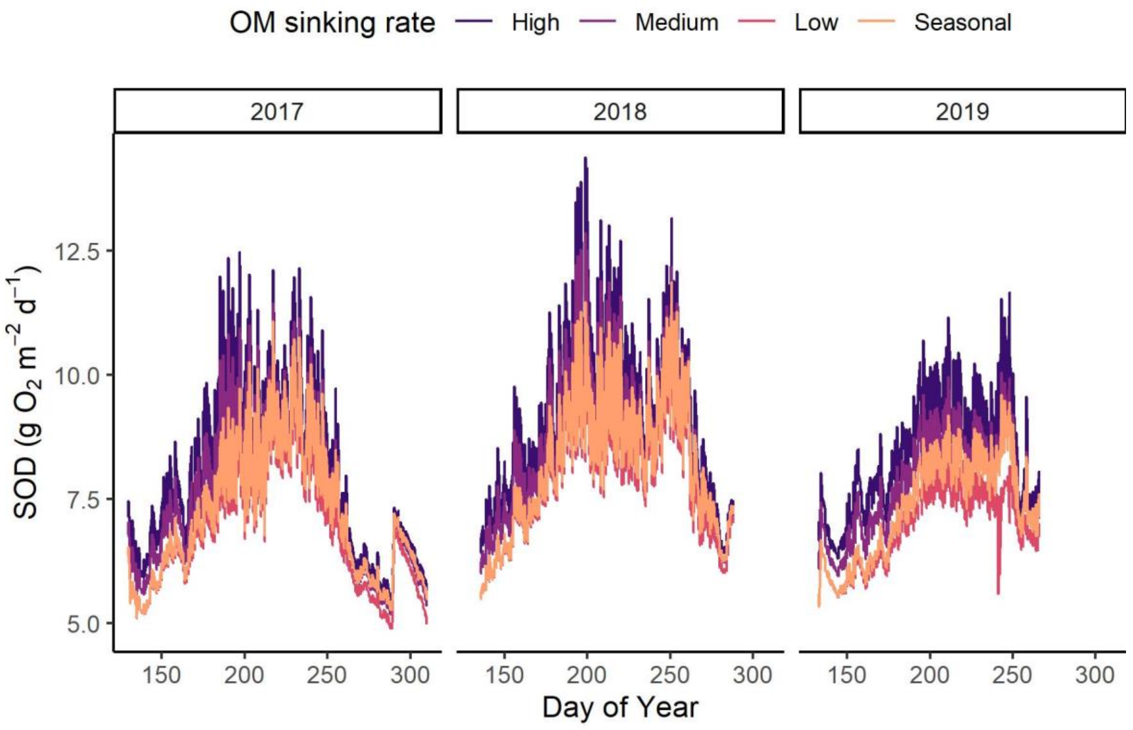
- Flux to water column (+)
- Highest under high OM sinking rate
- Variability: observed > shallow depth

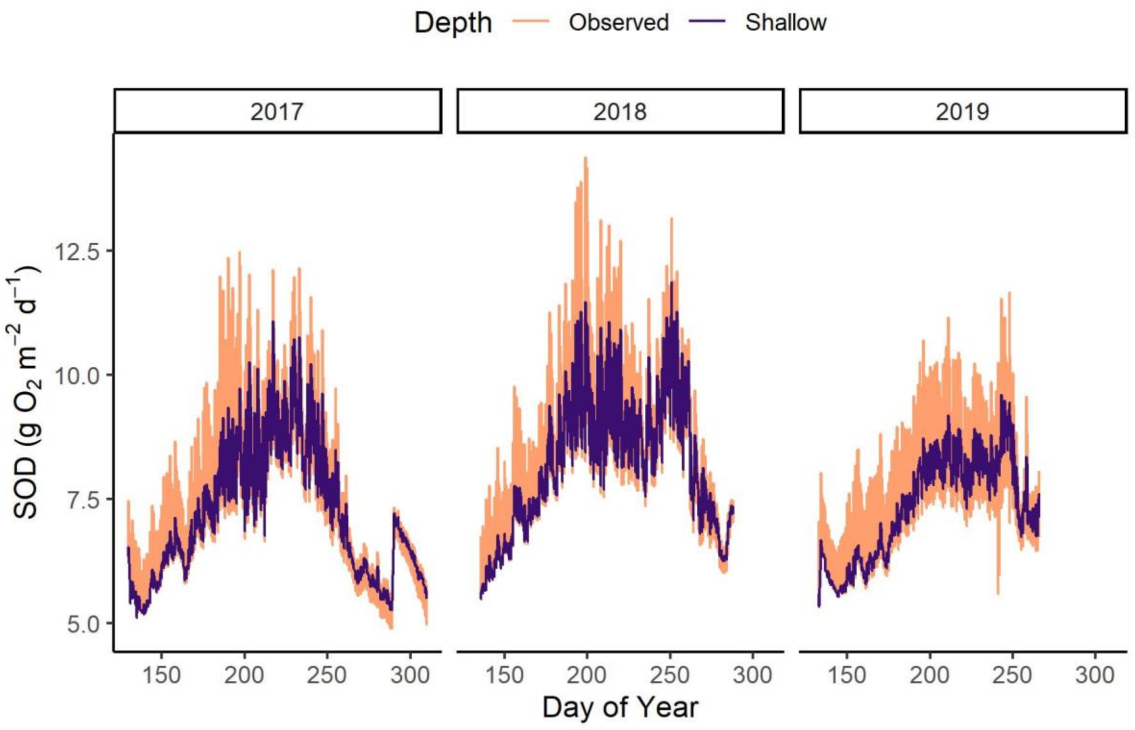




SEDIMENT OXYGEN DEMAND (SOD)

- Highest under high OM sinking rate
- observed > shallow depth



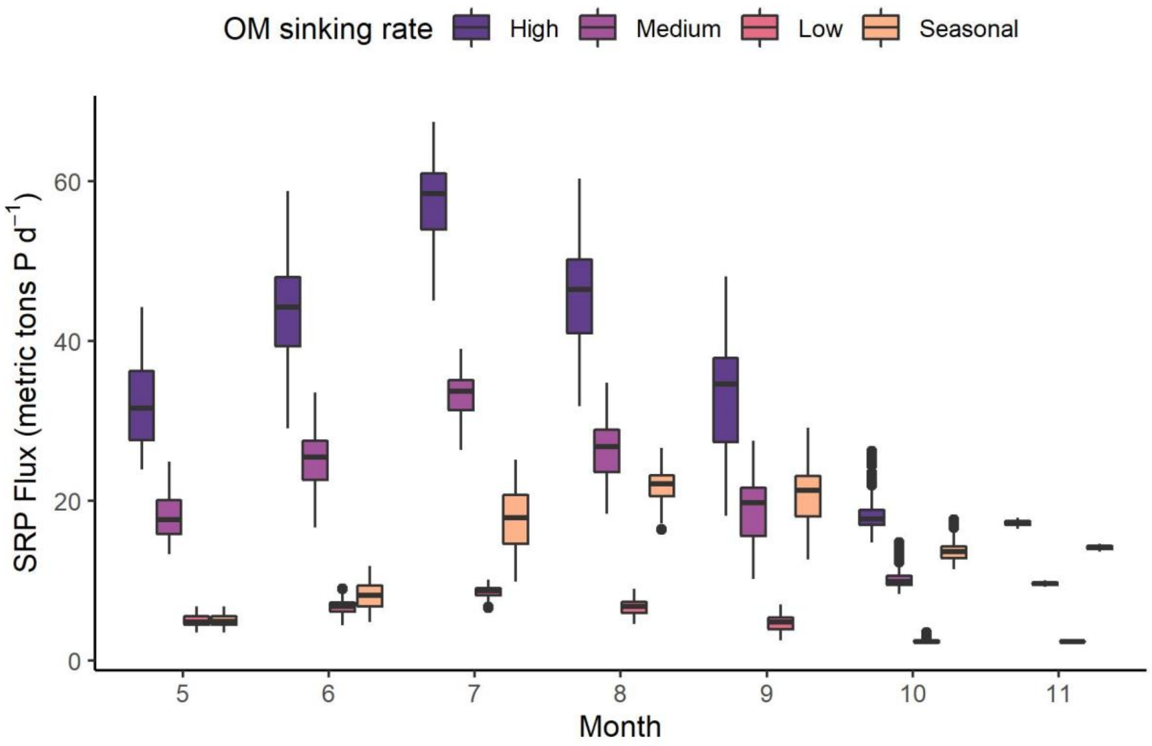


SOD EXPLORATION

- SOD not particularly sensitive to reaction network parameters
- SOD is sensitive to:
  - Water column DO concentration (accurate)
  - Settling rate of POC (inaccurate?)
- Hypotheses…
  - Sediment dilutes incoming POC
  - Frequent resuspension → does SOD become BOD?

ADDITIONAL SEDFLUX RESULTS

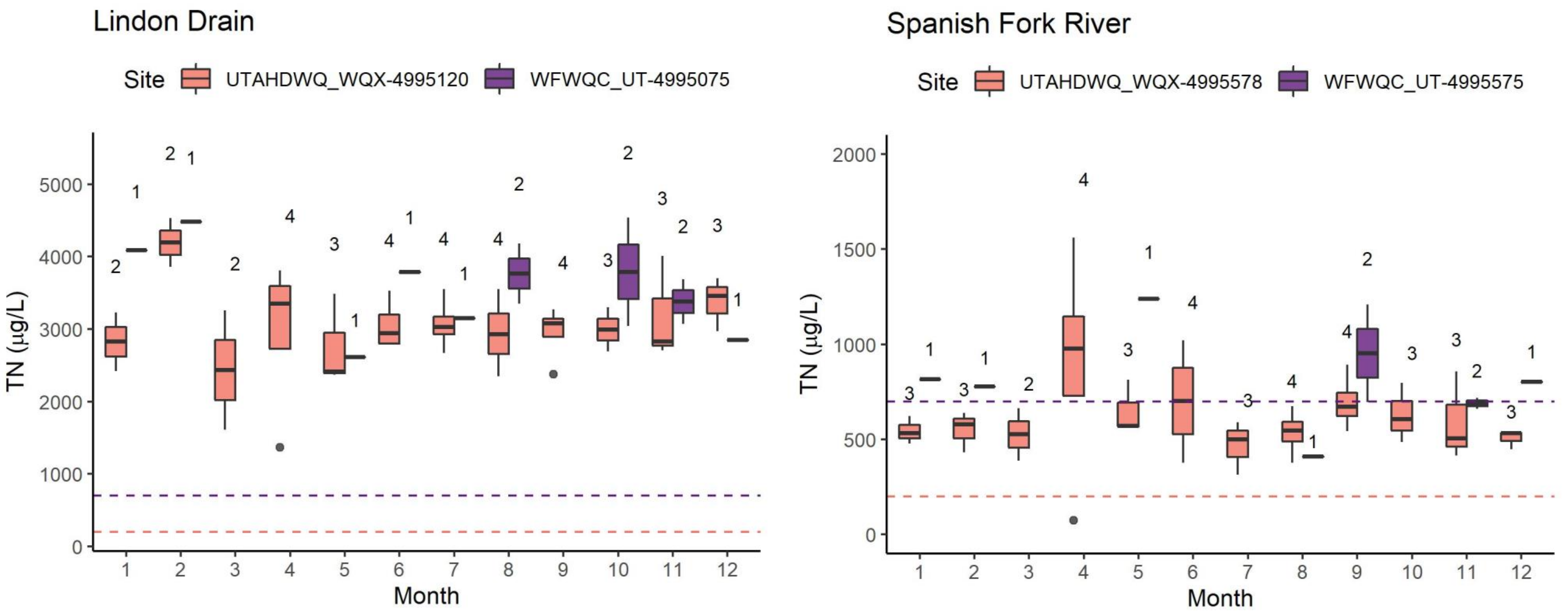
- Provo Bay
  - Similar response as main basin to OM levels
  - Rates: observed < deep
- Lakewide rates
  - Multiplied rates by daily lake area
  - Highly dependent on OM sinking rates
  - Seasonally variable
  - Lack of winter data → extrapolating to yearly rates not recommended, would likely overestimate true rates



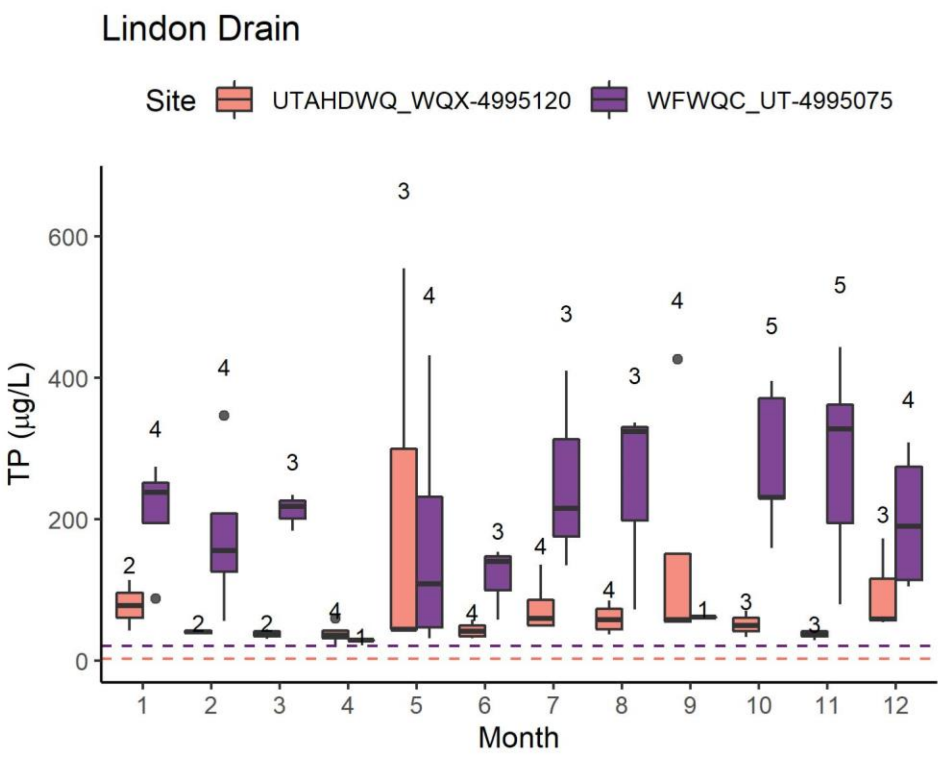
NEXT STEPS

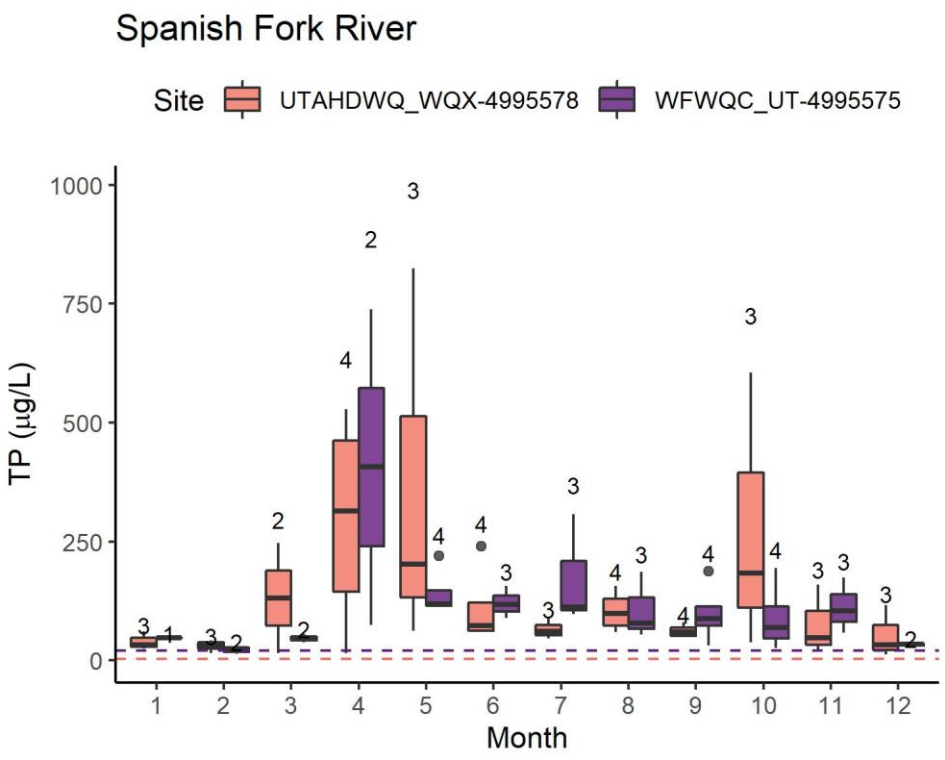
- Draft report complete
- SP sub-group review

TN


Lindon Drain
Site UTAHDWQ_WQX-4995120 WFWQC_UT-4995075
TN (µg/L)
Month
Spanish Fork River
Site UTAHDWQ_WQX-4995578 WFWQC_UT-4995575
TN (µg/L)
Month

TP


Lindon Drain
Site UTAHDWQ_WQX-4995120 WFWQC_UT-4995075
TP (µg/L)
Month


Spanish Fork River
Site UTAHDWQ_WQX-4995578 WFWQC_UT-4995575
TP (µg/L)
Month

Initial Charge Progress Reporting

ULWQS Science Panel Meeting

2021-06-10

Mike Paul, Tetra Tech

GOALS

1. Discuss process for quantifying uncertainty (amount and agreement of evidence)
2. Discuss options for developing charge question responses

Initial Charge – High Level Questions

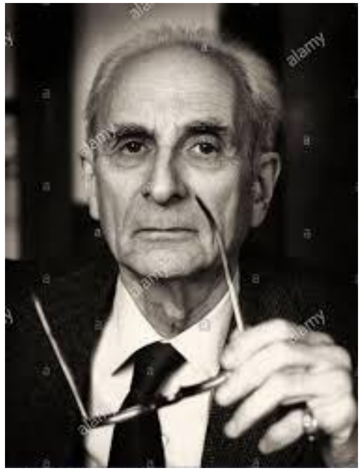
- What was the ***historical condition of Utah Lake*** with respect to nutrients and ecology pre-settlement and along the historical timeline with consideration of trophic state shifts and significant transitions since settlement?

- What is the ***current state of the lake*** with respect to nutrients and ecology?

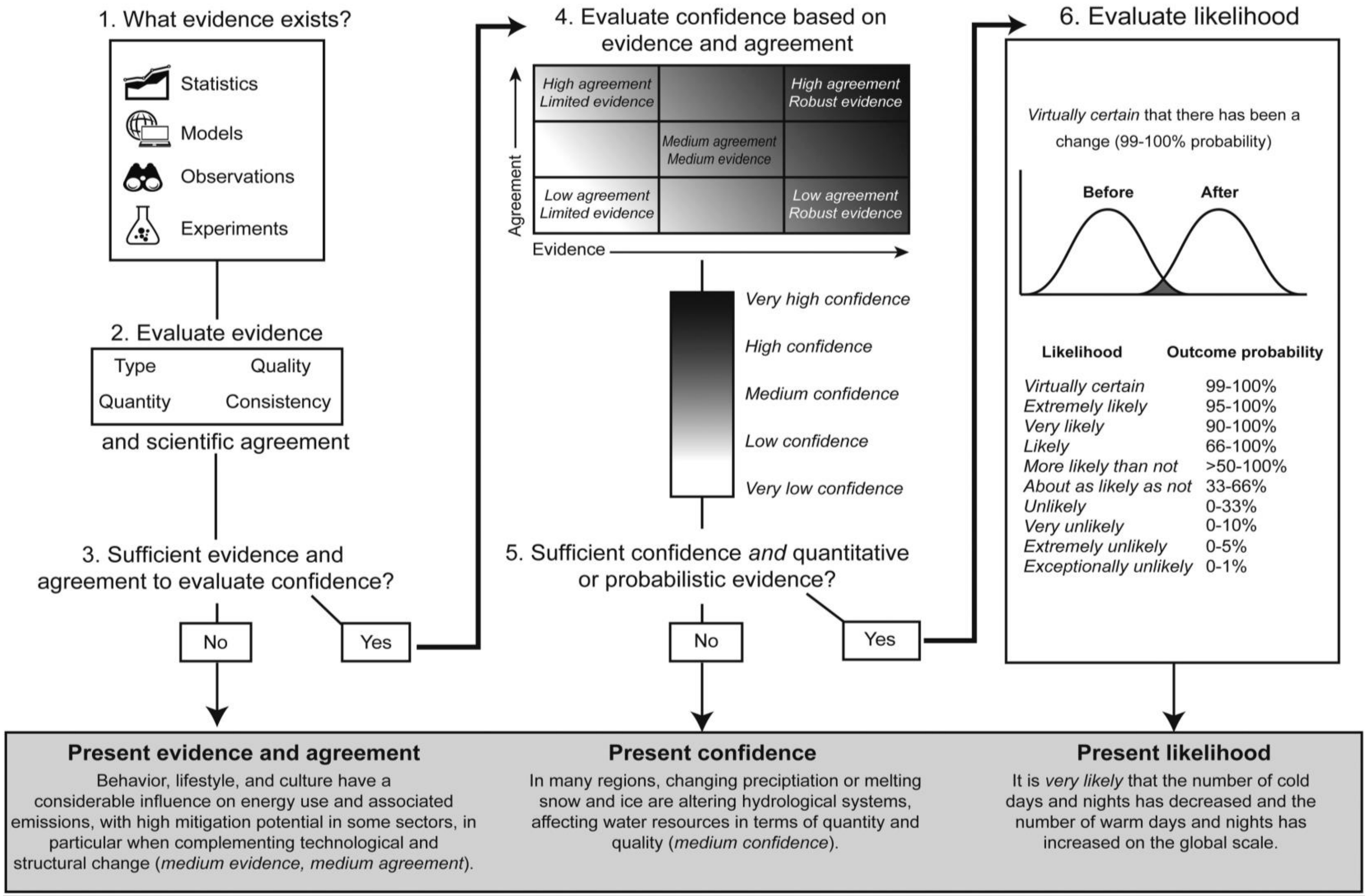
- ***What additional information is needed*** to define nutrient criteria that support existing beneficial uses?

"The scientist is not a person who gives the right answers, they are the one who asks the right questions."

C. Levi-Strauss



Process for Quantifying Evidence and Uncertainty



- What evidence exists?
- Evaluate Evidence
- Sufficiency for Confidence?
- Evaluate Confidence
- Sufficiency for Likelihood?
- Likelihood (if possible)

IPCC 2020

Process for Quantifying Evidence and Uncertainty

		Limited	Medium	High
Amount	***Mechanistic Model***	1 model run	2-3 model runs	>3 model runs
	S-R Analyses	1 independent analysis	2-3 independent analyses	>3 independent analyses
	Scientific Literature	1-2 studies	2-4 studies	>4 studies

- What evidence exists?
- **Evaluate Evidence**
- Sufficiency for Confidence?
- Evaluate Confidence
- Sufficiency for Likelihood?
- Likelihood (if possible)

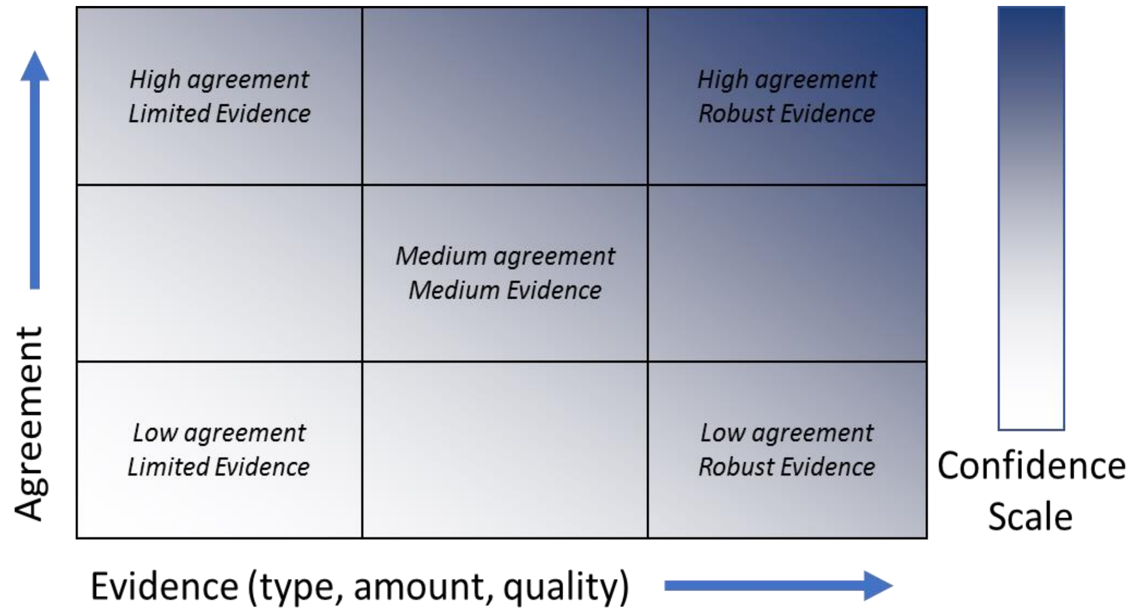
e.g., “Only Medium and Above Is Sufficient to Evaluate Confidence”

N.B. You can still make statements with limited data - no confidence or probability statement is made.
Q2.3.i: Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources?

“HABS most frequently occur where nutrient concentrations are elevated and in the eastern portion of the lake. (Low Evidence, High Agreement)”

Process for Quantifying Evidence and Uncertainty

		Agreement		
		Low	Medium	High
Amount		Half the lines of evidence agree	75% of the lines of evidence agree	All lines of evidence agree



ULWQS Uncertainty Guidance

- What evidence exists?
- Evaluate Evidence
- Sufficiency for Confidence?
- **Evaluate Confidence**
- Sufficiency for Likelihood?
- Likelihood (if possible)

Q2.3.i: Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources?

"HABS most frequently occur where nutrients above the lake average and start in the following 4 locations: A, B, C, D (High Confidence)"

Process for Quantifying Evidence and Uncertainty

		Evidence Quality		
		Limited	Medium	High
Quality	***Mechanistic Model***	75% Variables meet Very Good calibration criteria	75-90% Variables meet Very Good calibration criteria	>90% Variables meet Very Good calibration criteria
	S-R Analyses	• p<0.20 • Variance explained <30%	• P<0.10 • Variance explained 30 to 50%	• P<0.05 • Variance explained >50%
	Scientific Literature	• p<0.20 • Variance explained <30%	• P<0.10 • Variance explained 30 to 50%	• P<0.05 • Variance explained >50%

Language	Probability
Virtually certain	99-100% Probability
Very likely	90-100% Probability
Likely	66-100% Probability
About as likely as not	33 to 66% Probability
Unlikely	0-33% Probability
Very unlikely	0-10% Probability
Exceptionally Unlikely	0-1% Probability

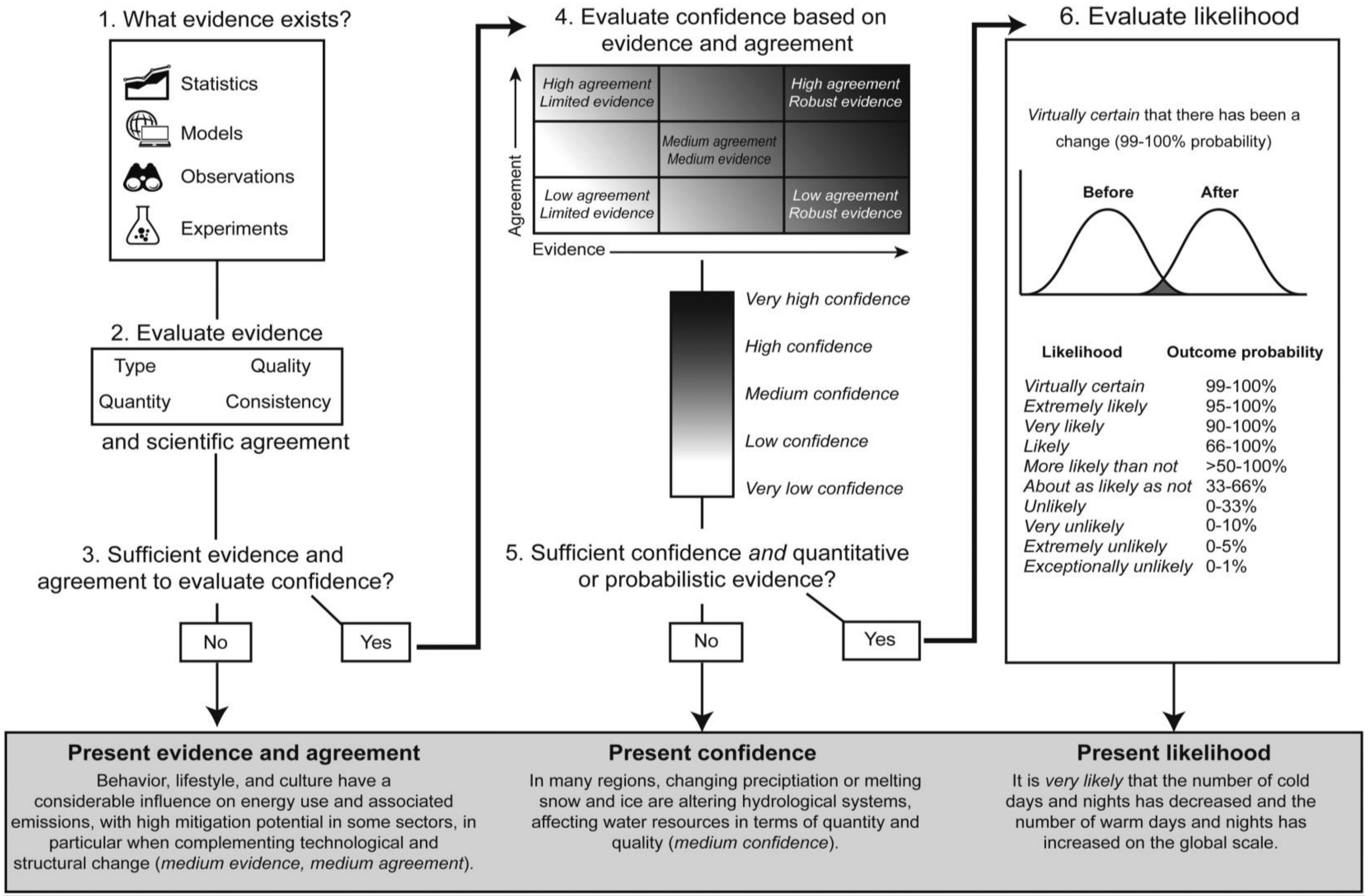
- What evidence exists?
- Evaluate Evidence
- Sufficiency for Confidence?
- Evaluate Confidence
- Sufficiency for Likelihood?
- **Likelihood (if possible)**

Are you medium confident or more?
Is there are sufficient data to quantify likelihood?

Q2.3.i: Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources?

"It is very likely that HABS start when nutrients are above lake averages in locations A and B, and likely that they start when nutrients are above lake averages in C and D"

Process for Quantifying Evidence and Uncertainty



IPCC 2020

So, the goal is to evaluate these elements for each charge question.

See Handout

- What evidence exists?
- Evaluate Evidence
- Sufficiency for Confidence?
- Evaluate Confidence
- Sufficiency for Likelihood?
- Likelihood (if possible)

Developing Charge Question Responses

Logistically, a few options:

Option A: Contractor takes a first stab at each question and passes on to the SP (or subsets of the SP) to review/revise/iterate with contractor.

Option B: SP Subsets agree to take the first stab at each question and pass on to other SP members to review/revise/iterate.

Option C: Some mix of A and B? E.g., SP Subsets could work with Contractor to evaluate evidence for each question.

Developing Charge Question Responses

Rubric? (Are we okay with Uncertainty Guidance examples, or do we need to flesh these out more?

		Limited	Medium	High
Amount	***Mechanistic Model***	1 model run	2-3 model runs	>3 model runs
	S-R Analyses	1 independent analysis	2-3 independent analyses	>3 independent analyses
	Scientific Literature	1-2 studies	2-4 studies	>4 studies

Schedule? (Do we wait to have WQ Model output for some questions?)