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
<table>
<thead>
<tr>
<th></th>
<th>TN - total</th>
<th>TN – Lindon Drain</th>
<th>TN – Spanish Fork</th>
</tr>
</thead>
<tbody>
<tr>
<td>DWQ</td>
<td>552</td>
<td>DWQ 38</td>
<td>DWQ 31</td>
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<tr>
<td>WFWQQC</td>
<td>111</td>
<td>WFWQQC 17</td>
<td>WFWQQC 7</td>
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<td></td>
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<tr>
<td>TP - total</td>
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<tr>
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<td>550</td>
<td>DWQ 38</td>
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<tr>
<td>WFWQQC</td>
<td>168</td>
<td>WFWQQC 10</td>
<td>WFWQQC 5</td>
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</tbody>
</table>
PROVO BAY: VARIATION IN ELEVATION


Min
POWELL SLOUGH: VARIATION IN ELEVATION

Max

2015

2016

2017

2018

2019

2020

Min
RECAP OF DECISIONS MADE AT LAST SP MEETING

• Lake boundary
  o If lake boundary = compromise elevation → generate loads from location directly upstream of compromise
  o If lake boundary = inundated area at time of sampling → generate loads from downstream location
  o Intermediate boundary is not possible to calculate (data limitations)
  o **Decision:** For Powell Slough and Mill Race, try both options

• Tributary monitoring data vs. DMR data
  o Monitored flows > DMR flows when WWTP is farther from the lake monitoring site
  o **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)
  o DMR: 279.52
  o Tributary: 294.86

• TP (metric tons/yr)
  o DMR: 45.92
  o Tributary: 32.87

• According to SP recommendation, used DMR data from Orem WWTP for final loading estimates

Sum together to calculate total load
MILL RACE EXPLORATION

Sum together to calculate total load

- 4996540
- 4996566
- 4996536
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)
    o DMR: 318.31
    o Tributary: 257.41
  • TP (metric tons/yr)
    o DMR: 51.88
    o Tributary: 27.27
• According to SP recommendation, used DMR data from Provo WWTP for final loading estimates
C, N, AND P BUDGETS: MONITORED SUB-CATCHMENTS

TOC loads highest for Provo River and Spanish Fork River
• High flows
• Large watershed area
• No WWTPs
C, N, AND P BUDGETS: MONITORED 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: MONITORED 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

TOC load (metric ton/yr)

TN load (metric ton/yr)

TP load (metric ton/yr)
C, N, AND P BUDGETS: ALL SUB-CATCHMENTS

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

TN load (metric tons/yr)

- WWTP: 67.5%
- No WWTP: 10.2%
- Unmonitored: 7.8%
- Atmosphere: 8.1%
- Groundwater: 6.4%
- Jordan River: -4.7%

TP load (metric tons/yr)

- WWTP: 83.2%
- No WWTP: 6.2%
- Unmonitored: 8.4%
- Atmosphere: 1.8%
- Groundwater: 0.3%
- Jordan River: -7.1%
**NUTRIENT BUDGETS: COMPARISONS TO OTHER STUDIES**

<table>
<thead>
<tr>
<th></th>
<th>This Study</th>
<th>Merritt and Miller 2016</th>
<th>PSOMAS and SWCA 2007</th>
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</thead>
<tbody>
<tr>
<td>TN (metric tons/yr)</td>
<td>2,091</td>
<td>1,946</td>
<td></td>
</tr>
<tr>
<td>TP (metric tons/yr)</td>
<td>273</td>
<td>247</td>
<td>270</td>
</tr>
</tbody>
</table>
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)
This Study

Hydrologic Inflow or Outflow (ac-ft$^3$/yr)

- Tributaries: 78.46%
- Precipitation: 13.58%
- Groundwater: 7.96%
- Jordan River: 31.69%
- Evaporation: 68.31%
- Balance: 0

Su and von Stackelberg (2020) – EFDC/WASP

Mean Inflows
Water Year 2006-2018

- Wastewater: 15.9%
- Groundwater: 10.5%
- Gaged Tributaries: 7.3%
- Ungaged Surface Water: 21.8%
- Precipitation: 37.5%

Mean Outflows
Water Year 2006-2018

- Jordan River: 55.9%
- Evaporation: 44.1%

PSOMAS and SWCA (2007) – LKSIM

Inflow Water Budget = 829,300 AFV

- Precipitation: 20%
- Groundwater: 20%
- Other Surface Inflow: 20%
- Stratus Inflow: 20%
- Jordan River: 15%

Outflow Water Budget = 402,000 AFV

- Evaporation: 47%
- Other Outflow: 23%
- Stream Outflow: 19%
SEDFLUX MODEL
SEDFLUX MODELING

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

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

<table>
<thead>
<tr>
<th>Rate (g m$^{-2}$ d$^{-1}$)</th>
<th>Main Basin</th>
<th>Hogsett et al. 2019</th>
<th>Goel et al. 2020</th>
<th>Provo Bay</th>
<th>Hogsett et al. 2019</th>
<th>Goel et al. 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRP Flux</td>
<td>0.006-0.20</td>
<td>-0.004-0.071</td>
<td>-0.0024 ± 0.0042</td>
<td>0.005-0.17</td>
<td>0.01</td>
<td>-0.012 ± 0.0097</td>
</tr>
<tr>
<td>NH$_4^+$ Flux</td>
<td>0.03-1.23</td>
<td>-0.033-0.141</td>
<td>-0.0098 ± 0.0034</td>
<td>0.005-0.89</td>
<td>1.442</td>
<td>-0.017 ± 0.01</td>
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<tr>
<td>NO$_3^-$ Flux</td>
<td>-0.01-0.01</td>
<td>-0.008-0.08</td>
<td>--</td>
<td>-0.13-0.009</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>SOD</td>
<td>4.90-14.38</td>
<td>0.9-2.04</td>
<td>2.97</td>
<td>1.91-14.58</td>
<td>4.61</td>
<td>0.05</td>
</tr>
</tbody>
</table>
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:
  o Water column DO concentration (accurate)
  o Settling rate of POC (inaccurate?)
• Hypotheses...
  o Sediment dilutes incoming POC
  o Frequent resuspension → does SOD become BOD?
ADDITIONAL SEDFLUX RESULTS

• Provo Bay
  o Similar response as main basin to OM levels
  o Rates: observed < deep

• Lakewide rates
  o Multiplied rates by daily lake area
  o Highly dependent on OM sinking rates
  o Seasonally variable
  o Lack of winter data → extrapolating to yearly rates not recommended, would likely overestimate true rates
NEXT STEPS

- Draft report complete
- SP sub-group review
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

1. What evidence exists?
   - Statistics
   - Models
   - Observations
   - Experiments

2. Evaluate evidence
   - Type: Quality
     - Quantity
     - Consistency
   - and scientific agreement

3. Sufficient evidence and agreement to evaluate confidence?
   - No
   - Yes

4. Evaluate confidence based on evidence and agreement
   - High agreement
     - Limited evidence
     - Medium agreement
     - Robust evidence
   - Low agreement
     - Limited evidence
     - Medium evidence
     - Robust evidence

5. Sufficient confidence and quantitative or probabilistic evidence?
   - No
   - Yes

6. Evaluate likelihood
   - Virtually certain: 99-100%
   - Extremely likely: 95-100%
   - Very likely: 90-100%
   - Likely: 66-100%
   - More likely than not: >50-100%
   - About as likely as not: 33-66%
   - Unlikely: 0-33%
   - Very unlikely: 0-10%
   - Extremely unlikely: 0-5%
   - Exceptionally unlikely: 0-1%

- Present evidence and agreement
  - Behavior, lifestyle, and culture have a considerable influence on energy use and associated emissions, with high mitigation potential in some sectors, in particular when complementing technological and structural change (medium evidence, medium agreement).

- Present confidence
  - In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality (medium confidence).

- Present likelihood
  - It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale.
Process for Quantifying Evidence and Uncertainty

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

<table>
<thead>
<tr>
<th>Amount</th>
<th>Limited</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanistic Model</td>
<td>1 model run</td>
<td>2-3 model runs</td>
<td>&gt;3 model runs</td>
</tr>
<tr>
<td>S-R Analyses</td>
<td>1 independent analysis</td>
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<td>2-4 studies</td>
<td>&gt;4 studies</td>
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- 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

<table>
<thead>
<tr>
<th>Agreement</th>
<th>Low</th>
<th>Medium</th>
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<tbody>
<tr>
<td>Amount</td>
<td>Half the lines of evidence agree</td>
<td>75% of the lines of evidence agree</td>
<td>All lines of evidence agree</td>
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</tbody>
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- 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

<table>
<thead>
<tr>
<th>Quality</th>
<th>Evidence Quality</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Limited</td>
</tr>
<tr>
<td>Mechanistic Model</td>
<td>75% Variables meet Very Good calibration criteria</td>
</tr>
<tr>
<td>S-R Analyses</td>
<td>75-90% Variables meet Very Good calibration criteria</td>
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<tr>
<td>Scientific Literature</td>
<td>&gt;90% Variables meet Very Good calibration criteria</td>
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<tr>
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<td>Medium</td>
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<td>P&lt;0.20</td>
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<td>Variance explained &lt;30%</td>
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<tr>
<td></td>
<td>P&lt;0.10</td>
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<td></td>
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- What evidence exists?
- Evaluate Evidence
- Sufficiency for Confidence?
- Evaluate Confidence
- Sufficiency for Likelihood?
- **Likelihood (if possible)**

Are you medium confident or more?  
Is there 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”
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?)

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

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