UTAH LAKE C, N, AND P PROJECT UPDATE

ULWQS Science Panel Meeting
2021-05-13
Presented by Kateri Salk, Tetra Tech
TOPICS: EXTERNAL MASS BALANCE MODELING

1. Nutrient and flow monitoring protocols
2. Preliminary water budget results
3. Flow and loading from unmonitored watersheds
4. Defining lake elevation
NUTRIENT AND FLOW PROTOCOL FOLLOW-UPS

• WFWQC TN protocol: designed for TKN, but calculates:
  \[ \text{TN} - (\text{NO}_3^- + \text{NO}_2^-) = \text{TKN} \]
  → Will move forward with using these values

• Streamflow methodology: WFWQC
  o Raw data from 2018 indicates 5 or fewer cross-sections used to generate discharge
  o USGS methodology: “Space the partial sections so that no partial section has more than 10 percent of the total discharge in it.” → minimum of 10 cross-sections needed
  o Do Theron or others have other documentation to share or any insights?
  o Would like advice on how to move forward
## Nutrient Protocols

<table>
<thead>
<tr>
<th>Constituent</th>
<th>UDWQ</th>
<th>WFWQC</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP &amp; TDP</td>
<td>3 µg/L</td>
<td>21 µg/L</td>
</tr>
<tr>
<td>Lower reporting limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP &amp; TDP</td>
<td>2.8 µg/L</td>
<td>1 µg/L</td>
</tr>
<tr>
<td>Minimum detection limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN &amp; TDN</td>
<td>200 µg/L</td>
<td>700 µg/L</td>
</tr>
<tr>
<td>Lower reporting limit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN &amp; TDN</td>
<td>185 µg/L</td>
<td>317 µg/L</td>
</tr>
<tr>
<td>Minimum detection limit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Values < detection limit → set at $\frac{1}{2}$ MDL
- Values > detection limit and < reporting limit → retained as-is
- Watersheds w/ values < WFWQC detection limit → only DWQ samples used:
  - Lehi Spring Creek (P)
  - American Fork River (P and N)
  - Provo River (P and N)
  - Hobble Creek (P)
  - Spanish Fork (N)
HYDROLOGIC BUDGET

Inputs
• Streamflow (monitored watersheds) → direct measurements
• Streamflow & runoff (unmonitored watersheds) → Model My Watershed (GWLF-E)
• Groundwater → EFDC estimates, 4 zones (N, S, Provo Bay, Goshen Bay)
• Precipitation → EFDC estimates

Outputs
• Jordan River → direct measurements
• Evaporation → EFDC estimates
## HYDROLOGIC BUDGET: INFLOW

<table>
<thead>
<tr>
<th>Study</th>
<th>Years</th>
<th>Streamflow (ac*ft/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study</td>
<td>2015-2020</td>
<td>411,257</td>
</tr>
<tr>
<td>Merritt and Miller (2016)</td>
<td>2009-2013</td>
<td>495,092</td>
</tr>
<tr>
<td>Merritt (unpublished LKSIM)</td>
<td>2015-2020</td>
<td>395,397</td>
</tr>
</tbody>
</table>

Inflow estimates fall in the middle of previous estimates

→ suggests monitored flow is not over- or under-predicted compared to other approaches
### Hydrologic Budget: Jordan River Outflow

Outflow estimates are lower than previous studies:

- Daily outflow values @ Narrows paired with nutrients @ outflow
- December-February: observed flows of zero at outflow → replace non-zero Narrows values

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<tr>
<td>This study</td>
<td>2015-2020</td>
<td>127,610</td>
</tr>
<tr>
<td>Merritt and Miller (2016)</td>
<td>2009-2013</td>
<td>336,045</td>
</tr>
</tbody>
</table>

![Outflow Graph](chart.png)
This Study

Hydrologic Inflow or Outflow (ac•ft²/yr)

- Streams & Runoff: 76.21%
- Precipitation: 16.63%
- Groundwater: 7.17%
- Jordan River: 28.28%
- Evaporation: 71.72%

Su and von Stackelberg (2020) – EFDC/WASP

Mean Inflows
Water Year 2006-2018

- Wastewater: 15.9%
- Groundwater: 10.5%
- Ungaged Tributaries: 7.3%
- Ungaged Surface Water: 28.8%
- Precipitation: 37.5%

Mean Outflows
Water Year 2006-2018

- Jordan River: 44.3%
- Evaporation: 55.9%

PSOMAS and SWCA (2007) – LKSIM

Inflow Water Budget = 829,300 AFY

- Precipitation: 120,000 (15%)
- Other Surface Inflow: 80,000 (10%)
- Jordan River Inflow: 429,600 (51%)
- Groundwater Inflow: 165,400 (20%)
- Springs Inflow: 31,200 (4%)

Outflow Water Budget = 849,200 AFY

- Evaporation: -349,200 (42%)
- Other Outflow: -45,200 (7%)
- Jordan River Outflow: 439,200 (51%)
- Streams Outflow: -439,200 (51%)
- Stream Outflow: -439,200 (51%)
- Groundwater Outflow: 165,400 (20%)
- Springs Outflow: 31,200 (4%)
- Other Outflow: -45,200 (7%)
- Jordan River Inflow: 429,600 (51%)
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UNMONITORED WATERSHED MODELING

• Original plan: paired watershed approach
• Issue: several watersheds have ephemeral flow w/ no monitored counterpart
• Revised plan: simple model to estimate flows and nutrient loads
• Model My Watershed
  o **Watershed Multi-Year Model:** simulates 30 years of daily data w/ Generalized Watershed Loading Function Enhanced (GWLF-E) model
  o **Hydrology:** NHDplus v2 medium resolution (1:100,000-scale) flow lines (includes ephemeral flow)
  o **Nutrient loading:** farm animal populations, point sources, land cover, soil N and P
  o Calibration of multi-year model conducted for some western watersheds, but none in Utah
• Ran Watershed Multi-Year Model for 54 unmonitored watersheds
• Output: monthly hydrology, annual nutrient and sediment loads
  o Hydrology: *overland flow*, *streamflow*, subsurface flow, point source flow, ET, precip
  o Nutrients: *TN and TP* parsed into land use, farm animals, stream bank erosion, subsurface flow, point sources, septic systems
UNMONITORED WATERSHED BUDGETS
EXTERNAL MASS BALANCE: DECISION POINTS

Focus today: changing lake level and tributary vs. DMR loads

2 Decision points:

1. Address changing lake level: assign lake boundary
2. For watersheds with WWTP, how to address DMR loads vs. tributary data?
• Loading estimates do not account for in-lake processes that impact the transformation of nutrients
  o Sediment uptake and release
  o Macrophyte uptake and senescence
  o Nitrification, denitrification, P binding
  o Biogeochemical impacts of wetting/drying

• Other studies & RFPs document the importance of changing lake level & sediments on nutrient conditions in Utah Lake

Scope of Work: Utah Lake Littoral Sediment Study
Scope of Work: Utah Lake Sediment–Water Nutrient Interactions
ACCOUNTING FOR CHANGING LAKE LEVEL

• Utah Lake experiences substantial changes in elevation (2010-2020: 10 ft)
• Several wetlands around the lake have capacity to take up, release, and/or transform nutrients
• BUT how do we account for these areas if they are sometimes inundated with lake water?
• Central question: What defines the lake boundary?
ACCOUNTING FOR CHANGING LAKE LEVEL

Study will generate average monthly loading from 2015-2020 → need to designate a lake level across the period of record

Compromise elevation: 4489.045 ft

<table>
<thead>
<tr>
<th>Year</th>
<th>Min Elevation (ft)</th>
<th>Max Elevation (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>4,486.80</td>
<td>4,489.07</td>
</tr>
<tr>
<td>2011</td>
<td>4,488.15</td>
<td><strong>4,491.30</strong></td>
</tr>
<tr>
<td>2012</td>
<td>4,485.98</td>
<td>4,489.45</td>
</tr>
<tr>
<td>2013</td>
<td>4,485.16</td>
<td>4,488.11</td>
</tr>
<tr>
<td>2014</td>
<td>4,484.34</td>
<td>4,487.20</td>
</tr>
<tr>
<td>2015</td>
<td>4,483.12</td>
<td>4,485.81</td>
</tr>
<tr>
<td>2016</td>
<td>4,481.93</td>
<td>4,484.94</td>
</tr>
<tr>
<td>2017</td>
<td>4,482.77</td>
<td>4,486.71</td>
</tr>
<tr>
<td>2018</td>
<td>4,483.64</td>
<td>4,486.72</td>
</tr>
<tr>
<td>2019</td>
<td>4,484.50</td>
<td>4,488.66</td>
</tr>
<tr>
<td>2020</td>
<td>4,485.90</td>
<td><strong>4,489.05</strong></td>
</tr>
<tr>
<td>2010-2021</td>
<td>4,481.93</td>
<td>4,491.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lake Stage (ft)</th>
<th>Daily Exceedance Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010 to 2020</td>
</tr>
<tr>
<td>4481</td>
<td>100.0%</td>
</tr>
<tr>
<td>4482</td>
<td>99.7%</td>
</tr>
<tr>
<td>4483</td>
<td>96.0%</td>
</tr>
<tr>
<td>4484</td>
<td>89.0%</td>
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<tr>
<td>4485</td>
<td>74.6%</td>
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<tr>
<td>4486</td>
<td>57.0%</td>
</tr>
<tr>
<td>4487</td>
<td>39.4%</td>
</tr>
<tr>
<td>4488</td>
<td>26.5%</td>
</tr>
<tr>
<td>4489</td>
<td>11.9%</td>
</tr>
<tr>
<td>4490</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

4489.045 9.3% 0.4%
WATERSHEDS OF INTEREST

Powell Slough (left) and Mill Race (right)
Downstream monitoring sites are below compromise elevation ➔ limited data
POWELL SLOUGH: VARIATION IN ELEVATION
<table>
<thead>
<tr>
<th>Option A: compromise (high) elevation</th>
<th>Option B: low elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Any nutrients reaching sometimes inundated locations are considered load to the lake, regardless of processing that may happen at low lake level”</td>
<td>“Nutrients are only considered load to the lake if they reach an inundated location at the time of loading”</td>
</tr>
<tr>
<td>• Calculate load at a point directly upstream of compromise</td>
<td>• Calculate loading at the most downstream location</td>
</tr>
<tr>
<td>• Would need to eliminate downstream sampling sites (DWQ &amp; WFWQC)</td>
<td>• Limited data (sites not sampled when inundated)</td>
</tr>
<tr>
<td>• Would not account for any nutrient transformation occurring during non-inundated periods</td>
<td>• Loading would be biased toward times when lake is at low level</td>
</tr>
</tbody>
</table>
DECISION POINT: DMR AND TRIBUTARY MONITORING DATA

• WWTPs report outflow volume and nutrient loading (DMR) → can generate end-of-pipe load from WWTP

• Need to decide whether to generate loads from:
  o DMR reports
  o Tributary monitoring data
  o Mix of both
**COMPARISONS OF FLOW: MONITORED SITES AND DMR REPORTS**

Monitored flows > DMR flows when WWTP is farther from the lake monitoring site

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Annual Flow – Monitored (ac*ft/yr)</th>
<th>Annual Flow – DMR (ac*ft/yr)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timp SSD (Timpanogos)</td>
<td>21,658</td>
<td>20,939</td>
<td>96.7%</td>
</tr>
<tr>
<td>Powell Slough Major (Orem)</td>
<td>19,538*</td>
<td>9,404</td>
<td>48.1%*</td>
</tr>
<tr>
<td>Mill Race (Provo)</td>
<td>15,240</td>
<td>12,690</td>
<td>83.3%</td>
</tr>
<tr>
<td>Spring Creek – Springville (Springville)</td>
<td>7,259</td>
<td>3,977</td>
<td>54.7%</td>
</tr>
<tr>
<td>Dry Creek – Spanish Fork (Spanish Fork)</td>
<td>15,790</td>
<td>4,603</td>
<td>29.2%</td>
</tr>
<tr>
<td>Benjamin Slough (Payson, Salem)</td>
<td>15,007</td>
<td>5,155</td>
<td>34.3%</td>
</tr>
</tbody>
</table>

*Generated from limited downstream data*
<table>
<thead>
<tr>
<th>Option A: tributary data</th>
<th>Option B: DMR data</th>
<th>Option C: mix of tributary and DMR data</th>
</tr>
</thead>
</table>
| Incorporates both wastewater and natural loads | Incorporates only wastewater loads | Use DMR data when WWTP is near tributary outflow  
• Timp SSD  
• Powell Slough  
• Mill Race |
| Estimated loads lower than or equivalent to option B | Upstream tributary monitoring data is limited  
→ natural loads difficult to quantify | Use tributary data when WWTP is far from tributary outflow  
• Spring Creek – Springville  
• Dry Creek – Spanish Fork  
• Benjamin Slough |