UTAH LAKE C, N, AND P PROJECT UPDATE

ULWQS Science Panel Meeting
2021-04-20
Presented by Kateri Salk, Tetra Tech
1. Quantify conceptual models of N and P cycles in Utah Lake
2. Create external mass balance of C, N, and P for Utah Lake
3. SedFlux modeling of sediment-water fluxes of nutrients and oxygen
CONCEPTUAL MODELS
Phosphorus model

External TP Loading
- Inflow sources: streams, WWTPs, drains, springs, groundwater, precipitation (152-298 tons/yr)
- Atmospheric Deposition (5.01±3.1 tons/yr)

TP
- Main Basin: 0.01-1 mg/L
- Provo Bay: 0.05-1 mg/L

TP Loading
- Inflow sources (streams, WWTPs, drains, springs, groundwater, precipitation)
- Atmospheric Deposition

TP Transformation
- DTP: 0.003-1 mg/L
- PO₄₃⁻: SRP
  - Main Basin: 0.01-0.85 mg/L
  - Provo Bay: 0.02-4 mg/L
- TDP: 0.003-1 mg/L
- PIP: 0.7-2 % P

TP Uptake
- Excretion, Decomp.: 0.1-100 ng/(L-h)
- Excretion: 0.01-1,000 µg/(ind.*d)

TP Resuspension
- PP settling: 192-1,230 tons/yr
- PP resuspension: 173-257 tons/yr

TP Distribution
- Porewater TDP
  - Main Basin: 1.48 mg/L (0.26-10.82)
  - Provo Bay: 3.85 mg/L (0.40-6.78)
- Periphyton
  - Negligible

TP Excretion
- Fish: 1-4.5 % P (0.1-4.5 kg/acre)
- Zooplankton: 0.5-1.6 % P
- P.05-100,000 µg/L (small)
- 50-1,600 µg/L (large)

TP Uptake
- Phytoplankton: 0.17-480 µg/(ind.*d)
- Zooplankton
- Uptake not possible to calculate

TP Sediment
- Macrophytes: 0.2-0.6 % P

Confidence
- Very high
- High
- Medium
- Low
- Very low

Literature-derived values
- Dashed boxes are derived from Randall et al. 2019 (PloS ONE)

Macroinvertebrates
- Uptake not possible to calculate
- 5.3-17.0 mg/g dry weight

Water

Sediment
QUESTIONS/DISCUSSION

Questions or comments on the conceptual models?
EXTERNAL MASS BALANCE
EXTERNAL MASS BALANCE: POOLED MONTHLY DATA 2015-2020

Inputs
• Tributary loads: monitored watersheds
• Tributary loads: unmonitored watersheds
• Groundwater loads
• Atmospheric loads → *values from Brahney 2019* and *ULWQS SP AD Loading Recommendation - Approved – Final* (subject to updates as new data come in)
• Precipitation (for water balance) → *values from EFDC/WASP output*

Outputs
• Jordan River
• Evaporation (for water balance) → *values from EFDC/WASP output*
EXTERNAL MASS BALANCE: DECISION POINTS

• Focus today: tributary loads in monitored watersheds

• 2 Decision points:
  1. Comparing DWQ and WFWQC data → use one or both entities?
     o Discussed with SP members 4/16
     o Preliminary decision presented today
  2. For watersheds with WWTP, how to address DMR loads vs. tributary data?
     o Does nutrient attenuation occur moving downstream of WWTP? If so, which watershed(s)?
     o Addressing changing lake level – how to deal with sites that are inundated sometimes?
     o To be discussed at future meeting, NOT a topic to discuss today
WATERSHEDS

- UDWQ sites: orange
- WFWQC sites: purple
- Facility sites: black

Majority of watershed is monitored
→ infer unmonitored watersheds from similar monitored watersheds and/or model for ephemeral flow
WATERSHEDS (NOT TO SCALE)

- UDWQ sites: orange
- WFWQC sites: purple
- Facility sites: black

- WFWQC sites are downstream or at the same location as UDWQ sites
- Some sites are below the compromise elevation
## Watersheds

<table>
<thead>
<tr>
<th>Watersheds w/o WWTP, monitored by only UDWQ</th>
<th>Watersheds w/o WWTP, monitored by both UDWQ and WFWQC</th>
<th>Watersheds with WWTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tickville Wash</td>
<td>Lehi Spring Creek</td>
<td>Timp SSD <em>(Timpanogos)</em></td>
</tr>
<tr>
<td>Dry Creek – Saratoga</td>
<td>American Fork River</td>
<td>Powell Slough Major <em>(Orem)</em></td>
</tr>
<tr>
<td>Currant Creek</td>
<td>Lindon Drain</td>
<td>Mill Race <em>(Provo)</em></td>
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<tr>
<td>Provo River</td>
<td></td>
<td>Spring Creek – Springville <em>(Springville)</em></td>
</tr>
<tr>
<td>Hobble Creek</td>
<td>Dry Creek – Spanish Fork <em>(Spanish Fork)</em></td>
<td>Benjamin Slough <em>(Payson, Salem)</em></td>
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<tr>
<td>Spanish Fork River</td>
<td></td>
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<tr>
<td>4000 South Drain Spanish Fork</td>
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</tr>
</tbody>
</table>

- Use values directly
- Compare entities, use values from one or both
- Compare entities + address potential for attenuation of WWTP loading
<table>
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<tr>
<th>Constituent</th>
<th>Method and Reporting Limit</th>
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<tbody>
<tr>
<td></td>
<td><strong>UDWQ</strong></td>
<td><strong>WFQWC</strong></td>
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<tr>
<td>TP</td>
<td>EPA-NERL: 365.1: (4823) Phosphorus (all forms) by Semi-Automated Colorimetry 0.02</td>
<td>Hach Co.: 8048: Orthophosphate by Colorimetry 0.021</td>
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<td>TDP</td>
<td>EPA-NERL: 365.1: (4823) Phosphorus (all forms) by Semi-Automated Colorimetry 0.02</td>
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<td>TN</td>
<td>APHA 4500-N Persulfate Method for Total Nitrogen 0.2</td>
<td>Hach Co.: 10242: (TNTplus 880) Simplified Spectrophotometric Measurement of TKN in Water and Wastewater 0.7</td>
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<td>APHA 4500-N Persulfate Method for Total Nitrogen 0.2</td>
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<td>TOC</td>
<td>APHA 5310 B Total Organic Carbon by Combustion-Infrared Method 0.5</td>
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</table>
C-Q RELATIONSHIPS
WATERSHEDS W/O WWTP

• Watersheds w/ similar distributions
  o Hobble Creek
  o 4000 South Drain Spanish Fork
  o Provo River (Q, TP)

• Watersheds w/ truncated distribution for WFWQC
  o Lindon Drain
  o Spanish Fork River

• Watersheds w/ few WFWQC samples
  o Lehi Spring Creek
  o American Fork River
  o Provo River (TN)
  o Spanish Fork River (TN)
Higher concentrations of nutrients $\rightarrow$ detection limit likely not an issue
Downstream monitoring sites are below compromise elevation $\rightarrow$ limited data

- Powell Slough
- Mill Race
- Dry Creek- Spanish Fork
C-Q RELATIONSHIPS  
WATERSHEDS W/ WWTP

• Watersheds w/ similar distributions  
  o Timp SSD  
  o Benjamin Slough

• Watersheds w/ truncated distribution for WFWQC  
  o Powell Slough Major

• Watersheds w/ few WFWQC samples  
  o Powell Slough Major  
  o Mill Race  
  o Spring Creek – Springville  
  o Dry Creek – Spanish Fork
TAKEAWAYS: COMPARISON OF DWQ AND WFWQC MONITORING

• Reporting limit is an issue for WFWQC samples in watersheds w/o WWTP
• UDWQ sampling is more comprehensive than WFWQC for some watersheds
• Concentrations and flows are often, but not always equivalent → discrepancies could be a function of bias or limited sampling
PRELIMINARY DECISIONS

• Most watersheds have comparable concentrations and flows → use both DWQ and WFWQC data

• Watersheds with low TN concentrations (below detection limit for WFWQC method) → use DWQ data only
  o Provo River
  o Hobble Creek
  o Spanish Fork River

• Watersheds with discrepancy between DWQ and WFWQC → follow up
  o Lindon Drain
  o Spanish Fork River
• When a watershed has missing data for a given month (≠ no flow) → interpolate to generate load estimate (nearest neighbor or linear)

• Follow-up on TN values from WFWQC (method listed as TKN)
  o Theron Miller to follow up with any info he knows
  o May need to add NO₃⁻ and NO₂⁻ to generate TN

• Theron Miller to update us w/ additional information known on:
  o Flow methodology (should be USGS w/ 10 cross-sections)
  o If lat/long for any site is inaccurate
Looking Ahead: Attenuation of Nutrients

Comparing WWTP DMR data to tributary monitoring data:

1. WWTP is far away from lake
   - Tributary data likely a better representation of the lake load
   - e.g., Benjamin Slough

2. WWTP is close to the lake + tributary site is above compromise elevation
   - Compare DMR and tributary data
   - e.g., Timpanogos SSD

3. WWTP is close to the lake + tributary site is below compromise elevation
   - Need to determine what constitutes loading “to the lake”
   - Analyze transect from WWTP to downstream site → attenuation or not?
     - e.g., Powell Slough, Mill Race
Questions or comments on the proposed approach?
SEDFLUX MODELING
SEDFLUX MODEL BACKGROUND

• Mechanistic model
• Calculates rates of processes and fluxes across the sediment-water interface (C, N, P, other elements)
• Includes sediment diagenesis
• User-supplied data:
  o Water column conditions across time series (input)
  o Initial sediment conditions at the start of the model run (initial)
  o Rate-specific parameters for reaction network (parameters)
MODEL INPUTS

- 6-hour increments, May-October, 2017-2019
- DO and Temperature: high-frequency buoy data
  - 4917390 for Main Basin
  - 4917446 for Provo Bay
- NH$_4^+$, NO$_3^-$, PO$_4^{3-}$, DOC: routine monitoring
  - average across sites
  - linear interpolation between sampled dates
- Salinity: 0.8 PSU
- Depth: 3.26 for Main Basin, 2.0 for Provo Bay
**INITIAL SEDIMENT CONDITIONS & REACTION PARAMETERS**

- **Initial conditions:** default SedFlux values except dissolved $\text{PO}_4^{3-}$ in porewater
  - $1.48 \text{ mg/L}$ in Main Basin
  - $3.85 \text{ mg/L}$ in Provo Bay
- **Parameters:** set to default except where noted in Su and von Stackleberg (2020)

<table>
<thead>
<tr>
<th>Nutrient WASP Input Parameter</th>
<th>Units</th>
<th>Value</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature-Correction for Nitrification</td>
<td>None</td>
<td>1.07</td>
<td>Stantec Consulting Ltd (2010) for the Jordan River WASP</td>
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<td>Half-Saturation for Nitrification</td>
<td>mg-O$_2$/L</td>
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<td>Maximum value recommended by WASP</td>
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<td>Orthophosphate Partition Coefficient to Water Column Solids (Silt)</td>
<td>L/kg</td>
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<td>“Best” Calibrated Value</td>
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<td>Orthophosphate Partition Coefficient to Water Column Solids (Clay)</td>
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<td>Temperature-Correction for DOP Mineralization</td>
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MODEL INPUTS: ORGANIC MATTER (OM)

Missing data: OM load to the sediment (aka sinking rate)

• OM stoichiometry estimated in conceptual model → just need total rate
• Range of rates observed in Molongoski and Klug 1980: Wintergreen Lake (KBS, MI)
• 4 scenarios run:
  o Low sedimentation: minimum rate, steady across time series
  o Medium sedimentation: mean rate, steady across time series
  o High sedimentation: maximum rate, steady across time series
  o Seasonal sedimentation: minimum rate at the start of the time series, linear increase to maximum rate on August 1. Maintain high rate for the rest of the time series. Consistent with phytoplankton biomass seasonal trends from Analysis Report
SEDIMENT OXYGEN DEMAND (L: MAIN BASIN, R: PROVO BAY)

- Somewhat variable based on sedimentation
- Peaks from mid-July through August
**NH₄⁺ FLUX (L: MAIN BASIN, R: PROVO BAY)**

- Considerable variability based on sedimentation
- Net positive flux = from sediment to water column
- Peaks from mid-July through August, comparable across sites
**NO$_3^-$ Flux (L: Main Basin, R: Provo Bay)**

- Main basin: flux to the sediment early and late in the season, flux to the water column in mid-summer
- Provo Bay: flux to the sediment for the entire season
- Somewhat variable based on sedimentation
DENITRIFICATION RATE (L: MAIN BASIN, R: PROVO BAY)

- Rate not variable based on sedimentation rate
- Considerable variability across season and years
- Provo Bay > Main Basin
• Considerable variability based on sedimentation
• Seasonality of sedimentation is important
• Flux from sediment to water column, comparable between sites
COMPARISON TO HOGSETT ET AL. 2019

**SOD:**
- SedFlux > Hogsett

**NH$_4^+$:**
- SedFlux ≈ Hogsett

**NO$_3^-$:**
- SedFlux ≈ Hogsett

**SRP:**
- SedFlux > Hogsett

Note: need to also compare to Goel et al. sediment report
NEXT STEPS

1. Explore sensitive parameters and initial conditions:
   - Water column depth
   - SOD-relevant parameters & inputs
   - SRP-relevant parameters & inputs
2. Compare rates with Utah Lake and other system measurements
Any questions or comments on:

• Approach

• Exploratory results