Utah Lake Water Quality Study (ULWQS)
Science Panel
April 28, 12:00 PM to 3:00 PM
Virtual Meeting
Meeting Summary

ATTENDANCE:
Science Panel Members: Janice Brahney, Mitch Hogsett, Ryan King, James Martin, Theron Miller, Hans Paerl

Steering Committee Members and Alternates: Scott Bird, Craig Bostock, Gary Calder, Eric Ellis, Heidi Hoven, and John Mackey

Members of the Public: Eric Duffin, Leland Myers, David Richards, Soren Simonsen, and Katie Slebodnik

Utah Division of Water Quality (DWQ) staff: Scott Daly and Jodi Gardberg

Technical Consultants: Mike Paul and Kateri Salk

Facilitation Team: Heather Bergman and Samuel Wallace

ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Mike Brett	Run his mass balance spreadsheet model with the highest and lowest estimated atmospheric deposition values to determine the degree of impact that different atmospheric deposition values have on the overall mass balance of Utah Lake.	May 13	
Janice Brahney, Greg Carling, and Mike Brett	Compare the phosphorus concentrations in the sediment cores to the known loading rate from point sources to back-calculate an upper limit for how much additional phosphorus is coming into the lake from non-point sources.	May 13	
Samuel Wallace	Distribute the slide deck with the atmospheric deposition survey results and the additional reports that partners provided in the survey to the Science Panel.	May 5	May 5
	Reach out to Mike Brett and Mike Mills to check whether they are available to attend a meeting on the afternoon of May 26.	May 5	May 5

DECISIONS AND APPROVALS
No formal decision or approvals were made at this meeting.

ULWQS UPDATES

John Mackey, DWQ, shared updates on the ULWQS. His comments are summarized below.

- John Mackey will step in as the interim director of DWQ until a new director is hired. Until that time, he will serve as the co-chair of the ULWQS.
- There will be a Utah Lake Sumit on the evening of May 3. The purpose of the Summit is to summarize what is known about Utah Lake in the context of science and policy. All Science Panel members are encouraged to attend the Summit in person or virtually. After DWQ's presentation, any Science Panel members in attendance may be asked to contribute during the question and answer session.

GROUND RULES AND PROCESS COMMITMENTS OVERVIEW

Heather Bergman, Peak Facilitation Group, gave an overview of the Science Panel ground rules and process commitments. The ground rules and process commitments of the Science Panel are listed below.

- The Science Panel process commitments are:
    - Seek to learn and understand each other's perspective
    - Encourage respectful, candid, and constructive discussions
    - Seek to resolve differences and reach consensus
    - As appropriate, discuss topics together rather than in isolation
    - Make every effort to avoid surprises
- The Science Panel ground rules are:
    - Focus on the task at hand
    - Have one person speaking at a time
    - Allow for a balance of speaking time by providing succinct statements and questions
    - Listen with respect

PRESENTATION ON SCIENCE PANEL MEMBER PERSPECTIVES ON PHOSPHORUS ATMOSPHERIC DEPOSITION

Before the meeting, Science Panel members received a survey asking them to share their perspectives on atmospheric deposition loading estimates. Samuel Wallace, Peak Facilitation Group, presented the results of the survey. His comments are summarized below.

- Five Science Panel members responded to the survey.
- The first set of questions asked Science Panel members to share their perspectives on what they think is the lowest, best, and highest scientifically defensible atmospheric deposition phosphorus loading estimate.
    - Science Panel members indicated the following values in ton/year as the lowest scientifically defensible atmospheric deposition phosphorus loading estimate:
        - 50 to 70
        - 2 to 4
        - 10
        - 77
        - 12.5
    - Science Panel members indicated the following values in ton/year as the highest scientifically defensible atmospheric deposition phosphorus loading estimate:
        - 200
        - 20 to 25
        - 200
        - 430

        - 23
    - Science Panel members indicated the following values in ton/year as the highest scientifically defensible atmospheric deposition phosphorus loading estimate:
        - 50-100
        - 5-8
        - 40-80
        - 175
        - 12.5
- The survey asked Science Panel members to provide any additional comments that informed their thinking on their atmospheric deposition phosphorus loading estimate. Science Panel members who responded to the survey shared the following comments:
    - Dust and regional fires are episodic. Wetter years will have low deposition rates, so it is important to have these years as brackets. Although wetter years may become less frequent, it is important to have historical context.
    - For context, two tons/year translates to 8 mg/m2/year and four to 16 mg/m2/year. The Sierra Nevadas (Spain) near the Sahara Desert, the largest dust source in the world, receive about 16 mg/m2/year of phosphorus. Two tons/year is also greater than deposition rates near an open pit phosphorus mine (Munroe 2014, Munroe et al. 2020, Munroe et al. 2015)
    - Twenty-five tons/year is similar to the highest average recorded phosphorus deposition in areas that receive intense ash deposition (which can be 50x more enriched in phosphorus compared to vegetation). Twenty-five tons/year translates to 105 mg/m2/year, which is orders of magnitude higher than the global mean of 60 mg/m2/year.
    - The Wasatch Front Water Quality Council (WFWQC) study estimates are conservative based on their bulk sampling methods, collection of substantial data from Bird Island, and because they lost their important sampler near the gravel pit after 2017.
    - The method used by Brahney (2019) for interpolating phosphorus fluxes across Utah Lake using a decay equation may underestimate phosphorus deposition.
    - The high atmospheric deposition values are attributed to local dust sources, which are given too much weight in the studies by Miller, Miller, and Williams. The loads in the middle of the lake are likely lower than the edges of the lake. Some decay equations should be used, but maybe not such an aggressive decay equation as Brahney (2019) used.
    - The sheer number of samples collected by Wood Miller suggests a low annual phosphorus atmospheric loading estimate of 77 tons/year.
    - Forty samples from 2017 near the active gravel pit indicate a high annual phosphorus atmospheric loading estimate of 430 tons/year.
    - It is more useful to discuss flux before calculating the load since both are important measures. A shoreline flux of 60 mg-TP/year appears to be a baseline flux as measured by the ULWQS. This flux translates to a max load of 12.5 tonnes TP/year at the compromise level, assuming 50% of the shoreline flux across the lake.
- Science Panel members asked the following additional questions in their survey responses:
    - What is the speciation of total phosphorus?
    - What are the total suspended solids, volatile suspended solids, and fixed suspended solids in the bulk samples?
    - How do Utah Lake fluxes measured by Wasatch Front Water Quality Council compare to other studies?

ATMOSPHERIC DEPOSITION PHOSPHORUS LOADING ESTIMATE DISCUSSION
Science Panel members discussed their perspectives on the atmospheric deposition phosphorus loading estimate in the ULWQS model. Their comments are summarized below.

Discussion of the Results of Atmospheric Deposition Studies

- WFWQC has collected over 1,400 data points, 1,200 of which are from the bulk deposition sampling effort alone. The results from WFWQC's precipitation-weighted samples reflect that the minimum atmospheric deposition phosphorus loading rate is 77 tons/year. Atmospheric deposition scientists have communicated that the precipitation-weighted samples are the conservative estimate for atmospheric deposition nutrient loading in Utah lake.
- The atmospheric deposition studies conducted by WFWQC complied with the National Atmospheric Deposition Program (NADP) guidelines. Researchers put splash guards on collectors and moved samplers away from other collection infrastructure, like the solar panels, to gather objective data and address feedback provided by the Science Panel.
- Utah has phosphorus loading from dust, but it is not the dustiest place in the world. The global average for atmospheric deposition for phosphorus loading is 50 milligrams/meter squared/year. The 200 tons/year estimate translates to 835 milligram/meter squared/year, which is twice as high as anyone has measured in any place around the world. It is unclear what mechanisms set Utah Lake apart, resulting in such high atmospheric deposition rates.
- The highest atmospheric deposition phosphorus loading estimates in the world occur in tropical areas with a high amount of biomass burning. In these areas, the phosphorus loading rates from atmospheric deposition rates are 100 to 150 milligrams/meter squared/year. Places like the Sahara Desert have high atmospheric deposition rates, but the material deposited into lakes around the Sahara Desert has low organic phosphorus content. The phosphorus loading estimates from atmospheric deposition in the Sahara Desert are 16 to 40 milligrams/meter squared/year. The atmospheric deposition material with the highest phosphorus content is ash, which comes from biomass burning.
- Biomass burning produces ash enriched in phosphorus but not nitrogen. The relative amount of phosphorus and nitrogen in ash depends on the pyrolysis intensity.
- When there is a data outlier in the context of other studies, there needs to be some mechanistic explanation as to why that outlier exists. Without a clear mechanistic explanation for why Utah Lake has much higher atmospheric deposition phosphorus loading rates than other places around the world, it is appropriate to lean towards the value from literature reviews. There are too many variables (e.g., insects and bird droppings) that are not accounted for to explain why the atmospheric deposition phosphorus loading rates are much higher in Utah Lake. It is difficult to accept values that are orders of magnitude greater than expected.
- If Utah Lake has had natural phosphorus contributions for eons, these natural contributions alone do not explain why there are suddenly very large concentrations of phosphorus in the surface sediments of Utah Lake and why phosphorus concentrations are higher on the east shore of Utah Lake and Goshen Bay.
- Utah Lake is unique in many ways. Utah Lake is located in an ancient lake bed with geologic phosphorus depositions. Mobilizing the dust from these ancient lake beds results in atmospheric dust high in phosphorus depositing into Utah Lake.
- The phosphorus loading estimates from WFWQC's studies are higher than those from other studies, but the nitrogen loading estimates from WFWQC's studies are similar to those of

other studies. It is unclear why the WFWQC's atmospheric deposition studies would result in anomalous phosphorus loading estimates but not anomalous nitrogen loading estimates.

- Brahney (2019) includes data from sites near open-pit phosphate mines in Utah. The phosphorus deposition rates from those studies are low compared to the high estimates identified in the WFWQC atmospheric deposition studies.
- Atmospheric deposition rates do not explain why phosphorus concentrations are higher on the eastern shore of Utah Lake. If atmospheric deposition contributed a large amount of phosphorus to Utah Lake, the expectation is that there would be a more even distribution of phosphorus across Utah Lake.
- Phosphorus concentrations are higher on the eastern side of the lake because more primary production occurs there, resulting in more organic matter in the sediments. Nutrient inputs increase primary production in this part of the lake.
- The wind blows the duck reed and algae to the north and northeast part of Utah Lake. When the duck reed and algae die and decay, it results in three feet of organic matter. The accumulation of organic matter, in addition to productivity, results in the rapid recycling of nutrients in the sediment.
- Published data on the wind patterns pushing algae to the eastern side of the lake would be helpful moving forward. The Utah Lake Windy App contains data on wind patterns. The ULWQS in-lake model will also incorporate lake circulation.
- It would be helpful to discuss the atmospheric deposition flux to Utah Lake before estimating the atmospheric deposition phosphorus load. It may be possible to back-calculate the atmospheric deposition phosphorus flux using the WFWQC wet sampler data.
- WFWQC used kriging to generate atmospheric deposition rates across the lake. The west side of Utah Lake has higher atmospheric deposition rates, particularly the sampling site near the gravel pit. The gravel pit has been observed to blow large amounts of dust in Utah Lake.

Discussion of Impacts of Episodic Events

- The Science Panel member who identified that their highest atmospheric deposition phosphorus loading estimate is 23 tons/year did so assuming that 23 tons/year is the baseline level. High deposition events occur, and these high deposition events may result in an atmospheric deposition phosphorus loading rate higher than 23 tons/year.
- Utah Lake has a baseline atmospheric deposition rate. Periodic events, like windstorms, can result in spikes of atmospheric deposition occurring in Utah Lake. The Science Panel may want to consider how to model those events.
- Large windstorms in Utah blow large amounts of phosphorus-rich dust and aerosols into Utah Lake. These windstorms are the mechanism that results in a high atmospheric deposition phosphorus loading rate. The WFWQC data confirms this high atmospheric deposition phosphorus loading rate is occurring.
- Brahney (2019) cites dust-related studies that include the impact of episodic events over long periods. The Brahney (2019) estimate includes the effects of episodic events on atmospheric deposition.
- The atmospheric deposition phosphorus loading estimate should include a range of values due to year-to-year variability resulting from episodic events, including wildfires.

Discussion of Atmospheric Deposition in the Context of Other Nutrient Sources

- The atmospheric deposition loading may be relatively small compared to other nitrogen and phosphorus sources. If the atmospheric deposition rates are relatively low compared to other sources, then the Science Panel may be over discussing the nutrient inputs from atmospheric deposition.

- According to the carbon, nitrogen, and phosphorus (CNP) budget study, the current phosphorus loading from tributaries at the compromise boundary of Utah Lake is 177 metric tons/year. Groundwater contributes an additional 100 metric tons of phosphorus. The outflow of the Jordan River removes 19.5 tons of phosphorus from Utah Lake each year.
- The publicly owned treatment works (POTWs) have made upgrades to their facilities since 2015. These upgrades result in the POTWs discharging less than 177 metric tons of phosphorus into Utah Lake each year. The 177 metric tons/year of phosphorus flowing to Utah Lake via tributaries in the CNP budget study is based on loading data from 2015 to 2020.
- Timpanogos Special Services District (TSSD) discharges effluent with a phosphorus concentration of 0.6 milligrams/liter; this value means TSSD contributes 15 tons/year of phosphorus to Utah Lake. Considering that TSSD is the largest POTW around Utah Lake, the total contributions from POTWs are likely around 60 to 70 tons/year of phosphorus. Once some of the POTWs upgrade their facilities, the total phosphorus contributions from POTWs may decrease to 50 tons/year.
- The Science Panel will need to discuss the internal cycling of phosphorus in Utah Lake and how sediment recycling impacts nutrient concentrations. Organic phosphorus will turn into dissolved phosphorus eventually. The amount of sediment resuspension in Utah Lake makes it important to speciate the total phosphorus entering Utah Lake. In lake systems, researchers often consider total phosphorus as what is bioavailable in different timescales, but in dust, phosphorus bound to apatite and iron is not bioavailable.

Atmospheric Deposition Next Steps

- The Tetra Tech modeling team is ready to move ahead with developing the Utah Lake models. They are waiting on atmospheric deposition values and phosphorus-binding study results before they can proceed. Not deciding on an atmospheric deposition phosphorus loading rate will result in a delay in developing the model. The Science Panel has some time to continue to discuss atmospheric deposition rates. However, there will not be additional time to collect more atmospheric deposition data over the summer due to the time constraints.
- It would be helpful to understand the model's sensitivity to relatively high and low atmospheric deposition phosphorus loading estimates. If the high atmospheric deposition phosphorus loading estimate does not have a large impact on the lake relative to other inputs, it may be easier for the Science Panel to agree upon an atmospheric deposition phosphorus loading estimate. It is expected that a large range would result in significant changes in the total Utah Lake phosphorus budget. Although this may be the case, understanding how sensitive the Utah Lake phosphorus budget is to different atmospheric deposition phosphorus loading values would be helpful. Mike Brett will run his mass balance spreadsheet model with the highest and lowest estimated atmospheric deposition values to determine the degree of impact that different atmospheric deposition values have on the overall mass balance of Utah Lake.
- Another calculation that would be helpful is to back-calculate an upper limit for how much additional phosphorus is coming into the lake from non-point sources by comparing the phosphorus concentrations in the sediment cores to the known loading rate from point sources. Janice Brahney, Greg Carling, and Mike Brett will compare the phosphorus concentrations in the sediment cores to the known loading rate from point sources to back-

- calculate an upper limit for how much additional phosphorus is coming into the lake from non-point sources.
- The atmospheric deposition data inputs in the ULWQS in-lake model will require a time series and phosphorus fractionation.

Public Comment on Atmospheric Deposition Discussion

- The WFWQC has collected site-specific data. If the Science Panel is going to reject the data, they have to identify a reason to reject it other than it is not consistent with other lake systems. The justification that the WFWQC's site-specific data is not valid because it does not align with other lake systems does not account for unique conditions that occur on Utah Lake. If the Science Panel cannot use the data, it is important that the Science Panel continue to collect more site-specific data before making a final decision. The Science Panel should consider a range of values, including the high values identified in the WFWQC's studies.
- The results of the ULWQS will eventually end up as a political decision in Utah. The Science Panel should consider all the science presented to them.
- The POTW are upgrading their facilities and decreasing the nutrient loads in their effluent. Using the loading values from 2015 to 2020 to calculate the CNP budget in Utah Lake does not accurately reflect current and future POTW operations.
- It will be helpful to back-calculate an upper limit for how much additional phosphorus is coming into the lake from non-point sources.

Public Clarifying Questions

Members of the public asked clarifying questions on atmospheric deposition. Their questions are indicated in italics below, with the corresponding responses in plain text.

How will climate change impact atmospheric deposition rates in the future?
The expectation is that climate change will increase drought conditions, which will result in higher atmospheric deposition rates. Population growth and land-use changes will likely also increase atmospheric deposition rates in the future.

NEXT STEPS

- The next Science Panel meeting is tentatively scheduled for May 26. Samuel Wallace will reach out to Mike Brett and Mike Mills to check whether they are available on the afternoon of May 26 to attend a meeting.
- The Science Panel and Steering Committee will be meeting in person in the late summer or early fall. Currently, the last week of August and early September works for most Science Panel members.
- Samuel Wallace will distribute the slide deck with the atmospheric deposition survey results and the additional reports that partners provided in the survey to the Science Panel.