Utah Lake Water Quality Study (ULWQS)
Steering Committee
March 25, 1:00 PM to 4:00 PM
Virtual Meeting
Meeting Summary - FINAL

ATTENDANCE:
Steering Committee Members and Alternates: David Barlow, Jamie Barnes, Scott Bird, Sam Braegger, Chris Cline, Eric Ellis, Erica Gaddis, Juan Garrido, Jon Hilbert, Heidi Hoven, Christopher Keleher, John Mackey, Nancy Mesner, Rich Mickelsen, Dave Norman, Jay Olsen, Cory Pierce, Mike Rau, Dennis Shiozawa, Brad Stapley, and Neal Winterton

Science Panel Members: Mitch Hogsett

Meeting Panelists: Kate Fickas, Alejandra Maldonado, Hans Paerl, and John Ravenscroft

Members of the Public: Dilworth Chamberlain, Tina Laidlaw, Renn Lambert, Chris Nelson, George Parrish, David Richards, Kateri Salk, and Lester Yuan

Utah Division of Water Quality (DWQ) staff: Scott Daly, Jeff DenBleyeker, Jodi Gardberg, and Nicholas von Stackelberg

Facilitation Team: Heather Bergman and Samuel Wallace

ACTION ITEMS

Who	Action Item	Due Date	Date Completed
Scott Daly	Share the PowerPoint presentation slides from today's meeting with Steering Committee members.	April 15	
Samuel Wallace	Share the Ideaflip Board that outlines the ULWQS process with Steering Committee members.	April 15	

DECISIONS AND APPROVALS
Below is a summary of the decisions and approvals the Steering Committee made at the meeting.
- The Steering Committee agreed to collect cell count data as a measure to assess progress toward attaining management goals to inform the development of criteria.

FACILITATOR INTRODUCTION
Erica Gaddis, DWQ, introduced Heather Bergman and Samuel Wallace from Peak Facilitation. Her comments are summarized below.
- Heather Bergman and Samuel Wallace from Peak Facilitation Group are replacing Paul De Morgan and Dave Epstein as the facilitators for the ULWQS. Paul De Morgan and Dave Epstein did a great job, but the DWQ oversaw a competitive bidding process and selected Peak Facilitation Group as the new contractor for the ULWQS.
- Heather Bergman and Samuel Wallace will facilitate the ULWQS Science Panel and Steering Committee meetings as the work for 2021 begins to ramp up.

GROUND RULES AND PROCESS COMMITMENTS OVERVIEW
Heather Bergman, Peak Facilitation Group, gave an overview of the Steering Committee ground rules and process commitments. The ground rules and process commitments of the Steering Committee are listed below.

- The Steering Committee 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 Steering Committee 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

UTAH LAKE PROCESS PRESENTATION
Erica Gaddis, DWQ, presented on the Utah Lake process and how the current Steering Committee activities fit into the process. Her comments are summarized below.

- Heather Bergman met with Steering Committee and Science Panel members before the meeting to discuss where there is room for improvement in the ULWQS process. A recurring comment from Steering Committee members was that they had lost track of the Utah Lake process.
- The Utah Lake numeric nutrient criteria process began in 2016. The goal of the process is to develop numeric nutrient and phosphorus criteria that protect the Lake's designated beneficial uses: recreation, aquatic life, and agriculture.
- Phase one of the ULWQS occurred from 2015 to 2018. Phase one involved gathering and characterizing available data.
- In 2018, phase two of the ULWQS began. The purpose of phase two is to develop numeric criteria for nitrogen and phosphorus. Phase two was supposed to be completed in 2021; the expectation at this time is that phase two will be completed in 2022.
- Phase three of the ULWQS will begin in 2021. Phase three will involve implementation planning. During implementation planning, partners will consider the economics and feasibility of implementing the nutrient criteria.
- DWQ remains committed to not implement the new nutrient criteria for publicly owned treatment work (POTW) permits until 2030.
- Once the Steering Committee finishes their work, they will submit their nutrient criteria recommendation and implementation plan to the Utah Lake Commission for approval. The Utah Lake Commission will then submit it to the Utah Water Quality Board for their approval. Any costs that exceed the Utah Legislature's cost threshold will require approval from the Utah Legislature as well. The Environmental Protection Agency (EPA) will also need to approve the nutrient criteria.
- The ULWQS Science Panel informs the work of the Steering Committee. In 2017, the Steering Committee developed charge questions and sub-questions to help guide the scientific research needed to define nutrient criteria. The four charge questions are:
  1. 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?
  2. What is the current state of the Lake with respect to nutrients and ecology?

3. What additional information is needed to define nutrient criteria that support existing beneficial uses?
4. Is there an improved stable state that can be reached under the constraints of current water and fishery management?

- Utah Lake is a complicated system. The Science Panel is spending significant resources to answer key information gaps to understand how nitrogen and phosphorus function in Utah Lake and interact with other water quality parameters, such as pH and ammonia. The Science Panel is currently overseeing a bioassay study, phosphorus-binding study, and sediment study to develop answers to the charge questions.
- The Utah legislature has recently introduced a bill to create the Utah Lake Authority, which would be a new organization with bonding and other funding abilities. This bill indicates that state leaders are recognizing the recovery and restoration of Utah Lake as a priority. The ULWQS Steering Committee and Science Panel will be best situated to inform policy decisions based on community concerns and the best available science.
- The Steering Committee worked on water quality management goals in 2020. The management goals are a part of the Strategic Research Plan and will be incorporated into the Numeric Nutrient Criteria Framework. The management goals are meant to be a clear expression of what the Steering Committee is trying to achieve in Utah Lake. The management goals will help the Steering Committee refine future models and plan for implementation.
- The Steering Committee's upcoming work will involve developing various scenarios to model what type of changes will help achieve the Utah Lake management goals. There may need to be a smaller subgroup of Steering Committee members to help develop those scenarios.

ULWQS IDEAFLIP BOARD

Samuel Wallace, Peak Facilitation Group, introduced a new tool that helps lay out the ULWQS process. His comments are summarized below.

- Samuel Wallace created the new tool through an online software called Ideaflip. Through Ideaflip, he laid out the major tasks for Phase 2 and Phase 3 of the ULWQS. If Steering Committees members click on each of the major tasks, the link will take them to a new Ideaflip board which shows a more detailed step-by-step process for each major task. He also included checkmarks to indicate completed tasks and color-coded the steps to indicate who was responsible for them.
- The Ideaflip is a work in progress. Samuel Wallace and Scott Daly will continue to build on the Ideaflip Board, including indexing the board to link to relevant documents.
- Samuel Wallace will share the Ideaflip Board with the Steering Committee members.

Steering Committee Comments

Steering Committee members discussed the ULWQS Ideaflip Board. Their comments are summarized below.

- The Ideaflip Board looks like it will be useful, but it would help if Steering Committee members could explore the tool and come back with suggestions to improve it.
- It is difficult to keep track of documents in the Google Drive Folder. The Ideaflip Board may be a more useful way to track documents.
- Once Steering Committee members become familiar with the tool, they should make it an active part of meetings to show how discussions fit into the overall process.
- The recreation survey, which is part of the ULWQS Strategic Research Plan, will help generate data on recreation use on Utah Lake.

Public Comments
Members of the public provided comments on the bioassay study. Their comments are summarized below.

- The Timpanogos Special Service District (TSSD) mesocosm study will take several years to complete.

HARMFUL ALGAL BLOOM (HAB) PRESENTATIONS
A panel consisting of Dr. Alejandra Maldonado, Utah Department of Health (UDOH), Dr. Kate Fickas, DWQ, John Ravenscroft, EPA, and Dr. Hans Paerl, University of North Carolina, gave presentations on HABs. Their presentations are summarized below.

***Health Effects Related to Harmful Algal Bloom Exposure,* Dr. Alejandra Maldonado, UDOH**

- The mission of the UDOH is to protect the public's health through preventing avoidable illness, injury, disability, and premature death; assuring access to affordable, quality health care; and promoting healthy lifestyles. Their vision is to make Utah a place where all people can enjoy the best health possible and live and thrive in healthy and safe communities.
- The UDOH uses a conservative risk assessment approach to minimize people's exposure to harmful effects.
- HABs are the rapid growth of cyanobacteria, also known as blue-green algae. HABs consist of a mixture of cyanobacteria communities. Some of these cyanobacteria can produce cyanotoxins that pose health risks to people.
- Cyanobacteria species can produce multiple toxins, and multiple species can produce the same toxin. Toxins can exist inside the cell, or cells can release the toxin into the water. Toxins primarily target the liver, nervous system, and skin.
- Exposure to toxic and non-toxic cyanobacteria can lead to health effects. Exposure to toxic cyanobacteria can result in more severe health effects, such as liver damage, kidney damage, hematological effects, and reproductive and developmental effects. Exposure to non-toxic cyanobacteria cells is less severe but can result in inflammatory responses, gastrointestinal distress, skin irritation, and allergic response.
- People are primarily exposed to cyanobacteria via incidental ingestion, inhalation of aerosols (from tubing or boating), and skin contact. Researchers primarily derive information on cyanobacteria and cyanotoxins' effect on human health from studies on recreational exposures, laboratory animals, reports of extreme human exposure events, and animal exposure reports.
- The health effects from ingestion include nausea, headache, neurological symptoms, muscle cramps, and kidney and liver damage in the worst-case scenario. Skin contact can result in eye irritation, rash, hives, and blisters or sores. Inhalation can result in nose irritation, sore throat, coughing, and difficulty breathing.
- The Utah HAB Advisory Guidance uses toxigenic cyanobacteria cell counts because exposure to cyanobacterial cells alone can have adverse inflammatory health effects, even in the absence of analyzed toxins. Epidemiological studies, including Pilotto et al. (1997), Stewart et al. (2006), Levesque et al. (2014), Levesque et al. (2016), and Lin et al. (2015), have identified a relationship between cyanobacteria cell counts and reported health effects.
- The Utah Lake HAB Advisory Program also uses cell counts because elevated cell counts are currently the most important early and integrative indicator for local health departments to warn the public about a public health threat.
- The goal of the HAB Advisory Program is to protect vulnerable populations like children. Children are more likely to become ill because they drink more water in recreational

settings, stay in the water longer, and have more skin exposure. They are also smaller in size, so exposure to toxins is larger relative to their size.
- UDOH ultimately uses toxigenic cell counts to meet its mission and vision in protecting public health.

***Toxigenic Cell Count Densities in Utah DWQ/DOH Recreational HAB Advisory Program,* Dr. Kate Fickas, DWQ**

- The HABs Advisory Program's overarching tasks are to recognize priority water bodies, collect and summarize data, coordinate analysis, make action and advisory recommendations to local health departments, and communicate emerging science and information to all stakeholders.
- The HABS Advisory Program process starts every year in June, at which point the UDOH and local departments have the authority to call an advisory. The Program oversees 25 waterbodies and samples them at least once a month. If they find the potential for a bloom through their quantitative analysis, they will reach out to the local management agency. They will then monitor the waterbody for cyanotoxins by sending samples to a lab in Michigan. The lab determines the concentration of toxigenic species.
- The HABs Advisory Program will make a recommendation to local health departments based on advisory thresholds. Local health departments then decide whether to issue an advisory. The thresholds are based on EPA's recommendations for microcystin and cylindrospermopsin. For Anatoxin-A, the HABs Advisory Program benchmarked the thresholds working with other states, nations, and World Health Organization (WHO). The warning advisory threshold is 100,000 toxigenic cyanobacteria cells per milliliter, and the danger advisory is 10,000,000 toxigenic cyanobacteria cells per milliliter. They also have a health watch tier based on several indicators so that local health departments can put a pre-advisory health watch in place before the quantitative analysis is complete.
- In 2020, the HABs Advisory Program went through a benchmarking process with the EPA, which incorporated a public commenting process. The benchmarking process resulted in a changed threshold for microcystin, cylindrospermopsin, anatoxin-A, and toxigenic cyanobacteria cell density.
- The HABs Advisory Program uses toxigenic cyanobacteria cell counts for several reasons. One reason is that exposure to cyanobacteria cells alone can have adverse health effects. Another reason is that the presence of cyanotoxins can be ephemeral, which makes it difficult to capture the presence of toxins at any given time. Cell counts are a proxy measure for the presence of toxins. A third reason is that cell counts are the best way to communicate to local health departments and the public what is going on in a water body. Using cell counts also allows the HABs Advisory Program to measure risk consistently and quantitatively. Once DWQ shares the cell counts with the local health department, the local health department can decide whether to act or make an advisory.
- Many states are using toxigenic cell counts in their advisory guidance programs. Utah's thresholds are similar to other states' thresholds, and some states have lower thresholds than Utah's HABs Advisory Program.
- From 2017 to 2019, local health departments issue 62 HAB advisories. Of the 62 HAB advisories, there were four advisories after which cyanotoxins did not follow the elevated cell counts. Utah Lake specifically has never had a recreation season when cyanotoxins did not precede, accompany, or follow elevated cyanobacteria cell counts.

***Recreational Ambient Water Quality Criteria and/or Swimming Advisories (AWQC/SA) for Cyanotoxins*, John Ravenscroft, EPA**

- The EPA developed recommended criteria for AWQC/SA in 2019, which they released in a publication. The purpose of the recommended criteria was for states to apply them to recreational water quality standards, swimming advisories, or both.
- The EPA issued recommendations based on the latest science for primary contact recreational use (i.e., recreational activities where the incidental ingestion of water is likely to occur).
- The EPA worked with various stakeholders, including the states, the public, and other stakeholders, to develop the criteria. They had multiple public commenting periods.
- The EPA used peer-revied information to develop the recommended values for microcystins and cylindrospermopsin. To develop these values, the EPA had to consider the kind of exposure people are subject to through different types of primary contact. The EPA publication contains data and values on different types of recreational exposure. The EPA also evaluated the science that describes the health effects of exposure to cyanobacterial cells.
- The EPA publication includes a conceptual model of cyanotoxin and cyanobacteria exposure pathways through recreation. The conceptual model represents a risk assessment approach to management. The model identifies the stressors (cylindrospermopsin, microcystins, and cyanobacteria cells), the sources of the stressors, exposure routes, receptors (i.e., those who are at risk of possible exposure to the stressors), and the endpoints (i.e., potential symptoms).
- The publication includes cyanobacteria cells as a stressor, including toxigenic and non-toxigenic cells). Toxigenic and non-toxigenic cells are visually indistinguishable from each other. Focusing on toxigenic cells is a good indicator of the toxins that the cells could produce.
- The publication focuses on criteria recommendations for freshwater sources (e.g., lakes, ponds, and rivers). The EPA considered oral, dermal, and inhalation exposure routes. The data on oral exposure routes are more robust than dermal and inhalation exposure routes. The receptors include both adults and children, but there is a specific concern for children who spend more time in contact with the water and are more susceptible to the effects. The endpoints of particular concern are kidney damage from cylindrospermopsin, liver damage from microcystin, and inflammatory responses from cyanobacteria cells.
- In 2003, the WHO highlighted the guidelines for safe recreation water. Their report outlined how health effects from cyanobacteria exposure must be differentiated between the irritated, inflammatory effects and the potentially more severe effects. They said one guideline for cyanobacteria exposure is not appropriate because there are two independent health outcomes. They included different risk levels and developed an associated cell count and toxin concentration for each risk level.
- The EPA's criteria recommendation is eight micrograms per liter for microcystin and 15 micrograms per liter for cylindrospermopsin.
- The associated duration for these recommended concentrations for recreational water quality was a one in ten-day assessment period across a recreational season. The EPA recommended that if microcystin and cylindrospermopsin concentrations are greater than the recommended criteria more than three times a year, the managing agency should consider that an exceedance of the standard. The EPA left it to the states to determine the upper limit on the number of years they would allow these patterns to occur.

- For swimming advisories, the EPA recommended that the microcystin and cylindrospermopsin concentrations do not exceed the recommended threshold ever to protect children in particular and the general public.
- In the EPA's publication, they encourage states to use cell counts, but the EPA did not develop specific criteria for cell counts due to data uncertainties. Studies did show a significant relationship between health effects and exposure to cyanobacteria cells, but the studies also had a large range on what they considered acceptable exposure. The EPA decided the range was large enough that they could not develop criteria for the entire country.
- The EPA developed a table that shows the health effects associated with cyanobacterial cells. In the table, they estimated that a microcystin-producing cell density of 40,000 cells per milliliter would likely produce eight micrograms per liter of microcystin and that a cell density of 100,000 cells per milliliter would likely result in an exceedance of the eight micrograms per liter threshold.

***Physical, Chemical, and Biotic Factors that Drive CyanoHABs*, Dr. Han Paerl, University of North Carolina**

- Several factors control algal blooms, including the amount of nutrient input, light, temperature, lake mixing, and residence time (the amount of time it takes for one drop of water to enter then leave the Lake). Sediments at the bottom of the Lake also exchange nutrients with the Lake's water column.
- Cyanobacteria have been around for 2.5 billion years and have been exposed to many extreme environmental conditions.
- Cyanobacteria are susceptible to physical factors. The perfect scenario for cyanobacteria is high nutrient inputs from a wet spring and snowmelt, followed by a low-flow drought condition. This scenario results in a high amount of nutrients entering the system, followed by high sunlight and stagnant water, allowing cyanobacteria to bloom.
- Among all the factors, the controllable factor is nutrient input. Stakeholders cannot control sunlight or precipitation.
- There are several scientific consensuses on HABs in Utah Lake. The consensuses are that:
    - Increased nutrient pollution promotes the development and persistence of HABs, mostly cyanobacteria.
    - Large HABs require external sources of nutrients to be sustained.
    - A reduction of nutrient inputs from watershed sources can significantly reduce HAB frequency and magnitude.
    - It is important to distinguish cyanoHABs from non-harmful algal taxa.
    - The conditions for blooms include nutrients, warm temperatures, good light, and low wind speed (stagnant conditions).
- Researchers conduct dilution bioassays to estimate the nutrient thresholds for algal blooms. In a dilution bioassay, researchers will dilute the lake water using nutrient-less water to determine how different nutrient levels impact algal growth. Researchers conducted these studies in Lake Taihu, China, and determined they needed to reduce in-Lake nutrients by 30%. Researchers are conducting a bioassay study in Utah Lake, which may have different results than the Lake Taihu study. The Utah Lake bioassay study is an experimental way to determine the lower thresholds of nutrient inputs needed to sustain a bloom.
- Researchers have studied whether there is a relationship between chlorophyll-a and microcystin production. Researchers use chlorophyll-a because it a sensitive, relevant, and easy-to-use indicator. Studies on Lake Taihu and Lake Eerie indicate a positive relationship with some variability, meaning the production of microcystin increases in relation to the

increase of chlorophyll-a. The variability is largely due to other factors, such as residence time, mixing, and wind intensity.

- Researchers have not been able to conclusively determine why cyanobacteria are producing toxins. There are multiple hypotheses about which environmental variables could be impacting toxin production.
- There are many different cyanotoxin producers in Utah Lake. The presence of cyanotoxin producers varies spatially and temporally in Utah Lake depending on different environmental conditions.
- Scientists can relate nutrients to toxin production because there is a strong relationship between nutrient inputs and the preponderance of cyanobacterial blooms. One challenge with measuring cyanobacteria biovolume and chlorophyll-a in relation to cyanotoxins is that not every cyanobacteria taxon produces toxins. This challenge creates a source of variability in the data.
- The EPA is on target with their criteria recommendation, but there is no perfect relationship between cell counts and toxin production. However, without cell count and identification data, researchers and managers will be moving forward blindly. Using cell count helps address the variability between biomass and toxin production. Although there are variabilities, one known piece of information is that high nutrient loads lead to algal blooms.

Steering Committee Questions

Steering Committee members asked questions on the HABs presentations. Questions are indicated in italics with corresponding answers in plain text.

Wastewater treatment plants reduced their previous phosphorus input levels to one part per million, representing a 60% reduction in phosphorus input. Their nitrogen input levels are less than ten parts per million but gradually increasing. How do those inputs help with the whole process?

It helps. Utah Like is likely experiencing a dual nutrient challenge. There is a lot of phosphorus in Utah Lake, so it will take a while to remove excess phosphorus from the system. Nitrogen more easily leaves the system through denitrification processes. Because nitrogen leaves the system more easily, limiting nitrogen inputs may help speed up the Lake's de-eutrophying process. It is good that there is less nitrogen entering the system historically.

Are lower nutrient levels more advantageous for algae than cyanobacteria?

Yes. Reducing total biomass will increase clarity and reduce surface-dwelling blooms. Cyanobacteria form surface blooms to choke out other organisms in the Lake, such as desirable phytoplankton. Reducing cyanobacteria populations will benefit desirable phytoplankton populations, like diatoms, that cannot compete with cyanobacteria.

How low do phosphorus and nitrogen levels need to go in Utah Lake?

There is a threshold for phosphorus and nitrogen, but it is not known yet. Dr. Zach Aanderud of Brigham Young University is conducting dilution bioassay studies, similar to the Lake Taihu studies. The studies' results will indicate the nutrient threshold that will reduce cyanobacteria populations enough so that they cannot compete effectively with desirable algae. Productivity in Utah Lake is good, but there is currently an undesirable level of production. The current level of production results in low-oxygen events and disrupts the food web.

Would not lowering nitrogen levels benefit the production of cyanobacteria that can fix nitrogen?

- Some limnologists would argue that is the case. There are currently studies underway that are measuring nitrogen-fixation rates in the Lake. The Science Panel will incorporate these numbers into a nitrogen budget model. Current information suggests that cyanobacteria in the Lake may not fix enough nitrogen to account for nitrogen reductions, and the rate of denitrification is likely exceeding the nitrogen fixation rate in the Lake.

- Some cyanobacteria can fix nitrogen, and some cannot. It takes energy for cyanobacteria to fix nitrogen, so they may not be growing as fast if they have to fix nitrogen. In a highly turbid lake, like Utah Lake, light can be a limiting factor to fixing nitrogen.

Is it possible to reduce phosphorus from the Lake given the legacy phosphorus deposition?

- If phosphorus inputs are reduced, there will be phosphorus leaving the Lake. However, there is a lot of phosphorus in the sediments and water column. There are studies underway looking at how much phosphorus is bioavailable and how much is needed to sustain a bloom. If the phosphorus inputs are not reduced, there will likely not be a major change to the phosphorus concentrations. Utah Lake will likely need a dual nitrogen and phosphorus approach.
- In Lake Erie, Canada and the United States reduced phosphorus concentrations in the Lake, but the algal blooms kept occurring. The cyanobacteria that were blooming were non-nitrogen fixers, indicating a need to reduce nitrogen to reduce the blooms in addition to phosphorus.

How can quantitative polymerase chain reaction (QPCR) data be used to help identify the genetic potential for cells to produce toxins?

- QPCR is a methodology that quantifies the number of gene copies present in a sample. For lake samples, researchers would be using the QPCR methodology to identify the number of toxigenic genes present in a sample. This data would help identify whether cells can produce cyanotoxins.
- QPCR is fast. It is possible to collect a sample and generate the QPCR data within a day. Given that algal blooms can happen in a short-term span, the QPCR method can quickly provide information to public health officials on toxin risks.

Did the EPA develop any thresholds or ranges for QPCR data in their recreation guidance?

- The challenge with QPCR is knowing the number of gene copies per cell. A cell can have multiple copies of the same gene, and the number of genes per cell can change based on what growth phase they are in. Using QPCR would require having a good estimate of the number of gene copies per cell for a specific water body and understanding what phase of growth the cells are in.
- QPCR can be helpful because it allows managers to determine the risk of an algal bloom before it occurs. There are multiple ways to measure biomass production by proxy other than QPCR, including chlorophyll-a and biovolumes.

Are there ways for managers to intervene with algal blooms in the interim to reduce exposure risk until they get a handle on nutrient inputs?

- There are different ways to kill cyanobacteria, including copper sulfate and hydrogen peroxide. These treatments will kill cyanobacterial locally. However, the treatments are impractical on a lake-wide basis. The treatments will not get rid of the toxins in the water, and sometimes killing cells results in them leaching toxins into the water.
- There are residual effects with the copper sulfate treatment that are not well understood. The EPA currently allows the use of copper sulfate except in water bodies used for drinking water. The copper sulfate treatment will clear up the water for people to swim.
- Hydrogen peroxide will kill the cyanobacteria and then convert to water. The hydrogen peroxide treatment requires multiple applications and does not get rid of the toxins.

- With the sediment resuspension of phosphorus, repeatedly using copper sulfate or hydrogen peroxide treatments will likely not be an effective management strategy.
- One management option to reduce exposure risk is to have dual guidelines for multiple stressors and endpoints. There are two groups of stressors: toxins and cells. The Utah guidelines are focused on toxins, which is good. The WHO recommendation of 20,000 cells per milliliter is a health-protective value to prevent exposure. Only focusing on toxigenic cells leaves out the opportunity to incorporate public advisories for the inflammatory health effects associated with total cyanobacteria counts. The 20,000 to 40,000 cell count recommendation is meant to be protective of two endpoints.

What do the Steering Committee and Science Panel gain and lose by focusing on one variable over others (chlorophyll-a, cell counts, and biovolume)?

- Each variable is measuring a similar parameter, the same way Celsius and Fahrenheit both measure temperature. Choosing which variable to measure depends on an organization's capabilities, needs, and monitoring frequency.
- It is important that the monitoring organization calibrates whatever variable they use so that the data they collect is meaningful (i.e., how does chlorophyll-a concentrations translate to cell density).
- The DWQ currently uses chlorophyll-a as an indicator for aesthetics and cell counts to measure the presence of particular cyanobacteria taxa.
- Chlorophyll-a is not a perfect measure. The WHO recommended a specific chlorophyll-a concentration as a threshold *if* cyanobacteria are dominant in the sample. Each variable has its pluses and minuses.
- It is possible to develop a threshold for chlorophyll-a, above which there will be an issue with toxicity, particularly in the summer. Data on chlorophyll-a should be collected in combination with other measures, such as phycocyanin, a pigment that cyanobacteria exclusively produce. There are available sensors that continuously collect data on chlorophyll-a and phycocyanin parameters.

The EPA's 2019 report outlines that people's drinking water has more than 12 parts per billion. Utah Lake rarely crosses that threshold. How do the concentrations in drinking water people consume daily correlate to the recreation advisory levels?

- The EPA bases their drinking water levels on animal toxicity studies. In those studies, they dose rats and look for adverse health effects. In the case of microcystin, researchers found damage to the kidney and liver of the rats. The EPA's base study in their 2019 report is Heinz (1999). The EPA modified the study's reference dose because the identified dose was for rats, not humans.
- When EPA sets the criteria for human health, they integrate safety factors and do not set the level at a threshold immediately above which there are adverse health effects. From a risk management perspective, EPA's approach is to recommend a level at which they do not expect to see adverse health effects. Anecdotally, people exposed to 40,000 to 50,000 cells per milliliter have had adverse health effects, so the EPA set their criteria lower than this count.
- If the recommended criterion protects people from exposure to cells, it will protect people from exposure to toxins too.

What are the nutrient levels needed in the Lake?

Scientists are trying to identify a nutrient threshold for lowering biomass. They do not know the number yet because the studies are currently underway. Based on studies on other lakes, the numbers may be around a 30% reduction, but the ULWQS studies will give a more specific answer for nutrient and phosphorus reduction. The numbers will likely be related to how much nutrient loading has increased over time.

Will the in-lake nutrient levels include contributions from non-point sources, stormwater, and atmospheric deposition?
The ULWQS is looking at multiple nutrient input sources, and no one source of nutrients should be singled out. Both non-point and point sources are important. The goal of management is not to starve the Lake of nutrients but to have a desirable level of productivity in Utah Lake.

How many years out until stakeholders will see a change in Utah Lake?
Scientists are trying to determine how long it will take for Utah Lake to experience changes. The process of eutrophication has occurred over several decades, so clearing the nutrient problems in Utah Lake will likely take a similar timeframe, considering the large size of Utah Lake.

In 2019, Utah's HABs Advisory Program changed its thresholds to 100,000 toxigenic cells per milliliter. Considering the HABs Advisory Program is counting toxigenic cells, should the threshold be set at 40,000 cells per milliliter?
The HABs Advisory Program sets a warning advisory at 100,000 toxigenic cyanobacteria cells. The EPA 2019 report set their criteria recommendation at 100,000 total cells per milliliter. The reference studies that set cell count thresholds did not consider the presence of the toxins; the studies looked at exposure to total cells and the correlated inflammatory responses. The guidelines should manage exposure to both cells and toxins. The EPA used 40,000 microcystin-producing cells per milliliter as a threshold because they estimate 40,000 microcystin-producing cells would produce eight micrograms of microcystin per milliliter.

Does the disclaimer in the footnote of Utah HABs Advisory Program's guidelines, which allows local health departments to look at aggravating circumstances below the 100,000 toxigenic cells per milliliter, help ease concerns?
Past Utah Lake outbreaks were not due to toxins; it was due to contact with cells. The EPA recommends that the warning and danger advisories consider both the endpoints from exposure to toxins and cells. Having an option in the table carries more weight programmatically than including the disclaimer as a footnote.

Steering Committee Comments
Steering Committee members provided comments on the HABs presentation. Their comments are summarized below.

- The WHO study shows the correlation between Microcystis and toxins, but Microcystis do not dominate Utah Lake. In the EPA's 2019 report, the EPA suggests in the third step of the monitoring plan that if managers understand Utah Lake's condition, they should base their criteria on the toxins in the Lake and not use the WHO's 20,000 cell count threshold as the criteria. One hundred thousand cells per milliliter in Utah Lake would not result in the exceedance of eight micrograms per milliliter of microcystin. Using the WHO's and EPA's criteria recommendation would result in too stringent criteria for Utah Lake.
- The recreation advisory levels are overprotective in Utah Lake, which results in people thinking the quality of Utah Lake is more degraded than it is.
- Different studies indicate different levels of cell counts at which exposure will lead to adverse health effects. These differing numbers can be confusing to the public and make it more difficult for the public to understand what is happening. The public has almost become desensitized to algal blooms.

- The Pilotto et al. (1997 and 2004) studies do not show a statistical relationship between exposure to cells and the occurrence of symptoms. The studies indicate that one out of 50 humans does not prove the skin reaction effect of cyanobacteria exposure. There are similar results from the Stewart et al. (2006) study.
- There are remaining questions on the impacts of non-point source deposition.
- Cell counts should be included in the management table for two reasons: 1) high cell counts appear to be associated with increased incidence of inflammatory response; and 2) as cell counts go up, the possibility of toxigenic effects increases. A third reason is that the measurements of cyanotoxins appear to be highly variable and appear unpredictably within the cycle of a bloom (e.g., sometimes as the bloom is getting started, sometimes as it is peaking, sometimes afterward, sometimes not at all). Additionally, the duration of the presence of cyanotoxins is also variable; they may be present for hours or days afterward, and sometimes they are not detected in a second monitoring effort. So practically, it seems like setting standards solely on cyanotoxin levels would have a lot of uncertainty. Whereas increasing cell levels 1) have an association with increasing possibility of cyanotoxins, and 2) excessive cells in and of themselves can cause an inflammatory response that is also a public health concern.

Public Questions
Members of the public asked questions on the HABs presentations. Questions are indicated in italics with corresponding answers in plain text.

What options are there to use biomanipulation to manage algal blooms?
The results of biomanipulation to manage algal blooms are mixed and can lead to more problems. Animals eating the algae can excrete more nutrients that can lead to follow-up blooms. Unless what is eating the cyanobacteria is removed from the Lake, biomanipulation can be a risky way to manage algal blooms.

Pilotto et al. (1997) did not show increased health effects associated with cell counts. Why is the study being interpreted as increasing adverse health effects?

- In the Pilotto et al. (1997) abstract, the authors indicate they found a significant trend between increasing symptom occurrence and increasing cell counts. They found that participants exposed to more than 5,000 cells per milliliter for more than one hour have a significantly higher symptom occurrence.
- Epidemiology studies do not indicate cause-and-effect, but they do show a statistically significant association between cell counts and symptoms. Researchers can only study cause-and-effect relationships between exposure and symptoms in clinical studies. Combining epidemiological studies with clinical studies can help make the direct linkage between exposures and endpoints.

In the Pilotto et al. (1997) study, they have a table for the study's statistics. The table indicates that the odds ratio is 1.87 for exposed participants, but the confidence interval range is from 0.68 to 1.54. How can the odds ratio be 1.87 and the confidence interval be 1.54?

- Establishing recommended criteria can be challenging based on a small sample size in the studies. It is difficult to find statistically significant data with small sample sizes, so the reference studies' statistically significant results are notable given the small sample size. However, the relatively small number of studies and participants makes it hard to find high-resolution data for developing criteria. The 5,000 to 100,000 cell count threshold is supportable based on the information available.

- An odds ratio is a confidence interval. For an odds ratio, the closer the value is to one, the less likely there is a statistically significant difference in the results. The table also includes the results of a p-test; in a p-test, the lower the p-value, the more statistically significant the results are. According to the table, there is a significant relationship between exposure to over 5,000 cells for over 60 minutes and the occurrence of symptoms. (The odds ratio is 3.44, and the p-value is 0.004.) The relationship between exposure to cells and the occurrence of symptoms is significant, but the data's resolution is not very high.

Public Comments

Members of the public provided comments on the HABs presentation. Their comments are summarized below.

- There is more to the Pilotto et al. (1997) study than the abstract. A member of the public shared a table that displays the statistical data from page three of Pilotto et al. (1997) study, which can be found in Appendix A of this summary. This study should be examined further.

Steering Committee Polling on Cell Counts

Steering committee members indicated whether they supported using cell counts, biovolume, and chlorophyll-a in the management goals table. A majority of Steering Committee members, but not a consensus, indicated they were supportive of using cell counts, biovolume, and chlorophyll-a in the management goals table. Those who did not agree with using cell counts in the management goals table stayed after the meeting for further discussion.

NEXT STEPS

- Several Steering Committee working groups will form in the next couple of months: the recreation survey working group, scenario planning working group, and communications and community engagement working group.
- Volunteers for the recreation survey working group will work with DWQ to write the request for proposals (RFP) to hire a contractor to write the recreation survey. The recreation survey will tie in with the management goals and help inform the numeric nutrient criteria development. Chris Keleher and Jamie Barnes volunteered to help draft the RFP. The working group will share the general direction and objectives of the RFP with the Steering Committee before it is released for bids. DWQ cannot share full RFPs with groups before they are released, so any Steering Committee member that wants to review the whole RFP should inform DWQ staff.
- The scenario planning working group will begin its work in late spring/June. Steering Committee members will have the opportunity to volunteer for the scenario planning working group at a future meeting.
- The communications and community engagement working group will begin in late summer once the Science Panel has finalized work products. Steering Committees members will have the opportunity to volunteer for that working group at a future meeting.

PUBLIC ENGAGEMENT DISCUSSION

Before the Steering Committee meeting, Heather Bergman met with the ULWQS Steering Committee and Science Panel members, who volunteered their time to talk with her. Some Science Panel and Steering Committee members commented that there is an opportunity to improve public engagement during meetings. Following the Steering Committee meeting, members of the public were invited to share their thoughts to improve the Steering Committee meetings' public engagement section.

CELL COUNT DISCUSSION

Following the Steering Committee meeting, a subset of meeting participants joined a virtual breakout room to discuss including cell counts in the management goals table. The concerns, agreements, and future discussions from that discussion are summarized below.

Concerns

- There were concerns that some of the epidemiological studies that EPA relies in their guidance document do not demonstrate a causal relationship between exposure to cyanobacteria and health effects. Rather, they indicate a correlation.
- There were concerns that basing a health advisory program on correlative epidemiological data is not appropriate.
- A counter point was that epidemiological studies are always correlative in nature, and this is why EPA uses a weight of evidence approach in developing guidance.

Agreements

- Cell counts are useful measures to have, in addition to data on chlorophyll-a and biovolume.
- Agreeing to collect cell count data and express potential changes in harmful algal blooms under different future scenarios using cell count measures does not equate to agreement that there is a pre-established threshold that should be attained by the numeric nutrient criteria.
- The Steering Committee and Science Panel can and should use chlorophyll-a, cell count densities, and biovolumes as measures to assess progress toward attaining management goals to inform the development of criteria.
- Speciation of cell counts and toxin measurements should be included in the data gathered and considered by the Steering Committee as well.

Future Discussions

- Future discussions and questions on specific cell count thresholds for advisory warnings are better suited for the Utah Division of Water Quality and Department of Health's Water Quality Health and Advisory Panel than the Steering Committee.
- Future Steering Committee scenario discussions regarding potential targets or thresholds should include considerations of achievability for each scenario in addition to other factors that the Steering Committee identifies.

APPENDIX A

Table from page 3 of Pilotto et al. (1997)

Table 2: Study of exposure to cyanobacteria: adjusted odds ratios[a] and 95% confidence intervals (CI) for four logistic regression models, before and after exclusion of participants who experienced symptoms or engaged in recreational water activities in the five days prior to the initial interview, for the reported incidence of at least one symptom during seven days' follow-up associated with exposure to water containing cyanobacteria, the duration of contact and cell density

	Group							
	All participants (before exclusion)				After exclusion[b]			
Model	*n*	Odds ratio	CI	Trend *P*	*n*	Odds ratio	CI	Trend *P*
Model 1: exposure								
Unexposed	75	1.00			43	1.00		
Exposed	776	1.12	0.60 to 2.07		295	1.87	0.68 to 1.54	
Model 2: duration of water contact								
Unexposed	75	1.00			43	1.00		
≤60 minutes	320	0.98	0.51 to 1.89		129	1.45	0.44 to 4.84	
>60 minutes	411	1.26	0.66 to 2.40	0.2	151	2.70	0.83 to 8.80	0.03
Model 3: cell density (cells/mL)								
Unexposed	75	1.00			43	1.00		
<5 000	267	1.05	0.54 to 2.06		89	0.92	0.30 to 2.81	
5 000–20 000	183	1.49	0.75 to 2.96		79	2.71	0.92 to 8.03	
20 000–80 000	260	0.80	0.41 to 1.59		80	1.43	0.47 to 4.30	
>80 000	66	1.49	0.65 to 3.42	1.0	47	2.90	0.95 to 8.88	0.04
Model 4: duration and cell density (cells/mL)								
Unexposed	75	1.00			43	1.00		
≤60 minutes, ≤5 000	102	1.00	0.46 to 2.18		31	0.55	0.10 to 2.95	
>60 minutes, ≤5 000	157	1.14	0.55 to 2.35		58	1.47	0.41 to 5.24	
≤60 minutes, >5 000	218	0.98	0.50 to 1.94		98	1.89	0.61 to 5.86	
>60 minutes, >5 000	251	1.34	0.68 to 2.63	0.3	93	3.44	1.09 to 10.82	0.004

Notes:

(a) Adjusted for age, sex, and swimming in the follow-up period, and accounting for clustering within families.

(b) After exclusion of those who had had recreational water contact or symptoms in the five days prior to the initial interview.