State of Utah

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

Department of
Environmental Quality

Alan Matheson
Executive Director

DIVISION OF WATER QUALITY
Erica Brown Gaddis, PhD
Director

Utah Water Quality Board Meeting

DEQ Board Room 1015
195 North 1950 West
Salt Lake City, UT 84116
June 26, 2019

Board Meeting Begins at 8:30 am

AGENDA

Water Quality Board Meeting – Roll Call

A. Minutes:
Approval of minutes for May 22, 2019 Water Quality Board Meeting.................. Jennifer Grant

B. Executive Secretary's Report .... Erica Gaddis

C. Funding Requests:
1. Financial Report.. Emily Cantón
2. Kearns Improvement District Request for Construction Assistance Authorization .... Ken Hoffman
3. Request to Amend the Utah Lake Water Quality Board Grant....................................... Scott Daly

D. Rule Making
1. Request for Adoption of Amendments to R317-1, Definitions and General Requirements and R317-2, Standards of Quality for Waters of the State .... Chris Bittner

E. Other Business:
1. Sudweeks Award Presentation... Robert Beers
2. Annual NPS Programmatic Report .... Jim Bowcutt

F. Public Comment Period

G. Meeting Adjournment

Next Meeting August 28, 2019
DEQ Board Room 1015
195 North 1950 West
Salt Lake City, UT 84116

In compliance with the American Disabilities Act, individuals with special needs (including auxiliary communicative aids and services) should contact Larene Wyss, Office of Human resources, at (801) 536-4281, TDD (801) 536-4284, or by email at lwyss@utah.gov at least five working days prior to the scheduled meeting.
Revised 6/20/2019
DWQ-2019-006021

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MINUTES

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY
UTAH WATER QUALITY BOARD
195 North 1950 West
Salt Lake City, UT 84116
May 22, 2019

UTAH WATER QUALITY BOARD MEMBERS PRESENT

Jennifer Grant	Mike Luers
Steven Earley	Gregg Galecki
Jim Webb	Alan Matheson
Brandon Gordon	Emily Neihaus (On Phone)
Excused:	Jim Vanderslice

DIVISION OF WATER QUALITY STAFF MEMBERS PRESENT

Ellen Bailey	Judy Etherington	John Mackey
Robert Beers	Erica Gaddis	Jeanne Riley
Ben Brown	Matthew Garn	Jerry Rogers
Emily Cantón	James Harris	Kim Shelley
Marsha Case	Ben Holcomb	Lenora Sullivan
Ryan Curtin	Brenda Johnson	Beth Wondimu
Skyler Davies	Andrea Kilbane	

OTHERS PRESENT

Name	Organization Representing
Scott Baird	Department of Environmental Quality
Bryan Meadows	Green River City
Kathy Ryan	Green River City
Devan Shields	Green River City
Greg Anderson	Kearns Improvement District
Riley Astill	Kearns Improvement District
Pamela Gill	Kearns Improvement District
Gordon Evans	South Valley Sewer
Justin Atkinson	Sunrise Engineering
Alex Buxton	Zions Bank

Ms. Grant called the Board meeting to order at 9:30 AM and took roll call for the members of the Board and audience.

APPROVAL OF MINUTES OF APRIL 10, 2019 MEETING

Motion: **Mr. Galecki moved to approve the minutes of the April 10, 2019 meeting. Mr. Luers seconded the motion. The motion passed unanimously.**

ELECTION OF NEW CHAIR AND VICE CHAIR

Motion: **Mr. Galecki nominated Ms. Grant as the new Chair for the Water Quality Board. Mr. Earley seconded the motion. The motion passed unanimously.**

Motion: **Mr. Luers nominated Mr. Galecki as the new Vice-Chair for the Water Quality Board. Mr. Earley seconded the motion. The motion passed unanimously.**

EXECUTIVE SECRETARY REPORT

National Level

- The 401 Water Quality certification program provides states and tribes the authority to ensure that state water quality laws are not violated by the issuance of a federal permit/ license.
  - Water Quality Certification Improvement Act of 2019 addresses concerns about states use of the tool to delay important energy projects.
  - Executive Order on Promoting Energy Infrastructure and Economic Growth directs EPA to develop new rules and guidance for the program.

State Level

- The Willow Creek spill near Highway 19. From a truck rollover there was between 300 and 500 gallons of crude oil released into Willow Creek about 4 miles above the confluence of Price River with no detectable contamination in the Price River. An under road culvert was blocked quickly by crews at the scene. The spill was cleaned up by crews in several days.

- The Ogden Swift building is currently owned by the City of Ogden and is being considered for re-development. In 2018, an EPA Targeted Brownfields Assessment was conducted on behalf of the City of Ogden at the site. This assessment documented more than 40,000 abandoned containers of chemicals including flammables, corrosives, toxic substances, water reactives, potential explosives and other dangerous chemicals. The site was referred to EPA's Emergency Response Unit. The City of Ogden granted the EPA access to the property on March 19, 2019 and the EPA initiated response operations on March 29, 2019. The EPA has ramped up the treatment of water reactive materials found on-site. The EPA is working to bring a full water treatment system on-line.

- Headwater NNC Rulemaking. There were substantial comments during the Public Notice process. The Rulemaking will be finalized in June.

- Dr. Gaddis updated the board on the Integrated Report and call for data.

- Nonpoint Source program. Water Quality has received 59 applications totaling $3.3 million in requests. The targeted basin for the year 2020 is the Jordan River, Utah Lake and the Provo River. Water Quality has granted 41 of the 59 projects.

- In Garfield County the Division of Water Quality has teamed up with the Utah Geological Survey and a Garfield County study to assess water quantity and quality issues related to growth and commercial expansion in the Bryce Canyon area.

- Dr. Gaddis also reported that she attended a legislative meeting regarding the need for a state-wide study of wastewater and stormwater.

- Dr. Gaddis asked the Water Quality Board to consider allocating money and how the board would like information presented for septic density studies. These studies were previously deferred by the Water Quality Board. There was a request made to the legislature for funding but that request was not funded during the last session. It is expected that there will be 1 or 2 requests per year for funding for septic density studies that will come before the Board. The Board would like to see those requests as they are submitted.

- Dr. Gaddis asked for an additional board member to be on the Sudweeks Award Committee as Myron Bateman's term on the Water Quality Board has expired. Mr. Luers and Mr. Earley had previously agreed to choose one of the Sudweeks nominees. Mr. Galecki agreed to be the third board member on the committee.

- DEQ held a ribbon cutting ceremony for the new Technical Support Center.

- The division launched an internship program. Water Quality will be recruiting for 5 interns for the summer.

- Dr. Gaddis introduced new employees Ms. Ellen Baily, Ms. Andrea Kilbane and Mr. Ryan Curtin.

<u>OTHER BUSINESS</u>

- Ms. Grant presented recognition of service on the Wastewater Operator Certification Council to Mr. Gordon Evans.

- Ms. Grant presented recognition of service on the Water Quality Board to Mr. Myron Bateman. Mr. Bateman served two terms on the Water Quality Board.

<u>FUNDING REQUESTS</u>

Financial Report: Mr. Rogers updated the Board on the Loan Funds and Hardship Grant Funds, as indicated in the packet.

Green River City Request for Hardship Planning Advance: Ms. Wondimu presented the city's request for a hardship planning advance in the amount of $54,000 to complete a wastewater facility plan to evaluate alternatives and to identify needed wastewater collection and treatment system improvements.

Motion: **Mr. Earley moved to approve the hardship planning advance in the amount of $54,000. Mr. Galecki seconded the motion. The motion passed with Mr. Webb opposing the request.**

Kearns Improvement District Introduction to Request for Construction Assistance: Mr. Mackey (representing Mr. Ken Hoffman) presented the city's request for construction assistance in the form of a loan from the Utah Water Quality Board in the amount of $4,595,000 for construction of a new pump station and sewer collection lines in support of community growth.

Public Comments:

- Board Member, Mr. Gregg Galecki commented that Scofield Reservoir shut downs affect the town of Scofield and the town needs better notification of those closures.

Meeting Adjournment

Motion: **Mr. Webb moved to adjourn the meeting. Mr. Earley seconded the motion. The motion passed unanimously.**

To listen to the full recording of the Board meeting go to: http://www.utah.gov/pmn/index.html

Next Meeting – June 26, 2019
195 North 1950 West
Salt Lake City, UT 84116

____
Jennifer Grant, Chair
Utah Water Quality Board

DWQ-2019-006592

LOAN FUNDS
FINANCIAL STATUS REPORT
JUNE 2019

STATE REVOLVING FUND (SRF)	State Fiscal Year 2019	State Fiscal Year 2020	State Fiscal Year 2021	State Fiscal Year 2022	State Fiscal Year 2023	State Fiscal Year 2024	State Fiscal Year 2025
Funds Available							
2016 - 2018 Capitalization Grants	20,811,801	-	-	-	-	-	-
2017 - 2018 State Match	3,128,600	-	-	-	-	-	-
Future Capitalization Grants (estimated)	8,357,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000	7,000,000
Future State Match (estimated)	1,671,400	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000	1,400,000
SRF - 2nd Round	103,784,174	137,870,364	96,204,649	64,347,459	22,445,018	557,791	6,401,836
Interest Earnings at 2.5%	224,684	3,581,734	2,499,301	1,671,683	583,099	14,491	166,313
Loan Repayments	-	14,049,551	14,992,510	18,374,876	17,378,674	17,478,554	17,364,830
Total Funds Available	137,977,659	163,901,649	122,096,459	92,794,018	48,806,791	26,450,836	32,332,979
Project Obligations							
Duchesne City	(27,295)	-	-	-	-	-	-
Logan City		(23,131,000)	(23,000,000)	(23,000,000)	-	-	-
Logan City - Supplemental Loan		(6,000,000)	-	-	-	-	-
Moab City	(80,000)	-	-	-	-	-	-
Salem City	-	(2,969,000)	-	-	-	-	-
San Juan Spanish Valley SSD	-	(1,997,000)	-	-	-	-	-
Loan Authorizations							
Central Valley Water Reclamation Facility	-	(5,000,000)	(15,000,000)	(20,100,000)	(23,000,000)	(2,000,000)	-
Provo City	-	-	(15,000,000)	(25,000,000)	(23,000,000)	(15,800,000)	-
South Davis Sewer District (with NPS)	-	(26,351,000)	(2,500,000)	-	-	-	-
South Salt Lake City	-	(2,249,000)	(2,249,000)	(2,249,000)	(2,249,000)	(2,249,000)	-
Planned Projects							
None at this time							
Total Obligations	(107,295)	(67,697,000)	(57,749,000)	(70,349,000)	(48,249,000)	(20,049,000)	-
SRF Unobligated Funds	$ 137,870,364	$ 96,204,649	$ 64,347,459	$ 22,445,018	$ 557,791	$ 6,401,836	$ 32,332,979

UTAH WASTEWATER LOAN FUND (UWLF)	State Fiscal Year 2019	State Fiscal Year 2020	State Fiscal Year 2021	State Fiscal Year 2022	State Fiscal Year 2023	State Fiscal Year 2024	State Fiscal Year 2025
Funds Available							
UWLF	$ 19,416,724	$ 2,772,724	$ 6,506,574	$ 10,459,166	$ 14,085,572	$ 17,262,660	$ 20,423,051
Sales Tax Revenue	-	3,587,500	3,587,500	3,587,500	3,587,500	3,587,500	3,587,500
Loan Repayments	-	3,139,250	3,357,992	3,031,806	2,582,488	2,565,791	2,565,235
Total Funds Available	19,416,724	9,499,474	13,452,066	17,078,472	20,255,560	23,415,951	26,575,786
General Obligations							
State Match Transfers	(4,800,000)	(1,400,000)	(1,400,000)	(1,400,000)	(1,400,000)	(1,400,000)	(1,400,000)
DWQ Administrative Expenses	-	(1,592,900)	(1,592,900)	(1,592,900)	(1,592,900)	(1,592,900)	(1,592,900)
Project Obligations							
Grantsville City	(3,728,000)	-	-	-	-	-	-
Loan Authorizations							
Kane Co Water Conservancy Dist (Duck Creek)	(1,000,000)	-	-	-	-	-	-
Planned Projects							
Plain City	(2,521,000)	-	-	-	-	-	-
*Kearns	(4,595,000)						
Total Obligations	(16,644,000)	(2,992,900)	(2,992,900)	(2,992,900)	(2,992,900)	(2,992,900)	(2,992,900)
UWLF Unobligated Funds	$ 2,772,724	$ 6,506,574	$ 10,459,166	$ 14,085,572	$ 17,262,660	$ 20,423,051	$ 23,582,886

*WQB Agenda Items

LOAN FUNDS
FINANCIAL STATUS REPORT
JUNE 2019

Contingency Calculation for Authorized Projects							
Total Unobligated Loan Funds	$ 140,643,088	$ 102,711,224	$ 74,806,625	$ 36,530,590	$ 17,820,451	$ 26,824,887	$ 55,915,865
25% Contingency for Authorized Projects	$ (250,000)	$ (8,400,000)	$ (8,687,250)	$ (11,837,250)	$ (12,062,250)	$ (5,012,250)	$ -
Remaining Balance	$ 140,393,088	$ 94,311,224	$ 66,119,375	$ 24,693,340	$ 5,758,201	$ 21,812,637	$ 55,915,865

*WQB Agenda Items

HARDSHIP GRANT FUNDS
FINANCIAL STATUS REPORT
JUNE 2019

HARDSHIP GRANT FUNDS (HGF)	State Fiscal Year 2019	State Fiscal Year 2020	State Fiscal Year 2021	State Fiscal Year 2022	State Fiscal Year 2023	State Fiscal Year 2024	State Fiscal Year 2025
Funds Available							
Beginning Balance		$ 2,415,161	$ 2,438,890	$ 2,741,668	$ 3,028,947	$ 3,292,880	$ 3,536,259
Federal HGF Beginning Balance	5,981,578	-	-	-	-	-	-
State HGF Beginning Balance	1,908,519	-	-	-	-	-	-
Interest Earnings at 2.5%	17,081	62,743	63,360	71,226	78,689	85,546	91,868
UWLF Interest Earnings at 2.5%	42,036	72,033	169,034	271,719	365,929	448,467	530,570
Hardship Grant Assessments	-	768,980	666,402	571,300	473,841	392,175	309,384
Interest Payments	-	419,973	403,983	373,034	345,473	317,191	289,421
Advance Repayments	220,000	-	-	-	-	-	-
Total Funds Available	8,169,214	3,738,890	3,741,668	4,028,947	4,292,880	4,536,259	4,757,502
Financial Assistance Project Obligations							
Eagle Mountain City - Construction Grant	(510,000)	-	-	-	-	-	-
Emigration Sewer Imp Dist - Planning Grant	(26,158)	-	-	-	-	-	-
Green River	(54,000)						
Kane Co Water Conservancy Dist (Duck Creek) - Hardship Grant	(2,034,500)						
Lewiston - Planning Advance	(40,000)						
USU Extension - Hardship Grant	(42,000)	-	-	-	-	-	-
Wellington City	(96,000)	-	-	-	-	-	-
Non-Point Source/Hardship Grant Obligations							
Fitzgerald ARDL interest-rate buy down	(51,056)						
McKees ARDL interest-rate buy down	(55,261)						
(FY11) Gunnison Irrigation Company	(48,587)	-	-	-	-	-	-
(FY11) DEQ - Willard Spur Study	(113,326)	-	-	-	-	-	-
(FY12) Utah Department of Agriculture	(461,074)	-	-	-	-	-	-
(FY13) DEQ - Great Salt Lake Advisory Council	(176,135)	-	-	-	-	-	-
(FY15) DEQ - Ammonia Criteria Study	(46,630)	-	-	-	-	-	-
(FY15) DEQ - Nitrogen Transformation Study	(14,500)	-	-	-	-	-	-
(FY16) DEQ - San Juan River Monitoring	(125,083)	-	-	-	-	-	-
(FY17) DEQ - GW Quality Study	(5,051)	-	-	-	-	-	-
*(FY17) DEQ - Utah Lake Water Quality Study	(489,853)	(300,000)	-	-	-	-	-
FY 2015 - Remaining Payments	(4,223)	-	-	-	-	-	-
FY 2016 - Remaining Payments	(141,507)	-	-	-	-	-	-
FY 2017 - Remaining Payments	(95,387)	-	-	-	-	-	-
FY 2018 - Remaining Payments	(396,311)	-	-	-	-	-	-
FY 2019 - Remaining Payments	(727,412)						
Future NPS Annual Allocations	-	(1,000,000)	(1,000,000)	(1,000,000)	(1,000,000)	(1,000,000)	(1,000,000)
Planned Projects							
Total Obligations	(5,754,054)	(1,300,000)	(1,000,000)	(1,000,000)	(1,000,000)	(1,000,000)	(1,000,000)
HGF Unobligated Funds	$ 2,415,161	$ 2,438,890	$ 2,741,668	$ 3,028,947	$ 3,292,880	$ 3,536,259	$ 3,757,502

*WQB Agenda Items

State of Utah
Wastewater Project Assistance Program
Project Priority List
As of June 14, 2019

Rank	Project Name	Funding Authorized	Total Points	Point Categories			
				Project Need	Potential Improvement	Population Affected	Special Consideration
1	Provo City	x	144	50	24	10	60
2	Central Valley Water Reclamation Facility	x	143	50	23	10	60
3	South Davis Sewer District	x	138	50	18	10	60
4	Plain City		105	50	10	5	40
5	Kearns		74	5	0	9	60
6	Kane County Water Conservancy District (Duck Creek)	x	62	40	21	1	0

Date Received: April 10, 2019
Date to be presented to the WQB: June 26, 2019

WATER QUALITY BOARD
FEASIBILITY REPORT FOR WASTEWATER TREATMENT PROJECT AUTHORIZATION

APPLICANT:	Kearns Improvement District 5350 West 5400 South Kearns, UT 84118 Telephone: (801) 968-1011
PRESIDING OFFICIAL:	Pamela Gill, General Manager
TREASURER/RECORDER:	Riley Astill, Finance Director
CONSULTING ENGINEER:	Keith Larson, P.E. Bowen & Collins 154 East 14075 South Draper, UT 84020 (801) 495-2224
BOND COUNSEL:	Randy Larsen Gilmore Bell 15 West South Temple, Suite 1450 Salt Lake City, UT 84101 (801) 364-5080

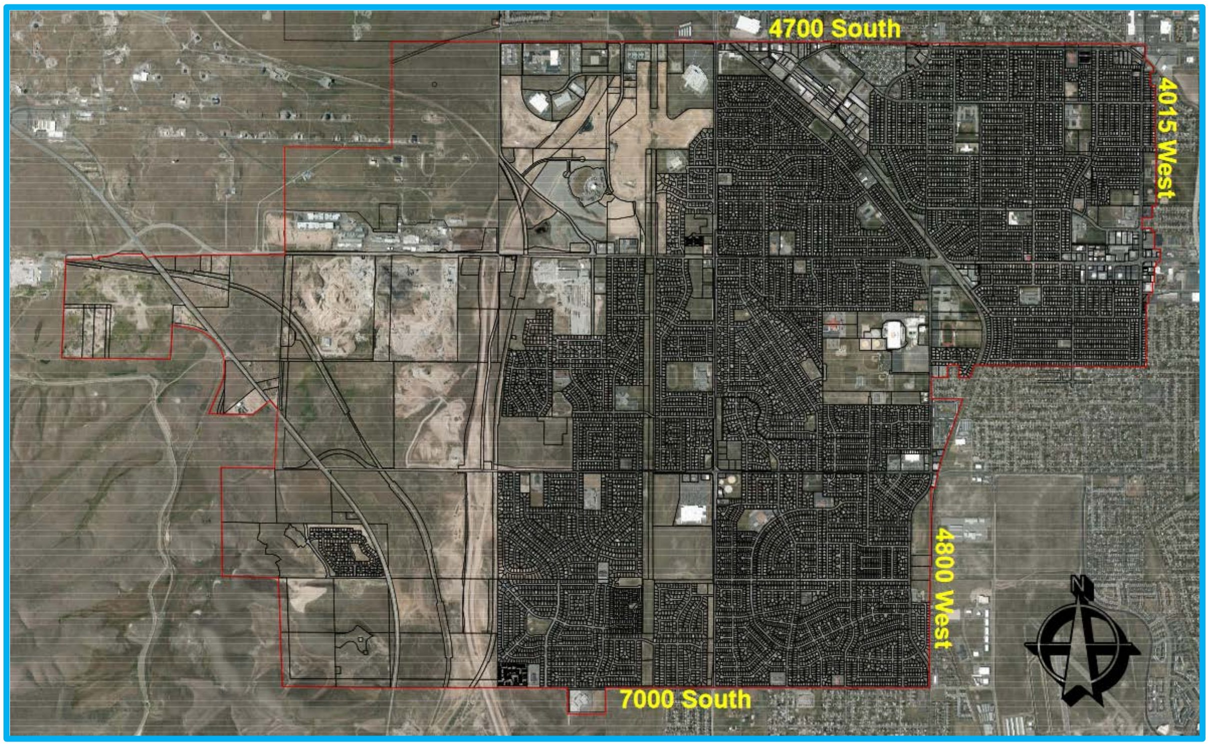
APPLICANT'S REQUEST:

Kearns Improvement District is requesting construction assistance in the form of a loan from the Utah Water Quality Board in the amount of $4,595,000 for construction of a new sewer lift station and sewer collection lines in support of community growth.

APPLICANT'S LOCATION:

Kearns Improvement District is located in Salt Lake County.

MAP OF APPLICANT'S LOCATION



BACKGROUND AND PROJECT NEED:

Kearns Improvement District (KID) provides water and sewer services to the Kearns community and portions of West Jordan City, West Valley City and Taylorsville City. KID has grown from 3,100 connections in 1957 to over 13,500 connections today. As the Kearns community grew, the original wastewater treatment plant did not have the capacity necessary to serve KID's customers. In 1981, KID partnered with six other entities to construct the Central Valley Water Reclamation Facility to provide regional treatment service. KID owns an equity interest in the Central Valley Water Reclamation Facility. KID has completed a Sewer Master Plan and new collection lines are necessary to support service area growth.

PROJECT DESCRIPTION:

The project will upgrade some existing sewer lines and construct new sewer lines in KID, as well as add new sewer lift station. The requested financing is needed to fund the following projects:

Capital Facilities Item No.	Project
3	Outfall Sewer 2A and Carrington Square Lift Station
10, 11, 12	Zone E Capital Sewer Main Extension (Gateway to the Oquirrhs & Glen Wood Properties)
16, 17	5400 South Sewer Main Extension (Mountain View Corridor to near U111 – Land Dynamics)

ALTERNATIVES EVALUATED:

The No Action alternative is not acceptable to the community. No alternatives other than providing these sewer services were considered.

POSITION ON PROJECT PRIORITY LIST:

This project is ranked 6th out of 6 projects on the Wastewater Treatment Project Priority List. Additional projects are expected to be added to the priority list in December 2019 when other funding applications are received under the Board's semi-annual review process.

POPULATION GROWTH:

There are an estimated 19,511 ERUs in KID's service area. The service area population growth was estimated by KID as follows:

Year	Population
2015	50,096
Estimated 2020	51,537
Estimated 2030	57,302
Estimated 2040	62,708

PUBLIC PARTICIPATION AND DEMONSTRATION OF PUBLIC SUPPORT:

KID has held public hearings on the Sewer Master Plan and invited public comment. There has been no opposition. Additionally, the proposed projects were included in the 2019 approved budget and were presented in a public hearing with no opposition.

EFFORTS TO SECURE FINANCING FROM OTHER SOURCES:

KID does not qualify for Community Impact Board (CIB) or US Rural Development funding. KID has worked with Zions Bank and been advised that additional public financing would be at a rate of 3.0 to 3.5 percent depending on terms. Staff used and interest rate of 3.25 percent on a term of 20 years in considering alternative financing options.

IMPLEMENTATION SCHEDULE:

The proposed schedule for the construction project is as follows:

WQB Introduction	May 22, 2019
WQB Funding Authorization	June 26, 2019
Start Construction	Fall 2019
Complete Construction	Summer 2020

FISCAL SUSTAINABILITY REVIEW:

KID participates in the MWPP self-assessment.

APPLICANT'S CURRENT USER CHARGE:

The 2017 median adjusted gross income (MAGI) for KID is $37,205, which is 19 percent lower than the state average of $45,895. The current user fee is $33.95 per month. Fees for treatment by Central Valley will increase by an additional $8 per month by 2024. The 2024 user fee will then be least $41.05 per month. Based on the Board's affordability criterion of 1.4% MAGI, the current maximum affordable sewer bill for KID is $43.41 per month per ERU.

COST ESTIMATE:

The estimated cost of the proposed collection system project is outlined in the following table:

Item	**Funded Project Cost**
Legal/Bonding	$ 50,000
DWQ Loan Origination	$ 45,000
Engineering, CMS	$ 600,000
Construction – Collections	$ 3,400,000
Construction - Pump Stations	$ 2,400,000
Total	**$ 6,495,000**

COST SHARING:

Funding Source	Cost Sharing	Percent of Project
Local Contribution (cash)	$ 1,900,000	29%
WQB Loan (Incl. 1% origination fee)	$ 4,595,000	71%
Total	$ 6,495,000	100%

ESTIMATED ANNUAL COST FOR SEWER SERVICE:

Staff developed cost models to evaluate several financing alternatives for the project. The basic cost model data used in modeling financial alternatives for the project are provided below:

Operations and Maintenance (O&M) – Annual $6,512,327
Existing Debt – Annual $1,225,000
Median Adjusted Gross Income (2017) $37,205
Maximum Affordable Sewer Rate at 1.4 % MAGI $43.41

The static model financing alternatives considered are given in Attachment 1. The static cost model shows that the weighted required user rates will be below the Board's affordability criteria of 1.4% of MAGI, i.e., a loan is affordable at market rates. Current market rates index as follows:

US 20-year Treasury Bond[1]	2.34%
US 30-year Treasury Bond[1]	2.6%
MBIS Municipal Bond Index, 20-year[2]	2.37%

1. U.S. Department of The Treasury https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield
2. EMMA Municipal Securities and Rulemaking Board. https://emma.msrb.org/ToolsAndResources/MarketIndicators

Staff prepared cost models for evaluation of possible Board loan terms and affordability. The static model (Attachment 1) presents a summary of multiple funding scenarios. The scenarios assume a conventional 20 year term loan approach based on 2024 adopted user rates. The first row in this model shows that for the proposed $4.595 million loan at 3.25%, the 2024 average user rate would be $42.38 per ERU per month, equating to about 1.37 percent of the 2017 MAGI. In comparison, the third row in the static model shows that a 0 percent interest loan would result in a 2024 average user rate of $42.02, which equates to 1.356 percent of 2017 MAGI.

The project is affordable at all options shown, but is very close to the Board’s hardship criterion. A Board loan has little impact on the community’s sewer rate although the overall debt service cost savings from a Board loan are significant. Debt service savings that could be realized over the 20 year loan term were estimated and are shown in Attachment 1.

<u>STAFF COMMENTS:</u>

Staff supports the KID collections project. It is an important project for KID to provide sewer service in their growing service area. Staff considered the following discounting factors to establish a recommended interest rate. The 20-year market loan rate is 2.37 percent based on the current MBIS Municipal Bond Index, which is 0.03% below the 20-year US Treasury bond.

Market Rate (20 year basis)		2.37 %
Discount Factors:	Maximum Discount	Recommended Discount
Economic Hardship	2.365 %	--
Other Hardship	1.0 %	--
SRF Programmatic Costs	1.0 %	0.5 %
Fiscal Sustainability Credit	0.5 %	0.25 %
Green Project Reserve	0.5 %	--
Regionalization	0.25 %	--
Discounted Interest Rate		**1.62%**

In considering financing for two large projects in 2018, the Board reserved $21 million in loan funds to support water quality projects through FY2023, equating to about $5 million per year in available funds. The Board also established an applications process to enable it to better prioritize use of its funds by “batching” applications for review. In the first 6 month funding "batch," the Kearns application was the only one received and the request represents, effectively, one year (FY2020) of the available loan funds for water quality loans.

Staff prepared three options for funding this project. These are:

- Option 1: "Conventional WQB" Financing at $4,595,000 at the discounted rate of 1.62%
- Option 2: Single Project Financing at $2,777,000 at the discounted rate of 1.62%
- Option 3: Reduced Project Financing at $1,414,00 at the discounted rate of 0.75%

These options are highlighted in Attachment 1; other interest rates are shown with each of the levels of Board Participation in funding. It should also be noted that the cost model does not project the closing costs of a market loan that are likely to occur but have not been estimated at this time.

OPTION 1: "CONVENTIONAL WQB" FINANCING

Option 1 finances the projects identified above under the Project Description section at the applicant's requested loan amount of $4,595,000 and the interest rate of 1.62 percent that was calculated above. This option would enable KID to move ahead immediately with its construction projects without delay in seeking alternative financing. Considering current other authorizations, approximately $17,000,000 in loan funds would remain available for future board authorizations through FY2023.

OPTION 2: SINGLE PROJECT FINANCING

Staff and KID discussed the possibility of a reduced funding package that would enable the Board to support the project at a lower amount. We identified the Outfall Sewer 2A and Carrington Square Lift Station Project as a single project that could be financed at $2,777,000.

Funding Source	Cost Sharing	Percent of Project
KID Other Funding Sources*	$3,700,000	59%
WQB (Loan to KID)	$2,777,000	43%
Total	$6,477,000	100%

Under this option, KID would need to bond separately for an additional $1,800,000 on the public market. In this case, the resulting weighted interest rate for KID is increased by 0.66 percent. That is, with KID borrowing $1.8 million from the market at 3.25 percent and $2.777 million from the board at 1.62 percent, the combined interest rate for the entire $6.45 million project would be 2.28 percent. KID would incur additional loan closing costs not included in staff's analysis as well.

OPTION 3: REDUCED PROJECT FINANCING

Staff considered financing approximately one half of the Outfall Sewer 2A and Carrington Square Lift Station project. The main idea with this option is to reserve more funds for other statewide projects while still supporting the KID projects with favorable financing terms. The cost sharing approach would be as follows.

Funding Source	Cost Sharing	Percent of Project
KID Other Funding Sources*	$5,050,000	78%
WQB (Loan to KID)	$1,414,000	22%
Total	$6,464,000	100%

In this option, KID will need to bond for an additional $3.15 million through the public market after the board loan of $1,414 million. Staff estimated this will increase the overall interest rate by 1.15 percent relative to the 1.62 percent of Option 1, i.e., the resulting weighted interest rate for the entire $6.45 million project package becomes 2.77% instead of 1.62 percent. Here, staff considered applying a lower interest rate to offset the impact of reduced financing and better support KID with a lower overall interest rate. An interest rate of 0.75 percent on a $1.414 million loan produces a 2.51 percent Attachment 1 summarizes the funding scenarios under this option.

SUMMARY:

The table below summarizes the financing options discussed above.

	Financing	WQB Financing @ Int. Rate	Local Cash	Additional Market Financing @ Int. Rate	Weighted Interest Rate
No assistance		$0 N/A	$1,900,000	$4,550,000 @ 3.25%	3.25%
Option 1	Conventional	$4,595,000 @ 1.62%	$1,900,000	$0 N/A	1.62%
Option 2	Single Project	$2,777,000 @ 1.62%	$1,900,000	$1,800,000 @ 3.25%	2.28%
Option 3	Reduced Financing	$1,414,000 @ 0.75%	$1,900,000	$3,150,000 @ 3.25%	2.51%

In 2018, the Board reserved $21 million in loan funds to support water quality projects through FY2023, equating to about $5 million per year in available funds. Based on that funding amount, Option 1 would effectively fund one year’s worth of projects. Option 2 would allow for one more similarly sized project to be funded in FY2020. Option 3 would allow for three more similar funding packages in FY2020. Staff notes that the annual amounts are simply planning amounts but the $21 million is effectively a cap until other new funds become available.

STAFF RECOMMENDATION:

Staff recommends that the Board authorize funding Option 2 to KID for the Outfall Sewer 2A and Carrington Square Lift Station Project in the form of **a loan of $2,777,000 at an interest rate of 1.62 percent repayable over 20 years,** subject to the following special conditions:

1. KID must agree to participate annually in the Municipal Wastewater Planning Program (MWPP).
2. KID must pursue and retain remaining funding necessary to fully implement the project.
3. KID must develop and implement an asset management program that is consistent with EPA's Fiscal Sustainability Plan guidance.

This financing package will enable KID to construct one of its top priority projects and enable the board to fully finance a complete project for Kearns with an interest rate that should be good for both KID and the SRF portfolio. By funding one complete project we will minimize the impacts of programmatic requirements for KID, providing them flexibility with financing their other projects.

DWQ-2019-006239
File: Kearns Improvement District, Admin, Section 1

Kearns Improvement District - Authorization
June 26, 2019
Attachment 1

ATTACHMENT 1

Kearns - Water Quality Board

20 Year Loan Static Cost Models for Different Funding Options

Project Costs	Total
Loan Origination Fee 1%	varies
Financing Process Costs	$ 50,000
Engineeernig	$ 600,000
Construction	$ 5,800,000
Total Project Cost:	**$ 6,450,000**

Project Funding		
Local Contribution		$ 1,900,000
Additional bonds @	3.25%	varies below
WQB Loan		varies below
Total Project Cost:		**$ 6,450,000**

Current Customer Base & User Charges	
Total ERU's (Projected 2020)	19,511
MAGI KID	$ 37,205
Affordable Monthly Rate at 1.4%	$ 43.41
Current Impact Fee	$ 2,943
2024 Average Monthly Fee (per ERU)	$ 41.05
Existing O&M expenses Treatment & Collecti	$ 6,512,327
Existing Sewer Debt Service	$ 1,225,000

Funding Conditions	
Loan Repayment Term:	20
Reserve Funding Period:	6

ESTIMATED COST OF SEWER SERVICE

Option	WQB Loan Amount	WQB Loan Interest Rate	Annual WQB Loan Debt Service	Required other new Debt Service Payemnts*	Estimated Total Savings from WQB Loan	Weighted Interest Rate for Project	Existing Debt Payments	2024 Annual Sewer O&M Cost	Total Annual Sewer Cost	Monthly Treatment Cost/ERU	Sewer Cost as a % of MAGI
	$ -		$ -	$ 312,944	$ -	3.25%	$ 1,225,000	$ 8,385,383	$ 9,923,327	$ 42.38	1.367%
1	$ 4,595,000	1.62%	$ 270,816	$ -	$ 842,562	1.60%	$ 1,225,000	$ 8,385,383	$ 9,881,199	$ 42.20	1.361%
1	$ 4,595,000	0.00%	$ 229,750	$ -	$ 1,663,878	0.00%	$ 1,225,000	$ 8,385,383	$ 9,840,133	$ 42.03	1.356%
1	$ 4,595,000	1.00%	$ 254,633	$ -	$ 1,166,211	0.98%	$ 1,225,000	$ 8,385,383	$ 9,865,016	$ 42.13	1.359%
1	$ 4,595,000	2.50%	$ 294,756	$ -	$ 363,757	2.49%	$ 1,225,000	$ 8,385,383	$ 9,905,139	$ 42.31	1.365%
2	$ 2,777,000	1.62%	$ 163,668	$ 121,945	$ 546,615	2.26%	$ 1,225,000	$ 8,385,383	$ 9,895,996	$ 42.27	1.363%
2	$ 2,777,000	0.75%	$ 150,043	$ 121,945	$ 819,118	1.72%	$ 1,225,000	$ 8,385,383	$ 9,882,371	$ 42.21	1.361%
2	$ 2,777,000	1.00%	$ 153,888	$ 121,945	$ 742,213	1.88%	$ 1,225,000	$ 8,385,383	$ 9,886,216	$ 42.22	1.362%
2	$ 2,777,000	1.25%	$ 157,790	$ 121,945	$ 664,175	2.03%	$ 1,225,000	$ 8,385,383	$ 9,890,118	$ 42.24	1.362%
2	$ 2,777,000	1.50%	$ 161,748	$ 121,945	$ 585,011	2.18%	$ 1,225,000	$ 8,385,383	$ 9,894,076	$ 42.26	1.363%
2	$ 2,777,000	2.00%	$ 169,832	$ 121,945	$ 423,335	2.49%	$ 1,225,000	$ 8,385,383	$ 9,902,160	$ 42.29	1.364%
2	$ 2,777,000	2.50%	$ 178,137	$ 121,945	$ 257,248	2.79%	$ 1,225,000	$ 8,385,383	$ 9,910,465	$ 42.33	1.365%
3	$ 1,414,000	0.75%	$ 76,399	$ 215,691	$ 417,081	2.47%	$ 1,225,000	$ 8,385,383	$ 9,902,473	$ 42.29	1.364%
3	$ 1,414,000	0.25%	$ 72,571	$ 215,691	$ 493,656	2.32%	$ 1,225,000	$ 8,385,383	$ 9,898,644	$ 42.28	1.364%
3	$ 1,414,000	0.50%	$ 74,470	$ 215,691	$ 455,660	2.40%	$ 1,225,000	$ 8,385,383	$ 9,900,544	$ 42.29	1.364%
3	$ 1,414,000	1.00%	$ 78,357	$ 215,691	$ 377,922	2.55%	$ 1,225,000	$ 8,385,383	$ 9,904,431	$ 42.30	1.364%
3	$ 1,414,000	1.25%	$ 80,344	$ 215,691	$ 338,186	2.63%	$ 1,225,000	$ 8,385,383	$ 9,906,418	$ 42.31	1.365%
3	$ 1,414,000	1.62%	$ 83,337	$ 215,691	$ 278,327	2.74%	$ 1,225,000	$ 8,385,383	$ 9,909,411	$ 42.32	1.365%

*3.25% interest rate used for estimating other new debt service

MEMORANDUM

TO: Utah Water Quality Board

THROUGH: Erica Brown Gaddis, Director, Division of Water Quality

FROM: Scott Daly, Watershed Protection Section

DATE: June 26, 2019

SUBJECT: Request to Amend the Utah Lake Water Quality Board Grant

At the August, 24 2016 Water Quality Board (Board) Meeting, the Board granted $1,000,000 to the Division of Water Quality (DWQ) to conduct Phase 2 of the Utah Lake Water Quality Study (ULWQS). DWQ staff provided an overview of the project phases and the progress made on each phase at the April, 2019 Board meeting. Staff's April 3, 2019 memo to the Board provides a summary of the project and status (Attachment 1).

Staff is recommending the Board amend the Utah Lake Water Quality Study (ULWQS) Board grant made to DWQ to redirect $385,608.29 from DWQ to the three near-term research projects presented in this memo.

ULWQS Budget Summary

DWQ is implementing the ULWQS utilizing two funding sources: 1) $1,000,000 Board grant; and 2) $500,000 appropriated during the 2019 Utah legislative session (Table 1). The legislative appropriation is intended to support the ULWQS and to investigate harmful algal bloom treatment options on Utah Lake. DWQ is currently evaluating proposed treatment options through a request for proposal (RFP) process to implement pilot-scale treatments during the summer and fall of 2019.

DWQ has obligated $640,631.87 to the ULWQS through several contracts including project facilitation, technical contractual support, purchase of monitoring equipment, and support of the ULWQS Science Panel. The unobligated balance of the WQB grant is $459,368.13.

Table 1. ULWQS Funding and contract summary.

Funding Summary			
Project Initiatives		**WQB Grant**	**Legislative Appropriation**
ULWQS		$1,000,000.00	$100,000.00 + TBD
Utah Lake Cyanobacteria Treatment		$0.00	TBD
Total Funding		**$1,000,000.00**	**$500,000.00**
Obligated Funds			
	Contract Total	**WQB Grant**	**Legislative Appropriation**
Project Facilitation	$349,086.07	$329,566.16	$19,519.91
NNC Technical Support	$247,235.00	$166,754.91	$80,480.09
Literature Review	$25,040.00	$25,040.00	$0.00
Steering Committee Support	$2,637.80	$2,637.80	$0.00
Science Panel Research Support	$16,633.00	$16,633.00	$0.00
Total Obligated	**$640,631.87**	**$540,631.87**	**$100,000.00**
Unobligated		**$459,368.13**	**$0.00**
Near-term research grants		$385,608.29	$0.00
Unobligated Balance		**$73,759.84**	**TBD**

ULWQS Near-term Research Prioritization

The three near-term research projects recommended for funding in this memo were developed over the last year through interactions between the Steering Committee and Science Panel. The following discussions summarizes the steps taken to identify and prioritize potential research projects, develop the associated scopes of work, request bids from qualified scientists, select the most qualified bid, and develop project work plans.

Steering Committee Charge to the Science Panel

The work of the Science Panel is guided by the *ULWQS Phase 2 Purpose and Initial Charge to the Science Panel from the Steering Committee* (Attachment 2). For this document, the Steering Committee developed three initial high-level charge questions that include:

1. What was the historic ecological and nutrient condition of Utah Lake pre-settlement and how has it changed;
2. What is the current ecological and nutrient condition of Utah Lake; and,
3. What additional information is needed to define nutrient criteria for Utah Lake?

In response, the Science Panel developed a series of scientific questions, or key questions that must be answered for each high-level charge question.

Identification and Prioritization of Near-term Research Projects
Answering the key questions is the primary responsibility of the Science Panel during Phase 2 of the ULWQS. The Science Panel, with support from the ULWQS technical consultant, is developing a Strategic Research Plan to include all scientific studies and analyses required to fill the knowledge gaps relevant to the Initial Charge. At the February 8th, 2019 Science Panel meeting, the Panel reviewed the Initial Charge and developed a prioritized list of research projects that can be initiated in 2019 that will inform the overall Strategic Research Plan. The research projects were prioritized using the following criteria:

- Projects that can be initiated to capitalize on the 2019 field season;
- Projects that can be initiated to utilize time sensitive funding sources;
- Projects that are a prerequisite for longer-term, more complicated studies; and
- Projects that can be developed with the information we currently have on hand.

The Panel identified three near-term research projects to initiate in 2019 using the prioritization criteria. The projects and their respective scopes of work include:

- Historic Trophic State and Nutrient Concentrations in the Paleo Record of Utah Lake (Attachment 3)
- Bioassays to Investigate Nutrient Limitation in Utah Lake (Attachment 4)
- Utah Lake Sediment-Water Nutrient Interactions (Attachment 5)

RFP Process and Proposal Evaluation
Upon completion of the scope of work for each project a request for proposal (RFP) process was initiated. The RFPs were distributed to local college and university science departments, the ULWQS Science Panel and Steering Committee, and a comprehensive list of local researchers and stakeholders. The RFPs were open for 3 weeks.

The proposal evaluation committee composed of the five independent members of the Science Panel and one DWQ staff member, ranked proposals and selected three research teams to complete the studies. The selected research teams and their project work plans are as follows:

- Historic Trophic State and Nutrient Concentrations in the Paleo Record of Utah Lake – Dr. Janice Brahney (USU), Dr. Soren Brothers (USU), and Dr. Mitch Power (U of U) (Attachment 6);
- Bioassays to Investigate Nutrient Limitation in Utah Lake – Dr. Zach Aanderud (BYU), Dr. Michelle Baker (USU), Dr. Ben Abbott (BYU) (Attachment 7)
- Utah Lake Sediment-Water Nutrient Interactions – Dr. Ramesh Goel (U of U) and Dr. Greg Carling (BYU) (Attachment 8)

The project work plans presented in Attachments 6 through 8 were developed following proposal selection and subsequently reviewed by the entire Science Panel membership. The work plans were then approved by the Science Panel. Furthermore, the results of the proposal selection process were presented to and endorsed by the Steering Committee.

Staff Recommendation

Staff recommends funding each of the three near-term research projects in the amounts presented below:

- $235,180.29: Historic Trophic State and Nutrient Concentrations in the Paleo Record of Utah Lake – Dr. Janice Brahney (USU), Dr. Soren Brothers (USU), and Dr. Mitch Power (U of U)
- $79,643.00: Bioassays to Investigate Nutrient Limitation in Utah Lake – Dr. Zach Aanderud (BYU), Dr. Michelle Baker (USU), Dr. Ben Abbott (BYU)
- $70,785.00: Utah Lake Sediment-Water Nutrient Interactions – Dr. Ramesh Goel (U of U) and Dr. Greg Carling (BYU)

Staff recommends that the Board amend the $1,000,000 WQB grant awarded to DWQ by de-obligating $385,608.29 from DWQ and re-obligating the same amount in the form of grant to the three near-term research projects as requested in the list above.

List of Attachments

Attachment 1	April 3, 2019 memo to the Board summarizing the phases of the ULWQS and progress report
Attachment 2	ULWQS Phase 2 Purpose and Initial Charge to the Science Panel from the Steering Committee
Attachment 3	Scope of Work: Historic Trophic State and Nutrient Concentrations in the Paleo Record of Utah Lake
Attachment 4	Scope of Work: Bioassays to Investigate Nutrient Limitation in Utah Lake
Attachment 5	Scope of Work: Utah Lake Sediment-Water Nutrient Interactions
Attachment 6	Work Plan: Historic Trophic State and Nutrient Concentrations in the Paleo Record of Utah Lake
Attachment 7	Work Plan: Bioassays to Investigate Nutrient Limitation in Utah Lake
Attachment 8	Work Plan: Utah Lake Sediment-Water Nutrient Interactions

DWQ-2019-006614

ATTACHMENT 1

M E M O R A N D U M

TO: Utah Water Quality Board

THROUGH: Erica Brown Gaddis, Director, Division of Water Quality

FROM: Jodi Gardberg, Watershed Protection Section Manager

DATE: April 10, 2019

SUBJECT: Utah Lake Water Quality Study Update

At the August 2016 Water Quality Board (Board) Meeting, the Board granted funding in the amount of $1,000,000 to the Division of Water Quality (DWQ) to conduct research in support of Phase 2 of the Utah Lake Water Quality Study (ULWQS). An additional $500,000 was awarded by the Utah Legislature in 2018. DWQ will present an update on the ULWQS three-phased study at the April 2019 Board meeting.

Background

The goal of the ULWQS is to develop site specific nutrient criteria to protect the recreation, aquatic life, and agricultural beneficial uses of Utah Lake using a 3 phased approach:

- Phase 1: Data compilation and characterization, Stakeholder Framework
- Phase 2: Development of in-lake nutrient criteria
- Phase 3: Implementation planning

Phase 1: Data Gathering and Characterization, Stakeholder Framework

Phase 1 of the study focused on the compilation and synthesis of existing water quality data and information and established a Steering Committee and a Science Panel, charged with gaining broad acceptance of the process and outcomes through a consensus based, transparent, and scientifically defensible approach.

This phase included coordination of research and monitoring efforts, data compilation, an evaluation of in-lake water-quality conditions, an evaluation of nutrient sources entering the lake from the surrounding watershed, and development of water-quality models to inform Phase 2. Also included was the development of a Stakeholder process and framework resulting in a 16-member Steering Committee representing diverse stakeholder interests and an independent Science Panel responsible for developing scientifically defensible water-quality goals for the lake. The Steering Committee and Science Panel are chaired jointly by the Utah Lake Commission (ULC) and DWQ. The Phase 1 report was completed in December 2018 and delivered to the Steering Committee and Science Panel.

Phase 2: Site-Specific Nutrient Criteria Development

The purpose of Phase 2 is to build off Phase 1and is mediated through the stakeholder process. The Steering Committee is charged with guiding water quality criteria development and recommending in-lake water quality criteria (including elements of magnitude, frequency, and duration) to the ULC and DWQ for adoption by the Board. The Steering Committee is supported by the Science Panel, whose purpose is to guide water quality criteria development on Utah Lake by overseeing targeted scientific studies. The panel is working under a Charter, a set of operating principles including six significant tasks, and a set of specific initial charge questions. Science Panel objectives are primarily to: develop a scientifically defensible approach for criteria development, identify gaps in understanding, provide recommendations for scientific studies to fill any gaps, recommend and prioritize studies/analyses of existing data, review study work plans, guide the scientific research, oversee peer review of the studies, develop a process to characterize uncertainty, and finally to recommend science-based water quality criteria options to the Steering Committee. The Science Panel’s charge questions from the Steering Committee can be distilled to:

1) What was the historic ecological and nutrient condition of Utah Lake pre-settlement and how has it changed?
2) What is the current ecological and nutrient condition?
3) What additional information is needed?

Tetratech Inc., a consulting firm who has provided nutrient criteria-related support to more than 35 state and tribes, was hired to provide technical support to the Science Panel to accomplish its objectives. Tetratech is currently developing the technical approach framework describing the path to numeric criteria, mapping individual components to the effort and linking these components to the Science Panel initial charge key questions. The following tasks are being deliberated:

- Literature review to evaluate and select applicable approaches for developing numeric nutrient criteria for shallow lake ecosystems like Utah Lake.
- Conceptual model that defines the relationships among all elements of the Utah Lake ecosystem affected by nutrients, from sources through assessment endpoints to management goals (beneficial use protection).
- Data gaps analysis to identify and track significant knowledge gaps.
- Data Characterization including additional empirical (statistical) characterization and stressor-response modeling to complement what was accomplished with Phase 1 data compilation.
- Process to incorporate scientific uncertainty into the weight of evidence approach.
- Strategic Research Plan that will include scientific studies required to fill gaps in understanding relevant to answering the initial charge questions and strengthen the

conceptual model and identifies early action projects that can be implemented during the 2019 field season.

Phase 3: Implementation Planning for Phase 2 Criteria

Phase 3 is currently planned to begin in 2020 and will focus on implementing the criteria developed during Phase 2 and may include the following elements:

- Evaluation of current use designations and the scientific and economic feasibility of achieving recommended criteria.
- Implementation of water-quality and watershed models to help identify sources of phosphorus and nitrogen, identify reductions required to meet criteria, and inform decisions on how to best reduce nutrient loading.
- Evaluation of costs to implement required reductions.
- Evaluation of scenarios for achieving the most cost-effective solutions for reducing excess nutrients.

DWQ-2019-003551

Utah Lake Water Quality Study

ULWQS Phase 2 Purpose and Initial Charge to Science Panel from Steering Committee

ULWQS Phase 2 Purpose

The main purpose of the Utah Lake Water Quality Study is to guide the development of site-specific nutrient criteria to protect the designated uses of Utah Lake. This will include the development of numeric criteria for both nitrogen and phosphorus, including specific elements for the magnitude (concentration of pollutants), duration (period of exposure to pollutants), and frequency (recurrence of the exposure to pollutants) necessary to protect defined uses. The following represents all of the existing uses for Utah Lake:

- Class 2A – Protected for frequent primary contact recreation where there is a high likelihood of ingestion of water or a high degree of bodily contact with the water. Examples include, but are not limited to, swimming, rafting, kayaking, diving, and water skiing.
- Class 3B – Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.
- Class 3D – Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.
- Class 4 – Protected for agricultural uses including irrigation of crops and stock watering.

Draft Initial Charge to Science Panel from Steering Committee

The following high-level questions (in bold) were identified by the Steering Committee as ones that need to be answered (i.e., to define what is possible in general and as it relates to how they would use the nutrient criteria lever) before they can articulate management goals for Utah Lake. The Steering Committee is proposing these as a first iteration of high-level questions for the Science Panel to answer.

It is expected that the Science Panel will guide development of answers to these high-level questions through a series of steps: 1) identify additional 'sub' questions that need to be answered; 2) assess the current research/existing studies' ability to answer 'sub' questions; 3) develop a conceptual map of nutrient linkages to beneficial uses; 4) identify gaps and commission additional research studies to fill those gaps; and 5) review the research results and finalize responses to the high-level questions.

In moving through these steps, the Steering Committee would like to emphasize the value (time, money, etc.) of relying, wherever possible, on existing studies to address high-level and sub questions. Further, UDWQ is positioned to be able to engage a technical contractor if the Science Panel feels this would benefit their efforts, in addition to the specific efforts that will be commissioned to conduct the studies identified by the Science Panel.

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?**

   1.1. What does the diatom community and macrophyte community in the paleo record tell us about the historical trophic state and nutrient regime of the lake?

      i. Can diatom (benthic and planktonic) and/or macrophyte extent or presence be detected in sediment cores? And if so, what are they?

      ii. What were the environmental requirements for diatoms and extant macrophyte species?

      iii. How have environmental conditions changed over time?

   1.2. What were the historic phosphorus, nitrogen, and silicon concentrations as depicted by sediment cores?

   1.3. What information do paleo records (eDNA/scales) provide on the population trajectory/growth of carp over time? What information do the paleo records provide on the historical relationship between carp and the trophic state and nutrient regime of the lake?

   1.4. What do pollen, resting spores, photopigments, DNA, midge head capsules, mollusks, and exuviae from zooplankton in the paleo record tell us about the historical water quality, trophic state, and nutrient regime of the lake?

2. **What is the current state of the lake with respect to nutrients and ecology?**

   2.1. What are the impacts of carp on the biology/ecology and nutrient cycling of the lake and how are those impacts changing with ongoing carp removal efforts?

      i. What contribution do carp make to the total nutrient budget of the lake via excretion rates and bioturbation? How much nutrient cycling can be attributed to carp?

      ii. What is the effect of carp removal efforts on macrophytes, nutrients, secchi depth, turbidity, and primary productivity?

      iii. How much non-algal turbidity and nutrient cycling is due to wind action versus carp foraging? How much does sediment resuspension contribute to light limitation, and does wind resuspension contribute substantially in the absence of carp?

   2.2. What are the environmental requirements for submerged macrophytes currently present at Utah Lake?

      i. What is the role of lake elevation and drawdown in macrophyte recovery? Are certain species more resilient to drawdowns and nutrient related impacts? Can some species establish/adapt more quickly?

      ii. What is the relationship between carp, wind, and macrophytes on non-algal turbidity and nutrient cycling in the lake? What impact could macrophyte reestablishment have?

2.3. What are the linkages between changes in nutrient regime and HABs?

i. Where do HABs most frequently start/occur? Are there hotspots and do they tend to occur near major nutrient sources?

ii. Which nutrients are actually controlling primary production and HABs and when?

iii. If there are linkages between changes in nutrient regime and HABs, what role if any does lake elevation changes play?

iv. How do other factors affect HAB formation in Utah Lake (e.g., climate change; temperature; lake stratification; changes in zooplankton and benthic grazers and transparency)?

v. What is the role of calcite "scavenging" in the phosphorus cycle?

vi. What is the relationship between light extinction and other factors (e.g., algae, TSS, turbidity)?

2.4. How do sediments affect nutrient cycling in Utah Lake?

i. What are current sediment equilibrium P concentrations (EPC) throughout the lake? What effect will reducing inputs have on water column concentrations? If so, what is the expected lag time for lake recovery after nutrient inputs have been reduced?

ii. What is the sediment oxygen demand of, and nutrient releases from, sediments in Utah Lake under current conditions?

iii. Does lake stratification [weather patterns] play a result in anoxia and phosphorus release into the water column? Can this be tied to HAB formation?

2.5. For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife:

i. Where and when in Utah Lake are early life stages of fish present?

ii. Which species are most sensitive and need protection from nutrient-related impacts?

3. What additional information is needed to define nutrient criteria that support existing beneficial uses?

3.1. For warm water aquatic life, waterfowl, shorebirds, and water-oriented wildlife

3.2. For primary contact recreation

3.3. For agricultural uses including irrigation of crops and stock watering

Additional High-level Question

NOTE: The Science Panel should investigate this question once studies for high-level questions 1 - 3 are fully underway and sufficient information from these efforts is obtained to inform the scope of question 4. It is the intent of the Steering Committee that question 4 be answered before developing final numeric nutrient criteria for the lake.

4. Is there an improved stable state that can be reached under the constraints of current water and fishery management?

4.1 What would be the current nutrient regime of Utah Lake assuming no nutrient inputs from human sources? This question may require the identification of primary sources of nutrients. [NOTE: discussion of intent of this question would be useful and, depending on discussion, assessing how it is framed?]

4.2 Assuming continued carp removal and current water management, would nutrient reductions support a shift to a macrophyte-dominated state within reasonable planning horizons (i.e., 30- 50 years)?

4.3 If the lake stays in a phytoplankton-dominated state, to what extent can the magnitude, frequency, and extent of harmful and nuisance algal blooms be reduced through nutrient reductions?

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Scope of Work: Historic Trophic State and Nutrient Concentrations in the Paleo Record of Utah Lake

1 Introduction

The Utah Department of Environmental Quality, Division of Water Quality (DWQ) is requesting grant proposals for technical support to conduct a paleolimnological study of Utah Lake. A Paleo experimentation was prioritized for 2019 by the Utah Lake Water Quality Study (ULWQS) Science Panel to determine the historical nutrient regime of the lake. The target completion date of this scope is January 31, 2020.

Please submit a grant proposal including a cost proposal to Emily Canton at ercanton@utah.gov by 5:00 PM MST May 22, 2019. Proposals must be limited to 10 pages; this page limit does not include resumes and project case studies that may be included in an appendix.

2 Background

The Utah Division of Water Quality (DWQ) recently initiated Phase 2 of the Utah Lake Water Quality Study (ULWQS) to evaluate the effect of excess nutrients on the lake's recreational, aquatic life, and agricultural designated uses and to develop site-specific nitrogen and phosphorus water quality criteria to protect these uses. The ULWQS is guided by the Stakeholder Process (Attachment A) developed during Phase 1, which established a 16-member interest-based Steering Committee and a 10-member disciplinary-based Science Panel. The Steering Committee has charged the Science Panel with developing and answering key questions to characterize historic, current, and future nutrient conditions in Utah Lake (Attachment B). Responses to the key questions will be used by the Steering Committee to establish management goals for the lake and by the Science Panel to guide development of nutrient criteria to support those goals.

Additionally, the Science Panel must complete a significant number of tasks to achieve its purpose of guiding the development of nutrient criteria as described in Attachment C including:

- Guiding the approach for establishing nutrient criteria
- Recommending and guiding studies to fill data gaps needed to answer key questions
- Interpreting and integrating study results into the rationale for nutrient criteria

- Guiding development of an approach for characterizing uncertainty
- Recommending science-based nutrient criteria to the Steering Committee

Problem Statement

Information on historic, even pre-settlement chemical and biological conditions in Utah Lake are underdeveloped but are important in developing nutrient thresholds for protection or restoration of the lake. Pre-settlement conditions are described for macrophyte resources in Utah Lake based on descriptions in pre-1974 literature, but a longer-term paleo record of macrophytes is not available. Paleoecological interpretation of diatom assemblages in the lake suggests that the lake has changed from a deep mesotrophic state to a shallow eutrophic state over time. Despite this and other research using paleolimnological coring to infer past conditions, consistent application of advanced core age-dating approaches and paleo-analytical techniques to spatially representative and comprehensive cores across this ecosystem has been limited. As a result, current estimates of the timing of changes observed in cores, associated sedimentation rates, and inference of past chemical and biological conditions remain somewhat speculative, and it is believed that research using consistently applied, advanced techniques would improve certainty. Knowing the pre-settlement chemical (phosphorus, nitrogen, silicon, calcium, iron, and potentially N and P isotopes) concentrations and how they have changed will help inform development of numeric nutrient targets. A long-term record of diatom and macrophyte assemblages in the paleo record of Utah Lake could provide information on the historical trophic state and nutrient regime of the lake, also important in understanding appropriate targets for protection or restoration.

DWQ recognizes that there may be difficulties in dating/quantifying changes in shallow, well-mixed lake ecosystems due to mixing of the surface sediments. Any details on the extent of this as an issue for characterizing past conditions in Utah Lake as well as recommendations on how that uncertainty will be overcome or quantified in the proposal are welcome.

Existing Data and Information (see also Attachment C)

Over the past several decades, a variety of paleolimnological and historical studies have attempted to recreate past conditions in the Utah Lake ecosystem using a variety of approaches. Early piston cores and analysis of algal and mollusk remains suggested a shift from oligo/mesotrophic conditions to eutrophic/alkaline conditions along the gradient of the core (Bolland 1974). A shift in diatom assemblage structure was noted in a later study of three cores from the lake (Javakul et al. 1980), but there was not as much effort to link these changes to paleoenvironmental reconstruction; however, they were linked to pre and post-settlement conditions using dandelion pollen. Finally, Macharia (2012) used lake cores to reconstruct historic and prehistoric environments through geochemical proxies and concluded that disturbance at the time of establishment of agriculture and urban settlement around Utah Lake altered nutrient and particulate matter fluxes into the lake.

Bushman (1980) calculated a net sedimentation rate from 1849 to 1972 of 1.38 cm per year based on the presence of dandelion pollen in sediment cores. He concluded that the rate of sediment deposition has increased since settlement of the Utah Valley; however, there was disagreement among researchers (e.g., Bolland 1974; Javakul et al. 1980) on sedimentation rates calculated from different cores using different dating methods and on interpretation of paleoecological conditions in the lakes based on various core proxies.

Aside from paleo-reconstruction using lake bed cores, Brotherson (1981) provided a thorough description of aquatic and semiaquatic plant communities around Utah Lake and its major bays. The study offered detailed descriptions taken from literature (pre-1974) and supplemented with 1976 field surveys. Plant community types identified and quantified across the lake included density characteristics representing the publication period (late 1970s). The early settlement period was also characterized. Although specific measures of plant community effects on water quality (e.g., dissolved oxygen, nutrients, biomass, phytoplankton, biochemical oxygen demand, etc.) were not included in the paper, it offered background information and a snapshot in time for water quality model support.

Study Objectives

The objective of this research is to address the following questions identified by the Science Panel as critical to understanding the historical condition of Utah Lake with respect to nutrients and ecology:

- What were the historical phosphorus, nitrogen, and silicon concentrations as depicted by sediment cores? (Science Panel charge 1.2, Attachment B).
- What does the diatom community and macrophyte community in the paleo record tell us about the historical trophic state and nutrient regime of the lake? (Science Panel charge 1.1, Attachment B)
  - Can diatom (benthic and planktonic) and/or macrophyte extent or presence be detected in sediment cores? And if so, what are they?
  - What were the environmental requirements for diatoms and extant macrophyte species?
  - How have environmental conditions changed over time?
- What do photopigments and DNA in the paleo record tell us about the historical water quality, trophic state, and nutrient regime of the lake? (Science Panel charge 1.4, Attachment B)

Expected Outputs and Outcomes

Specific outputs are expected to include, but are not limited to, a sampling and analysis plan (SAP), the project dataset, and a technical report with detailed results for all tasks. All data collected for this project must be made available to the Science Panel per the deliverable dates schedule in Section 6 of this RFP.

When this study is completed, the Science Panel will be able to answer the study objectives listed above and understand, with greater certainty:

- Historic nutrient and relevant elemental conditions (including analysis of relative availability of bound fractions); to include, at a minimum, Fe, Ca, Al, and other relevant elements as deemed appropriate by proposers

- Historic isotopic ^{15}N and ^{13}C conditions, and others as deemed appropriate
- Historic water clarity conditions
- Historic macrophyte presence, extent and quantity
- Historic diatom assemblage composition
- Inferred historic trophic state
- And, to the extent possible, inferred pH and thermal environmental conditions

3 Supporting Materials

A number of reports and documents were developed during the course of the ULWQS and previous study efforts on Utah Lake. These documents are provided as attachments for reference during response development. Additional ULWQS information including data, reports, meeting summaries, meeting recordings, and other related materials are available at utahlake.deq.utah.gov. A list and brief description of the relevant materials is included here:

Attachment A. Stakeholder Process https://documents.deq.utah.gov/water-quality/watershed-protection/utah-lake/DWQ-2017-004494.pdf. This document prescribes the structure, objectives, and duties of the Steering Committee, Science Panel, and other organizations with a role in the ULWQS. This process is directed by an independent professional facilitation team.

Attachment B. ULWQS Phase 2 Purpose and Initial Charge to Science Panel from Steering Committee. This document describes the Initial High Level Charge questions developed by the Steering Committee and an initial list of key questions designed to answer each high level charge https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf.

Attachment C. Utah Lake Literature Review – This literature review was developed as a Phase 1 task and assessed the ability of existing literature and studies to answer the Initial High Level Charge questions presented in the ULWQS Phase 2 Initial Charge document. See select references in the Utah Lake Literature Review under *Topical Category 1: In-Lake Water Quality Conditions* for a list and findings of references relevant to historical conditions in Utah Lake. https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf

Attachment D. Quality Assurance Program Plan for Environmental Data Operations, Final Plan, Revision No. 1.0, Effective September 5, 2014. https://deq.utah.gov/water-quality/quality-assurance-and-quality-control-program-monitoring-water-quality

References

Bolland, R. F. 1974. Paleoecological interpretation of the diatom succession in the recent sediments of Utah Lake. PhD. dissertation, University of Utah.

Brotherson, J.D. 1981. Aquatic and semiaquatic vegetation of Utah Lake and its bays. *Great Basin Naturalist Memoirs*: Vol. 5, Article 5.

Bushman, J.R. 1980. The Rate of Sedimentation in Utah Lake and the Use of Pollen as an Indicator of Time in Sediments.

Javakul, A., J.A. Grimes, and S.R. Rushforth. 1980. Diatoms in Sediment Cores in Utah Lake, Utah. U.S. Bureau of Reclamation WHAB Phase One Report #16.

Janetski, J. C. 1990. Utah Lake: its role in the prehistory of Utah Valley. Utah Historical Quarterly 58:5-31.

Macharia, A, N. 2012. Reconstruction of Paleoenvironments Using a Mass-Energy Flux Framework (Utah Lake). Doctoral dissertation. University of Utah. Salt Lake City, Utah.

4 Project Tasks

DWQ is seeking a qualified entity to provide technical support to the ULWQS Science Panel to assist with collecting information on the historic phosphorus, nitrogen, and silicon concentrations in Utah Lake as depicted by sediment cores. The tasks within this scope of work reflect a recommended approach for this work and are designed to help the proposer meet the study objectives and expected outputs and outcomes, which support the Science Panel in accomplishing its duties and fulfilling the Steering Committee's Charge (Attachment B). Proposers should feel free to include additional tasks in the proposal as they see appropriate to best achieve the study objectives and expected outcomes.

The deliverables for tasks presented in this Scope of Work will be reviewed collaboratively with the DWQ and ULWQS Science Panel. Prospective researchers will work closely with the Science Panel to perform each task and are expected to be responsive to any input and guidance provided by the Panel.

Task 1. Develop sampling and analysis plan (SAP)

A sampling and analysis plan (SAP) will be developed in accordance with the Utah DWQ's *Quality Assurance Program Plan for Environmental Data Operations, Final Plan* (Revision No. 1.0, see Attachment D). The essential elements for SAPs are listed in Appendix A of the *Quality Assurance Program Plan* and are as follows:

1. Introduction and background information
2. Objectives and design of the investigation
3. Special precautions and safety plan
4. Field sampling methods and documentation
5. Laboratory sample handling procedures
6. Analytical methods and laboratory documentation
7. Project quality control requirements
8. Data analysis, record keeping, and reporting requirements
9. Schedule and budget
10. Project team and responsibilities

Expected Deliverables

- Draft and final sampling and analysis plans in accordance with the Utah DWQ's Quality Assurance Program Plan for Environmental Data Operations, Final Plan.

Proposal Elements

Responses should:

- Provide demonstrated experience with developing sampling and analysis plans.
- Discuss a proposed approach for developing the deliverable for this task.

Task 2. Collect and preserve cores

Collection of cores across Utah Lake at locations optimized to characterize historic conditions across a variety of different lacustrine conditions from historic to present. Minimum core lengths should be sufficient to characterize substantial pre-settlement as well as post-settlement conditions up to the present, including the effects of historic lake level changes. Proposers should discuss core location strategies to maximize overcoming sediment mixing issues. Cores should be preserved for future analysis.

Expected Deliverables

- Replicate cores
- Preserved cores for future analysis

Proposal Elements

Responses should:

- Provide demonstrated experience with the collection of lacustrine sediment cores
- Discuss a proposed approach for developing the deliverable for this task.

Task 3. Analyze cores

Analysis of the cores, including dating of cores, nutrient, elemental, and isotopic composition, and historic diatom and macrophyte condition. Application of well-established techniques will be preferred over development of exploratory or experimental techniques, and proposers should explain and defend the method chosen.

Expected Deliverables

- An electronic dataset for each of the following items at the completion of analysis.
  - Dates for core segments at reasonable resolvable intervals
  - Elemental composition of core segments at reasonably resolvable intervals including:
    - At a minimum: P, N, and Si concentrations in Utah Lake
    - Ca, Fe, Al, total and organic C and isotope (^{15}N, ^{13}C) concentrations, and others as recommended by proposer
    - Forms of P in sediments and how that can/cannot be resolved (at a minimum, bulk and water-extractable phosphorus)

- Identification of historic diatom and macrophyte assemblage indicators along reasonably resolvable intervals.
- Photopigment analysis of core along reasonably resolvable intervals.
- eDNA interpretation along historic sequence, if justified for use as a measure to answer the problem statement. DWQ believes that application of eDNA approaches may be somewhat experimental or exploratory. At this time, the DWQ is mostly interested in applying proven and trusted techniques. Applicants wishing to use eDNA or other more exploratory techniques are asked to justify the value and defensibility of those approaches to this project.

Proposal Elements

Responses should:

- Provide demonstrated experience with lake core dating, nutrient, and elemental composition including forms of P in lake cores, N isotope composition in lake cores, historic diatom and macrophyte assemblage analysis techniques in lake cores, photopigment analysis of lake cores, eDNA analysis in lake cores, and any other applicable techniques deemed relevant and defensible that would provide additional strength to meeting the project objectives.
- Discuss a proposed approach for developing the deliverables for the following subtasks:

Task 3.1: Dating cores

Task 3.2: Nutrient, elemental, and isotopic composition of cores

Task 3.3: Historical diatom and macrophyte community record

Task 3.4: Photopigments

Task 3.5 (option): eDNA

Task 4. Inferred historical condition analysis

In this task, proposers are asked how they will use the analyses conducted in Task 3 to recreate the inferred historical physical, chemical, and biological conditions outlined in the *Study Objectives* and *Expected Outputs and Outcomes* sections. As above, proposers are encouraged to discuss potential impediments to inference and interpretation, such as wind mixing and mixing of sediments, and how they will be overcome.

Expected Deliverables

Estimates, with uncertainty, on historic conditions including:

- Historic nutrient and relevant elemental conditions (including analysis of relative availability of bound fractions) to include, at a minimum, Fe, Ca, Al and other relevant elements as deemed appropriate by proposers

- Historic isotopic total and organic C, total N, ^{13}C, and ^{15}N conditions, and others as deemed appropriate
- Historic water clarity conditions
- Historic macrophyte presence, extent and quantity
- Historic diatom assemblage composition
- Inferred historic trophic state
- To the extent possible, inferred pH and thermal environmental conditions

Proposal Elements

Responses should:

- Provide demonstrated experience with conducting paleolimnological reconstruction analyses necessary to meet the expected deliverables.
- Discuss a proposed approach for developing the deliverables for this task.

Task 5. Prepare technical report

For this task, proposers will compile the methods, results, and historic inferences used in Tasks 2–4 into one comprehensive report for review by the Science Panel. Proposers should prepare a draft and final report based on feedback from the Science Panel. The report must include the methods, results, and discussion that answers the study objectives.

Expected Deliverables

- Draft and final technical reports

Proposal Elements

Responses should:

- Provide demonstrated experience with developing technical reports of this nature.
- Discuss a proposed approach for developing the deliverable for this task.

5 Key Personnel

Grant proposals should discuss in detail the team members proposed for each task, their directly related experience and expertise, and the allocation of effort among team members. Responses must detail the allocation of proposed hours for each task and team member in the table below. Please also include team members and time allocation for project management, project support such as technical editing and GIS, and other allocations not directly associated with the tasks and deliverables presented in this scope.

Task #	Deliverable	Team Member (hours)	Team Member (hours)	Team Member (hours)	Team Member (hours)
1	Deliverable 1				
	Deliverable 2				

6 Deliverables and Preliminary Due Dates

Deliverable due dates are based upon days from the contract award date. The project and all deliverables must be completed with consideration of the milestones in the table below, the scope of work response, and the final work plan after scope award. Any change in the execution date of the contract must result in a mutually agreed upon change in deliverable dates. All final products generated by the contractor will be transmitted to DWQ in a mutually agreed upon format prior to the expiration of the contract.

Task	Deliverable	Due Date
Task 1 – Develop Sampling and Analysis Plan	Draft sampling and analysis plan (SAP) Final SAP	14 days after scope award 30 days after scope award
Task 2 – Collect and Preserve Cores	Replicate cores	70 days after scope award
	Preserved cores	80 days after scope award
Task 3 – Analyze Cores	Electronic datasets	125 days after scope award
Task 4 – Inferred Historical Conditions Analysis	Estimates on historic conditions	160 days after scope award
Task 5–Prepare Technical Report	Draft technical report Final technical report	190 days after scope award 210 days after scope award

7 Science Panel Collaboration and Data Sharing

Grant recipients are required to complete this scope of work in collaboration with the ULWQS Science Panel. Grant recipients will:

- Develop the final research work plan in consultation with the Science Panel;
- Be responsive to Science Panel input on the final approach, work plan, work plan execution deliverables, results, analysis, final report, and any other interest to the Science Panel;
- Make all data and information collected by this grant, or funded by the ULWQS, available to the Science Panel within 45 days of field or laboratory analysis.

8 Evaluation and Award

Offers will be evaluated based on the following criteria listed in relative order of importance:

Selection Criteria	Weight
Key Personnel proposed for project work (experience, expertise, and reliability) and experience of specific team members proposed for discrete tasks	20%
Method of approach and proposer's ability to perform the requirements of the grant	20%
Demonstrated understanding of work elements in the context of existing products, the Utah Lake ecosystem, and the Science Panel Initial Charge	20%
Proposed approach for Science Panel collaboration and data sharing	20%
Price	20%

9 Cost Proposal Form

Offers must include a cost proposal utilizing the format provided below. Please ensure the cost proposal can be removed from the proposal for independent evaluation by including it as an attachment to the proposal or as a separate section at the end of the proposal. Note that indirect costs may not exceed 10% on contracts with other state and local governmental agencies, including colleges and universities.

Task #	Deliverable	Proposed Cost (USD)
Total		

10 Instructions for Grant Proposal Preparation

Proposals must include the following elements to qualify:

1) Proposals must follow the proposal template presented in Section 11
2) Proposals must:
    a. Include a discussion of successfully completed projects relevant to the specific deliverables in this scope of work;
    b. Demonstrate that proposed team members have direct experience with and are qualified for conducting the specific tasks and deliverables for which they are proposed. Team member qualifications and resumes must be included as an appendix to the proposal. Resumes will not be counted against the proposal page limit;
    c. Specify all project roles for the proposed team members including, but not limited to, project management, analytical tasks, GIS, technical editing, and any other proposed roles;
3) Proposed approach for how each task will be performed to achieve the purpose and deliverables outlined in this Scope of Work. Applicants may propose supplemental work elements necessary to achieve the expected outputs and outcomes;
4) Schedule for key milestones and deliverables;
5) A table of estimated level of effort for each team member by task utilizing the provided template (in Section 5); and
6) A stand-alone cost proposal table utilizing the provided template (Section 0) to include key personnel rates, hours and rates for completing specific tasks and deliverables, total proposed hours, indirect costs, overhead, and total cost.

11 Proposal Template

1. Experience and Expertise
    1.1. Related project experience
    1.2. Experience and expertise of key personnel
2. Proposed Approach
    2.1. Task 1 (repeat for each task)
        2.1.1. Key team members
        2.1.2. Approach discussion
            2.1.2.1. Approach for required Scope of Work deliverables
            2.1.2.2. Supplemental approach
            2.1.2.3. Task milestones and deliverables
3. Approach for Science Panel Collaboration and Data Sharing
4. Project milestones and deliverables
    4.1. A table of project milestones and deliverables
5. Level of effort
    5.1. A table with level of effort estimates
6. Cost Proposal
    6.1. A stand alone cost proposal table
7. Resumes (not counted toward page limit)
8. Related Case Study (not counted toward page limit)

12 Notice to Proceed

Notice to proceed will be provided by DWQ after receiving a signed grant agreement and Science Panel approval on the final work.

Scope of Work: Bioassays to Investigate Nutrient Limitation in Utah Lake

1 Introduction

The Utah Department of Environmental Quality, Division of Water Quality (DWQ) is requesting grant proposals for technical support to conduct bioassay nutrient limitation studies on Utah Lake. Bioassay experimentation was prioritized for 2019 by the Utah Lake Water Quality Study (ULWQS) Science Panel to determine spatial and temporal nutrient limitation in the lake. The target completion date of the work is June 30, 2020.

Please submit a grant proposal including a cost proposal to Emily Canton at ercanton@utah.gov by 5:00 PM MST May 22, 2019. Proposals must be limited to 10 pages; this page limit does not include resumes and project case studies that may be included in an appendix.

2 Background

DWQ recently initiated Phase 2 of the Utah Lake Water Quality Study (ULWQS) to evaluate the effect of excess nutrients on the lake's recreational, aquatic life, and agricultural designated uses and to develop site-specific nitrogen and phosphorus water quality criteria to protect these uses. The ULWQS is guided by the Stakeholder Process (Attachment A) developed during Phase 1, which established a 16-member interest-based Steering Committee and a 10-member disciplinary-based Science Panel. The Steering Committee has charged the Science Panel with developing and answering key questions to characterize historic, current, and future nutrient conditions in Utah Lake (Attachment B). Responses to the key questions will be used by the Steering Committee to establish management goals for the lake and by the Science Panel to guide development of nutrient criteria to support those goals.

Additionally, the Science Panel must complete a significant number of tasks to achieve its purpose of guiding the development of nutrient criteria including:

- Guiding the approach for establishing nutrient criteria
- Recommending and guiding studies to fill data gaps needed to answer key questions
- Interpreting and integrating study results into the rationale for nutrient criteria
- Guiding development of an approach for characterizing uncertainty
- Recommending science-based nutrient criteria to the Steering Committee

Problem Statement

Understanding which nutrients limit primary production in Utah Lake will help describe the current state of the lake with respect to nutrients, trophic state, and ecology. Some shallow lake systems transition from phosphorus limitation early in the growing season to nitrogen limitation later in the season, which can provide an opportunity for late-season cyanobacterial dominance (due to their nitrogen-fixing capabilities). In other lakes, non-nitrogen fixers can dominate throughout the bloom season, or nitrogen-fixing species may increase but may not be actively fixing nitrogen. Little is known about nutrient limitation in Utah Lake, including which nutrients are limiting, and whether there are seasonal and spatial dynamics in nutrient limitation.

Existing Data and Information (see also Attachment C)

The Phase 1 report characterizes in-lake nutrient conditions and describes general linkages among trophic indicators, including nutrients. In the Phase 1 data analysis, chlorophyll-*a* and total phosphorus concentrations varied by site, with the highest concentrations in Provo Bay (Attachment D: Utah Lake Water Quality Study, Phase 1 report). Seasonal patterns in chlorophyll-a were observed, with peak algal growth in August through October. There were no clear seasonal patterns in total phosphorus or Secchi depth transparency (https://udwq.shinyapps.io/UtahLakeDataExplorer/).

Study Objectives

The objective of this research is to address the following question identified by the Science Panel as critical to understanding the current state of Utah Lake with respect to nutrients and ecology: Which nutrients are actually controlling primary production and HABs and when? (Science Panel charge 2.3.ii, Attachment B). The study is designed to address the following topics:

- Determine the nutrient limitation dynamics of Utah Lake (regarding phosphorus (P)-, nitrogen (N)-, or co-P and N limitation)
- Determine whether there is a seasonal dynamic to the above (i.e., P limitation leading to N limitation)
- Determine whether there is a spatial dynamic to the above (i.e., 3 sites—Provo Bay; main body of lake, east; main body of lake, west)

This study will provide baseline information on nutrient limitation in Utah Lake via bioassay experiments. The data may serve to inform a follow-up project investigating nutrient limitation in more detail.

Expected Outputs and Outcomes

When this study is completed, the Science Panel will be able to answer the study objectives listed above.

Specific outputs are expected to include, but are not limited to, a sampling and analysis plan (SAP), the project dataset from bioassay experiments, and a technical report. All data collected for this project must be made available to the Science Panel per the deliverable dates schedule in Section 6 of this RFP.

3 Supporting Materials

A number of reports and documents were developed during the course of the ULWQS and previous study efforts on Utah Lake. These documents are provided as attachments for reference during response development. Additional ULWQS information including data, reports, meeting summaries, meeting recordings, and other related materials are available at utahlake.deq.utah.gov. A list and brief description of the relevant materials is included here:

Attachment A. Stakeholder Process https://documents.deq.utah.gov/water-quality/watershed-protection/utah-lake/DWQ-2017-004494.pdf. This document prescribes the structure, objectives, and duties of the Steering Committee, Science Panel, and other organizations with a role in the ULWQS. This process is directed by an independent professional facilitation team.

Attachment B. ULWQS Phase 2 Purpose and Initial Charge to Science Panel from Steering Committee. This document describes the Initial High Level Charge questions developed by the Steering Committee and an initial list of key questions designed to answer each high level charge https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf.

Attachment C. Utah Lake Literature Review – This literature review was developed as a Phase 1 task and assessed the ability of existing literature and studies to answer the Initial High Level Charge questions presented in the ULWQS Phase 2 Initial Charge document. See select references in the Utah Lake Literature Review under *Topical Category 1: In-Lake Water Quality Conditions* for a list and findings of references relevant to historical conditions in Utah Lake. https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf

Attachment D. ULWQS Phase 1 Report – This report was developed by DWQ to fulfill the work elements of the Phase 1 work plan including stakeholder development, data compilation and management, beneficial use assessment, loading characterization, and model development. https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001841.pdf

Attachment E. Quality Assurance Program Plan for Environmental Data Operations, Final Plan, Revision No. 1.0, Effective September 5, 2014. https://deq.utah.gov/water-quality/quality-assurance-and-quality-control-program-monitoring-water-quality

4 Project Tasks

DWQ is seeking a qualified entity to provide technical support to the ULWQS Science Panel to assist with collecting information on nutrient limitation in Utah Lake. The tasks within this scope of work reflect a recommended approach for this work and are designed to help the proposer meet the study objectives and expected outputs and outcomes, which support the Science Panel in accomplishing its duties and fulfilling the Steering Committee's Charge (Attachment B). Proposers should feel free to include additional tasks in the proposals as they see appropriate to best achieve the study objectives and expected outcomes.

The deliverables for tasks presented in this Scope of Work will be reviewed collaboratively with the ULWQS Science Panel. The selected contractor will work closely with the Science Panel to perform each task and is expected to be responsive to input and guidance provided by the Panel. If, during the course of the project, there are deviations from the project tasks as described here, the selected contractor should contact DWQ and the Science Panel and come up with a mutually agreed upon course of action.

Task 1. Develop sampling and analysis plan (SAP)

A sampling and analysis plan (SAP) will be developed in accordance with the Utah DWQ's *Quality Assurance Program Plan for Environmental Data Operations, Final Plan* (Revision No. 1.0, see Attachment E). The essential elements for SAPs are listed in Appendix A of the *Quality Assurance Program Plan* and are as follows:

1. Introduction and background information
2. Objectives and design of the investigation
3. Special precautions and safety plan
4. Field sampling methods and documentation
5. Laboratory sample handling procedures
6. Analytical methods and laboratory documentation
7. Project quality control requirements
8. Data analysis, record keeping, and reporting requirements
9. Schedule and budget
10. Project team and responsibilities

Expected Deliverables

- Draft and final sampling and analysis plans in accordance with the Utah DWQ's Quality Assurance Program Plan for Environmental Data Operations, Final Plan.

Proposal Elements

Responses should:

- Provide demonstrated experience with developing sampling and analysis plans.
- Discuss a proposed approach for developing the deliverable for this task.

Task 2. Conduct bioassay experiments

Bioassay experiments will be conducted three times: mid-summer (2019), early fall (2019), and spring bloom (2020). The experiments should adhere to the following:

- 1-gallon cubitainers (16 cubitainers per experiment)
- Three replicates and four treatments (control, N, P, N+P); after protocols are established and results are shown to be reproducible, two replicates may be used.
    - Control: lake water at time of sampling
    - N+P treatment: N:P 16:1 (molar)
    - P concentration for P and N+P amendments: 0.1 mg/L
    - Amend all bioassays with bicarbonate to avoid carbon limitation

- Collect lake water, homogenize into a 55-gallon drum, then pour back into cubitainers.
- Deployments will take place over the course of the growing season: one deployment to examine spring bloom, one in mid-summer, and one in the early fall. Because the timing of this project will not allow a deployment during the spring bloom of 2019, the spring bloom deployment will occur in 2020.
- Place into PVC corrals with nets. To facilitate experimental set-up, experiments may be performed within a sheltered, easy-access location (e.g., marina) that has light levels and temperatures similar to the water collection sites.
- 24, 48, and 72-hour endpoints: Use these endpoints in the first experiment to determine the rate of increase in biomass in the nutrient amendments vs. controls. Fine-tuning of the endpoints may be needed for the remaining experiments.
- Measure chlorophyll-*a*, species composition (biovolume), phosphorus and nitrogen fractions (TP, TN, NH_4-N, NO_x-N, soluble reactive phosphorus), HPLC for pigments, toxins (suggested to use ELISA kit approach). Measure dissolved oxygen and pH of cubitainers immediately after opening.
- Conduct the above at 3 sites in Utah Lake, ranging in trophic state and nutrient delivery— Provo Bay; main body of lake, east; main body of lake, west.

Expected Deliverables

- Electronic files with field observations and laboratory results

Proposal Elements

Responses should:

- Provide demonstrated experience with conducting nutrient bioassays.
- Discuss a proposed approach for conducting the bioassay experiments.

Task 3. Prepare technical report

The technical report will describe primary productivity limitation in Utah Lake, seasonally and spatially. The report must include the methods, results, and discussion that answers the study objectives.

Expected Deliverables

- Draft and final technical reports.

Proposal Elements

Responses should:

- Provide demonstrated experience with developing technical reports of this nature.
- Discuss a proposed approach for developing the deliverable for this task.

5 Key Personnel

Grant proposals should discuss in detail the team members proposed for each task, their directly related experience and expertise, and the allocation of effort among team members. Responses must detail the allocation of proposed hours for each task and team member in the table below. Please also include team members and time allocation for project management, project support such as technical editing and GIS, and other allocations not directly associated with the tasks and deliverables presented in this scope.

Task #	Deliverable	Team Member (hours)	Team Member (hours)	Team Member (hours)	Team Member (hours)
1	Deliverable 1				
	Deliverable 2				

6 Deliverables and Preliminary Due Dates

Deliverable due dates are based upon days from the contract award date. The project and all deliverables must be completed with consideration of the milestones in the table below, the scope of work response, and the final work plan after scope award. Any change in the execution date of the contract must result in a mutually agreed upon change in deliverable dates. All final products generated by the contractor will be transmitted to DWQ in a mutually agreed upon format prior to the expiration of the contract.

Task	Deliverable	Due Date
Task 1 – Develop Sampling and Analysis Plan	Draft sampling and analysis plan (SAP) Final SAP	14 days after scope award 30 days after scope award
Task 2 – Conduct Bioassay Experiments	Electronic files with field observations and laboratory results	45 days after each deployment
Task 3 – Prepare Technical Report	Draft technical report Final technical report	June 12, 2020 June 30, 2020

7 Science Panel Collaboration and Data Sharing

Grant recipients are required to complete this scope of work in collaboration with the ULWQS Science Panel. Grant recipients will:

- Develop the final research work plan in consultation with the Science Panel;
- Be responsive to Science Panel input on the final approach, work plan, work plan execution deliverables, results, analysis, final report, and any other interest to the Science Panel;
- Make all data and information collected by this grant, or funded by the ULWQS, available to the Science Panel within 45 days of each bioassay deployment;

8 Evaluation and Award

Offers will be evaluated based on the following criteria listed in relative order of importance:

Selection Criteria	Weight
Key Personnel proposed for project work (experience, expertise, and reliability) and experience of specific team members proposed for discrete tasks	20%
Method of approach and proposer's ability to perform the requirements of the grant	20%
Demonstrated understanding of work elements in the context of existing products, the Utah Lake ecosystem, and the Science Panel Initial Charge	20%
Proposed approach for Science Panel collaboration and data sharing	20%
Price	20%

9 Cost Proposal Form

Offers must include a cost proposal utilizing the format provided below. Please ensure the cost proposal can be removed from the proposal for independent evaluation by including it as an attachment to the proposal or as a separate section at the end of the proposal. Note that indirect costs may not exceed 10% on contracts with other state and local governmental agencies, including colleges and universities.

Task #	Deliverable	Proposed Cost (USD)
Total		

10 Instructions for Grant Proposal Preparation

Proposals must include the following elements to qualify:

1) Proposals must follow the proposal template presented in Section 11
2) Proposals must:
    a. Include a discussion of successfully completed projects relevant to the specific deliverables in this scope of work;
    b. Demonstrate that proposed team members have direct experience with and are qualified for conducting the specific tasks and deliverables for which they are proposed. Team member qualifications and resumes must be included as an appendix to the proposal. Resumes will not be counted against the proposal page limit;
    c. Specify all project roles for the proposed team members including, but not limited to, project management, analytical tasks, GIS, technical editing, and any other proposed roles;
3) Proposed approach for how each task will be performed to achieve the purpose and deliverables outlined in this Scope of Work. Applicants may propose supplemental work elements necessary to achieve the expected outputs and outcomes;
4) Schedule for key milestones and deliverables;
5) A table of estimated level of effort for each team member by task utilizing the provided template (in Section 5); and
6) A stand-alone cost proposal table utilizing the provided template (Section9) to include key personnel rates, hours and rates for completing specific tasks and deliverables, total proposed hours, indirect costs, overhead, and total cost.

11 Proposal Template

1. Experience and Expertise
    1.1. Related project experience
    1.2. Experience and expertise of key personnel
2. Proposed Approach
    2.1. Task 1 (repeat for each task)
        2.1.1. Key team members
        2.1.2. Approach discussion
            2.1.2.1. Approach for required Scope of Work deliverables
            2.1.2.2. Supplemental approach
            2.1.2.3. Task milestones and deliverables
3. Approach for Science Panel Collaboration and Data Sharing
4. Project milestones and deliverables
    4.1. A table of project milestones and deliverables
5. Level of effort
    5.1. A table with level of effort estimates
6. Cost Proposal
    6.1. A stand alone cost proposal table
7. Resumes (not counted toward page limit)
8. Related Case Study (not counted toward page limit)

12 Notice to Proceed

Notice to proceed will be provided by DWQ after receiving a signed grant agreement and Science Panel approval on the final work.

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Scope of Work: Utah Lake Sediment–Water Nutrient Interactions

1 Introduction

The Utah Department of Environmental Quality, Division of Water Quality (DWQ) is requesting grant proposals for technical support to conduct experiments to characterize the sediment-phosphorus chemistry of Utah Lake. Sediment-phosphorus chemistry of the lake was prioritized for 2019 by the Utah Lake Water Quality Study (ULWQS) Science Panel to determine the sediment-phosphorus equilibrium, release of nutrients from the sediment, sediment oxygen demand, and related sediment chemistry in the lake. The target completion date of the work is December 31, 2019.

Please submit a grant proposal including a cost proposal to Emily Canton at ercanton@utah.gov by 5:00 PM MST May 22, 2019. Proposals must be limited to 10 pages; this page limit does not include resumes and project case studies that may be included in an appendix.

2 Background

The Utah Division of Water Quality (DWQ) recently initiated Phase 2 of the Utah Lake Water Quality Study (ULWQS) to evaluate the effect of excess nutrients on the lake's recreational, aquatic life, and agricultural designated uses and to develop site-specific nitrogen and phosphorus water quality criteria to protect these uses. The ULWQS is guided by the Stakeholder Process (Attachment A) developed during Phase 1, which established a 16-member interest-based Steering Committee and a 10-member disciplinary-based Science Panel. The Steering Committee has charged the Science Panel with developing and answering key questions to characterize historic, current, and future nutrient conditions in Utah Lake (Attachment B). Responses to the key questions will be used by the Steering Committee to establish management goals for the lake and by the Science Panel to guide development of nutrient criteria to support those goals.

Additionally, the Science Panel must complete a significant number of tasks to achieve its purpose of guiding the development of nutrient criteria including:

- Guiding the approach for establishing nutrient criteria
- Recommending and guiding studies to fill data gaps needed to answer key questions

- Interpreting and integrating study results into the rationale for nutrient criteria
- Guiding development of an approach for characterizing uncertainty
- Recommending science-based nutrient criteria to the Steering Committee

Problem Statement

Understanding the cycling of nutrients within Utah Lake will help describe the current state of the lake with respect to nutrients and ecology, and sediments are an important component of the nutrient cycling within the lake. Available reports and initial information on sediment oxygen demand (SOD) and nutrient release from sediments in Utah Lake provide some insight into sediment phosphorus characteristics and fluxes, but stop short of converting bulk measurements into mobile or bioavailable fractions. Available reports also provide some insight into the relationship between calcite and phosphorus in the lake. High calcite concentrations observed in surface sediments and cores suggest that carbonate precipitation from the Utah Lake water column, and possibly associated turbidity, have been components of the Utah Lake system for millennia, but not all available sediment core data are consistent.

Existing Data and Information

Hogsett and Goel (2013) report lake sediment phosphorus speciation and mineralogy, as well as sediment and water column oxygen demand. Merrell (2015) reports phosphorus and iron content of lake sediments and near-lake soils, as well as a qualitative description of phosphorus fluxes from lake sediments under oxic and anoxic conditions. It is noted in the Utah Lake Literature Review (Attachment C) that the results of the two studies differ in terms of reported percentage of lake sediment phosphorus that is bound to calcium.

Randall (2017) quantified lake sediment phosphorus in 26 sediment samples, with phosphorus concentrations ranging from 306 to 1,894 ppm, and the highest being from Provo Bay. Results showed that approximately 25–50 percent of phosphorus is bound with calcium minerals. The study also included batch sorption experiments, which indicate that lake sediments have a capacity to adsorb 70–96 percent of water column phosphorus over the range of 1 to 10 mg/L phosphorus.

Abu-Hmeidan et al. (2018) carried out a lake-wide sediment sampling study that showed similar phosphorus concentrations in lake sediment to those in surrounding soils (average of 666 ppm, typical range of 600-800 ppm), suggesting the importance of geological phosphorus sources to lake sediments. Phosphorus hotspots were located near known anthropogenic nutrient sources (a feedlot and tributary outlets containing wastewater effluent), and areas of low phosphorus were associated with groundwater seeps. Simple lab experiments designed to show the potential mobility of phosphorus from sediments were suggestive but not conclusive. The overall conclusion that the eutrophic state of the lake was due to natural phosphorus rather than anthropogenic phosphorus was not consistent with some observed data of phosphorus hotspots, and bioavailability of phosphorus in sediments was not actually quantified; only bulk phosphorus was quantified, much of which may not be bioavailable.

Brimhall and Merritt (1981) describe a 520-cm sediment core from Utah Lake, along with surface sediment analyses from 140 stations. Direct age control (e.g., radioisotopes or pollen) was not reported for the sediment core, but estimation of sedimentation rates based on assignment of a subsurface seismic reflector as corresponding to the last Lake Bonneville deposits yielded linear sedimentation rates of 0.8 to 1.5 mm/yr. Peat/sand at 450-cm depth in the core was assigned to the altithermal period (very arid) about 5,000 years ago. Surface calcite concentrations ranged from 35–80 percent and were lowest in bays and along the east shore, but highest in the north central area of the lake. Down-core calcite ranged from 20 to 30 percent of the sediment, with the balance attributed to silica (quartz, diatoms) and clays. A 0.5-meter-thick nepheloid/fluid mud layer was typically observed at the sediment surface during sampling.

Study Objectives

The objective of this research is to address the following questions identified by the Science Panel as critical to understanding the current state of Utah Lake with respect to nutrients and ecology:

- What are current sediment equilibrium phosphorus concentrations (EPC) throughout the lake? (Science Panel charge 2.4.i, Attachment B).
- What is the role of anoxia in nutrient releases and sediment dynamics over a range of phosphorus concentrations?
- What is the role of pH in water column–sediment interactions and nutrient releases? How does the equilibrium phosphorus concentration change over a range of water column pH?
- What is the sediment oxygen demand of, and nutrient releases from, sediments in Utah Lake under current conditions? (Science Panel charge 2.4.ii, Attachment B).
- What is the role of calcite "scavenging" in the phosphorus cycle? (Science Panel charge 2.3.v, Attachment B). What is the role of sediment resuspension on nutrient releases or removal, primarily via calcite scavenging?

Expected Outcomes and Outputs

When this study is completed, the Science Panel will be able to answer the study objectives listed above.

Specific outputs are expected to include, but are not limited to, a sampling and analysis plan (SAP), the project dataset, and a technical report. All data collected for this project must be made available to the Science Panel per the deliverable dates schedule in Section 6 of this RFP.

3 Supporting Materials

A number of reports and documents were developed during the course of the ULWQS and previous study efforts on Utah Lake. These documents are provided as attachments for reference during response development. Additional ULWQS information including data, reports, meeting summaries, meeting recordings, and other related materials are available at utahlake.deq.utah.gov. A list and brief description of the relevant materials is included here:

Attachment A. Stakeholder Process https://documents.deq.utah.gov/water-quality/watershed-protection/utah-lake/DWQ-2017-004494.pdf. This document prescribes the structure, objectives, and duties of the Steering Committee, Science Panel, and other organizations with a role in the ULWQS. This process is directed by an independent professional facilitation team.

Attachment B. ULWQS Phase 2 Purpose and Initial Charge to Science Panel from Steering Committee. This document describes the Initial High Level Charge questions developed by the Steering Committee and an initial list of key questions designed to answer each high level charge https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf.

Attachment C. Utah Lake Literature Review – This literature review was developed as a Phase 1 task and assessed the ability of existing literature and studies to answer the Initial High Level Charge questions presented in the ULWQS Phase 2 Initial Charge document. See select references in the Utah Lake Literature Review under *Topical Category 1: In-Lake Water Quality Conditions* for a list and findings of references relevant to historical conditions in Utah Lake. https://documents.deq.utah.gov/water-quality/locations/utah-lake/DWQ-2019-001842.pdf

Attachment D. Quality Assurance Program Plan for Environmental Data Operations, Final Plan, Revision No. 1.0, Effective September 5, 2014. https://deq.utah.gov/water-quality/quality-assurance-and-quality-control-program-monitoring-water-quality

References:

Abu-Hmeidan, H.Y., Williams, G.P. and Miller, A.W., 2018. Characterizing Total Phosphorus in Current and Geologic Utah Lake Sediments: Implications for Water Quality Management Issues. *Hydrology* 5(1): 8.

Brimhall, W. H. and Merritt, L. B. 1981. Geology of Utah Lake: implications for resource management. *Great Basin Naturalist Memoirs*: Vol. 5, Article 3.

Hogsett, M., and R. Goel, 2013. *Determination of nutrient fluxes and sediment oxygen demand at selected locations in Utah Lake*. Civil & Environmental Engineering, University of Utah, Prepared for: Utah Division of Environmental Quality.

Merrell, P. D., 2015. *Utah Lake Sediment Phosphorus Analysis*. M. S. thesis. Brigham Young University. Department of Civil and Environmental Engineering.

Randall, M. C. 2017. *Characterizing the Fate and Mobility of Phosphorus in Utah Lake Sediments*. M. S. thesis. Department of Geological Sciences. Brigham Young University.

Spears, B. M., L. Carvalho, R. Perkins, A. Kirika, and D. M. Paterson. 2007. Sediment Phosphorus Cycling in a Large Shallow Lake: Spatio-Temporal Variation in Phosphorus Pools and Release. *Hydrobiologia* 584(1): 37–48. https://doi.org/10.1007/s10750-007-0610-0.

4 Project Tasks

DWQ is seeking a qualified entity to provide technical support to the ULWQS Science Panel to assist with collecting information on Utah Lake sediment–water nutrient interactions. The tasks within this scope of work reflect a recommended approach for this work and are designed to help the proposer meet the study objectives and expected outputs and outcomes, which support the Science Panel in accomplishing its duties and fulfilling the Steering Committee's Charge (Attachment B). Proposers should feel free to include additional tasks in the proposals as they see appropriate to best achieve the study objectives and expected outcomes.

The deliverables for tasks presented in this Scope of Work will be reviewed collaboratively with the DWQ and ULWQS Science Panel. The selected contractor will work closely with the Science Panel to perform each task and is expected to be responsive to input and guidance provided by the Panel. If, during the course of the project, there are deviations from the project tasks as described here, the selected contractor should contact the Science Panel and come up with a mutually agreed upon course of action.

Task 1. Develop sampling and analysis plan (SAP)

A sampling and analysis plan (SAP) will be developed in accordance with the Utah DWQ's *Quality Assurance Program Plan for Environmental Data Operations, Final Plan* (Revision No. 1.0, see Attachment D). The essential elements for SAPs are listed in Appendix A of the *Quality Assurance Program Plan* and are as follows:

1. Introduction and background information
2. Objectives and design of the investigation
3. Special precautions and safety plan
4. Field sampling methods and documentation
5. Laboratory sample handling procedures
6. Analytical methods and laboratory documentation
7. Project quality control requirements
8. Data analysis, record keeping, and reporting requirements
9. Schedule and budget
10. Project team and responsibilities

Expected Deliverables

- Draft and final sampling and analysis plans in accordance with the Utah DWQ's Quality Assurance Program Plan for Environmental Data Operations, Final Plan.

Proposal Elements

Responses should:

- Provide demonstrated experience with developing sampling and analysis plans.
- Discuss a proposed approach for developing the deliverable for this task.

Task 2. Collect sediment cores from Utah Lake

Collect 78 cores with overlying water from two sites: a site in Provo Bay and a site in the main body of Utah Lake at an established DWQ monitoring site. Minimum core length is 20 cm. Cores will likely be collected by gravity corer or Jenkin surface sediment sampler by boat, or by SCUBA diving. Cores should be preserved in the dark and on ice for transport to the laboratory.

Expected Deliverables

- Electronic files with field observations

Proposal Elements

Responses should:

- Provide demonstrated experience with collecting sediment cores in shallow lakes for purposes of achieving the objectives described above.
- Discuss a proposed approach for developing the deliverable for this task.

Task 3. Perform sediment core experiments and laboratory analysis

Three experiments will be performed in the laboratory under dark conditions, following the general approach used in Spears et al. (2007). The experiments will be performed on cores collected from two sites in Utah Lake—one site in Provo Bay and one site from the main body of the lake at an established DWQ monitoring site.

1. Aerobic conditions: Collect 12 cores per site, and apply the following laboratory treatments, with three replicates of each:
    a. Control: ambient P concentration
    b. 0.5 x ambient P concentration (dilute with reconstituted Utah Lake water)
    c. 2 x ambient P concentration
    d. 4 x ambient P concentration

   To generate turbulence and maintain suspended sediment throughout the experiment (~50 NTU), use a shaker table or an airstone and pump placed immediately above the unconsolidated sediment. Proposers may suggest alternative approaches to generate turbulence. Remove water samples from the bottom water at the beginning and end of ~72-hour incubation and analyze for soluble reactive phosphorus (SRP) and calcite. The proposer may suggest additional analytes (e.g., NH4-N or NOx-N); if additional analytes are proposed, the justification should be included in the proposal. Calculate change in SRP in overlying water and plot change in SRP vs. overlying water SRP concentration. Estimate equilibrium P concentration using linear regression.
2. Anaerobic conditions: Using the cores from experiment #1 after it has been completed, generate anaerobic conditions and estimate equilibrium P concentration for the same treatments as in experiment #1. Additional cores do not need to be collected for this experiment.
3. pH gradient: Generate turbulence in the same way as in experiment #1, and estimate equilibrium P concentration for two additional pH conditions.

In addition to the above three experiments, SOD will be measured in triplicate using sediment cores or *in-situ* at each site.

Table 1 summarizes the number of cores per experiment and identifies the cores that can be used for multiple experiments. 39 cores are needed for each of the two sites, for a total of 78 cores.

Table 1. Sediment core specifications

Experiment # (see above list)	Number of Cores	Dissolved Oxygen	Phosphorus Concentration	pH
1, 2, 3	3	Aerobic, then anaerobic	Ambient	Ambient (~8.5)
1, 2, 3	3	Aerobic, then anaerobic	0.5x	Ambient (~8.5)
1, 2, 3	3	Aerobic, then anaerobic	2x	Ambient (~8.5)
1, 2, 3	3	Aerobic, then anaerobic	4x	Ambient (~8.5)
3	3	Aerobic	Ambient	7.0
3	3	Aerobic	Ambient	9.5
3	3	Aerobic	0.5x	7.0
3	3	Aerobic	0.5x	9.5
3	3	Aerobic	2x	7.0
3	3	Aerobic	2x	9.5
3	3	Aerobic	4x	7.0
3	3	Aerobic	4x	9.5
SOD	3	–	–	–
Total # cores per site	*39*			

Expected Deliverables

- Electronic files with observations and laboratory results

Proposal Elements

Responses should:

- Provide demonstrated experience with performing sediment core experiments to calculate equilibrium phosphorus concentrations.
- Discuss a proposed approach for performing the sediment core experiments and laboratory analyses.

Task 4. Prepare technical report

Methods, results, and discussion that answers the study objectives. The technical report will include calculations and results of sediment equilibrium phosphorus concentrations under aerobic conditions, anaerobic conditions, and a pH gradient. It will also include estimates of sediment oxygen demand.

Expected Deliverables

- Draft and final technical reports

Proposal Elements

Responses should:

- Provide demonstrated experience with developing technical reports of this nature.
- Discuss a proposed approach for drawing conclusions from the experiments and developing the technical report for this task.

5 Key Personnel

Grant proposals should discuss in detail the team members proposed for each task, their directly related experience and expertise, and the allocation of effort among team members. Responses must detail the allocation of proposed hours for each task and team member in the table below. Please also include team members and time allocation for project management, project support such as technical editing and GIS, and other allocations not directly associated with the tasks and deliverables presented in this scope.

Task #	Deliverable	Team Member (hours)	Team Member (hours)	Team Member (hours)	Team Member (hours)
1	Deliverable 1				
	Deliverable 2				

6 Deliverables and Preliminary Due Dates

Deliverable due dates are based upon days from the contract award date. The project and all deliverables must be completed with consideration of the milestones in the table below, the scope of work response, and the final work plan after scope award. Any change in the execution date of the contract must result in a mutually agreed upon change in deliverable dates. All final products generated by the contractor will be transmitted to UDWQ in a mutually agreed upon format prior to the expiration of the contract.

Task	Deliverable	Due Date
Task 1 – Develop Sampling and Analysis Plan	Draft sampling and analysis plan (SAP) Final SAP	14 days after scope award 30 days after scope award
Task 2 – Collect Sediment Cores	Electronic files with field observations	80 days after scope award
Task 3 – Perform Sediment Core Experiments and Laboratory Analysis	Electronic files with observations and laboratory results	110 days after scope award
Task 4–Prepare Technical Report	Draft technical report Final technical report	150 days after scope award 170 days after scope award

7 Science Panel Collaboration and Data Sharing

Grant recipients are required to complete this scope of work in collaboration with the ULWQS Science Panel. Grant recipients will:

- Develop the final research work plan in consultation with the Science Panel;
- Be responsive to Science Panel input on the final approach, work plan, work plan execution deliverables, results, analysis, final report, and any other interest to the Science Panel;
- Make all data and information collected by this grant, or funded by the ULWQS, available to the Science Panel within 45 days of field or laboratory analysis.;

8 Evaluation and Award

Offers will be evaluated based on the following criteria listed in relative order of importance:

Selection Criteria	Weight
Key Personnel proposed for project work (experience, expertise, and reliability) and experience of specific team members proposed for discrete tasks	20%
Method of approach and proposer's ability to perform the requirements of the grant	20%
Demonstrated understanding of work elements in the context of existing products, the Utah Lake ecosystem, and the Science Panel Initial Charge	20%
Proposed approach for Science Panel collaboration and data sharing	20%
Price	20%

9 Cost Proposal Form

Offers must include a cost proposal utilizing the format provided below. Please ensure the cost proposal can be removed from the proposal for independent evaluation by including it as an attachment to the proposal or as a separate section at the end of the proposal. Note that indirect costs may not exceed 10% on contracts with other state and local governmental agencies, including colleges and universities.

Task #	Deliverable	Proposed Cost (USD)
Total		

10 Instructions for Grant Proposal Preparation

Proposals must include the following elements to qualify:

1) Proposals must follow the proposal template presented in Section 11
2) Proposals must:
    a. Include a discussion of successfully completed projects relevant to the specific deliverables in this scope of work;
    b. Demonstrate that proposed team members have direct experience with and are qualified for conducting the specific tasks and deliverables for which they are proposed. Team member qualifications and resumes must be included as an appendix to the proposal. Resumes will not be counted against the proposal page limit;
    c. Specify all project roles for the proposed team members including, but not limited to, project management, analytical tasks, GIS, technical editing, and any other proposed roles;
3) Proposed approach for how each task will be performed to achieve the purpose and deliverables outlined in this Scope of Work. Applicants may propose supplemental work elements necessary to achieve the expected outputs and outcomes;
4) Schedule for key milestones and deliverables;
5) A table of estimated level of effort for each team member by task utilizing the provided template (in Section5); and
6) A stand-alone cost proposal table utilizing the provided template (Section 9) to include key personnel rates, hours and rates for completing specific tasks and deliverables, total proposed hours, indirect costs, overhead, and total cost.

11 Proposal Template

1. Experience and Expertise
   1.1. Related project experience
   1.2. Experience and expertise of key personnel
2. Proposed Approach
   2.1. Task 1 (repeat for each task)
      2.1.1. Key team members
      2.1.2. Approach discussion
         2.1.2.1. Approach for required Scope of Work deliverables
         2.1.2.2. Supplemental approach
         2.1.2.3. Task milestones and deliverables
3. Approach for Science Panel Collaboration and Data Sharing
4. Project milestones and deliverables
   4.1. A table of project milestones and deliverables
5. Level of effort
   5.1. A table with level of effort estimates
6. Cost Proposal
   6.1. A stand alone cost proposal table
7. Resumes (not counted toward page limit)
8. Related Case Study (not counted toward page limit)

12 Notice to Proceed

Notice to proceed will be provided by DWQ after receiving a signed grant agreement and Science Panel approval on the final work.

Work Plan

Paleolimnology and Paleoecology of Utah Lake

Brahney, J.[1], Power, M.[2], Brothers, S.[1]

[1] Department of Watershed Sciences, Utah State University, 5210 Old Main Hill, Logan UT 84322

[2] Natural History Museum of Utah, Department of Geography, University of Utah, Salt Lake City, UT

This work plan provided details on how each task will be completed including rationale and methods. Answers to questions posed by the science committee are highlighted in blue. A timeline and budget is provided for each task and subtask.

Task 1: Develop sampling and analysis plan (SAP)

Key team members

- Dr. Janice Brahney, Dr. Mitchell Power, Dr. Soren Brothers

Approach discussion

Upon approval of the grant agreement all PIs will work in conjunction to develop the Sampling and Analysis Plan (SAP). All PIs collectively have over 50 years of experience conducting research and developing SAPs.

Approach for required Scope of Work deliverables

Upon grant receipt the PIs will develop the SAP in accordance with DWQ's "Quality Assurance Program Plan for Environmental Data Operations", including all essential elements described in Appendix A of the same document. These include,

1. Introduction and background information
2. Objectives and design of the investigation
3. Special precautions and safety plan
4. Field sampling methods and documentation (where applicable)
5. Laboratory sampling methods and documentation
6. Analytical methods and laboratory documentation
7. Project quality control requirements
8. Data analysis, record keeping, and reporting requirements
9. Schedule and budget
10. Project team and responsibilities

Supplemental approach *NA*

Task 1 milestones and deliverables

The SAP will be drafted and delivered to DEQ within two weeks of approval of the grant agreement. PI Brahney will be responsible for delivering the SAP on time. Associated costs are included in the month of salary requested by PI Brahney.

Task 2. Collect and Preserve Cores

Key team members

- Dr. Janice Brahney, Dr. Mitchell Power, Dr. Soren Brothers

Approach discussion

Utah Lake is a large (385 km^2) shallow lake with multiple point and nonpoint sources of pollution and other influences. As such, reconstructing the limnological changes that have occurred in recent history of such a large lake will require multiple sediment cores to evaluate changes in the distinct sub-basins. We will use existing sediment cores from 4 locations including Provo Bay (PB), Goshen Bay (GB), Bird Island (BI), North of Provo Bay (NPB), and the northern reach (N) in the main body of the lake (Figure 1). These sites were chosen as representative of the basin for four reasons; i) Provo Bay is a shallow distinct bay that has a unique chemistry and biology[1], ii) Harmful Algal Blooms (HAB's) occurring frequently in Utah Lake often begin in Provo Bay or Goshen Bay *(pers. Comm. S. Daly*), both of which are expected to have the lowest effective fetch, iii) the Bird Island site is the deepest area of the lake and represents a pelagic region with a higher probability of minimizing wind mixing, iv) site NPB will provide reference for the northern basin.

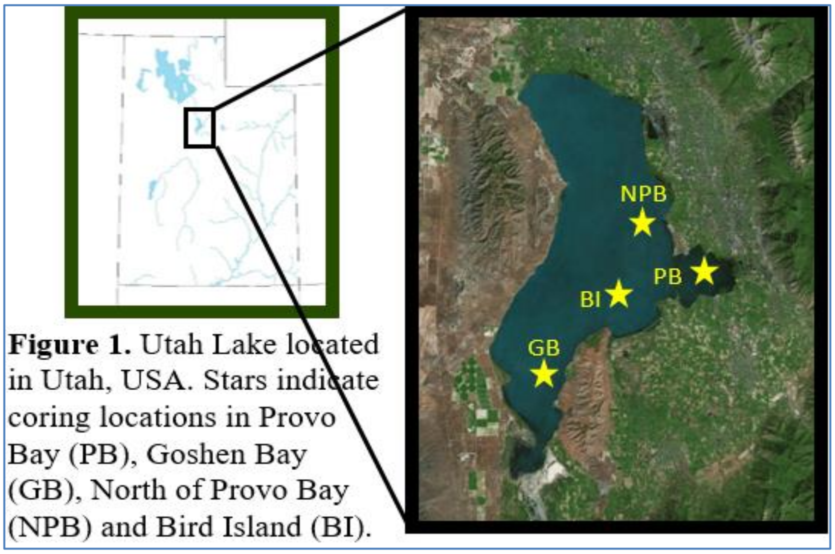


Figure 1. Utah Lake located in Utah, USA. Stars indicate coring locations in Provo Bay (PB), Goshen Bay (GB), North of Provo Bay (NPB) and Bird Island (BI).

Existing lake sediment cores (collected in 2011-2018) will be used for the bulk of these analyses. These cores were collected using a Livingston/Bolivia piston coring system that can recover 1.0 to 1.5 m-long sediment cores with each drive. Drs Brahney and Power have archived multiple sediment cores from Utah Lake, providing over 10,000 years of history from the Utah Lake basin. Existing sediment cores have been stored in refrigerated conditions at the Natural History Museum and Environmental Biogeochemistry and Paleolimnology Lab (EBPL) at Utah State University. These existing cores will be subsampled at 0.1 to 0.5cm resolution. Uncontaminated samples from the interior of the core will be collected using sterilized protocols to recover eDNA samples and fossil pollen samples, as well as additional material for nutrient, isotope and fire history analyses. Piston cores have been split lengthwise and have undergone initial core description (ICD) which includes cleaning and logging of the stratigraphy in detail, photography, smear slide analysis, and sediment classification according to accepted protocols. ICD also includes multisensory logging from the LacCore facility at the University of Minnesota, including magnetic susceptibility, X-radiography, and X-Ray Fluorescence. This data combined with Loss on Ignition (LOI) (1 cm resolution), which is used to determine water, organic, and carbonate content, will be used to define facies changes and lay the foundation for further sampling and analysis (see below).

Note that LOI is used for facies determination only and not for absolute reconstructions of organic matter concentrations due to uncertainties associated with loss of water vapor from clay minerals. Organic carbon mass (see below) will be used to assess organic matter concentrations.

We will collect an additional 7 “short cores” from nearshore areas to assess changes in macrophyte species using plant fossil remains. Because large plant fossil remains typically do not travel far and because large volumes of sediment are required, sediment cores from nearshore environments are required to examine macrofossil remains[41]. These cores will be collected to approximately 50 cm depth using a hand auguring method. Macrofossil remains will be examined from top and bottom sections of the core to assess current versus historical condition. *Note these cores will not be analyzed for stratigraphy, sectioned, or dated.

Approach for required Scope of Work deliverables

Replicate cores and archive halves from PB, GB, BI, and NPB are stored on-site at the EBPL in the Natural History Museum of Utah as well as archived at the LacCore National Lacustrine Core Facility. Sediments archived at LacCore are available to outside researchers, metadata is available through their website and images are available upon request.

Supplemental approach

Additional cores from the main body of the lake were not proposed due to the less than one-year time frame and potential budget constraints associated with recommended procedures around core collection and ICD, as well as additional analytical and person costs (about $27K). However, there may be value in collecting an additional core from the north basin. Specifically, this may help address the distribution of macrophytes in the sub-basins and examine how the basin may capture spatial differences between major inflows and outflows that may not be represented in the North of Provo Bay core. Macrophyte distribution to an extent will be covered by the proposed additional nearshore cores led by PI Brothers. Note also that diatoms (Grimes and Rushforth 1983) and sediment phosphorus (Abu-Hmeiden 2018) data do not suggest that the pelagic region of the north basin would be substantively different from the Bird Island or North Provo Bay sediment records. Additional costs and time associated with this endeavor are outlined in the timeline and budget sections labeled SACores for all Tasks below.

Task milestones and deliverables

Four sediment cores have been previously collected, split, logged, photographed, and archived at the EBPL, LacCore, or UofU. Metadata is available through the LacCore National Lacustrine Core Facility. All data is also available upon request from the PIs.

Task	Deliverable	Proposed Cost
2	Core Collection and archiving (BI, PB, GB, NPB)	$0.00
2	Nearshore cores (5)	$400.00
SACore		
2	Core Collection and Archiving (N)	$4,000.00

		2019		2020
	Completed	Summer	Fall	Winter
Collect: sediment cores from (PB, GB, BI) *(Brahney)*				
Archive: Split, ICD, and Archive Cores *(Brahney)*				
Data: Archive core metadata available online (PB, BI) *(Brahney)*				
Data: Core metadata available upon request (GB) *(Brahney)*				
Collect: sediment cores from (NPB) *(Power)*				
Archive: Split, ICD, and Archive Cores *(Power)*				
Data: Core metadata available upon request (NPB) *(Power)*				
Collect: sediment cores from nearshore locations *(Brothers)*				
Data: Core metadata available upon request *(Brothers)*				
SACore				
Collect: sediment core from north of Provo outlet (N) *(Brahney, Power)*				
Archive: Split, ICD, and Archive Cores (N) *(Brahney)*				
Data: Archive core metadata available online (N) *(Brahney)*				
Data: Core metadata available upon request (N) *(Brahney)*				

Task 3 Analyze Cores

Key team members

- Dr. Janice Brahney, Dr. Mitchell Power, Dr. Soren Brothers, Students *to be identified*

Approach discussion

Dating cores **(Task 3.1)** PI's Brahney and Power

Multiscanner information (described above) and LOI will be used to describe major facies changes in the sedimentology of Utah Lake, defining periods when abrupt or gradual shifts took place. This information along with age-models will allow us to determine when major ecological changes took place and to calculate sedimentation rates, which can inform on watershed loading of nutrients either through natural or anthropogenic process.

Sediments will be primarily dated using ^{210}Pb and when available radiocarbon dates may supplement the record. Lead-210 dating analysis will be conducted at the University of Regina, Leavitt Lab and radiocarbon at the Keck Facility, University of California Irvine. The EBPL has been checked and cleared for radiocarbon contamination. Cesium-137 will be used as define a marker horizon as well as to establish the degree of mixing within Utah Lake sediments. Cesium-137 was produced during nuclear weapons testing and so first appears in atmospheric fallout in 1952 and peaked in 1963. Thus, ^{137}Cs can be used as a tool to determine the degree of sediment mixing based on the abruptness of the 1963 peak. Age-depth models with uncertainty will be produced using Bayesian techniques (BACON) and data will be reported and archived as recommended[2,3]. There is a high-probability that constant wind mixing of Utah Lake sediments will diminish our capacity to accurately date recent events in the sediment record; however, we plan to use additional information such as eDNA (see below) and pollen to define strata where exotics (e.g. dandelions) and cultigens (e.g. plums, cherries) are represented as Euro-American maker horizons. The BACON model allows for multiple sources and types of geochronological data including, ^{210}Pb, marker horizons, and radiocarbon. The age-models produced will include an estimate on error based on sedimentation prior and uncertainties in the ^{210}Pb dates and ^{137}Cs marker horizons.

Because Utah Lake is currently turbid with frequent wind-mixing, we anticipate that the historical sediment chronology could have some degree of uncertainty as compared to the more ancient, deep stratified lake system, present over ~10,000 years ago. To illustrate, a dated sediment layer within the last decade would typically come with an error of +/- 2 to 5 years, but we may anticipate the error to be +/- 5-8 years. Error estimates for each sediment interval will be provided as determined in the Bayesian age-model described above. Despite potential chronological uncertainty, the multi-proxy nature of our proposed study will still provide important context based information with respect to how the lake changed through time pre- and post-anthropogenic disturbance. For example, we anticipate being able to distinguish between an abrupt impact, e.g. carp introduction in 1881, versus the gradual effects of increasing anthropogenic influence on nutrient concentrations through time.

Preliminary data: Multiscanner data including magnetic susceptibility (MS) has been completed on all cores. MS is a measure of concentration of ferromagnetic materials in the sediment[4,5], and indicates periods of accentuated minerogenic sediment supply through time. Preliminary analysis suggests the upper 50 cm and below 350 cm in the Utah Lake sediments were interrupted by periods of low supply. NPB (Power) has been dated using ^{210}Pb and Goshen Bay has been submitted for ^{210}Pb and ^{137}Cs analysis. Upon receipt of the grant, BI and PB sediment samples will be submitted for analysis.

Task	Deliverable	Proposed Cost
3.4	Core Dating (NPB complete), Bim,PB, GB	$4,500.00
SACore		
3.4	Core dating (N)	$1,500.00

*Please note that dating can take 8 months or longer.

<u>Nutrient, elemental, and isotopic composition of cores (N, P Si)</u> **(Task 3.2)**

We will use a combination of well-established and novel methodologies to reconstruct historical trophic characteristics of Utah Lake including proxies for historical phosphorus and nitrogen loading. Elemental characterization of the cores will be used to evaluate shifts in sediment sourcing and potentially mixing conditions as in Brahney et al. (2008).

Phosphorus PI Brahney

Reconstructing historical water column phosphorus concentrations from lake sediments has been a longstanding challenge due to the post depositional mobility of P within sediments[6,7]. Because of this process, *total P or pore-water P cannot be used to determine historical P loading*[8]. Alternative means for reconstructing historical phosphorus concentrations rely on complex statistical relationships using diatom communities. These generally require sampling dozens of similar lakes to establish a relationship between diatom communities and ambient phosphorus concentrations before applying this information to sediment core records[9]. Beyond the significant time commitment involved in producing regional diatom-phosphorus calibration sets and historical sediment records, these reconstructions are fraught with statistical and practical uncertainties[10]. We instead will reconstruct historical P loading using two methods. First, since the RFP requires the use of the standard methods, we will use an existing method[11] to sequentially extract different phosphorus fractions including, exchangeable, Fe-/Me-bound, organic, and the acid-soluble (“calcite”) fraction. The only fraction that is unlikely to undergo post-depositional alteration within the alkaline environment of Utah Lake is the calcite fraction[12]. However, most extraction methods are not target specific leading to operational (acid-leachable) rather than true sediment fraction categories (e.g. calcite). For example, the acid leach will also target humic-P and some Fe-P minerals[13,14]. Sequential leaching can also mix between operational categories where P leached from the Fe-/Mn-leach can attach itself to calcium, artificially elevating the acid leachable (“calcite”) fraction.

Based on these uncertainties, we will also use a novel technique to reconstruct ambient water column P concentrations. Specifically using a Scanning Electron Microscope with Energy Dispersive X-Ray (SEM-EX) and Laser-Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) we will measure phosphate inclusions in calcite precipitated in the water column as a measure of epilimnion phosphorus concentrations. The method is based on the premise that the precipitation of calcite ($CaCO_3$) in the water column will incorporate PO_4^{3-} at concentrations that parallel ambient water column conditions. It is well established that phosphate binds strongly to calcite and can scavenge phosphate from the water column[15]. Because conditions within lake sediments do not generally promote calcite dissolution particularly in Utah Lake[16] post depositional alteration of this fraction is not likely. Thus, P incorporated into crystalline calcite may accurately record relative, even quantitative, shifts in Utah Lake water column phosphorus. To test this hypothesis we have performed a preliminary laboratory experiment at Utah State University (USU).

Preliminary data: Precipitation of $CaCO_3$ in phosphate-spiked solutions was studied to determine the relationship between calcite scavenged P and initial concentrations (r^2 of 0.996, $p << 0.001$). We further examined P scavenged by calcite using SEM-EDX and LA-ICP-MS to relate starting P concentrations to SEM-EDX determined P. This step is crucial to establish the relationship between water column P and sediment core crystalline calcite-P, which can only be determined via SEM-EDX or LA-ICP-MS analyses. This experiment was also successful producing an r^2 of 1, $p << 0.001$. The success of Experiment 1 and 2 have indicated this method will likely provide, for the first time, a paleolimnological record of ambient phosphorus concentrations using a direct method for reconstruction. As described above, select sediment samples from each of the Utah Lake cores will be analyzed for phosphorus concentrations within crystalline calcite using SEM-EDX and LA-ICP-MS. Samples run on the SEM-EDX will be processed and analyzed under the guidance of Dr. Greg Carling (letter of collaboration attached). LA-ICP-MS will be conducted at USU.

Task	Deliverable	Proposed Cost
3.2	Phosphorus reconsturction data	$5,280.00
SACore		
3.2	Phosphorus reconstruction data (N)	$1,760.25

<u>*Carbon and Nitrogen Mass and Isotope Composition PI Brahney and Power*</u>

Because different sources of nitrogen have distinct isotopic compositions, relative changes in $\delta^{15}N$ will be used to track wastewater effluent (10-15‰) as compared to other sources including, inorganic fertilizers (0‰), atmospheric deposition (<0‰), and natural terrestrial sources (0-5‰)[17]. Carbon isotopes can also be used to distinguish between different sources and in-lake processing[18].

Sediment samples for $\delta^{13}C$ and $\delta^{15}N$ will be analyzed at 5-cm intervals through each core to establish long-term trends in nutrient fluxes in Utah Lake. Each sample will consist of an aliquot of 600–700 mg of sediment and be weighed into centrifuge vials and placed in an oven to dry for at least 48 hours at 60°C. Two subsamples of about 300mg each will then be transferred to new pre-labeled centrifuge vials. One of the 300mg samples destined for elemental (organic carbon and nitrogen) and isotope analysis will be fumigated with dilute hydrochloric acid to remove carbonates so that the analysis constitutes only the organic fraction. The other 300mg sample will be left untreated and used for carbonate analysis. The sediments samples destined for organic matter isotope analysis will be further rinsed to remove halides, dried, and homogenized by crushing in a petri dish. The homogenized samples will then be weighed in compressed tin capsules and analyzed together with internal laboratory standards of known isotopic and elemental composition. The samples will be combusted in a Costech 4010 Elemental Analyzer at 1650ºC and inlet to a Finnigan® MAT 252 Isotope Ratio Mass Spectrometry (IRMS) in continuous flow mode. The stable isotope analyses will be done in the Geochemistry laboratory directed by Dr. Cerling at the University of Utah and in the Newell Lab at USU. Carbon and nitrogen are both subject to post-depositional alteration (diagenesis) and methods developed by Brahney et al. 2014 will be used to distinguish between diagenesis and other influences

Preliminary data: Carbon and nitrogen mass and isotopes have been completed on 3 of 4 cores and indicate abrupt shifts in nutrient sources above >30cm.

Task	Deliverable	Proposed Cost
3.2	Carbon/Nitrogen Mass Isotope Data (NPB, GB, PB complete) (BI)	$450.00
SACore		
3.2	Carbon/Nitrogen Mass Isotope Data (N)	$450.00

Elemental (and organic) Composition PI Brahney and Power

Sediment geochemistry can provide critical information on both changing sediment sources through time as well as conditions at the sediment-water interface including lake mixing[19]. Given the shallow nature of Utah Lake and extensive fetch, it is unlikely that the lake would stratify to the point at which suboxic condition might develop near the sediment water interface. However, if historically widespread macrophyte beds were capable of stabilizing sediments and reducing water turbulence, intermittent suboxic conditions might have occurred in a naturally mesotrophic system. Elemental ratios of redox sensitive elements (e.g. Fe/Mn) can be used to infer changes in oxygen concentration because the Mn-oxides are preferentially reduced compared to Fe-oxides[8]. Geochemistry will be determined using scanning X-ray fluorescence (XRF) on split cores at LacCore in Minnesota. An additional 25 samples from each core will be analyzed for elemental composition using ICP-MS. Organic and carbonate accumulation will be determined using percent loss-on-ignition (LOI). LOI is accomplished by drying sediments, obtaining the dry weight, combusting at 550°C for two hours, and then weighing samples again. LOI analysis will be done in the laboratory facilities of Natural History Museum of Utah and in the EBPL at Utah State. The measurement of sediments minerals (e.g., haematite and goethite) will help determine the variations in sedimentation rate in Utah Lake from wind and hydrological changes[20] and variations in organic matter, evaporites, or diagenesis through time. X-ray diffraction (XRD) will be used to quantify the mineralogical composition of the sediment core. The method relies on the unique absorbance characteristics of minerals to X-ray radiation and has been effectively used in quantifying calcite (Ca) to aragonite (Ar) ratios. Ca/Ar ratio provides a sensitive indicator of lake level depth and will offer an independent proxy for evaluating lake level fluctuations in Utah Lake through time and the potential influence on trophic characteristics and sediment mixing. XRD analysis will be done in RED Lab at the University of Utah.

Task	Deliverable	Proposed Cost
3.2	Elemental Composition Data ICP	$2,500.00
SACore		
3.2	Elemenetal Composition Data (N, GB)	$4,350.00

Historical diatom and macrophyte community record **(Task 3.3)**

Historical Macrophyte PI Brahney

The historical presence or absence of regional macrophyte species will be assessed through 1) physical fossil remains of plant matter within the PB, GB, BI cores, 2) pollen if present, 3) carbon and nitrogen mass ratios and isotopes, and 4) Rock-Eval pyrolysis, and 5) eDNA analysis (see below). Carbon to nitrogen ratios and Rock-Eval pyrolysis have previously been successfully used to distinguish between algal and plant biomass within lake sediments[18,21,22]. Similarly, these analyses within Utah Lake sediment cores will be used to determine, both in time and in space, whether a transition from a clear water macrophyte- to a turbid algal-dominated system occurred.

The presence or absence of vegetation remains embedded within the sediments will be recorded and documented during sediment core logging at USU and at the University of Utah. Carbon and nitrogen concentration in cores can be used to determine historical production with greater concentrations reflecting greater production, and C:N ratios can effectively be used to distinguish between algal versus plant derived sources because plants contain greater C-rich structural compounds compared to protein (N)-rich algae[18]. Rock-Eval pyrolysis will be conducted at BYU and can provide more detailed information on the character of the organic matter preserved in the sediments. By looking at the relative concentrations of H, C, and O within preserved organic material, we can discern whether that organic matter is more similar to plant derived products (lignin, cellulose) versus algal products (lipids, proteins).

Historical Macrophyte and Benthic vs Pelagic Production PI Brothers

The primary objectives of this component of the investigation are 1) Produce direct evidence of historic submerged macrophytes in Utah Lake 2) Calculate current and historic benthic and planktonic primary production rates in Utah Lake.

Objective 1 will be carried out by retrieving near-shore sediment cores from multiple lake areas (representing the full lake) and analyzing them for historic changes in submerged macrophyte communities in Utah Lake's littoral-zone. The loss of historic species such as *Chara aspera* and *Ceratophyllum demersum* may reflect either carp invasion and/or anthropogenic eutrophication of the lake[42,43]. Through literature analyses and consultation with submerged macrophyte experts, we also plan to infer historic water quality and transparency conditions in Utah Lake, as required for the various submerged macrophyte species. To carry out this work, we plan to carry out a top-bottom survey of undated sediment cores from seven littoral locations to identify lake areas where *C. aspera* oospores are present in the sediment record.

For Objective 2, diel dissolved oxygen (O_2) curves following Staehr et al. 2010[44] and using the R package "LakeMetabolizer[45]" will be calculated using data from in-lake monitoring station oxygen probes to determine current lake primary production rates (technically integrating benthic and planktonic sources). These rates will be compared to models describing benthic and planktonic primary production in Utah Lake (following Brothers et al., 2016; 2017a), and will be used to validate current primary production rates, and further provide more reliable estimates for primary productivity for months of the year for which dissolved oxygen data are unavailable. Given that submerged macrophytes have minimum light requirements for underwater photosynthesis, and our models for planktonic and benthic primary production both require light as an input variable, we plan to coordinate our paleolimnological and modelling approaches to derive historic estimates of whole-lake benthic primary production. We may further apply these data to estimates of the fractional coverage of Utah Lake's sediments by submerged macrophytes, which may provide insights into whether the community was large enough to historically influence lake-wide phytoplankton productivity[46].

Our modeling of the current and historical pelagic and benthic primary productivity of Utah Lake will provide a valuable and important two-way service with respect to analyzing macrophyte remains in near-shore sediments, as well as improving our understanding of the historical water quality/conditions of the lake. Identifying macrophyte presence in localized nearshore cores will provide us with some key initial information which would help produce more realistic historical models regarding water clarity across the lake, allowing us to better reconstruct the likely historic extent of benthic primary producers in the lake. This could in turn provide evidence to a period of greater sediment stability from wind mixing events, and allow us to further examine net historic changes in the lake's primary productivity over the past 150 years.

Figure 2. Nearshore hand augering coring sites for historical macrophyte cover.

Sites will be chosen based on accessibility by car, and chest waders will be used for entering the lake zones (Figure 2). In areas where there is visible evidence of frequent traffic (i.e. boating, recreating), efforts will be made to locate sites of minimal physical disturbance to retrieve cores which are most likely to contain historic macrophyte materials. All selected sites will be documented by GPS and photographs. Two cores from each location will be taken by hand from relatively shallow sites (~30-50cm water depth), and efforts will be made to retrieve approximately 50cm of material (following initial analyses which indicate a historic shift in Utah Lake's sediment records at 30 cm). Clear polycarbonate tubes will be used by hand to retrieve the sediment and promptly photographed. Coring site descriptions will be recorded for each core (i.e. GPS location, apparent frequency and type of local traffic, local emergent macrophyte coverage, etc.). Approximately 200g of material will be taken from the surface and bottom (50cm deep) of each core and carefully transferred to a Whirl-Pak bag which will be labeled and stored in a cool for transport back to USU, where samples will be analyzed. For any locations where emergent macrophyte roots or other sediment conditions make retrieving 50cm by hand with a tube corer too difficult, a backup Russian peat corer will be used to retrieve sediments

Task	Deliverable	Proposed Cost
3.3	In-Lake core analysis for macrofossile remains (N,PB,BI, GB)	$0.00
3.3	Nearshore core collection for macrofossil analysis	$3,014.97
3.3	Benthic vs pelagic production modeling	$9,507.99

**Note Brothers Summer Salary is included here within the production modeling scope whereas salary for other PI's and students are included in Tasks 4 and 5.*

Historical diatom community composition (PI Power and Brahney)

Diatom analysis will be conducted externally at BSA Environmental who indicated they could meet the tight timeline. Diatoms sample preparation and counts will follow standard methods used by BSA that do not include diatom production. Standard preparation methods involves chemical digestion (hydrogen peroxide and potassium dichromate) of organic matter in a pre-determined volume of sediment (approximately 0.25 cubic centimeters), and the washing and rinsing off organic residues with distilled water. Diatom slides are then prepared on a heated plate by adding a few drops of mounting solution with sufficiently high refractive index (e.g. Pleurax/Naphrax) and covering the slides with cover slips and counted using oil emersion at 1000X. Note that diatom taxonomic data will be provided before the January 2020 deadline, but interpretation of this data through statistical analysis may take additional time depending on the delivery date of the data. The diatoms will provide a means of evaluating the past changes in lake water salinity, pH, temperature, and nutrient budgets[47]. Specifically, diatoms community shifts will be evaluated using statistical methods including non-metric multidimensional scaling and cluster analyses to define distinct shifts in community composition. Where data is available, diatom taxa will be categorized according to their preferred habitat conditions including trophic status, growth habitat (pelagic, benthic, epiphytic, etc), and other physical habit requirements such as pH and/or temperature.

Task	Deliverable	Proposed Cost
3.3	Diatom analysis (PB, BI, GB) (25 samples per core)	$22,500.00
SACore		
3.3	Diatom analysis (N)	$7,500.00

Photopigments (Task 3.4) PI Brahney

We will use several complementary methods to reconstruct algal production within the lake including 1) algal pigments, 2) diatom production, and 4) eDNA (see below). Algal pigments preserved within Utah Lake sediments will be analyzed using methods outlined in Leavitt and Hodgson (2001) at the University of Regina by Dr. Peter Leavitt. Pigment analyses can be used to reconstruct shifts in algal species that would not otherwise produce a fossil. For example, Echinenone, Myoxanthophyll, and Zeaxanthin can be used to quantitatively reconstruct cyanobacteria abundance and Alloxanthin to reconstruct cryptophytes[23]. As above, we will use eDNA analyses as a complementary technique to reconstruct algal community composition, unlike pigments, eDNA can provide taxonomic information to the species level.

Preliminary data: Photopigments have been completed on the GB core, upon receipt of the grant sediments from BI and PB will be submitted for pigment analyses. Receipt of data is anticipated within 6 to 8 months of sample submission

Task	Deliverable	Proposed Cost
3.4	Photopigment Data (BI, PB, GB)	$28,500.00
SACore		
3.4	Photopigment Data (N)	$5,250.00

eDNA (Task 3.5) PI Brahney

The development of metabarcoding of environmental DNA ‘eDNA’ has opened up new areas of research using lake sediment archives with unparalleled detail. eDNA based methods have been used to successfully reconstruct algal, zooplankton, and fish community shifts that have occurred parallel to anthropogenic activities within catchments[24,25]. However, eDNA is not always well preserved and has the capacity for regional transport. Nevertheless, we expect eDNA to provide a complimentary data on the species present in the area, and may provide additional historical biomarkers due to the presence of exotic species (e.g. dandelions) and the establishment of agriculture in the catchment (e.g. curcurbits). eDNA will be conducted at Jonah Ventures in Boulder, CO, and will provide a regional perspective on the types of aquatic plants present at the time of sediment deposition.

> We do not anticipate that eDNA will provide sufficient stand-alone evidence however we do anticipate that it will provide complementary and supporting evidence. Please note that we have not requested funds for this exploratory analysis.

Preliminary data: eDNA analyses have been conducted and though exploratory they indicate they will provide complementary data to support age-model and shifts in plant and algal communities.

2.3.2.1 Approach for required Scope of Work deliverables All PIs and Students

Electronic datasets (Core logs, Age Model, Elemental and Isotopic Composition, Ecological Proxies)

The project includes the collection of physical samples and the generation of analytical data. Physical samples are stored in a walk-in fridge at the EBPL or LacCore Facility where they will be permanently archived. Data will be compiled and stored in Microsoft Excel spreadsheets, comma separated values files, and fasta files, and are backed-up to external hard drives and USU's Box cloud storage daily, which allows for centralized and secure file management. Chronological and elemental data with uncertainty will be reported and archived according to recommended protocols including deposition of data into the Neotoma, Interdisciplinary Earth Data Alliance (IEDA) and the Linked Paleo Data (LiPD) repositories where appropriate[3].

> Science Panel team members will have access to all data through the above repositories and all data will be made available to the Science Panel through a file-sharing program (Google Drive) and/or upon request.

Supplemental Approach

Zooplankton PI Brahney

We will reconstruct shifts in habitat including macrophyte densities and turbidity using cladoceran remains, specifically concentration and community composition. Cladocera carapaces and ephippia preserve well in buried sediments and have been used successfully to reconstruct shifts in habitat availability using species that prefer littoral macrophyte beds versus open water[26,27] and secondary production[28–30]. The potential loss of macrophytes and increase in turbid state of Utah Lake could have had a strong effect on cladoceran community composition and concentration[31,32], shifting dominant taxa towards small rotifers[33]. Because many cladoceran taxa are non-discriminant filter feeders (e.g., Daphnia, Bosmina), high particulate concentrations lowers their ability to extract energy, and thus impacts their growth and reproduction[34,35]. Sediment concentrations in Utah Lake from 1990 to 2016[36] have consistently been at or near concentrations that can induce starvation in daphnids[33], and thus reconstructing the historical concentration of cladocera can provide additional important information on historical lake condition, particularly turbidity. This analysis will be conducted as part of a cost-share with another grant.

Pollen Analysis PI Power

To determine if changes in vegetation cover are linked to ecological changes in Utah Lake, and, to provide chronological sediment marker horizons, pollen assemblages will be processed following palynological methods[37] Once chemically processed, the pollen grains will be identified and counted to obtain relative abundance of pollen grains of different taxa. One cubic centimeter samples will be used for pollen analysis and initial sampling will be conducted every ~1 to 4 cm resolution of the core. Based on the observed sedimentation rates from the preliminary freeze core analysis at the deepest part of the lake (0.91-1.05 mm/yr), a sampling interval of ~1 cm should provide ~10 year resolution. This resolution seems reasonable given the expected response times for lake response to vegetation change.

Task	Deliverable	Proposed Cost
3.3	Pollen data (NPB)	$2,800.00

<u>Charcoal Analysis PI Power</u>

Historical fire events can influence lake water chemistry, depending on the frequency and magnitude of fires occurring within the catchment. Large wildfires may destabilize soils, altering soil composition and structure and contribute to changes in post fire nutrient fluxes to waterbodies. While volatile elements like carbon are lost, particulate P remains in the ash and is easily mobilized along with many other major nutrients. Post-fire fluxes of phosphorus can be 0.3- 431 times unburned fluxes and nitrogen form 3-250[38]. One aspect we will investigating are the post-fire recovery times (e.g. How many years or decades before pre-fire conditions return?) of nutrient fluxes, particularly around significantly large historical fire events. Microscopic charcoal greater than 125µm will be used to reconstruct the regional fire history to identify extreme fire events, inferred from large charcoal peaks, and to explore changes in biological and geochemical during and immediately following large fire events that may be linked to nutrient flux changes in Utah Lake. Previous work demonstrates that changes in fire activity through time are closely linked to climate variability on multiple time scales and can influence nutrient delivery to lake basins[39]. Charcoal counts will be performed at contiguous ~1.0 to 5.0 mm intervals and all charcoal particles will be tallied for each sample. Charcoal data will be generated according to the methods by Brown and Power (2012), and applied by Power et al. (2006; 2011). A fixed volume of sediment from each sample interval of the core will be disaggregated with potassium hydroxide, washed through a 125µm sieve, and counted with a dissecting microscope at 36X. Fire events will be statistically determined by CharAnalysis© software whereby peaks in the charcoal counts that exceed a locally determined background will constitutes fire episodes. The largest ~10 past fire events will be interrogated for information of ecological response and recovery times by detailed core sampling around these events. Other identifiable macroscopic plant or animal remains (e.g., conifer needles, ostracod shells) will be recorded to corroborate evidence from biological and geochemical analysis.

Task	Deliverable	Proposed Cost
3.3	Charcoal (Includes ICD, LOI, and C/N)	$2,550.00

Task milestones and deliverables

Complete: All cores have been analyzed for XRF, MS, LOI.

Partial completion: Only one core has been dated and additional cores will be dated with anticipated data by late Fall or Winter. Similarly, 3 of the four cores have been analyzed for C,N mass and isotopes providing needed information on nutrient loading and organic matter source. Zooplankton analysis is underway and we anticipate this and Rock-Eval pyrolysis data by end of Summer. One core has been analyzed for eDNA and one core is partially analyzed for pollen and charcoal, the remainder will occur should we receive the grant.

To be completed: Phosphorus concentration and historical loading, and algal pigment analyses will be conducted on three cores will expected completion by Winter 2020. Diatom fossils will be counted on one core with expected completion by Winter 2020.

TASKS	Completed	2019		2020		
		Summer	Fall	Winter	Summer	Fall
Age-Model Construction (NPB)						
Age-Model Construction (GB)						
Age-Model Construction (BI, PB)						
Carbon/Nitrogen Mass Isotope Data (NPB, PB, GB)						
Carbon/Nitrogen Mass Isotope Data (BI)						
Phosphorus Reconstruction Data						
Elemental Composition Data (XRF) (PB, BI)						
Mineral Composition (XRD) (PB, NPB)						
Rock-Eval (BI, GB, PB)						
Diatom taxonomic record						
Diatom interpretation						
Historical Macrophyte Production						
Photopigment Data (GB)						
Photopigment Data (BI, PB)						
eDNA Data						
Pollen/Charcoal Data (NPB)						
Fossil zooplankton Data (PB, GB)						
SACore						
Age-Model Construction (N) *(Brahney)*						
Carbon/Nitrogen Mass Isotope Data (N) (Brahney)						
Phosphorus Reconstruction Data(N) (Brahney)						
Elemental Composition Data (XRF) (N) (Brahney)						
Mineral Composition (XRD) (N) (Brahney)						
Rock-Eval (N) (Brahney)						
Diatom record (N) (Brahney)						
Photopigment Data (N) (Brahney)						

Task 4 Inferred historical condition analysis *All PIs and Students*

Key team members

- Dr. Janice Brahney, Dr. Mitchell Power, Dr. Soren Brothers, Graduate Students

Approach discussion

In the Utah Lake basin as with many North American locations, the effects of settlement on the landscape and freshwater basins have generally occurred long before monitoring programs were in place. As such, paleoenvironmental records can provide critical missing information on baseline conditions and natural system variability[9]. Advances in paleolimnological research since the early Utah Lake sediment studies[40] have allowed researchers to use the biological and geochemical record to reconstruct a variety of processes that would inform the Utah Division of Water Quality on past limnological conditions and freshwater communities that resided within Utah Lake. Because any individual proxy can be influenced by multiple-drivers, a multi-proxy approach is often necessary to deduce environmental changes in lake systems.

To acquire a geochronology we will combine radioisotope methods with chronological information in a Bayesian framework. We anticipate that the lead-210 data may exhibit large errors from sediment mixing in recent decades. However, chronological markers like exotic pollen and agricultural crop DNA provide distinct marker horizons to anchor the chronology. Pairing multiple types of data into a bayesian framework produces an age-model with well-constrained confidence bounds from our interpretation on the timing of observed changes will be interpreted. Chronological control will be cross validated with known historical perturbations, including settlement and the onset of agriculture in the valley in the 1840's, the introduction of carp in 1881, and the gradual increase in wastewater effluent from a growing populations center around the lake.

Because of Utah Lake's unusual features as a large shallow remnant of ancient Lake Bonneville, it may be difficult to assume anything about its historical trophic conditions. However, it is possible that in recent history the lake underwent a regime shift transitioning from a clear-water macrophyte dominated system, as described by some early settlers, to a turbid system. To evaluate shifts in the trophic status, the loci of production (benthic versus pelagic) and the species composition we will again take a multi-proxy approach. Changes in nutrient loading (N, P) will be determined using the methods outlined above. However, assessing the impact of increased loading will require linking geochemical, fossil, and genomic data. Overall production will be determined using sediment organic matter concentrations, carbon content, amorphous silica, and algal pigment concentrations. Community composition shifts will be analyzed based on diatom and zooplankton fossil remains as well as pigment and eDNA data. Determining when and whether a shift from a clear macrophyte dominated to a turbid state occurred we will link geochemical data (C/N ratios, Rock-Eval), with fossil and eDNA data on macrophyte occurrence as well as zooplankton fossil remains that may link to changes in littoral habitat or turbidity. Finally, the loci of production will be modeled using contemporary and historical data to evaluate benthic versus pelagic production. Altogether, we aim to couple measurements and models of current and historic productivity rates and habitat partitioning to better understand the roles of changing water clarity and water levels on community structures in the lake, with the aim of providing actionable data for lake managers to use in improving Utah Lake's future water quality. The study will provide a clear historical framework for the timing of environmental shifts as they may relate to natural variability of anthropogenic forcing in the catchment and the lake basin itself.

Approach for required Scope of Work deliverables

We anticipate producing a preliminary report and all data files to DEQ in January 2020, recognizing that some data analyses are limited by laboratory timelines (e.g. ^{210}Pb) and counting fossils can take an extended period of time to complete. DEQ should note that a study of this size would normally take several years to complete, however, we have a large team and the benefit of having completed some of the work in advance saving DEQ both time and money.

Supplemental approach NA

Task milestones and deliverables

Given the tight timeline of the project, reporting will begin upon receipt and analysis of data as outlined above. We will attempt to maintain a strict schedule, however, we are limited to the turn-around times at some laboratories. **We anticipate providing a data report by Winter 2020.**

> All available data will be provided to the Science Panel by the January 2020 date either through a shared electronic resource (Google Docs) or by request. We are committed to collaborating with the Science Panel on research products provided the PIs and their students retain the first right to publish in peer-reviewed journals and appropriate PIs retain authorship on all ensuing publications from the data produced.

Task 5. Prepare technical report

Key team members

- Dr. Janice Brahney, Dr. Mitchell Power, Dr. Soren Brothers, Graduate Students

Approach discussion

The technical report will be drafted by all PIs and their students. For each proxy, methods, results, and discussion sections will be provided that link specifically to the main study objectives including.

Approach for required Scope of Work deliverables

PI Brahney will draft the following sections, 1) Historical phosphorus loading, 2) changes in community composition using the following proxies, macrophyte fossils and eDNA, zooplankton remains, and pigment data, Brahney and Power together will draft 3) geochronology, and 4) historical nitrogen loading and sources of carbon and nitrogen, and 6) changes in elemental loading and sediment conditions. Power will draft 6) natural sources of nutrients to the lake basin from catchment processes, Brahney and Brothers will draft 7) the section on current and historical production using lake metabolism modeling and oospores (Brothers), as well as macrophyte fossils, carbon, carbon to nitrogen ratios, and Rock-Eval pyrolysis (Brahney).

Supplemental approach NA

Task milestones and deliverables **(see table)**

A draft of the technical report will be provided to DEQ by January 31, 2020.

Task	Deliverable	Proposed Cost
4,5	Interpretation and Reporting (Primarily Brahney, Powers, Students)	$106,373.50

Table 2 Level of Effort								SACore	
Task	Deliverable	Brahney	USU Student	Power	UofU Student	Brothers	USU Ugrad	Brahney	USU Student
1	SAP	4	0	4	0	2	0	4	0
2	Collect/Preserve/sampl	40	80	20	40	8	0	10	40
3.1	Dating cores	8	40	10	40	0	0	0	15
3.2a	Nutrient - Phosphorus	120	1190	0	0	0	0	10	300
3.2b	Elemental	16	16	16	80	0	0	0	16
3.3c	Isotope	20	20	20	80	0	0	0	20
3.3d	Fossil Zooplanktoin	40	680	0	0	0	0	0	0
3.3e	Macrophyte fossils	40	680	10	40	16	680	0	0
3.3f	Production model	0	0	0	0	170	0	0	0
3.3g	Diatom record	30	0	0	0	0	0	0	20
	Charcoal and LOI	0	0	200	1200	0	0	0	0
3.3g	Pollen	0	0	20	500	0	0	0	0
3.4	Photopigment	16	170	0	0	0	0	0	20
3.5	eDNA	36	850	0	0	0	0	0	0
4	Interpretation	80	80	80	80	40	40	0	20
5	Report	80	80	80	80	40	40	0	20
Total	Hours	**530**	**3886**	**460**	**2140**	**276**	**760**	**24**	**471**

Table 3 Deliverables				
Task	Deliverable	Proposed Cost	Additional Core	Total
1,2,3,4,5	**Brahney and Student** **Task 1 and 2 are completed*	$61,675.50	$500.00	$62,175.50
2	Core retreival and Archiving	$0.00	$4,200.00	$4,200.00
3.1	Age-Model **(with Power)** (3/4 cores)	$4,500.00	$1,500.00	$6,000.00
3.2	Carbon/Nitrogen Mass Isotope Data **(with Power)** (1/4 cores)	$450.00	$450.00	$900.00
3.2	Phosphorus Reconstruction Data	$5,280.00	$1,760.00	$7,040.00
3.2	Elemental Composition Data **(with Power)**	$2,500.00	$4,350.00	$6,850.00
3.3	Diatom analysis	$22,500.00	$7,500.00	$30,000.00
3.4	Photopigment Data	$28,500.00	$5,250.00	$33,750.00
3.5	eDNA Data	$0.00	$0.00	$0.00
3.3	Fossil zooplankton	$0.00	$0.00	$0.00
3.3	Macrophyte fossils **(with Brothers)**	$0.00	$0.00	$0.00
1,2,3,4,5	**Brothers and Student**	$11,522.96	$0.00	$11,522.96
3.3	Contemporary and historical benthic/algal production modeling	$1,000.00	$0.00	$1,000.00
1,2,3,4,5	**Power and Student**	$44,698.00	$0.00	$44,698.00
3.3	Pollen data (lab technician)	$2,800.00	$0.00	$2,800.00
3.1	Charcoal, LOI, C:N (grad student)	$2,550.00	$0.00	$2,550.00
Total Direct		$187,976.46	$25,510.00	$213,486.46
Indirect UofU		$5,005.00	0	$5,005.00
Indirect USU		$14,137.83	$2,551.00	$16,688.83
Total Direct and Indirect		$207,119.29	$28,061.00	**$235,180.29**

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Utah Lake Bioassay Work Action Plan

Bioassays to investigate nutrient limitations in Utah Lake

Version 1.2 June 2019

Prepared by the Utah Lake Bioassay Team

List of Contributors

PI: Dr. Zachary Aanderud, Brigham Young University
Co-PI: Dr. Ben Abbott, Brigham Young University
Co-PI: Dr. Michelle Baker, Utah State University
Rachel Buck, Utah State University (PhD candidate)
Erin Jones, Brigham Young University (PhD candidate)
Gabriella Lawson, Brigham Young University (MS candidate)

Revision History

June 6, 2019	Initial release within the Utah Lake Bioassay Team
June 7, 2019	Initial release to the Utah Department of Environmental Quality-Water Quality
June 9, 2019	Second release to the Utah Department of Environmental Quality-Water Quality

Acknowledgements

The work was supported by the Utah Department of Environmental Quality-Water Quality. Any recommendations expressed here are those of the author(s) and do not necessarily reflect the views of the Utah Department of Environmental Quality.

Contents

Acronyms/Abbreviations

BYU	Brigham Young University
USU	Utah State University
UT-DWQ	Utah Department of Environmental Quality-Water Quality
ULWQS	Utah Lake Water Quality Study Science Panel
iUTAH	Innovative Urban Transitions and Aridregion Hydro-sustainability
SAP	Sample and Analysis Plan
HAB	Harmful algal bloom
P	phosphorus
N	nitrogen
PAR	Photosynthetically active radiation
CUWCD	Central Utah Water Conservancy District
SOP	Standard operating procedures
SAP	Sample action plan
DIN	Dissolved inorganic nitrogen
SRP	Soluble reactive phosphorus or orthophosphate
TN	Total nitrogen (mg/L)
TP	Total phosphorus (mg/L)
TSS	Total suspended solids
VSS	Volatile suspended

1. Introduction

Excess nutrients from human activity trigger toxic cyanobacterial and algal blooms creating expansive hypoxic dead zones in lakes damaging ecosystems, hurting local economies, undermining food and water security, and directly harming human health (Brooks et al 2016). The inception of a blooms is linked to the appropriate conditions allowing photosynthetic organisms to break dormancy and become abundant (Aanderud et al 2016). Cyanobacteria and algae become dominant under specific conditions physiochemical water conditions generally connected to total phosphorus availability, but many other phosphorus and nitrogen chemical forms and lake physiochemical conditions influence blooms (Descy et al 2016; Song et al 2017). Additionally, blooms may be dominated by a single species or a cohort of species responding to a cadre of environmental factors and interacting one with another (Wood et al 2017; Randall et al 2019). Besides chemistry and biology, weather fluctuations (e.g., temperature, wind speed, and solar irradiance) may facilitate different species to contribute the bloom (Wu et al 2016). Algae and diatoms species are part of blooms and are sensitive to chemistry and weather; however, deleterious effects of HAB are due to cyanobacteria producing cyanotoxins. Regardless, both organisms are degrading the ecological function of water bodies across the United States.

Human activities are causing blooms. Economic damage from nitrate (NO_3^-) contamination alone is estimated to cost 0.2 to 2.3 trillion USD annually—up to 3% of the global gross domestic product (Boirsky et al 2014). Over the past 50 years, global fertilizer use increased by over 500%[4], and nitrogen and phosphorus pollution are expected to keep pace with population growth, meat consumption, and wastewater discharge from sewage treatment facilities (Foley et al. 2011). Further, agriculture has disturbed approximately three-quarters of the Earth's ice-free land surface[7], reducing the capacity of ecosystems to buffer and process nutrient inputs and contaminating waters through poorly-defined non-point sources (Seitzinger et al 2010; Pinay et al 2015). Freshwater ecosystems along the Wasatch Front are, in particular, being hit hard due to concentrated and growing human development. Utah Lake, the largest naturally occurring freshwater lake in the western U.S., and many of the diversions (e.g., Deer Creek and Jordanelle Reservoir) along its tributaries, are experiencing frequent and extensive HABs leading to lake impairment due to nutrient overloading, altered hydrology, and climate (PSOMAS 2007; Randall et al. 2019).

2. Problem Statement

Understanding which nutrients limit cyanobacteria and algal primary production in Utah Lake will help describe the current state of the lake with respect to nutrients, trophic state, and ecology. Often, shallow lake systems transition from P limitations early in the growing season to N limitations later in the season, providing opportunities for algal dominated waters to transition to late-season cyanobacterial dominance due to their N-fixing capabilities. In other lakes, non-N fixing cyanobacteria may dominate throughout the bloom season, or N-fixing species may increase but may not be actively fixing N. Little is known about nutrient limitation in Utah Lake, including which nutrients are limiting, and whether there are seasonal and spatial dynamics in nutrient limitation among algal or different species of cyanobacteria.

3. Study Objectives

The objective of this research is to address the following question identified by the ULWQS as critical to understanding the current state of Utah Lake with respect to nutrients and ecology, specifically, which nutrients are actually controlling primary production and HABs and when? Special attention is given to cyanobacteria due to their ability to generate cyanotoxins dramatically impacting Utah Lake designated uses. The study is designed to address the following topics:

3.1. Nutrient limitation and HAB primary production

Determine the potential for N, P, and/or N+P limitations to influence the primary production/growth of algal and cyanobacterial species.

3.2. Seasonal nutrient limitations of HABs

Determine if there is a seasonal component (i.e., spring, summer, and fall) driving the potential nutrient limitations and algal and cyanobacteria species growth.

3.3. Spatial nutrient limitations of HABs

Determine whether there is a spatial aspect to the nutrient limitations of algal or cyanobacterial growth (i.e., Provo Bay; main body of lake, east; main body of lake, west).

4. Outcomes and Deliverables

Our study will provide baseline information on nutrient limitation in Utah Lake via bioassay experiments. The data may serve to inform a follow-up project investigating nutrient limitation in more detail. When this study is completed, the ULWQS will be able to answer the study objectives listed above and provide the following deliverables:

- We will identify the potential for N, P, and N+P to limit/co-limit the growth of individual species of algae and cyanobacteria.
- We will identify spatial and seasonal water chemistry and nutrient triggers that facilitate blooms of individual HAB species.
- We will be able to predict the influence of N and P chemical species on HAB severity
- We will generate relationships between common cyanobacterial species and the level of cyanotoxins they produce.

5. Task 1 - Develop SAP

5.1. SAP

The SAP will be created by Aanderud and Baker in accordance with the UT-DWQ's Assurance Program Plan for Environmental Data Operations. All essential elements outlined in Appendix A of the Quality Assurance Program Plan will be included. Baker has partnered extensively with UT-DWQ and is familiar with DWQ's Quality Assurance Program Plan. Both Aanderud and Baker have created multiple SAPs. Section 8.1 contains an example SAP created for the iUTAH biweekly sampling of water quality/chemistry in three watersheds across the Wasatch Front that was followed by multiple investigators over two years. Baker was the lead of iUTAH and Aanderud was the lead for Research Focal Area 1: Ecohydrology, that evaluated water quality and quantity. The SAP for bioassays will follow the same template as outlined in the iUTAH SAP with the iUTAH SAP serving as a starter document for the SAP.

The SAP will also include field and laboratory handling procedures, QA/QC documentation for all samples, and standard operating procedures (SOPs) for each analytical analysis adopted from the Baker's Aquatic Biogeochemistry Laboratory (ABL) analytical procedures (attached 8.2 ABL analytical lab manual, attached pdf) and from Aanderud SOP documents (SOPs listed on box.com; an example SOP is provided in 8.3 SOP-total suspended solids and volatile suspended solids). All QA/QC and SOPs will be clearly outlined in the SAP and approved by UT-DWQ to reach a final SAP.

5.2. Key Team Members: Aanderud, Baker, Jones, Lawson

5.3. Approach discussion

5.3.1. Approach for required Scope of Work deliverables

Aanderud and Baker are budgeted a ½ month summer salary to expedite the development of SAP and SOPs in the summer of 2019. Aanderud will be the point meeting with Baker and UT-DWQ to quickly develop a suitable SAP.

5.3.2. Supplemental approach

None for Task 1

5.3.3. Task milestones and deliverables

The draft of the SAP will be delivered to the UT-DWQ and ULWQS) 14 days after the approved grant agreement, with the final SAP delivered 16 days after receiving feedback from the UT-DWQ and ULWQS (approximate duration = 30 days after the approved grant agreement).

6. Task 2 - Conduct Bioassay Experiments

6.1. Introduction

We propose to follow much of the design outlined in the Scope of Work: Bioassays to Investigate Nutrient Limitations in Utah Lake prepared by UT-DWQ and the ULWQS. The scope of work outlines two experiments. The first experiment, will be conducted in the summer of 2019 (Bioassay Experiment 1) to determine to the time necessary to measure the rate of increase in cyanobacterial biomass between nutrient amendments. The second experiment, will be completed through the year, including the summer (2019) time point, in addition, to early fall (2019) and spring (2020; Bioassay Experiment 2) to assess the whether there is a seasonal component to HAB-nutrient interactions. The number of experimental units vary between the two experiments: Bioassay Experiment 1 = three locations × three endpoints (including time zero for five replicates) × four treatments (control, N, P, N+P) × three replicates = 113 experimental units); Bioassay Experiment 2 = three locations × one time (including time zero for five replicates) × four treatments (control, N, P, N+P) × three seasonal times × replicates = 113 experimental units, but the two experiments share 36 replicates so the total number of experimental units = 190. We are open to adding two additional bioassay sampling dates to capture seasonal HAB responses to nutrients. We propose additional dates for late summer/early fall sampling in 2019 and an early spring sampling in 2020. If incorporated the sampling dates will be as follows: early spring (last week in April), spring (last week in May), summer (mid-July), late summer (last week in August), and fall (mid-October). In additions to adding bioassay dates, we have an opportunity to preform monthly evaluations of Utah Lake, see section 2.2.4.

6.2. Bioassay Design

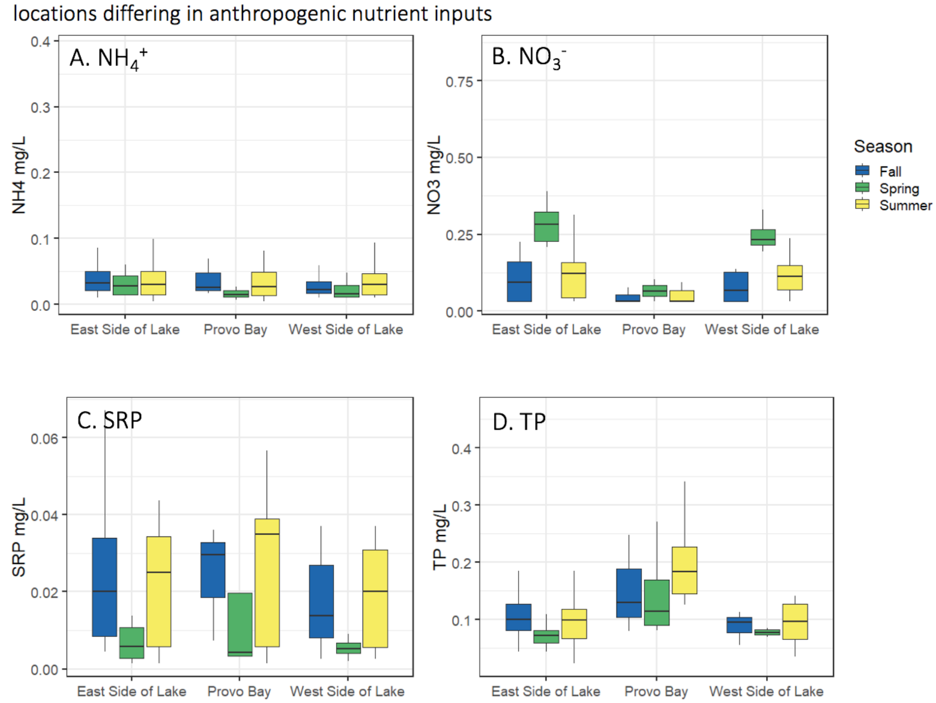
6.2.1. Utah Lake Sampling Locations

We propose to conduct the bioassays at three locations in Utah Lake: Provo Bay, main body east, and main body west. Nearly all urban development and anthropogenic nutrient inputs border the east side of Utah Lake, providing an opportunity to evaluate HABs in relation to a gradient of N and P concentrations in the water column and legacy sediments between the east and west sides of the lake (Randall et al. 2019). Provo Bay is also a unique area of the lake (Collins 2019). The bay is highly impacted by urbanization and is shallow leading to anaerobic conditions and potentially alterations in N and P availability. The locations will be located as close as possible to a UT-DWQ sampling buoy at the main body east and Provo Bay site. The main body west site will be located west of the Provo Marina and south of Goose Point where there are few anthropogenic inputs to the lake.

6.2.2. Nutrient Treatments

To determine the rate of increase in cyanobacterial species biomass in response to nutrients, we propose to create three nutrient treatments (N, P, and N+P) and a control. P amendments will equal 0.10 mg-P/L added as K_2HPO_4, and N amendments will equal 0.83 mg-N/L added as NH_4NO_3. The molar ratio for N:P, or more specifically DIN:SRP, additions will equal 16:1. Based on water chemistry in 2017 across the three proposed sampling locations, DIN concentrations were roughly higher in spring than summer and fall, while SRP concentrations were higher in fall and summer than spring, suggesting that N-fixing cyanobacteria may be favored in fall and summer while non-heterocystous cyanobacteria may be favored in spring (Figure 1). Across the three sites, N availability was relatively lower in DIN and higher in SRP at the mouth of Provo Bay, and SRP was relatively higher in the east- compared to the west-side of the lake. The N amendments will roughly increase DIN availability by a factor of two in spring and a factor of four in fall and summer. The amendments of P are more intensive, with P availability increasing roughly by a factor of five in fall and summer and a factor o 10 in spring.

Figure 1: The concentrations of N and P species in Utah Lake across seasons and between locations differing in anthropogenic nutrient inputs



6.2.3. Bioassay Experiment 1-Time Selection

The time series is proposed to occur over a relatively brief time frame with sampling time points at 24-, 48-, and 72-hours. We suggest that the times are lengthened to 48- (2 day), 96- (4 day), and 144-hours (6 days). Increasing the time will ensure that we capture growth and allow time for cyanobacteria to recover from any disturbance during the set-up of the treatments. The most sensitive time point with earliest significant cyanobacterial growth will be selected as the evaluation time for Bioassay Experiment 2.

6.2.4. Possible Monthly HAB Evaluation in Utah Lake

We may be able to leverage existing research to help determine the seasonal and spatial dynamics of HAB-nutrient relationships in Utah Lake. In collaboration with the CUWCD, we are proposing to create an early detection network to predict the interactions among nutrients, water chemistry, and weather influencing cyanobacteria and algae in the Provo River's reservoirs and identify the whether or not the cyanobacteria are transported downstream into the Provo River. Specifically, starting in June and continuing for the next five years, we will identify relationships among nutrient species, water chemistry, and cyanobacteria in Deer Creek Reservoir, Jordanelle Reservoir, and Olmstead Diversion along the Provo in the reservoirs and immediately following the impoundments. We will further generate relationships between common cyanobacterial species and the level of cyanotoxins they produce using RT-qPCR cyanotoxin gene evaluation. There is no evidence to suggest harmful levels of cyanobacteria have ever existed in the Provo River, but because of the critical nature of the river as a drinking water source, CUWCD wants to closely monitor trends in cyanobacteria in the River (which historically are extremely low). The network will provide insights into the minimal information necessary to accurately predict temporal patterns of cyanobacteria within the Provo River, especially in reaches managed by the CUWCD. The creation of our cyanobacteria detection network will be accomplished through three focal areas: 1. Ecohydrology and Bloom Sensor Network (EBS Network)-three sondes measuring a suite of water chemistry, water quality, and phycocyanin (surrogate for cyanobacteria biomass) and chlorophyll a (surrogate for cyanobacteria and algal biomass) downstream of the reservoirs; 2. biweekly nutrient analyses-grab samples to check EBSN sondes and measure the availability of multiple forms of P and N in outflows and reservoirs; and 3. Cyanobacteria detection-biweekly direct counts and molecular identification of cyanobacteria and algae, quantitative PCR of cyanobacteria species and determinations of major cyanotoxin downstream and within reservoirs. We have asked CUWCD if we may also sample in Utah Lake as part of the network. For this research, CUWCD isn't interested in Utah Lake, but we are proposing to measure the same suite of analyses in Utah Lake at the three buoys managed by UT-DWQ. We don't have funds for Utah Lake and we are currently going to conduct an abbreviated suite of analyses. We are open to discussing the possibility of adding/altering sites or performing the same suite of analyses monthly if some more funds are made available to help with the costs.

6.2.5. HAB Conditions During Bioassay

The scope of work focuses on alleviating nutrient limitations to better understand cyanobacterial species growth. We believe that the ideal water conditions to track nutrient-HABs relationships are not necessarily an active bloom. If there is already a bloom present when we run the trial, we are identifying if nutrients intensify the bloom instead of if excess nutrients are causing blooms. With the monthly HAB detection along with time zero measurement we will at least know a general HAB history prior to the bioassay and be able to explain the differences in our results.

6.3. Methods

6.3.1. Cubitainers

We propose to conduct all experimental units in 3.8 L (1 gallon) cubitainers. Surface waters from top 20 cm will be carefully collected in a 200 L (55 gallon) drum from each site to ensure that the sample water is well mixed. While being gently homogenized, 3 L will be placed in each cubitainers and each cubitainers will receive their respective nutrient treatments in a liquid dose of 10 mL. Every day, all cubitainers will be opened to allow the headspace to equilibrate with the atmosphere to lessen the potential for changes in oxygen or carbon dioxide to impact cyanobacterial growth. Surface waters will be collected with our 24' Sunchaser pontoon boat with a 115 HP Mercury outboard motor. The boat is modified to provide 112V AC power in several protected outlets, the inclusion of a work table, and the addition of deployment points for instruments/cubitainers.

6.3.2. Common Garden in Provo Marina

We propose to conduct all experiments in common water garden in the Provo Marina. We will place cubitainers in nets strung across two boat slips to allow the cubitainers from all treatments to be readily accessed, remain at a common depth, and exposed to the same light and temperature conditions. We will measure PAR daily at the dock to evaluate differences between radiation levels across seasons. We will ask the Utah Lake Commission to provide two slips free of charge to run the experiments.

6.4. Analyses

We will conduct analyses in three general areas: *in-situ* lake chemistry, nutrients, and biology as outlined in the SOW to identify if N and/or P are controlling the primary production of HABs. SOPs for all analyses will be included in the SAP. Further, the SAP will include a detailed discussion of the procedures related to the bioassays: deployment of experiment, sampling timeline, sample handling, and sample QA/QC.

6.4.1. *In-situ* lake chemistry

In-situ lake chemistry analyses will be conducted immediately after opening the cubitainers. For *in-situ* lake chemistry, we will use a YSI EXO2 probe to capture multiple water chemistry parameters, see Table 1 for EXO2 details (Jones et al. 2017). The sonde will allow an immediate estimate of chlorophyll-a and phycocyanin. We will still perform the chemical analyses for chlorophyll-a and phycocyanin to provide a more accurate estimate of cyanobacteria pigments.

Table 1. YSI EXO2 water quality sonde sensors to measure a suite of *in-situ* lake chemistry.

Sensors	Specifications
pH	0 to 14 unit measurement range/±0.1 pH unit accuracy
Temp/Electrical Conductivity	0 to 200 mS/cm measurement range/±0.5% of reading or 0.001 mS
Dissolved oxygen	0 to 50 mg/L measurement range/±0.1 mg/L
Turbidity	0 to 4000 FNU measurement range/0.3 FNU or ±2% of reading accuracy
Dissolved organic matter	0 to 300 ppb Quinine Sulfate equivalent (QSE) measurement range
Blue Green Algae-phycocyanin	Range: ~0 to 280,000 cells/mL; 0 to 100 RFU/Detection Limit: ~220 cells/mL
Chlorophyll-a	Range: ~0 to 400 ug/L; 0 to 100 RFU/Detection Limit: ~0.1 ug/L

6.4.2. Nutrient Analyses

Nutrient analyses include: TP, TN, NH_4-N, NOx-N (nitrate and nitrite), SRP as outlined in multiple pubs by the PI and Co-PIs and outlined in the ABL Manual (8.2).

6.4.3. Biology: cyanobacteria pigments, direct counts, and cyanotoxins

The biology evaluations will help determine the growth of individual cyanobacteria during the bioassay. Chlorophyll a will be measured via an ethanol extraction and evaluated on an Aqualog (Horiba Scientific, NJ USA). Phycocyanin, a major phycobiliprotein pigment produced by cyanobacteria, will be analyzed with fluorometry (Kasinak et al 2014). The growth of cyanobacterial species (biovolume, cells per mL) will be analyzed by direct microscopy (quantitative cyanobacteria identification and enumeration between time points), but we will only perform a general quantitative evaluation of algae to the division level. All microscopy will be conducted on a Zeiss Axioplan2 upright fluorescent microscope (Ziess, SD USA) with an Axiocam SO3 color camera and a PhotoFluor LM-75 light source in the Aanderud Lab. We will only conduct direct microscopy on two of the three replicates for all treatment and season combinations. We will measure three cyanotoxins (i.e., microcystin, anatoxin-a, and cylindrospermopsin) using ELISA (Abraxis Inc., PA USA) immediately after opening the cubitainers based on the dominant cyanobacteria found in Utah lake during 2017 (i.e., *Aphanizomenon, Microcystis, and Dolichospermum sp*; Collins 2019). Toxins will be measure in only two of the three replicates due to the high cost of the analyses. There is the potential to evaluate cyanotoxin expression with the same RNA extraction detailed in 2.4.4. Along with CUWCD, we are developing primers to evaluate gene expression of cyanotoxins by the three dominant cyanobacteria in Utah Lake. One benefit to the genetic approach is that it quantifies the expression of the gene and not the cyanotoxin itself which may be difficult to detect.

6.4.4. Biology: cyanobacterial molecular identification and quantification, N fixation, and TSS

For biology, we propose to more fully evaluate cyanobacteria form and function. We will extract RNA from cubitainers using a DNEASY Powerwater kit (Qiagen, MD USA) and characterize the active cyanobacterial community by sequencing the rRNA transcripts of the 16s rRNA gene on MiSeq Illumina Sequencer at USU. Transcripts will identify all cyanobacterial species including picocyanobacterial species, which are neglected in microscopy due to their small cell size but may constitute upwards of 30% of the cyanobacteria in Utah Lake (Collins 2019). Further, picocyanobacteria may also produce microcystin (Sliwinska-Wilczewska et al. 2018) and obscure relationships between other microcystin-producing species. The same RNA extractions will be used in reverse-transcriptase PCR (RT-qPCR) analyses (Eppendorf RealPlex, NY USA) to: 1) capture the total biomass of cyanobacteria, including picocyanobacteria, that will serve as a biomass estimate of all cyanobacterial species from the sequencing effort, and 2) estimate N fixation rates using nitrogenase (*nif*H) expression (Turk et al. 2011). We included N fixation estimates since we are already extracting RNA and nitrogenase activity occurs *in-situ* in the cubitainers and it provides valuable information about the nutrient activity of cyanobacteria. Alternatively, other N fixation proxies, such as acetylene reduction assays, requires an additional set of samples and analysis pathway (acetylene reduction uses gas chromatography). The RT-qPCR *nif*H expression will be expressed as the number of *nif*H transcripts per L and further divided by time and the cells counts of N_2-fixing species from molecular or microscopy techniques, but not as an amount of N_2 fixed. We have conducted acetylene techniques often but the gene approach is more conducive to what we do best in our lab.

RT-qPCR and sequencing are common analyses performed in the Aanderud Lab and will be conducted on the same two replicates measured by direct microscopy and cyanotoxins. We will generate regressions for each species relating the direct microscopy cell counts to the number of genes. It is our hope that we will be able to replace molecular HAB detection with microscopic HAB detection that is labor intensive and often cost prohibitive. We will also measure TSS and VSS for another estimate of photosynthetic biomass.

6.5. Key Team Members: Aanderud, Buck, Jones, Lawson, and Abbott

Aanderud will help advise the bioassay deployment and biology analyses. Erin Jones, Rachel Buck, Gabriella Lawson, and BYU undergraduate students will perform the bioassays on the lake. Erin Jones will oversee/conduct the field research. Rachel Buck will advise/perform the nutrient analyses and Erin Jones will advise perform the *in-situ* lake chemistry and cyanotoxin evaluations, and biological analyses. Abbott will also help advise the nutrient analyses.

6.6. Task milestones and deliverable

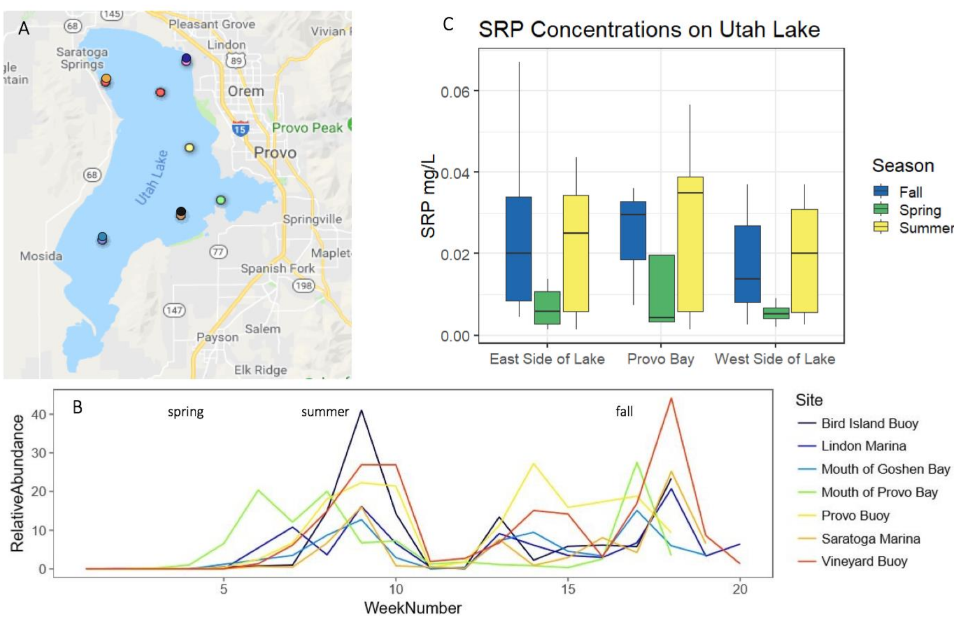
The data for the fall and spring bioassays will be provided to the Utah DWQ and ULWQS 45 days. We are requesting to provide the first bioassay data 75 days after the sampling effort. The summer bioassay is composed of 72 experimental units, shorlty proceeds another bioassay run in the fall, and requires lab set-up to perform analyses. The only exception to the data delivery is the sequencing of cyanobacterial composition that will be run at the end of all three seasons to save costs. However, all other metrics biological metrics, RT-qPCR of *nif*H and cyanobacterial biomass and microscopy determinations, will be delivered on schedule.

7. Task 3 - Prepare Technical Report

The technical report will describe the primary production limitations of cyanobacteria and algae in Utah Lake across seasons and from east to west and in the Provo Bay. Specifically, the technical report will focus on determining the nutrient limitations/co-limitations regarding P, N, and NP influencing individual cyanobacterial and algal species; discerning if there is a seasonal signature to primary production nutrient limitations; and identifying the spatial intensity of nutrient limitations on photosynthetic biomass. Further, the technical report will provide baseline information on nutrient limitation in Utah Lake and serve to inform follow-up project investigating nutrient limitation in more detail.

The PI and Co-PI are professors and are prolific science writers, each with an outstanding publication record, averaging 3-5 publications a year for the last five years. The technical report will follow the same outline as a standard scientific publication: introduction, methods, results, figures, tables, and discussion. The technical report will be more extensive than a standard publication providing baseline data and quantitative analyses to address the questions. Further, nutrient and cyanobacterial abundance data from the Aanderud Lab's extensive 2017 sampling effort (1.1.1.4. *Tracking Utah Lake cyanobacteria blooms*) will also be provided to identify multiple years of spatial and temporal data on Utah Lake (for example of data, see Figure 1). The technical report, with the consent of UT-DWQ, will be submitted to a scientific journal with Aanderud as the lead and all other participants co-authors.

Figure 2: the seven locations sampled for water chemistry and cyanobacterial species in 2017 spring, summer, and winter (A), the population dynamics of *Aphanizomeon flos-aquae* over time (B), and the concentrations of soluable reactive P across the lake (C).



7.1. Key Team Members: Aanderud, Baker, and Abbott

7.2. Approach discussion

7.2.1. Approach for required Scope of Work deliverables

Aanderud is budgeted for ½ month summer salary in year 2 to draft and complete the technical report. Abbott will also receive 1/4th month summer salary and will also contribute 20 hours to the preparation and editing of the technical report. Both Baker and Abbott will consult on data analysis and the interpretation of the results, but Aanderud will be primarily responsible for the report and interacting with the DWQ and ULWQS.

7.2.2. Supplemental approach

None for Task 3

7.2.3. Task milestones and deliverables

The technical report will be extensively reviewed by the PI and Co-PIs. A draft of the report will be provided to the UT-DWQ and ULWQS Science Panel on June 12th 2020 and the final technical report will be submitted on June 30th 2020.

8. Approach for Science Panel Collaboration and Data Sharing

8.1. Data sharing plan (DSP)

All team members are committed to openly sharing data with the UT-DWQ and ULWQS in a timely manner as possible. The team will create data spreadsheets, which will be shared online, with the minimum parameters of: analysis date, analyst name, sample identification, concentration of each analyses, calibration information, reagent blanks, check standards. The team will also create a series of figures demonstrating the growth of cyanobacteria, algae, and specific species for bioassays in a given season that will also be provided. The team will work with UT-DWQ to provide data in the optimal format for their needs.

8.2. Sample management and data availability

Each physical sample (consisting of sampling bottles and a cubitainer) collected will be assigned a globally unique identifier before the sample is collected in the field. These identifiers will be affixed to the sampling containers and will accompany the samples in the field and in the laboratory. Data will be immediately entered into the shared google document-excel spreadsheets.

9. Project Milestones and Deliverables

Table 2. The milestones and attending dates for bioassay deliverables to the UT-DWQ and ULWQS

Task #	Deliverable	Due date
1	Deliver first draft SAP, SOPs, DSP to DWQ and ULWQS	14 days after award
1	Deliver complete SAP, SOPs ,DSP to DWQ and ULWQS	30 days after award
2	Set-up bioassays	summer, fall, spring
2	Conduct bioassays	summer, fall, spring
2	Analyze physiochemical characteristics	summer, fall, spring
2	Analyze cyanobacteria and algae	summer, fall, spring
2	Deliver raw data and interpretation of data to DWQ and ULWQS	45 days after each bioassay
3	Deliver draft technical report	June 12th, 2020
3	Incorporate edits and deliver final technical report	June 30th 2020

10. Level of Effort

Table 3. The time allocation of proposed hours for project management, support, and completion. One semester of graduate stipends is equivalent to approximately 600 hours

Task #	Deliverable	Team Member (hours)				
		Aanderud (PI)	Baker (Co-PI)	Abbott (Co-PI)	Jones (GS)	Buck (G)
1	Develop SAP	40	30	×	×	×
	Edit SAP with DWQ/ ULWQS	20	10	×	×	×
2	Set-up bioassays	10	×	×	120	40
	Conduct bioassays	×	×	×	440	180
2	Analyze physiochemical characteristics	×	×	10	300	360
2	Analyze cyanobacteria and algae	×	×	×	360	×
2	Manage data	10	×	×	40	20
	Interpret data	30	10	20	×	×
3	Prepare technical report	40	10		×	×
3	Edit technical report	10	10	10	×	×

11. Cost Proposal

Table 4. The cost of wages, supplies, and travel based on 190 total experimental cubitainers. The budget is also provided as a separate table and the budget summary for BYU is provided. If needed due to a change in bioassay design, the addition of an experimental unit is $113.

Task #	Deliverable	Costs (USD)
Wages		
1, 2, 3	Aanderud ½ month salary @ $5,430 with $1,358 benefits in summer and spring	13,576
1, 3	Baker ½ month salary @ $6,150 with $1,538 benefits	7,688
3	Abbott ¼ month salary @ $2,420 with $679 benefits	3,099
2	Rachel Buck summer and fall (spread over two semesters @ $6,600	6,600
2	Erin Jones summer, fall, spring (spread over three semesters @ $6,600	13,200
2	Undergraduate student research help @ $9 hour for 20 hours most weeks in summer, fall, spring	5,760
Supplies		
2	Field consumables	2,500
2	Lab consumables	2,600
2	Water chemistry costs: TP, SRP, PP, TN, ammonium, nitrate, and nitrite	2,800
2	Pigments (phycocyanin)	1,296
2	ELISA toxins (three cyanotoxin species)	4,320
2	Chlorophyll-a	504
2	TSS and VSS to estimate photosynthetic biomass	0
2	Cyanobacterial species and algal division composition direct microscopy (in the cost of graduate students)	0
2	RNA transcript extractions	3,600
2	RT-qPCR cyanobacteria biomass	750
2	RT-qPCR of *nif*H to estimate biological nitrogen fixation	750

2	Sequencing of cyanobacterial composition	2,160
Travel		
2	Truck and boat	1,200
Indirect costs (10%)		7,240
Total		79,643

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Utah Lake Sediment–Water Nutrient Interactions

Dr. Ramesh Goel, Professor, University of Utah
Dr. Greg Carling, Associate Professor, Brigham Young University

1.0 Experience and Expertise

1.1 Related project experience

The importance of nutrient dynamics at the interface of sediment and water column in Utah Lake was realized in Dr. Ramesh Goel's lab in 2012 when his lab determined sediment oxygen demand (SOD), nutrient fluxes under varying dissolved oxygen and pH conditions, sediment mineralogy and phosphorus speciation (please see Hogsett et al., 2013; Hogsett et al., 2019 and Hogsett and Goel, 2013) mostly using in-situ experimental approaches with research funding support from the Utah Division of Water Quality. Additionally, Goel lab has been studying the ecology of cyanobacteria as a function of different environmental factors in Utah Lake under an EPA Star grant. Likewise, Dr. Greg Carling's lab has studied the fate of P in the water column, P speciation and sediment mineralogy in Utah Lake sediments more recently with funding from Wasatch Front Water Quality Council (please see Randall et al., 2019).

1.2 Experience and expertise of key personnel

Both PI's have adequate expertise needed to accomplish different tasks included in this project. **Dr. Ramesh Goel** has more than 18 years of research experience in water quality related research. More specifically, he studies nitrogen and phosphorus removal in engineered bioreactors, nutrient dynamics in wetlands, streams and lakes. His research related to organic matter and nutrient dynamics in Jordan River was transformative and helped Utah DWQ in its completing phase I TMDL of Jordan River. Additionally, with funding from the Utah DWQ, Dr. Goel conducted bioassays (i.e., nutrient limitation experiments) to determine the fate of nitrogen and phosphorus in Willard Spur open water of Great Salt Lake. He also contributed to understanding the fate of nutrients, especially in the plant root zone, in Great Salt Lake wetlands under an EPA funded wetland development grant. He has published more than 50 journal papers with more recent publications appearing in "Nature Communications", "Scientific Reports", "Environmental Science & Technology", "Water Research", "Science of the Total Environment" and "Journal of Environmental Monitoring.

Dr. Greg Carling has 15 years of research experience in northern Utah, including numerous studies on lakes, wetlands, rivers, and groundwater in the Utah Lake/Great Salt Lake watershed. He has spent the past five years investigating sediment and water chemistry of Utah Lake and is currently a member of the Utah Lake Science Panel. Carling is the principal investigator on seven state and federal research projects since 2013 with 20 peer-reviewed publications since 2011. He recently published a paper on Utah Lake sediment chemistry with a graduate student first-author (Randall, M.C., Carling, G.T., Dastrup, D.B., Miller, T., Nelson, S.T., Rey, K., Hansen, N., Bickmore, B.R., Aanderud, Z.T., **2019**. Sediment potentially controls in-lake phosphorus cycling and harmful cyanobacteria in shallow, eutrophic Utah Lake. PLOS ONE 14:e0212238). During the summer of 2017, Carling and students continued sediment and water sampling across Utah Lake with an emphasis on understanding phosphorus fluxes from sediment to the water column. In addition to local field research, Carling has investigated trace element and nutrient dynamics in Wyoming, Alaska, and Ecuador.

Graduate and undergraduate students: Graduate students expected to work on this project will be required to have prior experience in sediment related research. Priority will be given to students with some demonstrated experience in phosphorus cycling in sediment to the extent possible. In case we do not find students with prior sediment research experience, newly hired graduate students will be first given one week of extensive training before they start working on different project elements. Ms. Hanyan Li, a current PhD student working on EPA project and an extensive experience in sediment core sampling and analysis, will also be available to assist in this project.

The BYU student involved with this project is Sheena Smithson, who is a 2nd-year Geology M.S. student in Dr. Carling's lab. Sheena has one-year of experience doing field work on Utah Lake and performing laboratory experiments and analyses with Utah Lake sediments. During the summer of 2018, Sheena collected over 36 sediment samples from Utah Lake using a percussion corer. In the lab, she analyzed the samples for bulk chemistry and did batch sorption and sequential leaching tests.

2. Proposed Approach

2.1. *Task 1. Develop sampling and analysis plan (SAP) (Drs. Goel and Carling and graduate students)*

2.1.1. Key team members and prior experience with SAP documents: This task will be jointly completed by Drs. Goel (project principle investigator) and Carling (project Co-PI). Graduate students working directly on this project are also expected to help with the sampling and analysis plan. Engaging students in SAP development will train students during the initial stages of this project for their better performance in the project. The PI Dr. Goel has an extensive experience in preparing quality assurance, sampling and analysis plan under several USEPA and Utah DWQ funded projects. In his current USEPA Star grant, a complete quality assurance project plan (QAPP) and SAP were prepared for different water quality parameters, sediment chemistry and molecular biology work in Utah Lake and Jordan River. In another project funded under EPA region VIII Wetland Development program, comprehensive QAPP and SAP documents were developed and are already in place. The PI has been actively engaged in projects funded by Utah DWQ and QAPP and SAP documents have been revised accordingly.

2.1.2 Approach discussion

2.1.2.1 Approach for required scope of work: We propose to follow a similar strategy that we have followed for our EPA and current UDWQ funded projects. In summary, we plan to submit all necessary QAPP and SAP documents to the Utah Lake science panel before the beginning of any field work. We will access the available QAPP and SAP documents related to water quality sampling and sediment work available at the UDWQ website as reference material (https://deq.utah.gov/water-quality/quality-assurance-and-quality-control-program-monitoring-water-quality). ***UDWQ's vision is that QAPP is meant to be an umbrella document outlining the minimum QA/QC requirements for environmental data collection***. As a team, we share DWQ's vision about QAPP and SAP importance and will adhere to these standards while coordinating with the Science Panel and UDWQ. In developing QAPP and SAP documents, we will coordinate with UDWQ through in person meetings and phone calls. After such meetings, a first draft of QAPP and SAP will be submitted to UDWQ for their input. Thereafter, once the documents are finalized, these will be submitted to the Science Panel for their comments and approval. The format of SAP will follow the style suggested by the Science Panel in the sediment RFP document. Please refer to task 3 for detailed information about different parameters that will be evaluated to investigate sediment P biogeochemistry.

2.1.2.2. Task milestones and deliverables: As requested in this RFP, a detailed milestone table is presented in section 4.0 of this proposal. Hence, to avoid repeatability, we are abstaining ourselves in including another table in this section. Briefly, assuming a project start date of June 15th, 2019, we expect to complete this task within 2 weeks from the start of this project. We anticipate receiving comments from UDWQ and the Science Panel on the first draft document within one week from the submission. We will incorporate these suggestions in the revised document within 2 weeks (e.g., 4 weeks after scope of award). **Hence, <u>the important deliverable</u>** of this task will be detailed draft and final QAPP and SAP plans related to experimental plan presented in tasks 2 and 3.

2.2 *Task 2. Collect sediment cores from Utah Lake (Both labs)*

2.2.1. Key team members and prior experience sediment core collection: This task will be jointly completed by Drs. Goel and Carling. Graduate students working directly on this project are also expected to help with sediment core collection. PI Goel has been conducting research related to sediment-water column interactions in lakes, stream and sediments for the past 18 years. His research has been instrumental in phase I Jordan River TMDL development where his research helped UDWQ determine the role of sediment oxygen demand in DO impairment in the lower Jordan River. Additionally, with funding from UDWQ, he evaluated SOD in Utah Lake sediments using in-situ methodology (Hogsett and Goel 2013) and collected sediment cores (through SCUBA diving) to determine sediment P speciation and mineralogy (Hogsett et al., 2018). In a different project funded by USEPA region VIII, Dr. Goel's research evaluated the role of bacteria mediated nitrogen transformations in Great Salt Lake sediments. These experiments were conducted on sediment cores collected from different wetland sites. Likewise, co-PI Carling has extensive experience in sediment research (please see Randall et al., 2019). He has collected sediment from Utah Lake over the past five years using various techniques including a percussion corer.

2.2.2. Approach discussion

2.2.2.1 Approach for required scope of work: In the past, we have been able to collect sediment cores using a hand-driven PVC tube by SCUBA diving or using a percussion corer as detailed in our previous publications (Hogsett and Goel, 2013; Hogsett et al., 2018; Randall et al., 2019). We anticipate that we will be able to collect sediment cores using similar strategies employed in the past. For this, we will need a person to assist with SCUBA diving (perhaps a student) to collect sediment cores using methods described in the SAP document (to be developed under task 1). In case this plan does not work due to safety reasons, we will use a percussion corer fitted with 60 cm long and 5 cm internal diameter core tubes. Co-PI Carling has successfully collected dozens of 20-30 cm long cores with overlying water from multiple sites across Utah Lake using a percussion corer. As suggested in the RFP document, we will sample one site in Provo Bay and a second site in open water (presumably having a different eutrophication status than the Provo Bay) at an established UDWQ monitoring location, with a total of 39 core collected per site. The details of these cores is provided in table 1. To access sampling sites, we will ride with UDWQ or use a pontoon boat at BYU that is available to the PIs. Our strategy is to sample the first site and finish all related experiments before sampling the second site. This strategy will allow us to avoid storing the sediment cores for an extended period of time. Nevertheless, we will make sure that both sites are sampled within a time span with no more than a ±5°F change in ambient water temperature difference over days of sampling. Cores will be preserved in the dark and on ice during transport to the lab. In the lab, the cores will be stored in the dark at 4°C in a walk-in refrigerator until further processing. If conducted ex-situ, sediment oxygen demand (SOD) experiments will be conducted immediately after coming to the lab.

2.2.2.2. Supplemental approach: This particular RFA focuses on sediment P chemistry. In addition to P measurements, we will take advantage of the cores to evaluate other physical parameters related to sediment quality. These parameters are currently needed by Utah Lake modeling team to model Utah Lake sediment transport and scouring (personal communication, Nicholas von Stackelberg, Environmental Engineer, Watershed Protection, UDWQ). These parameters include sediment bulk density, dry density, grain size distribution and organic content. An extra set of cores will be collected from each site for these supplemental analyses. No additional budget is included for this supplemental portion of the project.

2.2.2.3. Task milestones and deliverables: As requested in the RFP, a detailed milestone table is presented in section 4.0 of this proposal. Pending approval of this project and approval of QAPP and SAP documents, we expect to sample one site towards the end of July 2019 and the second site during August 2019. We expect to have the following deliverables; (1) electronic files including pictures, videos of field observations and, (2) a written short report on field challenges, any field safety and quality control followed and information on individuals and their roles involved in sampling. These will be submitted within ~10-12 weeks after scope of award.

2.3 Task 3. Perform sediment core experiments and laboratory analysis

2.3.1. Key team members *and prior experience sediment analysis:* This task will be jointly completed by Drs. Goel and Carling. Graduate students working directly on this project are also expected to help with sediment experiments and laboratory analysis. Given the amount of work required to complete the experiments and the short time frame outlined in the RFP, we feel that a team approach with Dr. Goel, Dr. Carling, and graduate students allow us to successfully complete the project by combining our efforts. Both Drs. Goel and Carling have been engaged in sediment research with particular emphasis on phosphorus in sediment and sediment oxygen demand for the past several years. Please refer to our previous publications (Hogsett and Goel, 2013, Hogsett et al., 2018, Li et al., 2018, Randall et al., 2019) for sediment and cyanobacteria related research in Utah Lake. We have also included relevant results in the "Related Case Study" section of this proposal for further demonstration of this team's proven track record in sediment-water column related research.

2.3.2. Approach discussion

2.3.2.1. Approach for required scope of work: The experiments and measured parameters are outlined in the table below.

<u>Table 1</u>: Detailed scope of work including supplemental work.

Parameter/s and experiments	Rationale
Set 1: Sediment core P spiking in the water column under aerobic conditions, no spiking (control), 0.5, 2 and 4 times the ambient P concentration. (**12 cores**)	To determine the fate of dissolved P present in the overlying water column when the water column is in constant contact with sediments. Different concentration ranges reflect low, medium and high end of spiking.
Set 1 continuation: Sediment core P spiking in the water column under aerobic conditions, no spiking (control), 0.5, 2 and 4 times the ambient P concentration and then create anaerobic conditions after an equilibrium has been established under previous aerobic conditions. (Same 12 cores from ambient aerobic spiking experiments)	To determine the fate of dissolved P present in the overlying water column when the water column is in constant contact with sediments under oxygen free conditions. This experiment is a continuation from the previous set of experiments under aerobic conditions.
Set 2: Sediment core P spiking in the water column under aerobic conditions at a pH of 7.0, no spiking (control), 0.5, 2 and 4 times the ambient P concentration. (**12 cores**)	To determine the fate of dissolved P present in the overlying water column when the water column is in constant contact with sediments at neutral pH. Different concentration ranges reflect low, medium and high end of spiking.
Set 3: Sediment core P spiking in the water column under aerobic conditions at a pH of 9.5, no spiking (control), 0.5, 2 and 4 times the ambient P concentration. (**12 cores**)	To determine the fate of dissolved P present in the overlying water column when the water column is in constant contact with sediments at a slightly alkaline pH. Different concentration ranges reflect low, medium and high end of spiking.
Supplemental experiments/approach	
Dissolved P, SRP, TOC, dissolved nitrogen, nitrate, nitrite, sulfate, and pH (**3 cores**)	To determine pore water chemistry in sediment cores.
Sediment oxygen demand (SOD) (**3 cores** if conducted ex-situ)	To determine the amount/flux of oxygen consumed in sediments due to various biogeochemical activities.

Note: ***Total number of sediments cores collected at each site is 39 (36 if SOD conducted in-situ)***

General description of different set of experiments: In all three sets, a stock solution of KH_2PO_4 will be first prepared in filtered and sterilized Utah Lake water. One set of experiments consisting of 12 cores will be conducted at one time to maintain the highest level of quality control. The soluble reactive P (SRP) concentration in the overlying water column of each core will be determined in triplicate. The total volume of the overlying water column based on tube geometry will also be determined. We will use four plate shakers equipped with holders and three sediment cores will be mounted on each shaker. Additionally, each core tube will be wrapped with aluminum foil during the experiments to avoid exposure to direct light. To spike P in the water column, a pre-calculated volume of KH_2PO_4 stock solution will be added into the water column of each sediment core to obtain the specified dissolved P concentration.

Experimental details for set 1 under aerobic and anaerobic conditions (Dr. Goel's lab): Cores in triplicate will be mounted on each of the four horizontal shaker and the shaking will be initiated at a gentle speed as not to disturb the sediments. We may need to calibrate the speed with a dummy sediment core collected from the Utah Lake. Additionally, we will also conduct separate batch experiments with sediment cores to determine the approximate time needed to reach equilibrium between the sediment and the overlying water column in terms of dissolved P. According to Spears et al. (2007) a 72-h time period was deemed sufficient to reach such equilibrium. However, we expect this duration to be highly dependent on sediment characteristics and hence this separate batch test will enable us the approximate duration of time needed to reach equilibrium. This single batch experiment will be conducted under aerobic and anaerobic conditions.

The water column in each set of triplicate cores will be gently aerated using an aeration stone placed at approximately 1/3 height of the water column from the bottom (e.g., water column-sediment interface). Thereafter, the predetermined volume of KH_2PO_4 stock will be added to increase the soluble P concentrations as follows: (1) no addition to the first set and this will serve as a control, (2) add KH_2PO_4 stock to accomplish a dissolved P concentration equivalent to 0.5 times the ambient P concentration, (3) add KH_2PO_4 stock to accomplish dissolved P concentration equivalent to 2 times the ambient P concentration, and (4) add KH_2PO_4 stock to accomplish dissolved P concentration equivalent to 4 times the ambient P concentration. Unlike demonstrated by Spears et al. (2007) we will collect water column samples from just above the interface, mid depth of the water column and 2 cm below the water level. Additionally, we will also collect water samples 24, 48 and 72 hours.

After aerobic experiments, the aeration stones will be removed and a predetermined volume of a stock solution of sodium sulfide containing trace amount of cobalt chloride will be added to each column to create anaerobic conditions. The shaking will be continued and a 5th set of samples from three different depths as stated earlier will collected after approximately 48-72 hours as determined from aforementioned batch experiment.

Along with SRP, water samples will also be analyzed for pH, nitrogen species, TOC, and turbidity. Based on the column diameter, water and sediment height, dissolved P fluxes from the water column to sediments and vice-versa will be expressed as kg P/m^2/day. For other detailed analysis, please refer to the statistical analysis section of this project detailed later in this document.

Experimental details for set 2 with P spiking at neutral pH (Dr. Carling's lab): These experiments will follow the similar strategy detailed earlier for set 1 experiments under aerobic conditions only except that the pH of the overlying water column will be gently adjusted to 7 by adding 0.5 N H_2SO_4. All other experimental conditions and sampling strategy will be similar to set 1 experiments.

Experimental details for set 2 with P spiking at a pH of 9.5 (Dr. Carling's lab): These experiments will follow the similar strategy detailed earlier for set 1 experiments under aerobic conditions only except that the pH of the overlying water column will be gently adjusted to 9.5 by adding 0.5 N NaOH. All other experimental conditions and sampling strategy will be similar to set 1 experiments.

Analytical methods: The following table details different analytical methods for different parameters.

Parameter/s	**Method**	**Comments if any**
All anions including nitrate, nitrite, phosphate (dissolved P and SRP) and sulfate	Ion chromatography (supplemental with acid extraction as needed for P)	The IC is available in PI's lab.
Total organic carbon in liquid and sediment samples	Shimadzu total organic carbon analyzer	The Toc machine is available in PI's lab.
Ammonium nitrogen	HACH kit	Widely used method by ecologists and engineers with high accuracy
Polyphosphate accumulating organisms	DAPI staining after fixing cells with paraformaldehyde	Polyphosphate granules presence inside cells stains bright yellow with DAPI.
Metals	ICP-MS	Available at the University of Utah core facility
Turbidity	Turbidity meter	Available in the PI's lab.

Statistical analysis: We will use the R package to conduct all statistical analysis. We will use t-tests for more direct tests and comparison between data sets. Significance levels (p values) will be reported to levels of 0.05, and 0.01. For small sample sizes, we will also report p values between 0.05 and 0.10. Two-tailed Pearson correlation analysis will be used to determine the correlations between different parameters between different treatments. Principal component analysis will be used to evaluate interdependency of different parameters.

Sediment oxygen demand: For shallow site with accessibility (for example Provo Bay), we will install SOD chamber in-situ using the methodology demonstrated by us in the past for the Utah Lake (Hogsett et al., 2018). For open water site, we will first try to go in the route of installing in-situ SOD chamber using a SCUBA diver.

In case this does not work out, we will collect sediment cores in triplicate and determine SOD under laboratory scale controlled conditions. If conducted in the lab, care will be taken to inhibit any primary production by covering the sediment cores with dark cloth or aluminum foil. For in-situ determination, automated data sonde borrowed from UDWQ will be installed for continuous monitoring of DO. For lab scale SOD measurements, digital luminescent DO probe will be installed in the sediment column. The sediment column during SOD determination in the lab will be gently agitated to enhance DO mass transfer but not to the extent to disturb sediments. In both cases, water samples will be collected every 20~30 minutes to determine nutrient fluxes. The duration of experiments will be 90 minutes. Please refer to our previous publication (Hogsett et al., 2018) for details.

2.3.2.3 Task milestones and deliverables: Table below shows important milestones from this task. Please refer to section 4 of this document for detailed milestones. Key deliverables will be electronic files with observations and laboratory results in the form of interim and final reports. We will complete these experiments within four months from the date of award. Briefly, deliverables will include electronic pictures of lab scale setups, Excel files with laboratory data, and a short report on lab scale challenges and planned data analysis.

2.4 Task 4. Prepare technical report (Drs. Goel, Carling and both graduate students)

2.4.1. Key team members and *prior experience in report writing*: This task will be jointly completed by Drs. Goel (project principle investigator) and Carling (project Co-PI). Graduate students are also expected to help with data analysis and report writing. Dr. Goel has been actively receiving research funding from the United States National Foundation (6 active projects), the United States EPA (one Star grant active), the US Department of Energy, the United States Agency for International Development (one active project), the U.S. Department of Defense (one active project), local wastewater treatment plants (one active project), environmental consulting firms (one active project), and the UDWQ (one active project). All these ongoing projects require annual reporting and some of these (for example USAID) also require quarterly reporting. Additionally, Dr. Goel has been able to submit project reports with all the analyzed data (for example Hogsett et al., 2013) in the past to the UDWQ successfully for several UDWQ supported projects. Likewise, Dr. Carling is actively engaged in research projects funded by US NSF and other state and local agencies and has been meeting the reporting requirements without any fail.

2.4.2. Approach discussion

2.4.2.1. Approach for required technical report deliverables: We are proposing a three tier reporting strategy. First, we will periodically present results at in-person meetings with UDWQ personnel and the Science Panel to inform about project progress and to seek input on future research direction. Secondly, we will submit a synopsis of preliminary analysis within one week from the date of experiments in the form of interim reports. Lastly, we will submit draft and final project reports containing all analyzed data, project rationale, future recommendations. The final project report will also contain raw data in the appendix.

Data analysis will focus on the following questions; (**1**) What is the equilibrium phosphate concentration in the water column under all scenarios tested, (**2**) what is the internal P recycling from sediments to the water column based on P released from sediments expressed as flux (mg P/m^2/hour) and loading (e.g., kg/day), (**3**) is there any anaerobic release and if yes, is it purely related to redox chemistry, primarily iron reduction or bacteria mediated or both, and (4) how does the mineralogy of top sediments (e.g., interface) change after P spiking experiments. A detailed statistical analysis will be conducted (**see section 2.3.2.1 for statistical analysis details**) on different data sets to established correlations and interdependency. We will follow standard format for report preparation which we have been following for our EPA and UDWQ funded research projects.

2.4.2.2. Supplemental approach: We will disseminate project results through regional (such as SLC symposium, WEAU mid and annual conference), national (AWRA, WEFTEC, AEESP), and international (IWA and others) conferences. Publishing in peer reviewed journals is an integral part of this project.

2.4.2.3. Task milestones and deliverables: The following timetable shows important milestones

In person meetings: We will setup meetings with UDWQ at the beginning of the project, before beginning of the lab work, after completion of the first set of experiments, and after completing all experiments.

*Interim reports***:** This will depend upon field and lab work (hence subjective). However, we expect to submit at least three interim reports during the project period.

Draft and final reports: The draft report will be submitted within 5 months form the date of award or within one month from the date of completion of all experiments. Pending comments from the Science Panel and UDWQ, we will submit the final project report within 6 months from the date of award or within 2 months form the date of completion of all experiments.

3. Approach for Science Panel Collaboration and Data Sharing

Our goal is to closely work with the Utah Lake Science Panel during the project period. We will accomplish this goal right from the beginning of the project. SAP and QAPP documents will be prepared in collaboration with the Science Panel by sharing the documents in the ULWQS Dropbox folder for their inputs and comments. Additionally, we will also attend Science Panel meetings as needed during the course of this project. Towards the middle of the project when we have finished field sediment core collection, we will request an Adobe Connect meeting with all Science Panel members to update them about the progress of the project and seek their inputs on pending lab work.

The data management and data sharing are an integral part of this project and, the success of the scientific and engineering outcomes will depend upon a robust data sharing and data management plan. The new data generated by the project includes raw metadata from lab and literature review. The quality control and quality assurance plan for all the acquired data will be implemented according to US EPA established rules. Management of data will be accomplished on daily basis by maintaining proper lab notebooks and then managing the data electronically. Data will be made accessible to the Science Panel, UDWQ, other interested people, and the environmental community through presentations, interim reports, and peer reviewed publications. All the data including raw lab results, QA/QC results, final lab results, interpreted results, and any other associated data product will be shared with the Science Panel at the frequency stated in the RFP. We will also create a password protected online data repository to be shared with the Science Panel. All the collected data will be stored electronically with a weekly backup on an external hard drive. Proper statistical analyses will be conducted. Statistical analysis incorporating ANOVA and t-tests will be conducted to compare performance data between different experiments. The quality of sample measurements will be maintained by the daily use of standards and periodic analysis of blind standards. Our data dissemination plan will include presentations to local and national conferences, publishing in peer reviewed journals of international repute. No intellectual property is expected from this research.

Table: Tentative milestones for different tasks assuming project start date to be June 15th, 2019)

Different tasks	2019							2020		
	June	July	August	September	October	November	December	January	February	March
Task 1. Develop sampling and analysis plan (SAP)										
Task 2. Collect sediment cores from Utah Lake										
Provo Bay site										
Open water site										
Electronic file and writen report										
Task 3. Perform experiments and laboratory analysis										
Set 1: P spiking under aerobic conditions			site 1	site 2						
Set 1: Conitnue under anaerobic conditions			site 1	site 2						
Set 2: P spiking at pH 7.0				Site 1	site 2					
Set 3: P spiking at pH 9.5				Site 1	Site 2					
Statistical analysis										
Task 4. Prepare technical report										
Interim report										
Draft final report										
Final report										
Dissemination and publications										

4. Project milestones and deliverables

4.1. Important milestones: Table below shows important milestones for all tasks. Please note that the sediment core collection at the two sites is separated over a month to maintain quality control and make sure the lab work is not overwhelming for students and budget purposes.

4.2 Project deliverables: The following outputs will be delivered; (a) Written QAPP and SAP documents for all field and lab activities, (b) final project report with complete analysis, rationale and results comparison with the literature with future recommendation, (c) electronic files containing all raw and processed data obtained during the project, (d) a final presentation to the Science Panel.

5. Level of effort

5.1. Table below shows our approximate estimates of efforts by different team members. Graduate students will be hired on semester basis**.**

Task	Deliverable	Grad student 1 (U of U)	Grad student 2 (BYU)	Dr. Goel	Dr. Carling
Task 1: Develop Sampling and Analysis Plan	(1) Draft sampling and analysis plan (SAP) Final SAP	Approximately 15 to 20 hours	Approximately 15 to 20 hours	Approx. 20 hours	Approx. 10 hours
Task 2 – Collect Sediment Cores	(1) Electronic files with field observation. (2) A written short report	Approx. 10 hours	Approx. 10 hours	Approx. 15 hours	Approx. 5 hours
Task 3 – Perform Sediment Core Experiments and Laboratory Analysis	(1) Electronic files with observations. (2) laboratory results	3 hours preparation+72 hours aerobic spiking for one set (e.g one site) plus 72 hours anaerobic + 3 hours cleaning = 150 hours/site= 300 hours plus 10 hours per site for additional parameters= 320 hours	3 hours preparation+72 hours aerobic spiking for one set (e.g one site) plus 72 hours anaerobic + 3 hours cleaning = 150 hours/site= 300 hours	25 hours spread at U of U and 20 hours at BYU over three weeks	5 hours
Task 4– Prepare Technical Report	(1) Interim reports (2) Draft technical report (3) Final technical report	10~15 hours spread over 2 weeks	10~15 hours spread over 2 weeks	20~25 hours spread over 2 weeks	10 hours spread over 2 weeks

Note: The # of hours do not include time required for field sampling and travelling.

5.2 Team management: Dr. Goel is the project director. He will oversee the whole project. Interim and final project reports will be prepared in collaboration with Dr. Greg Carling, who is project Co-director from BYU. All QAPP and SAP documents will be jointly developed between the two labs resulting in one comprehensive document. Experiment set 1 (aerobic and anaerobic column experiments) and all supplemental research will be conducted in Dr. Goel's lab at the

University of Utah and sets 2 and 3 (pH 7 and pH 9.5 column experiments) will be conducted in Dr. Carling's lab at BYU. However, students from both universities will jointly perform all tasks under direct supervision of Drs. Goel and Carling. This implies that the student at the University of Utah will help in all experiments to be conducted at BYU and vice versa. This strategy will ensure a consistent execution of the experimental plan between two labs with all quality controls. Additionally, this will also ensure timely completion of all tasks in light of the proposed demanding experimental schedule. Both PI and CO-PI's have extensive expertise with a proven track record in sediment related research. Dr. Goel has been researching nutrient dynamics at the interface of sediments and water column for the past 12 years. The level of efforts is equally divided into both PI and CO-PI except the additional work related to SOD and supplemental tasks which will be performed in Dr. Goel's lab. The subcontract amount included in the budget is provided by Dr. Greg Carling. Dr. Carling will likely be on sabbatical leave during Fall 2019 (pending university approval) and thus will take a secondary role to PI Dr. Goel on this project. This should not be detrimental to the project because Dr. Carling is fully available during the summer for field and laboratory work and is available remotely during the fall for data analysis and reporting. Dr. Carling's student Sheena Smithson is fully available for the length of the project.

6. Cost Proposal

6.1. A stand alone cost proposal table

Tasks	Deliverable	Proposed cost (USD_
Task 1	QAPP and SOPs	**$10,000**
Task 2	Electronic files with field observation	**$8,000**
	Short report	**$2,000**
Task 3	Electronic files	**$2,000**
	Raw and analyzed results	**$35,000**
Task 4	Interim report	**$5,000**
	Draft technical report	**$2,000**
	Final project report	**$6,785**
Grand Total		**$70,785**

Detailed cost table with different breakups

Dr. Goel	0.5 month summer salary	**$7,500.00**
Graduate student 1		**$18,000.00**
Fringe	34 % for Goel and 10 % for student	**$4,350.00**
Travel	$500 for local	**$500.00**
Supply	To cover basic consumables, analytical chemcials, DO probe, PVC tube for core	
	collection, gloves, standards and consumables for IC, TOC, filter papers, syringes	**$9,000.00**
Core facility chanrges	For ICP analysis for metals	**$1,000.00**
Equipment	Two shaking mixer for column experiments	**$3,000.00**
Subcontract	Subcontract to BYU (for set 2 and 3 experiments)	**$21,000.00**
Total Direct		**$64,350.00**
Indirect	10 % of total direct	**$6,435.00**
Project grand total		**$70,785.00**

Budget Justification: Summer support for Dr. Goel for 0.5 month is included in the project. The graduate student at the U of U will be supported in summer for extensive experimental work and then in fall for report writing and help with other tasks related to the project. As stated in the table, fringe benefits are calculated at 34 % for senior personnel and 10 % for the student. Cost for local travel will cover driving to Utah Lake and BYU. The supply budget will cover cost of consumables, analytical chemicals, pH and DO probes, ion chromatography, HACH kits, pipette tips and gloves. The subcontract budget is provided by Dr. Greg Carling based on the two tasks. As stated in the RFP, the University indirect cost is calculated at 10 % of the total direct cost.

7. Resumes

Biographical Sketch: Ramesh K. Goel

RAMESH K. GOEL
Professor, Environmental Engineering
Civil & Environmental Engineering
University of Utah- Salt Lake City
110 South Central Campus Drive, 2000 MCE
Salt Lake City, UT-84112

Professional Preparation

Institution	*Major/Area*	*Degree*	*Year*
Jadavpur University	Civil Engineering	BS	1994
Jadavpur University	Environmental Engineering	MS	1996
University of South Carolina	Environmental Engineering	Ph.D.	2003
University of Wisconsin, Madison	Environmental Engineering	Post Doc	2005

Appointments

July 2017-present- Professor, Environmental Engineering, UU, Salt Lake
January-14 to May-14- Visiting professor, Radboud University, The Netherlands
June-14 to December-14- Visiting professor, EAWAG-ETH. Zurich, Switzerland
July 2011- June 2017- Associate professor, Environmental Engineering, UU, Salt Lake
January 2006- June 2011-Assistant professor, Environmental Engineering, UU, Salt Lake
August 03-December 06- Post Doc- Environmental Engineering, UW, Madison (**with Dr. Noguera**)
January 01- August 03 –Research Assistant-Environmental Engineering- USC, Columbia
July 96 – September 99- Engineer- CES (I) Ltd, India
July 94 – July 96- Graduate Research Assistant- Jadavpur University, India

Publications most closely related (out of a total 62 and more than 150 conference papers)

1. Hanyan, L., Alsanea, A., Barber, M. and Goel, R. (2019). High-throughput DNA sequencing reveals the dominance of pico- and other filamentous cyanobacteria in an urban freshwater Lake; Science of the Total Environment; **661: 465-480.**
2. Hogsett, M., Li, H. and Goel, R. (2018). The role of internal nutrient cycling in a Freshwater shallow alkaline lake. Environmental Engineering Science; DOI: 10.1089/ees.2018.0422.
3. Motlagh, A., Bhattacharjee, A. Casjens, S., Coutinho. F. Dulith, B.E. and Goel, R. (2017). Metagenomic approach to study phage- host interaction in sediments of hypersaline environment of Great Salt Lake. *Frontiers in Microbiology*. 8:352. doi:10.3389/fmicb.2017.00352
4. Kainthola, J., Kalamdhad, A.J., Goud, V.V. and Goel R. (2019). Fungal pretreatment and associated kinetics of rice straw hydrolysis to accelerate methane yield from anaerobic digestion. *Bioresource Technology*: https://doi.org/10.1016/j.biortech.2019.121368.
5. Windy D. Tanner., James A. VanDerslice., Ramesh K. Goel ., Molly K. Leecaster ., Mark A. Fisher., Jeremy Olstadt., Catherine M. Gurley., Anderson G. Morris., Kathryn A. Seely., Leslie Chapman ., Michelle Korando ., Kalifa-Amira Shabazz.[a], Andrea Stadsholt ., Janice VanDeVelde., Ellen Braun-Howland ., Christine Minihane ., Pamela J Higgins ., Michelle Deras., Othman Jaber ., Dee Jette ., Adi V. Gundlapalli . (2019). Multi-state study of *Enterobacteriaceae* harboring extended-spectrum beta-lactamase and carbapenemase genes in U.S. drinking water. Accepted in Scientific Report, Nature.
6. Motlagh, A., Bhattacharjee, A. Casjens, S., Coutinho. F. Dulith, B.E. and Goel, R. (2017). Metagenomic approach to study phage- host interaction in sediments of hypersaline environment of Great Salt Lake. *Frontiers in Microbiology*; 8:1-15.
7. Motlagh, A., Bhattacharjee, A. and Goel, R. (2015) Microbiological Study of Bacteriophages Induction in Presence of Chemical Stress Factors in Enhanced Biological Phosphorus Removal (EBPR). *Water Research*: 81: 1-14.
8. Lawson, C., Bhattacharjee, A., Wu, S., McMahon, T., Goel, R. and Noguera, D. (2017). Metabolic network analysis reveals microbial community interactions in anammox granules. "***Nature Communications 8:15416: 1-12***.

9. Bhattacharjee, A.S., Motlagh, A.M., Gilcrease, E.B., Islam, M.I., Casjens, S. and Goel, R. (2017). Complete genome sequence of lytic bacteriophage RG-2014 that infects the multidrug resistant bacterium Delftia tsuruhatensis ARB-1. Standards in Genomic Sciences; 12 (82): https://doi.org/10.1186/s40793-017-0290-y.
10. Hogsett, M. and Goel, R. (2013). Dissolved Oxygen Dynamics at the Sediment–Water Column Interface in an Urbanized Stream. Environmental Engineering Science; 30(10): 594-605.

SYNERGISTIC ACTIVITIES AND SERVICES

1. RPT Chair- Civil & Environmental Engineering, University of Utah, January 2018- till date.
2. Graduate Director- Civil & Environmental Engineering, University of Utah, January 2011- till date.
3. Chair- Academic Misconduct Committee-College of Engineering, University of Utah- July 2018-till date.
4. Member- Academic Misconduct Committee-College of Engineering, University of Utah- July 2015-2018.
5. Member- University of Utah Scholarship committee- August 2018- current
6. Secretary: United States of America National Committee of the International Water Association (USANC)- August 2015- till date
7. Chair- AEESP Distinguished Lecture committee- July 2017-2018
8. Vice Chair- AEESP Distinguished Lecture committee- July 2014-2017
9. Member- AEESP Distinguished Lecture committee- July 2011-2014
10. Member- AEESP Student Services Committee- July 2011-till date
11. Vice Chair- AEESP Distinguished Lecture committee- July 2014-2017
12. Chair: WEAU Preconference workshop.
13. Member: U of U College of Engineering Curriculum Development Committee- May 2015- till date
14. Member: U of U College of Engineering Excellence in Teaching Committee- May 2011- 2017
15. NSF panels: 2017 (5 panels), 2018 (7 panels),
16. Associate Editor-Water Research (August 2015- till date)
17. Associate editor- WEF's Water Environment Research Journal- August 2011-September 2018.
18. Environment Research and Education Foundation- Panel Reviewer- 2017 (3 proposals), 2018 (2 proposals).
19. USDA; 2016 (water panels), 2017 (nano panels).
20. Reviewer for International Science Panels: France, Israel, Jordan, Georgia, Mexico, Chile
21. Shota Rustaveli National Science Foundation of Georgia's Review Panel (2015, 2016, 2017 and 2018).
22. Board Advisor- WEF's Water Environment Research Journal- October 2018-till date.
23. Chair-WEFTEC Research Symposium- August 2015- September 2018.
24. Member-WEFTEC Research Symposium- September 2018- till date
25. Member: Association for Environmental Engineers and Professional's Lectures Committee- August 2011-till date.
26. Reviewer for Water Research, J. of Applied Microbiology, Microbial Ecology, ASCE-J. of Environmental Engineering, Chemosphere, Bioresource Technology, Journal of Hazardous Waste Management, International Journal of Hydrogen Energy, Environmental Engineering Science, Water Environment Research, Water Science & Technology, Biochemical Engineering, Environmental Microbiology, Science of the total Environment, Water Research, Environmental Science & Technology, Chemosphere, Desalination, Applied Microbiology, Ecological Engineering, Chemical Engineering Journal, Biodegradation, Applied Biochemistry and Biotechnology, Journal of General Virology, Microbial Ecology and Journal of Applied Electrochemistry. Total number of papers reviewed in 2017 (>25) and 2018 (>30).

Past Graduate Students

Doctoral Students (Total 9)

Name	**Current status**
Dr. Tania Datta (2010)	Assistant professor, Tennessee Tech University
Dr. Liang Li (2012)	Associate Professor, Shanghai Sci & Technology
Dr. LeeAnn Racz (2010)	Assistant Professor, Air Force Institute of Technology
Dr. J. Choi (2013)	Assistant Professor, Korean Transportation University
Dr. Mitch Hogsett (2014)	Engineer, Forsgren Associates Inc. Salt Lake City
Dr. Sha Wu (2016)	Employed in China
Dr. Pei Huang (2016)	Employed in Salt Lake City
Dr. Amir Motlagh (2016)	Assistant Professor, California State University
Dr. Ananda Bhattacharjee (2016)	Research Scientist- Bieglo Lab, Maine
Sunayna Dasgupta (2018)	Research Scientist-University of Minnesota, Twin Cities

Biographical Sketch: Gregory T. Carling

(a) Professional Preparation

Brigham Young University	Geology	B.S. 2005
Brigham Young University	Geological Sciences	M.S. 2007
University of Utah	Geology	Ph.D. 2012

(b) Appointments

2018-present	*Associate professor*, Geological Sciences, Brigham Young University
2012-2018	*Assistant professor*, Geological Sciences, Brigham Young University
2011-2012	*Graduate research assistant*, Geology, University of Utah
2008-2010	*NSF-GK-12 fellow*, Geology, University of Utah
2005-2007	*Teaching assistant*, Geology, Brigham Young University

(c) Publications

Publications most closely related to the proposed project:

1. Randall, M.C., Carling, G.T., Dastrup, D.B., Miller, T., Nelson, S.T., Rey, K., Hansen, N., Bickmore, B.R., Aanderud, Z.T., **2019**. Sediment potentially controls in-lake phosphorus cycling and harmful cyanobacteria in shallow, eutrophic Utah Lake. *PLOS ONE* 14:e0212238.

2. Dastrup, D.B., Carling, G.T., Collins, S.A., Nelson, S.T., Fernandez, D.P., Tingey, D.G., Hahnenberger, M., Aanderud, Z.T., **2018**. Aeolian dust chemistry and bacterial communities in snow are unique to airshed locations across northern Utah, USA. *Atmospheric Environment* 193:251-261.

3. Selck, B.J., Carling, G.T., Kirby, S.M., Hansen, N.C., Bickmore, B.R., Tingey, D.G., Rey, K., Wallace, J., Jordan, J.L., **2018**. Investigating anthropogenic and geogenic sources of groundwater contamination in a semi-arid alluvial basin, Goshen Valley, Utah, USA. *Water, Air, and Soil Pollution* 229:186.

4. Goodsell, T.H., Carling, G.T., Aanderud, Z.T., Nelson, S.T., Fernandez, D.P., Tingey, D.G., **2017**. Thermal groundwater contributions of arsenic and other trace elements to the middle Provo River, Utah, USA. *Environmental Earth Sciences* 76:268.

5. Carling, G.T., Tingey, D.G., Fernandez, D.P., Nelson, S.T., Aanderud, Z.T., Goodsell, T.G., Chapman, T.R., **2015**. Evaluating natural and anthropogenic trace element inputs along an alpine to urban gradient in the Provo River, Utah, USA. Applied Geochemistry 63: 398-412.

6. Johnson, W.P., Swanson, N., Black, B., Rudd, A., Carling, G.T., Fernandez, D.P., Luft, J., van Leeuwen, J., and Marvin-DiPasquale, M., **2015**. Total- and methyl-mercury concentrations and methylation rates across the freshwater to hypersaline continuum of the Great Salt Lake, Utah, USA. *Science of the Total Environment* 511:489-500.

7. Naftz, D.L., Carling, G.T., Angeroth, C., Freeman, M., Rowland, R., Pazmiño, E., **2014**. Density-stratified flow events in Great Salt Lake, Utah, USA: Implications for mercury and salinity cycling. Aquatic Geochemistry 20:547-571.
8. Carling, G.T., Richards, D., Hoven, H., Miller, T., Fernandez, D.P., Rudd, A., Pazmino, E., and W.P. Johnson, **2013**. Relationships of surface water, pore water, and sediment chemistry in wetlands adjacent to Great Salt Lake, Utah, and potential impacts on plant community health. Science of the Total Environment 443: 798-811.
9. Naftz, D.L., Angeroth, C., Freeman, M., Rowland, R., and Carling, G.T., **2013**. Monitoring change in Great Salt Lake. *Eos*, Transactions American Geophysical Union 94:289-290.
10. Carling, G.T., Fernandez, D.P., Rudd, A., Pazmino, E., and W.P. Johnson, **2011**. Trace element diel variations and particulate pulses in perimeter freshwater wetlands of Great Salt Lake, Utah. Chemical Geology 283: 87-98.

(d) State and Federal Research Grants

7/2019-21 Utah Division of Air Quality, $150,000, "Characterizing air quality impacts from exceptional events along the Wasatch Front"

7/2015-19 NSF Hydrologic Sciences, $269,796 ($338,324 including U of U), "Collaborative Research: Investigation of the fate and transport of dust-borne trace metals and solutes during snowmelt"

7/2017-18 Utah Division of Forestry, Fire and State Lands, $29,770, "Understanding environmental impacts of Great Salt Lake dust: Using isotopic "fingerprints" to determine dust sources and quantifying changes in trace metal concentrations from source to deposition"

7/2015-16 Utah Division of Forestry, Fire and State Lands, $39,717, "Characterizing harmful effects of dust emissions from the dry lakebed of Great Salt Lake relative to other regional dust sources"

9/2014-15 Utah Geological Survey, $24,472, "Groundwater resources in Goshen Valley, Utah: Assessing water quality impacts from agriculture, legacy mining, playa soils, septic tanks, and geothermal waters"

(e) Teaching and Mentoring

Courses Taught: Introduction to Geology (Geol 101), Geological Communications (Geol 230), Geological Field Methods (Geol 420), Groundwater (Geol 435), Water in the West (Geol 490), Contaminant Hydrogeology (Geol 535), Advanced Hydrogeology (Geol 635), Advanced Hydrochemistry (Geol 636)

Advisor for Geology M.S. students: Sheena Smithson (expected 2020), Natalie Barkdull (expected 2019), Michael Goodman (2019), Colin Hale (2018), Brian Packer (2018), Hannah Checketts (2018), Matt Randall (2017), Dylan Dastrup (2016), Brian Selck (2016), Timothy Goodsell (2016)

Undergraduate mentoring: Served as primary mentor for 36 undergraduate students since 2012 with over 90 conference presentations by students

8. Related Case Study

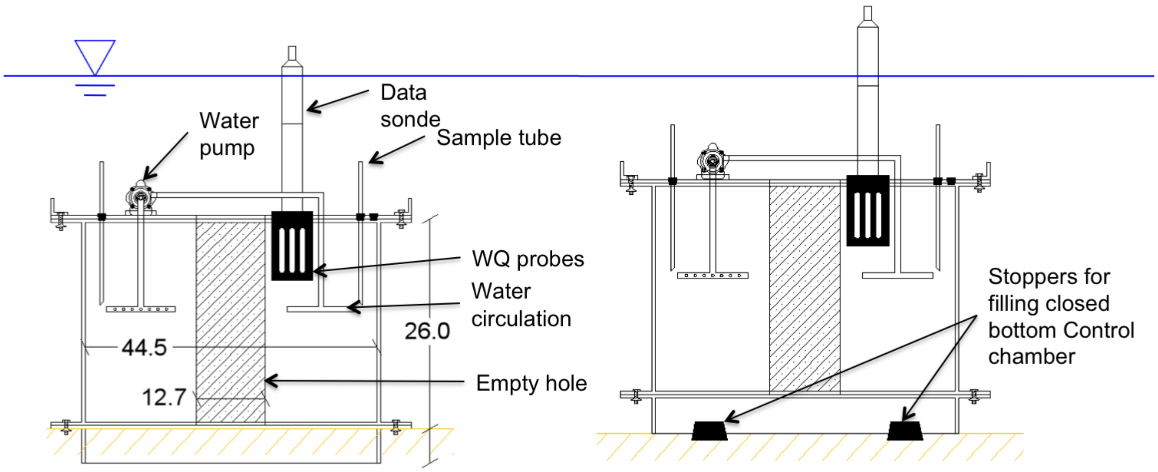

Figure 1: Schematic of SOD chambers used in the past to evaluate COD in Utah Lake. The left side schematic shows the testing SOD chamber and the top right side schematic shows the water column chamber (not in contact with sediment). These chambers were designed in collaboration with USEPA. These chambers were also used for evaluating SOD in Jordan River and other water bodies in Utah. Dr. Goel's lab was the first one to bring this simple technology to Utah in 2008-2009.

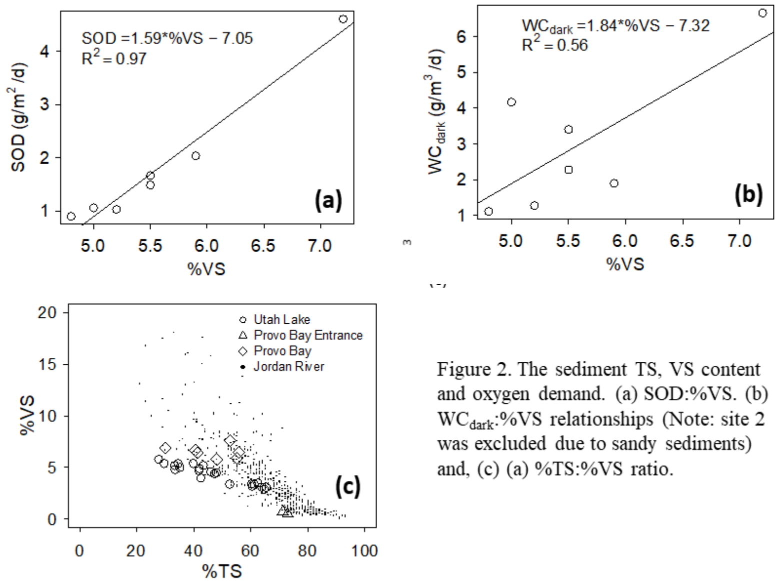

Figure 2. The sediment TS, VS content and oxygen demand. (a) SOD:%VS. (b) WC_{dark}:%VS relationships (Note: site 2 was excluded due to sandy sediments) and, (c) (a) %TS:%VS ratio.

Figure 2: The measured %VS as a function of SOD is plotted in Figure 2(a) for several sites in Utah Lake. The SOD values and SOD fluxes were higher in sediments that had higher %VS. The nearly-linear correlation (r =1.59, R^2 =0.96) supported the relationship between them. It appeared that the %VS could be more or less related to WC_{dark} in Utah Lake (r =1.84, R^2 = 0.47) (Panel b in Figure 2), because the phytoplankton would eventually die and settle to the sediment, contributing to the sediment organic matter content. The decay of that organic matter in the sediment would create a future SOD and considered to be a major contributor of potential anoxic conditions

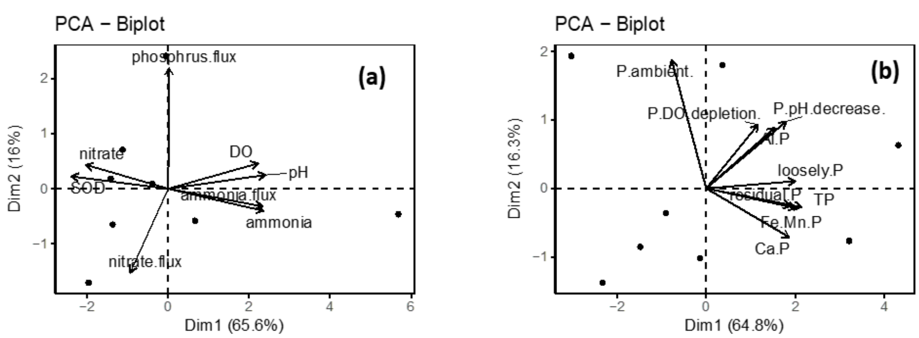

Figure 3: PCA analysis of environmental factors on nutrient flux, (a) Nutrient flux with ambient conditions, (b) P release under different conditions with sediment TP and P speciation. The fluxes of different nutrients and ambient parameters were plotted in Figure 4(a). Surprisingly, ammonia, rather than phosphorus, was the major nutrient released from sediment under ambient conditions. The release of ammonia was highly correlated with eutrophication conditions. Sites with higher DO (r = 0.29, p <0.05, Spearman), SOD (r = 0.46, p <0.05, Spearman), and pH (r = 0.44, p<0.05, Spearman) were found to have the most ammonia flux and the highest ambient ammonia concentrations. It can be inferred that ammonia flux from sediment was one of the sources for ambient ammonia-N.

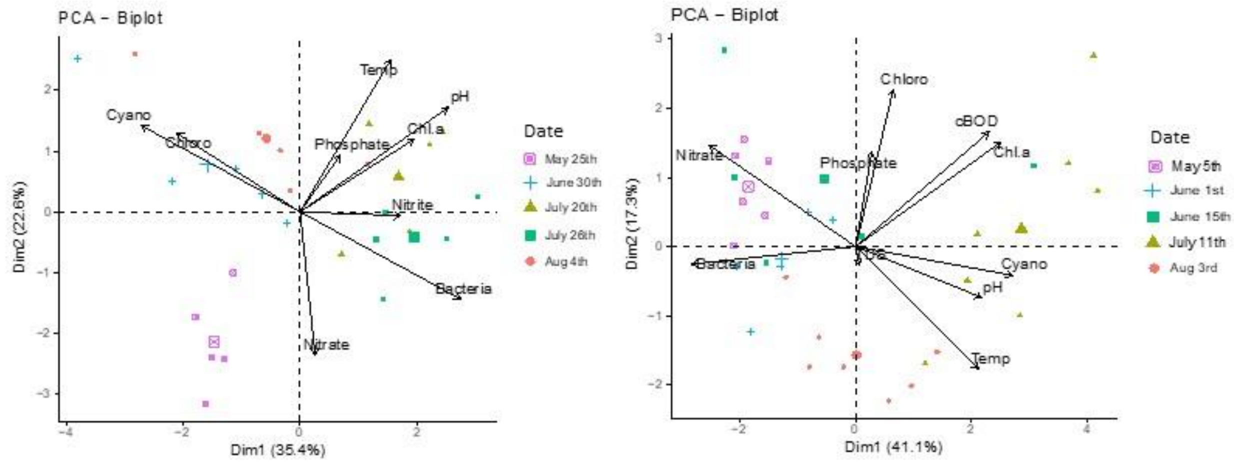

Figure 4: The principle component analysis (PCA) was conducted with the environmental parameters (temperature, pH, TDS, chlorophyll a, etc) and the relative abundance of bacterial groups (cyanobacteria, heterotroph bacteria and chloroplast community) (Figure 7). Two principle components (Dim 1 and Dim 2) with the highest percentages were shown on the plots, which explained 58.0 % and 58.4% of the variations for 2016 and 2017. For the analysis of variance, cyanobacteria were found to be negatively linked with heterotrophs and nitrate in both years. Environmental factors such as Chl a, pH, temperature and cBOD are positively correlated with each other. Occurrence of chloroplast communities were observed to have the same trend as cyanobacteria. A clear pattern was observed when individuals are grouped based on months rather than geographical locations. In 2016, heterotrophs dominated the algal bloom in July and were linked to nitrogen sources (Left panel). Cyanobacteria and chloroplast community accounted for higher relative abundance before and after the bloom. By the contrast, the dominance of cyanobacteria in July was mostly related to temperature in 2017 (right panel).

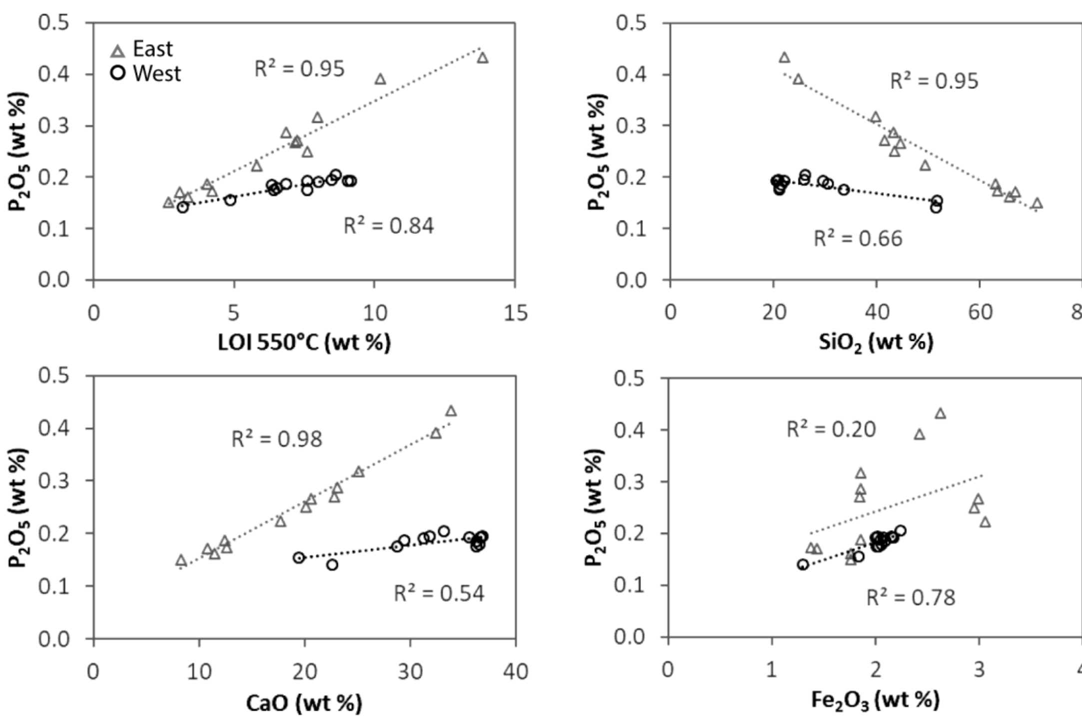

Fig 5. P_2O_5 abundance versus LOI 550°C, CaO, and SiO_2. LOI 550°C is a measure of organic matter concentration. West samples (*n*=13) were collected from sites 2-3, 5-10, and 14 and east samples (*n*=13) were collected from sites 1, 4, 11-13, and 15

Table 1. Utah Lake surface sediment mineral composition

Utah Lake surface sediment mineral composition (% mass)													
	carbonates			clays				silica oxides	feldspars		other		
site	calcite	aragonite	dolomite	illite	smectite	kaolinite	chlorite	quartz	K-feldspar	plagioclase	magnetite	pyrite	zeolite
1	54	0.6	2.2	3.3	4.7	2.1	1.9	17.9	7.4	4.9		1	
2	9.8		1.7	2.3	3	1.2	1.4	52.1	13.2	11			4.3
3	60	0.5	2.2	3.8	6.8	2.4	1.6	10.5	6.6	4.9		0.1	0.6
4	43.8	0.3	1.5	4.5	3.9	2.2	0.7	27.0	8.0	6.9	0.3	0.7	0.2
5	48.8	0.2	3.1	4.4	6.0	2.7	2.1	18.3	7.2	6.8		0.2	0.2
6	62.4	0.4	2	4.3	5.6	2.2	1.3	11.4	5.6	4.7		0.1	
7	27.3	4.7	1.8	3	3.3	2	0.1	38.7	6.8	10.2		0.4	1.7
8	64.1	0.2	2.2	4.8	6.0	2.2	1.9	8.4	5.7	4.1		0.1	0.5

Table 2. Phosphorus speciation in Utah Lake sediments

Sediment P (mg P/kg dry mass)							
site	loosely bound	Fe & Mn bound	minerals & Al oxides	Ca bound	residual	total P	% Ca bound
1	253	439	148	778	150	1767	44
2	12	15	0	234	22	282	83
3	135	309	116	888	226	1674	53
4	16	136	26	314	36	528	59
5	41	110	208	505	60	924	55
6	33	142	14	605	18	811	75
7	26	69	10	541	22	669	81
8	60	134	43	723	77	1037	70

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Hanyan, L., Alsanea, A., Barber, M. and Goel, R. (2019). High-throughput DNA sequencing reveals the dominance of pico- and other filamentous cyanobacteria in an urban freshwater Lake; *Science of the Total Environment*; **661: 465-480.**

Hogsett, M., Li, H. and Goel, R. (2018). The role of internal nutrient cycling in a Freshwater shallow alkaline lake. *Environmental Engineering Science*; DOI: 10.1089/ees.2018.0422.

Hogsett, M. and Goel, R. (2013). Dissolved Oxygen Dynamics at the Sediment–Water Column Interface in an Urbanized Stream. *Environmental Engineering Science*; 30(10): 594-605.

Hogsett, M., and R. Goel, 2013. *Determination of nutrient fluxes and sediment oxygen demand at selected locations in Utah Lake*. Civil & Environmental Engineering, University of Utah, Prepared for: Utah Division of Environmental Quality

Randall, M.C., Carling, G.T., Dastrup, D.B., Miller, T., Nelson, S.T., Rey, K., Hansen, N., Bickmore, B.R., Aanderud, Z.T., **2019**. Sediment potentially controls in-lake phosphorus cycling and harmful cyanobacteria in shallow, eutrophic Utah Lake. *PLOS ONE* 14:e0212238.

Spears, B.M., Carvalho, L., Perkins, R., Kirika, A. and Paterson, D.M. (2007). Sediment phosphorus cycling in a large shallow lake: spatio-temporal variation in phosphorus pools and release. *Hydrobiologia*; 584:37-48.

State of Utah

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

Department of
Environmental Quality

Alan Matheson
Executive Director

DIVISION OF WATER QUALITY
Erica Brown Gaddis, PhD
Director

MEMORANDUM

TO: Water Quality Board Members

Through: Erica Brown Gaddis, Director

FROM: Jim Bowcutt, Nonpoint Source Program Coordinator

DATE: June 26, 2019

SUBJECT: State Nonpoint Source Program Annual Report for Fiscal Year 2019

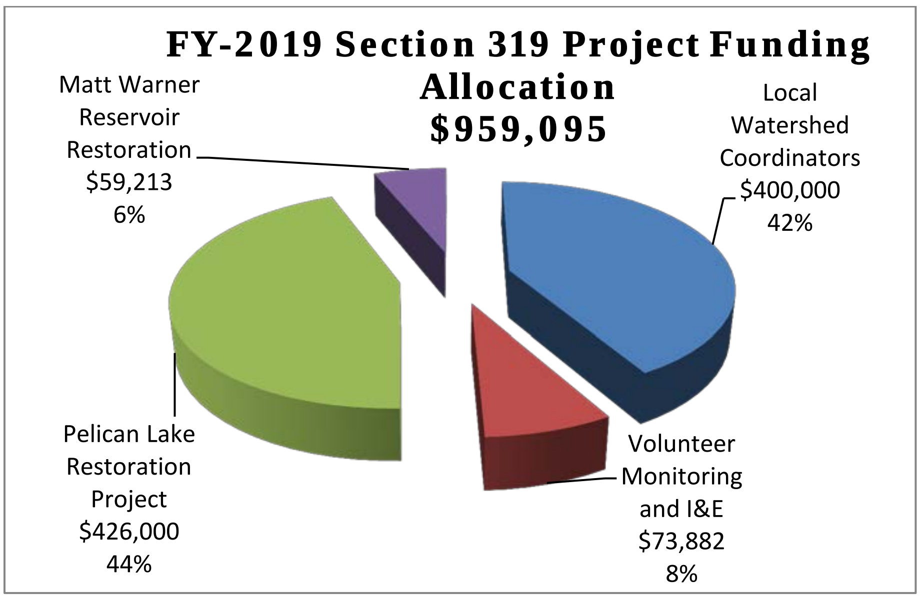
The Division of Water Quality receives grant funds to help implement nonpoint source pollution control projects throughout the state. These grants include Section 319(h) funds from the Environmental Protection Agency and State Nonpoint Source funds authorized by the Water Quality Board. Every year an annual report is submitted to EPA on the accomplishments of the State's Nonpoint Source Program. Staff will present a summary of this report to the Water Quality Board during the meeting scheduled for June 26th.

195 North 1950 West • Salt Lake City, UT
Mailing Address: PO Box 144870 • Salt Lake City, UT 84114-4870
Telephone (801) 536-4300 • Fax (801) 536-4301 • TDD (801) 536-4284
www.deq.utah.gov

State of Utah Nonpoint Source (NPS) Annual Report
Utah Water Quality Board Meeting
June 26, 2019

Section 319 Nonpoint source funds

- In FY-19 the State of Utah received $1,445,000 in Federal Section 319(h) funds. Of these funds, $485,905 was used for staffing and support, while the remaining $959,095 was dedicated to 4 projects.



- In addition to the FY-19 Section 319 funds Utah continues to manage five other federal grant awards, which have been expended to a varied degree. Table 1 summarizes grant awards by year and the approximate percentage that has already been expended in each grant.

Table 1

Section 319(h) Nonpoint Source Funding Project Allocations			
Federal Fiscal Year	Grant Award	Total Expenditures	**Percent Expended**
FY-14	$893,621	$893,621	**100%**
FY-15	$879,703	$858,981	**98%**
FY-16	$987,458	$709,384	**72%**
FY-17	$1,004,260	$780,372	**78%**
FY-18	$970,494	$154,085	**16%**
FY-19	$959,059	$0	**0%**
Total	**$5,694,595**	**$3,396,443**	**60%**

- The targeted basin approach continues to be implemented (See Table 2). In the spring of 2019 the Jordan River/Utah Lake watershed was the targeted basin; projects in this basin were prioritized for funding with the FY-2020 grants. Table 3 shows the nonpoint source grants that were selected for funding.

Table 2

Basin Priority Funding Schedule						
Watershed	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
(1) Jordan/ Utah lake						
(2) Colorado River						
(3) Sevier, Cedar-Beaver						
(4) Bear River						
(5) Weber River						
(6) Uinta Basin						

Projects Funded in FY-2020

- 60 Grant Applications were received totaling $3,246,677. Of these proposals 35 were fully or partially funded using State Nonpoint Source Grants and eight were funded using Section 319 funding.

Other Accomplishments

- The State Nonpoint Source Pollution Management Plan was approved by EPA in April 2019.
- A success story was submitted to EPA for the Main Creek Watershed, which has shown a significant decrease in water temperature as a result of restoration.
- The ARDL Loan Principle Buy-down Program was developed for large AFO/CAFOs.
- A statewide campaign focusing on reducing pollution from small farming operations was initiated.

Table 3- FY-2020 Grant Awards

Projects Funded with State Nonpoint Source Grants

Project Title	Watershed	Sponsor	Project Type	Amount Requested	Amount Awarded
Onsite Waste water Hardship Grant Assistance Program	Statewide	UDWQ	Onsite Waste Water	$35,000	$35,000
Lower Jordan River Watershed Coordination	Jordan River/Utah Lake	Salt Lake County	Technical Assistance	$30,000	$30,000
Wallsburg RCPP Phase 2	Jordan River/Utah Lake	Wasatch Conservation District	Stream Bank	$130,000	$100,000
Nebo Creek Restoration	Jordan River/Utah Lake	Timp-Nebo Conservation District	Fire Rehab	$53,000	$53,000
PWO Maintenance Yard Improvements	Jordan River/Utah Lake	Salt Lake County	Storm Water	$25,000	$25,000
Wasatch Front Urban Ranger Program	Jordan River/Utah Lake	University of Utah	I&E	$108,000	$25,000
Envirothon	Statewide	Utah State University	I&E	$5,000	$5,000
Producer Website and Small Farm Education	Statewide	Utah State University	I&E	$18,750	$10,000
Write Conservation Easement	Weber River	Summit Land Conservancy	Easement	$15,000	$15,000
Otter Creek Restoration	Upper Sevier	BLM	Riparian Improvement	$65,000	$65,000
Provo River Watershed Council Watershed Education	Jordan River/Utah Lake	Wasatch County Planning Department	I&E	$10,000	$10,000
Helper City Stream Restoration	Colorado	Helper City	Stream Bank	$19,500	$19,500
Olsen riparian Project Phase 2	San Pitch	Sanpete Conservation District	Stream Bank	$13,500	$13,500
University of Utah Storm Water Demonstration Project	Jordan River/Utah Lake	University of Utah	Storm Water	$107,800	$55,000
700 North Storm Water Improvement and Demonstration	Bear River	Utah State University	Storm Water	$82,500	$65,000
East Canyon Creek Restoration	Weber River	Kamas Valley Conservation	Stream Bank	$45,450	$45,450

		District			
BLM Mill Creek Restoration	South East Colorado	Bureau of Land Management	Riparian Improvement	$40,000	$30,000
Catalyst for Change	Jordan River/Utah Lake	Thanksgiving Point	I&E	$6,000	$3,000
Upper Sevier Watershed I&E	Upper Sevier	Upper Sevier Conservation District	I&E	$9,700	$9,700
Bingham Creek Watershed Management Plan Development	Jordan River/Utah Lake	City of West Jordan	Planning	$90,100	$40,000
Storm Water Prevention BMP Workshop	Weber River	Utah State University	I&E	$11,100	$11,100
Montezuma Creek Effectiveness Monitoring	South East Colorado	UGS	Monitoring	$19,935	$10,000
Heber Valley Watershed Plan	Jordan River/Utah Lake	Wasatch Conservation District	Planning	$50,000	$40,000
American Fisheries Society Support	Statewide	American Fisheries Society	Group Support	$1,000	$1,000
Spring Creek Manure Management	Jordan River/Utah Lake	Wasatch Conservation District	Nutrient Management	$5,000	$5,000
Snake Creek Stream Bank Restoration	Jordan River/Utah Lake	Wasatch Conservation District	Stream Bank	$20,000	$20,000
Lower Weber River Restoration	Weber River	Ogden City	Stream Bank	$47,632	$47,632
Summit Park Fuels Reduction	Weber River	Kamas Valley Conservation District	Fire fuels/restoration	$75,000	$50,000
Stephens Farm Riparian Enhancement	Weber River	Kenneth and Isabel Stephens	Stream Bank	$27,400	$27,400
Grass Creek Stock Water System	Weber River	Summit Soil Conservation District	Grazing	$48,000	$35,000
SEUHD Onsite Waste Water Digital Database	South East Colorado	South East Utah Health Department	Onsite Waste Water	$8,000	$8,000
4000 West Field Drain Restoration	Jordan River/Utah Lake	Timp-Nebo Conservation District	Field Drain	$60,000	$35,000
East Fork Hilliard Canal Diversion	Upper Bear River	Trout Unlimited	Diversion Rebuild	$15,000	$15,000

North Cache Soil Health Implementation and Monitoring	Bear River	North Cache Conservation District	Soil Health	$57,127	$35,000
Henefer City Source Water Protection	Weber River	Terry Diston - Private Landowner	Stream Bank	$25,000	$5,718
			Total	**$1,379,494**	**$1,000,000**

Projects Funded with Section 319 Funding

Project Title	**Watershed**	**Sponsor**	**Project Type**	**Amount Requested**	**Amount Awarded**
Local Watershed Coordinators	Statewide	Utah Division of Water Quality	Technical Assistance	$500,000	$410,000
West Jordan Big Bend Project	Jordan River/Utah Lake	West Jordan City	Stream Bank	$331,541	$331,540
USU NPS Education Program	Statewide	USU Water Quality Extension	I&E	$69,948	$69,948
Nuttall Riparian Stabilization Project	San Pitch	Sanpete Conservation District	Stream Bank	$10,200	$10,200
Sidwell Riparian Improvement Project	San Pitch	Sanpete Conservation District	Stream Bank	$4,200	$4,200
Madsen Riparian Stabilization Project	San Pitch	Sanpete Conservation District	Stream Bank	$27,000	$27,000
Stewart Riparian Stabilization Project	San Pitch	Sanpete Conservation District	Stream Bank	$46,000	$46,000
Lower Spanish Fork River Restoration	Jordan River/Utah Lake	Timp-Nebo Conservation District	Stream Bank	$100,000	$60,000
			Total	**$1,088,889**	**$958,888**

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Alan Matheson
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DIVISION OF WATER QUALITY
Erica Brown Gaddis, PhD
Director

MEMORANDUM

TO: Utah Water Quality Board

THROUGH: Erica Brown Gaddis, PhD, Executive Secretary

FROM: Chris Bittner, DWQ Standards Coordinator

DATE: June 26, 2019

SUBJECT: Amendments to R317-1-1, Definitions and R317-2, Standards of Quality for Waters of the State

Board Action: Staff recommends that the Water Quality Board adopt the amendments as proposed in the April 1, 2019 Bulletin as a Board Order with an effective date of July 1, 2019.

DWQ staff initiated the rulemaking for several changes to R317-2, Standards of Quality for Waters of the State, by publishing the proposed amendments in the April 1, 2019 Utah Bulletin (No. 43585 and No. 43586). A public hearing was held in Salt Lake City on May 1, 2019 and the public comment period ended on May 3, 2019. No oral comments were received and the written comments and staff responses are presented in Attachment 1, Public Participation Responsiveness Summary. The proposed changes, comments received and staff recommendations are summarized in this memorandum. Detailed supporting documentation for the proposed changes are attached or referenced.

In summary, the proposed amendments are:

1. Add recreational and aquatic life use numeric nutrient criteria for Category 1 and Category 2 waters statewide.
2. Add definitions to R317-1-1 to support the numeric nutrient criteria.
3. Add drinking water use to Sheep Creek, Cache County.
4. Adopt a site-specific agricultural use total dissolved solids (TDS) criterion for Silver Creek, Summit County.
5. Adopt site-specific aquatic life use ammonia criteria for a portion of the Jordan River, Salt Lake County.
6. Correct statewide human health criteria in Table 2.14.6.

1. Numeric nutrient criteria for headwater streams (Antidegradation Category 1 and 2, R317-2-3) to protect both aquatic life and recreation use classes is proposed. Comments were received by David Richards, Friends of Great Salt Lake, and U.S. EPA.

David Richards provided comments about the evaluations on compositional changes in macroinvertebrate and diatom assemblages associated with nutrient enrichment (Technical Support Document, Chapter 6). The principal concern raised in these comments is that nutrients may actually be responding to covariates (e.g., nutrients, temperature) as opposed to nutrients. These concerns are not without merit, but the ramifications to the proposed NNC are overstated. Structural responses were one of many different lines of evidence that UDWQ evaluated to derive the proposed numeric nutrient criteria (NNC) for headwater streams. None of the structural responses and related total nitrogen and total phosphorus thresholds derived from structural responses was directly incorporated into the NNC. These analyses were useful because they helped confirm that proposed NNC aligned with existing, independently developed, indicators of biological use support.

Friends of Great Salt Lake provided comments in support of this proposal.

The United States Environmental Protection Agency (EPA) provided technical comments to Utah's Division of Water Quality (UDWQ) about the proposed headwater numeric nutrient criteria (NNC) and its underlying rationale. EPA did not raise any concerns of the elements of the NNC intended to protect recreational uses, so the responses focus on NNC elements intended to be protective of aquatic life uses.

EPA raised several concerns about the ecological relevance of the statistically derived response thresholds and their ability to ensure protection of aquatic life uses in headwater streams. UDWQ addresses specific concerns by expanding on the information provided in the supporting documentation in the Detailed Responses below in Attachment 2.

EPA also makes several recommendations, which nearly all involve requests for additional clarification in supporting materials for the proposed headwater numeric nutrient criteria (NNC). Additional EPA recommendations include providing additional supporting materials such as the Standard Operating Procedures (SOPs) for filamentous algae cover data collection and the approach that UDWQ intends to follow for criteria implementation. While these materials have already undergone extensive technical review, UDWQ appreciates the fresh perspectives provided by stakeholders outside of these discussions. EPA is particularly well suited to highlight circumstances where additional details would provide additional rationale that the proposed criteria align with regulatory water quality standard requirements (40 C.F.R. Part 131). UDWQ has revised supporting documentation—*Technical Support Document: Utah's Nutrient Strategy* (hereafter TSD) (https://documents.deq.utah.gov/water-quality/standards-technical-services/DWQ-2019-006461.pdf) and *Proposed Nutrient Criteria: Utah's Headwater Streams* (hereafter Proposal) (https://documents.deq.utah.gov/water-quality/standards-technical-services/DWQ-2019-006505.pdf)—to further clarify the underlying rationale behind the NNC. Additional requested documents will be submitted in conjunction with the rulemaking packet provided to EPA for formal review and approval in accordance with section 303(c) of the Clean Water Act (CWA).

Inclusion of the recommended clarifications in supporting documentation will improve the strength of the underlying rationale. However, the comments do not substantively alter the proposed rules or supporting documentation, nor do they raise concerns about the scientific defensibility of the rules as an important regulatory tool that will help the agency maintain and protect water quality in Utah's headwater streams. The proposed headwater NNC does not remove any existing protections from adverse effects caused by excessive nutrient enrichment. Instead, they establish additional protections that can be used to identify adverse effects of nutrient enrichment. The 2015 confirmation investigation (TSD, Chapter 13) confirmed that the NNC were able to identify headwater streams exhibiting adverse effects of nutrient enrichment.

Many headwater streams have naturally-occurring physical attributes that provide natural protections form the effects of nutrient enrichment and this sometimes obscures otherwise significant stressor-response (S-R) relationships. However, the inability of the NNC to identify adverse effects in these circumstances is not evidence that the criteria lack protections for aquatic life uses; in fact, these observations are evidence that combining nutrients with ecological responses is needed to avoid an unreasonable number of false-positive impairment determinations. The responses included in the NNC facilitate an evaluation of the two most important causal pathways leading to degradation of aquatic life uses. Among all of the responses that UDWQ evaluated in the TSD, these responses were also most easily integrated into routine monitoring and assessment programs.

Staff recommends that the Board adopt this amendment. Additional supporting documentation is provided as Attachment 3.

2. Definitions are proposed for a few terms to support the adoption of the numeric nutrient criteria. No comments were received regarding these definitions.

Staff recommends that the Board adopt these definitions to support the numeric nutrient criteria.

3. In response to a request by the homeowners association that was supported by the Utah Division of Drinking Water, the Class 1C use is proposed for Sheep Creek, Cache County. No comments were received regarding Sheep Creek.

Staff recommends that the Board adopt this amendment. Additional supporting documentation is provided as Attachment 4.

4. For Silver Creek, Summit County, a site-specific total dissolved solids criterion for the Class 4 agricultural use that is higher than the statewide criterion is proposed. The higher criterion is appropriate because of irreversible human-caused road salting. The higher criterion applies only to the upper Silver Creek. The statewide criterion for lower Silver Creek is unchanged.

No adverse comments were received but U.S. EPA expressed concerns regarding the potential continued degradation of Silver Creek from road salting. Staff shares these concerns and will continue to work with stakeholders in Park City to identify effective practices to reduce the water quality impacts of road salting.

Staff recommends that the Board adopt this amendment. Additional supporting documentation is provided as Attachment 4.

5. A site-specific aquatic life use ammonia criteria are proposed for Mill Creek from I-15 to the Jordan River, downstream in the Jordan River and the Surplus Canal to 900 S. in Salt Lake County. These ammonia criteria are based on U.S. EPA's updated 2013 ammonia criteria. No adverse comments were received but U.S. EPA identified an extra digit in one of the exponents for the criteria in the rule. Normally staff would request that the Board adopt a Change in Proposed Rule to correct this error. However, the Utah Division of Administrative Rules is currently updating their rule software and strongly recommends that no Change in Proposed Rules be filed now because of the administrative burden.

Staff recommends that the Board adopt this amendment and staff will file a nonsubstantive change to correct the typographical error. Additional supporting documentation is provided as Attachment 4.

6. Several statewide human health water quality criteria were corrected. No adverse comments were received but U.S. EPA noted that the criteria for butylbenzyl phthalate were not corrected as proposed. Butylbenzyl phthalate is not a common pollutant in Utah and these criteria have little current impact.

Staff recommends that the Board adopt all of these criteria and staff will correct the butylbenzyl phthalate criteria in a future rulemaking. Additional supporting documentation is provided as Attachment 4.

Attachments

Attachment 1: Proposed Board Order of Adoption
Attachment 2: Public Participation Responsiveness Summary
Attachment 3: Detailed Supporting Documentation for Headwaters Numeric Nutrient Criteria
Attachment 4: Detailed Supporting Documentation for Sheep Creek drinking water use, Silver Creek total dissolved solids, Jordan River ammonia, and human health criteria.
Attachment 5: Utah Bulletin mark-up of proposed amendments

ATTACHMENT 1

ORDER
BEFORE THE UTAH WATER QUALITY BOARD IN THE MATTER OF REVISING STANDARDS OF QUALITY FOR WATERS OF THE STATE (R317-2, UTAH ADMINISTRATIVE CODE)

This matter came for hearing before the Utah Water Quality Board pursuant to notice given under the provisions of *Sections 19-5-110, Utah Code Annotated*, 1953, as amended, on the 26th day of June, 2019 in the Department of Environmental Quality Board Room, Salt Lake City, Utah for the purpose of considering revisions to the *Utah Administrative Code R317-2,* “Standards of Quality for Waters of the State.” The proposed amendments were published in the April 1, 2019 Utah Bulletin, Nos. 43585 and 43586.

The Board having taken cognizance of the oral and written statements received, and having fully considered all of the facts in the is matter, it is therefore ORDERED that the revised “Standards of Quality for Waters of the State” (*R317-2, UAC*) be reissued effective July 1, 2019 with the changes as adopted by the Board on June 26, 2019.

ATTACHMENT 2
Public Participation

State of Utah

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

Department of
Environmental Quality

Alan Matheson
Executive Director

DIVISION OF WATER QUALITY
Erica Brown Gaddis, PhD
Director

PUBLIC PARTICIPATION

RESPONSIVENESS SUMMARY

Comments and responses for the Proposed Amendments to UAC R317-1-1, Definitions and R317-2, Standards of Quality for Waters of the State, published in the April 1, 2019 Utah Bulletin Nos. 43585 and 43586

Public Participation:

A legal notice was published in the Deseret News and Salt Lake Tribune on March 31 and April 24, 2019

The proposed changes were published on the Division of Water Quality Public Notices Website (https://deq.utah.gov/water-quality/water-quality-laws-and-rules-proposed-rule-changes) March 18, 2019, the State Public Notices Website and in the April 1, 2019 Utah Bulletin (https://rules.utah.gov/publications/utah-state-bull/).

A notice (postcard) was mailed to the leader of every political subdivision prior to the public hearings.

A Public Hearing was held on the following date and location:

PUBLIC HEARING DATE	TIME	LOCATION	HEARING OFFICER	ATTENDANCE
Wednesday, May 1, 2019	6:00 PM	Utah Department of Environmental Quality Multi-State Agency Office Building, DEQ Board Room 195 N. 1950 W Salt Lake City, UT 84116	Chris Bittner, Staff	None

Public Hearing Attendance

PUBLIC HEARING ON PROPOSED AMENDMENTS TO THE
DEFINITIONS, R317-1-1 and
STANDARDS OF QUALITY FOR WATERS OF THE STATE,
R317-2, UTAH ADMINISTRATIVE CODE
UDEQ Board Room,
195 N. 1950 W
Salt Lake City, UT
May 1, 2019
6:00 – 7:00 p.m.

NAME/ AFFILIATION (Please Print)	ADDRESS/ E-MAIL
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

NO ATTENDANCE

David Richards Comments

Filename: David Richards public comment of Nutrient Headwaters technical support document April 7 2019
Version 1.0

A brief review of Utah Division of Water Quality's:
TECHNICAL SUPPORT DOCUMENT: UTAH'S NUTRIENT STRATEGY
Scientific Investigations to Support Utah's Nutrient Reduction Program
2019 Public Draft[1]

By
David C. Richards, Ph.D.
Oreohelix Consulting
Vineyard, UT 84058

April 7, 2019

Introduction

Utah's headwater streams are invaluable and deserve the greatest protection we can provide. UDWQ has done an excellent job putting together this headwater nutrient criteria document and should be applauded for their efforts. However, I do have a few concerns regarding several of the 'multiple-lines-of evidence' measures presented in TECHNICAL SUPPORT DOCUMENT: UTAH'S NUTRIENT STRATEGY: Scientific Investigations to Support Utah's Nutrient Reduction Program. Utah Division of Water Quality Public Draft, particularly the Structural Response group. I will discuss these in the following review.

My background

I have been conducting ecological research on biological criteria related to water quality for several decades. My MS Thesis (Richards 1996) was titled, "The use of macroinvertebrates as indicators of water quality in mountain streams of Montana" (obviously mountain streams are headwater streams). My Ph.D. dissertation focused on population viability of a sensitive aquatic mollusk and its interactions with an invasive freshwater taxon (Richards 2004). I was employed by one of the leading macroinvertebrate taxonomy labs in the western USA, EcoAnalysts Inc. for approximately 13 years conducting many biological assessments throughout the western USA using and developing a multitude of bioassessment methods and metrics. I was instrumental in the development of biocriteria programs for the State of Montana, State of Idaho, and State of Arizona. Along with my colleagues from EcoAnalysts Inc. and Idaho Department of

[1] https://documents.deq.utah.gov/water-quality/standards-technical-services/DWQ-2019-001512.pdf

Environmental Quality, I recently published a paper in the journal *Environmental Monitoring and Assessmen*t titled, "Temperature threshold models for benthic macroinvertebrates in Idaho wadeable streams and neighboring ecoregions" (Richards et al. 2018), which extensively incorporated the TITAN model used by UDWQ as two of the multiple-lines-of-evidence for headwater stream nutrient criteria development. As a technical member of this team and co-author of one of the chapters of the main nutrient criteria document, I bring exceptional expertise in our efforts to develop useful and meaningful nutrient criteria based on the best available science that will help protect our headwater streams.

Structural Responses

TITAN models

Diatom and macroinvertebrate TITAN models for TN and TP **can not** be used as part of the multiple-lines-of evidence and should be removed from the document and analyses. These models are irrelevant because they did not account for other covariates, including temperature or substrate composition. It is well known that temperature is the major driver in diatom and macroinvertebrate assemblage structure and occurrences in streams. Substrate type is also critically important for macroinvertebrate assemblages (Miller et al. 2019). Diatom and macroinvertebrate thresholds and assemblage changes shown in Table 7.2 of the UDWQ document are responding to natural changes from headwaters downstream i.e. the river continuum, not specifically to nutrient enrichment.

Richards et al. (2018) conducted TITAN analysis on over 400 macroinvertebrate taxa and 221,240 records from Idaho wadeable streams in relation to water temperature and produced threshold values for all of these taxa. Their paper also reported whether taxa significantly increased or decreased with increased temperatures.

I compared UDWQ's TITAN results for TP and TN (Table 7.3 starting on page 92)vs. Richards et al. (2018) TITAN results for water temperatures. All (100%) of UDWQ's significantly sensitive (decreaser) taxa for TP were also significant (or near significant) decreasers for water temperature reported by Richards et al. (2018) (Table 1). Likewise, all (100%) of UDWQ's significant increaser taxa with increased TP were significant or near significant increaser taxa with increased water temperatures in Richards et al. (2018) (Table 2). There were > 100 taxa that covaried with TP and water temperature as reported by UDWQ and Richards (2018). In addition, many of these taxa were considered significant 'indicator taxa' for temperature by Richards et al. (2108). That is to say, there is a complete, 100% overlap between UDWQ's taxa reported to be either positively or negatively affected by TP and Richards et al. (2018) taxa that responded to increases and decreases in water temperature. Any threshold values that UDWQ reported for TP were not responding to TP but to temperature, as it is the primary driver in macroinvertebrate assemblages.

Table 1. Taxa that UDWQ (2015) reported decreased with increased TP and Richards et al. (2018) reported decreased with increased temperature. See Part 3: Sensitivity of Macroinvertebrates to TP, page 125 in Ostermiller et al. 2014 for taxa list.

	Taxon	Temp (^{0}C) zenv.cp	purity	reliability
1	Ameletus sp.	20.5	0.999	1.000
2	Apatania sp.	20.5	0.999	1.000
3	Arctopsyche grandis	22.5	0.994	1.000
4	Baetis bicaudatus	20.5	1.000	1.000
5	Baetis sp.	24.5	0.965	1.000
6	Brachycentridae	20.5	0.897	0.984
7	Brachycentrus americanus	22.5	0.996	1.000
8	Brachycentrus sp.	23.5	0.973	0.995
9	Capniidae	20.5	0.999	1.000
10	Cercobrachys (Neothremma sp.)	20.5	1.000	1.000
11	Chloroperlidae	20.5	0.997	1.000
12	Cinygmula sp.	22.5	1.000	1.000
13	Cleptelmis addenda	22.5	0.957	1.000
14	Diamesa sp.	22.5	1.000	1.000
15	Dicranota sp.	22.5	0.957	1.000
16	Dolophilodes sp.	20.5	0.998	1.000
17	Drunella coloradensis/flavilinea	20.5	1.000	1.000
18	Drunella doddsi	20.5	0.999	1.000
19	Drunella grandis	22.5	0.952	1.000
20	Drunella sp.	22.5	0.951	1.000
21	Drunella spinifera	22.5	1.000	1.000
22	Epeorus deceptivus	20.5	1.000	1.000
23	Epeorus grandis	16.5	1.000	1.000
24	Epeorus longimanus	22.5	0.980	1.000
25	Epeorus sp.	20.5	1.000	1.000
26	Ephemerella aurivillii	17.5	0.998	0.997
27	Ephemerella dorothea/excrucians	22.5	0.997	1.000
28	Ephemerella sp.	22.5	0.999	1.000
29	Ephemerellidae	20.5	0.999	1.000
30	Glossosoma sp.	20.5	0.998	1.000
31	Glossosomatidae	20.5	0.998	1.000
32	Hesperoperla pacifica	22.5	0.962	1.000
33	Heterlimnius corpulentus	20.5	0.999	1.000
34	Heterocloeon	NA		
35	Hexatoma sp.	22.5	0.878	1.000

36	Hydroptilidae (Leucotrichia sp.)	23.5	0.790	1.000
37	Hygrobatidae	NA		
38	Larsia sp.	25.5	0.686	1.000
39	Lepidostoma sp.	22.5	0.962	1.000
40	Leptophlebiidae	24.5	0.901	1.000
41	Leuctridae	22.5	1.000	1.000
42	Maruina sp.	23.5	0.673	1.000
43	Megarcys sp.	20.5	1.000	1.000
44	Micrasema sp.	20.5	0.998	1.000
45	Narpus sp.	22.5	0.999	1.000
46	Nemouridae	19.5	0.998	1.000
47	Neothremma sp.	20.5	1.000	1.000
48	Nilotanypus fimbriatus[1]	8.5	0.598	1.000
49	Nilotanypus sp[1.]	10.5	0.836	0.999
50	Oreogeton sp.	16.5	1.000	1.000
51	Ostracoda	22.5	0.992	1.000
52	Pagastia sp.	20.5	0.993	1.000
53	Paraleptophlebia sp.	22.5	0.918	1.000
54	Parapsyche elsis	20.5	1.000	1.000
55	Parapsyche sp.	20.5	0.999	1.000
56	Perlidae	22.5	0.964	1.000
57	Procladius sp.[1]	8.5	0.684	1.000
58	Pteronarcella sp.	22.5	0.826	1.000
59	Radotanypus sp.	9.5	0.827	1.000
60	Rhithrogena sp.	22.5	0.995	1.000
61	Rhyacophila alberta gr.	16.5	1.000	1.000
62	Rhyacophila angelita gr.	22.5	0.982	1.000
63	Rhyacophila betteni gr.	20.5	1.000	1.000
64	Rhyacophila brunnea/vemna gr.	22.5	0.999	1.000
65	Rhyacophila coloradensis gr.	19.5	0.999	1.000
66	Rhyacophila hyalinata gr.	20.5	1.000	1.000
67	Rhyacophila narvae	16.5	1.000	1.000
68	Rhyacophila pellisa/valuma	16.5	1.000	1.000
69	Rhyacophila sibirica gr.	16.5	1.000	1.000
70	Rhyacophila sp.	20.5	0.999	1.000
71	Rhyacophila vagrita gr.	16.5	0.999	1.000
72	Rhyacophila verrula gr.	17.5	1.000	1.000
73	Rhyacophila vofixa gr.	20.5	1.000	1.000
74	Serratella sp.	20.5	0.967	1.000

75	Sperchon sp.	22.5	0.888	1.000
76	Suwallia sp.	20.5	0.998	1.000
77	Sweltsa sp.	22.5	0.998	1.000
78	Taeniopterygidae	16.5	1.000	1.000
79	Thienemanniella sp.	25.5	0.870	1.000
80	Thienemannimyia gr. sp.	25.5	0.592	1.000
81	Uenoidae (Neothrema sp.)	20.5	1.000	1.000
82	Zaitzevia parvula	25.5	0.576	0.995
83	Zaitzevia sp.	23.5	0.552	1.000
84	Zapada columbiana	20.5	1.000	1.000
85	Zapada frigida	20.5	1.000	1.000
86	Zapada oregonensis gr.	16.5	1.000	1.000
87	Zapada sp.	20.5	0.999	1.000

Table 2. Taxa that DWQ reported increased with increased TP and Richards et al. (2018) reported increased with increased temperature. See Part 3: Sensitivity of Macroinvertebrates to TP, page 125 in Ostermiller et al. 2014 for taxa list.

	Taxon	Temp (^{0}C) zenv.cp	purity	reliability	increasers with increased temperature
1	Brychus sp.	8.5	0.699	1	increaser
2	Caecidotea	not enough temp data. But are known to mostly occur in warm waters			
3	Coenagrionidae	9.5	0.991	0.997	increaser
4	Corixidae	13.5	0.974	1	increaser
5	Dolichopodidae	NA			
6	Ephydridae	7.5	0.422	0.994	increaser
7	Erpobdellidae	9.5	0.653	0.999	increaser
8	Gyraulus sp.	8.5	0.754	0.999	increaser
9	Hyalella sp.	8.5	0.948	1	increaser
10	Hydrobiidae (most likely P. antipodarum)	Hydrobiids occur at all temps and conditions including warm springs. Lumping into family level is not useful			
11	Microcylloepus sp.	9.5	0.918	0.998	increaser
12	Oligochaeta	Much too general of a taxonomic grouping			
13	Physella sp.	9.5	0.903	1	increaser
14	Planorbidae	8.5	0.909	0.999	increaser
15	Tricorythodes sp.	9.5	0.898	1	increaser
16	Tubificidae; Naididae	much too general of a taxonomic grouping. Some taxa increase, some decrease with increased temperatures			

A majority of the taxa that UDWQ considered to be decreasers (sensitive to) with increased TP were the EPTs (Ephemeroptera, Plecoptera, and Trichoptera). These are well known cold-water dependent taxa, with the exception of a very few Es' and Ts' that prefer warmer water. Plecoptera are classic cold, well-oxygenated water taxa that prefer faster moving water with unconsolidated substrates. Thus, water temperature and substrate type affect the distribution of Plecoptera more than any other variable, including nutrients. As an example, *Pteronarcella* sp. often occurs in highly productive waters as long as they are moderately cold and well oxygenated. An experienced aquatic entomologist would look at Table 1 (and page 25 in Ostermiller 2014) and immediately determine that this is a cold-water taxa list and nutrients probably have little secondary effect. There were however, three or four chironomid taxa that Richards et al. (2018) reported as water temperature increasers but UDWQ reported as TP decreasers. Those taxa should be more closely examined, as their occurrences could be affected by nutrients and not just water temperature. A more useful analysis would have included multivariate methods such as the commonly used non-metric multidimensional scaling along with multivariate tests of significance.

Several examples of macroinvertebrates responding to increased temperature gradients and not increased nutrient gradients as proposed by UDWQ can be seen in Table 2. Coenagrionidae (a family of damselflies) are known to mostly occur in warm, slower moving waters. If these conditions are met, then the amount of nutrients in the waters they occur in is not important or only very slightly secondarily important. Likewise, *Tricorythodes* sp. (Family Ephemeroptera = mayfly), which are almost completely dependent on warmer water environments with finer sediments and lower water velocities, with little response to nutrient levels. There were several snail taxa that UDWQ suggested which significantly increased with increased nutrients (e.g. TP): *Physella* sp., Planorbidae, *Gyraulus* sp. Hydrobiidae, and Corbicula (e.g. TN). It is well known that these taxa, other than Hydrobiids, prefer higher temperatures, lower flows, and higher levels of $CaCO_3$ in the water, all of which are more representative of lower elevation streams with lower gradients. However, nutrients do co-vary with these factors and also tend to be higher in these types of environments. Hydrobiids are a diverse group of snails and can occur in many types of waters including warm springs with low nutrient levels, regardless of increased nutrient levels. One of the likely misidentified hydrobiid was *Potamopyrgus antipodarum* (New Zealand mudsnail), which is actually not a hydrobiid but in a different family. Potamopyrgus can occur in a wide variety of conditions and its occurrence is more likely due to the locations where it has been introduced rather than from nutrient levels. Even though its population densities are dependent on nutrient levels, population levels and thus detectability of *P. antipodarum* can fluctuate substantially from year to year and are not nutrient dependent. *Caecidotea* sp. (a genus of isopods) is most often found in slower, warmer waters. Even though ostracods are a diverse group, UDWQ reported these are sensitive to increased TP. Richards et al. (2018) reported that ostracods were also sensitive to increased water temperatures. One only has to look at macroinvertebrate assemblages in Utah Lake and Farmington Bay of the Great Salt Lake, two water bodies that UDWQ considers nutrient impaired, to realize that their abundances can reach extreme high densities and are primarily governed by water temperature (i.e. they are cold water taxa and occur mostly from late autumn to early spring even though nutrient levels do not vary much annually). In addition, ostracods are typically uncommon and rare in headwater streams. A closer more thorough look at the taxa that were reported as nutrient sensitive should have been a priority by UDWQ. There were several more deficiencies in UDWQ's macroinvertebrate database, as used in TITAN models, and there is a real need for UDWQ to update its taxonomic database.

Based on our understanding of macroinvertebrate assemblages, there is no evidence that macroinvertebrates responded to TP as suggested by the TITAN model and there is really no reason for its inclusion in nutrient criteria development. It is misleading at best. Taxa that UDWQ report as sensitive to TN are actually responding to water temperature, sediments, velocity etc. within the river continuum from headwaters downstream. Also, macroinvertebrate assemblage threshold values that UDWQ reported for TP and TN are likely to completely correspond with temperature threshold values reported by Richards et al. (2018). Decreaser taxa sensitive to increased water temperatures had an assemblage level threshold $\approx$ 20.5 ^{0}C, the widely accepted temperature transition between cold water and warm water fisheries (Richards et al. 2018). Thus, there is substantial evidence that macroinvertebrates in UDWQ TITAN models responded mostly to temperature and not nutrients. Nutrient assemblage level threshold values reported by UDWQ likely correspond to the temperature threshold values from cold-water to warm-water presented by Richards et al. (2018), nothing more. I understand that UDWQ collected temperature data during field sample collections and suggest that UDWQ re-run the TITAN model using temperature in order to evaluate this relationship directly. Sediment particle size is another important variable that should be directly evaluated.

As a further hypothetical example, although the plecopteran families Chloroperlidae and Taeniopterygidae were evaluated by DWQ to be highly significantly sensitive to TP (0.004 mg L^{-1}; Table 7.3), we would **not** expect to see an increase in abundance of individuals within these two families if TP was reduced in lower elevational, warmer, sediment laden stream settings. They are clearly more sensitive to increased temperatures and stream embeddedness than nutrients.

I also examined UDWQ diatom taxa TITAN results and my conclusions are similar to macroinvertebrate TITAN results: that is, there is no evidence that diatoms respond to nutrients based on the models but most likely were responding to water temperature and other covariates. Any nutrient threshold values for diatoms are also likely to be erroneous and should not be included in criteria development. I have consulted with a phycology lab with experts on Utah's diatoms to help evaluate the TITAN results (Rushforth Phycology, Provo, UT personal communication). Consensus was the diatom assemblage shift for TP using TITAN was a headwaters to lower elevation assemblage shift (i.e. river continuum) and it was not possible to conclude the shift was due to TP.

Selection of stream sites

One of the major problems with UDWQ's TITAN analysis was that presumably, data used were not only from headwater streams but also lower elevation wadeable streams. A quick review of UDWQ's data showed this for both diatoms and macroinvertebrates. Miller et al. (2019) wrote an entire chapter on covariates and uncertainty for the Ostermiller et al. (2019) nutrient document and explicitly addressed this problem. The proper way to use TITAN models would have been to use a subset of the data collected from only headwater streams. This would have reduced the influence of temperature and other River Continuum effects (see Miller et al. 2019).

Another confounding factor is that UDWQ may have not collected diatom or macroinvertebrate data concurrently with their most recent field collections for nutrients (please correct me if I am wrong). Thus, there is no way to compare diatom and macroinvertebrate assemblage composition from samples collected perhaps 5 or more years prior to collection of nutrient data (i.e. recent nutrient data need to be excluded from analyses if diatoms or macroinvertebrates were not collected concurrently). Other factors, such as drought or storm events, likely have affected diatoms and macroinvertebrate assemblages and the assumption UDWQ may have made in doing so was that nutrient levels during their most recent field season had an effect on diatom and macroinvertebrate assemblages that were present several years prior. That is, the present somehow influenced the past (see Miller et al. 2019 for a discussion on this error).

Taxonomic Resolution

There are also some problems associated with using higher level taxonomic resolution to determine TP and TN effects on macroinvertebrates, even if TITAN models were valid, which they were not. Several researchers have commented on this to UDWQ in the past and Richards (2016b) documented that this is certainly not the case for ammonia. UDWQ (2019) has also acknowledged that taxonomy/phylogeny is not a good predictor of sensitivity to ammonia. In addition, UDWQ's TITAN results for diatoms illustrate this problem (Table 7.3 in Ostermiller et al. 2019). At least three genera showed clear, large, species level sensitives to TP; *Cymbella, Nitzchia*, and *Synedra. Cymbella naviculaformis* had a TP threshold = 0.01, whereas *C. minuta* threshold = 0.609, which was about a 60X difference in sensitivity to TP. *Nitzchia incospicua* TP threshold = 0.021, wheras *N. apiculate* = 0.679, a 27X difference in sensitivity. All Cymbella and Nitzchia taxa were decreasers, that is they decreased in abundance with increased TP. However, and even more revealing, *Synedra delicatissima* was a decreaser with TP sensitivity = 0.013 but *S. ulna* was an increaser with sensitivity = 0.041. Within a genus of diatoms (*Synedra*), one species was highly sensitive and decreased with increased TP and another species increased with increased TP.

Based on Richards (2016b), UDWQ (2017), and DWQ TITAN diatom results for TP, I presume nutrient sensitivity is also not predicted by phylogeny. Thus, the use of family or higher-level taxonomy can lead to imprecise estimates of nutrient sensitivity or erroneous, biased, conclusions and care must be taken when using taxonomic levels greater than species level if taxa metrics will be used to develop nutrient criteria.

RIVPACS models

Similar to the TITAN problems discussed above; RIVPACs macroinvertebrate models may suffered from the inability to account for covariates (e.g. temperature, substrate type), non-concurrent sample events, and samples collected from streams other than headwater streams (please correct me if only headwater stream data were used in the RIVPAC models or if only data that had concurrent nutrients and macroinvertebrates were used; the methods and data set do not make this clear). Subsequently, the RIVPACs macroinvertebrate results have the same flaws as the TITAN models and should not be used in criteria development.

Unfortunately, the three Structural Response measures; TITAN diatoms, TITAN macroinvertebrates, and perhaps RIVPACs O/E macroinvertebrate models should not be used to help determine threshold criteria for nutrients in headwater streams. However, these models may be useful in the future if only headwater stream data is used and the major covariate, water temperature is accounted for.

Other Metrics for Consideration

There are a wealth of diatom, macroinvertebrate, and fish metrics being used by other agencies, which is known as a multi-metric approach (see Miller et al. 2019, Chapter 15 in Ostermiller et al. 2019, as a start). Over reliance on RIVPACs O/E for assessing streams by UDWQ results in inadequate assessments (Richards 2016a). It appears that there is institutional inertia and reluctance of UDWQ to use metrics other than RIVPACs O/E models for macroinvertebrates. Several dozen or so metrics were suggested in Miller et al. (2019) Chapter 15. A few of these metrics directly measure the effects of nutrient related increased productivity on fish populations and macroinvertebrate assemblages and are relatively easy to use in the field and in criteria development and implementation.

Changes in Taxa Relative Abundances in Diatom and Macroinvertebrate Assemblages

Ecologists continue to show that environmental changes (e.g. nutrients) can affect ecosystem function well before a change in taxa richness occurs, including relative contributions of individual taxa to ecosystem functions via changes in their abundance or biomass (often measured using evenness and diversity indices) or to changes in assemblage composition (e.g. relative abundance) (Loreau 1998; Fox 2006; Spaak et al. 2017; Fox & Kerr 2012; Suding et al.2008). In the context of UDWQ nutrient criteria development, this would mean that there is a gradient from most sensitive to least sensitive measures of nutrient impairment from changes in:

1) relative abundances (biomass) of individual taxa (i.e. diatoms, macroinvertebrates, fish) to,

2) species (taxa) composition (i.e. diatoms, macroinvertebrates, fish) to,

3) ecosystem functioning responses (i.e. respiration and primary production).

Obviously, we want to use the most sensitive, early warning metrics available to assess nutrient impairment, e.g. changes in relative abundances. UDWQ already has diatom and macroinvertebrate abundance data and were used to develop TITAN models. It would be fairly easy to develop a change in relative abundance metric(s) for diatoms and macroinvertebrates using this data. I would certainly be willing to participate in the development of these changes in taxa relative abundance metrics with UDWQ.

Benchmarks

Designated Beneficial Use

UDWQ headwater stream designated beneficial use is to protect cold-water fisheries and the aquatic food chain they depend on. The Clean Water Act also includes protection and propagation of fisheries and shell fisheries (i.e. mollusks: mussels, clams, and snails) and a 'biological integrity' clause. At this time, it appears that only the literature for fish and macroinvertebrate response to nutrients directly address beneficial use of headwater streams. Thus there is a real need to focus on fish, macroinvertebrate, and diatom metrics in the development of nutrient criteria. I suggest that until we develop appropriate biotic metrics and get those correct, we put less emphasis on the less responsive metrics such as production and respiration. The other metrics proposed (e.g. primary production, respiration) are less responsive, secondary substitutes for fish, macroinvertebrate, and diatom-based metrics. While we have an improved understanding of macroinvertebrate responses to changes in primary production and respiration, DWQ should not ignore the need for a robust knowledge of the fish community and the macroinvertebrate assemblages that are explicitly identified as the beneficial use of cold-water fisheries. Obviously, it is easy to measure primary production and respiration and those metrics can certainly supplement a comprehensive macroinvertebrate, diatom, and fish bioassessment program. I am not sure why UDWQ does not use fish, diatom, and macroinvertebrate-based metrics more often or develop these criteria given that the designated beneficial use for headwater streams is to protect cold-water fisheries and the aquatic life they depend on (i.e. macroinvertebrates). I suggest that UDWQ consult more frequently with state fisheries biologists to develop a comprehensive fish bioassessment program.

Watershed based criteria.

It would behoove us to start our bioassessment program at the watershed or mountain range/plateau level, not at a regional level. UDWQ will eventually have to go to the watershed-site specific level any way. Why not just start there and save time and money?

Conclusion

UDWQ has put together an admirable report on nutrient criteria for headwater streams. They are to be commended. However, all three of the Structural Responses (TITAN-Diatoms; TITAN-Macroinvertebrates; Biological Assessments: O/E) in the multiple-lines-of-evidence are invalid and need to be removed from criteria development. Rational and methods used in the development of headwater stream nutrient criteria will set precedence for other water body nutrient criteria in UT and should be developed using the best science available. Changes in diatom and macroinvertebrate taxa relative abundances should be strongly considered as first responder metrics to help insure that early detection of nutrient impairment can be made.

Acknowledgements

I thank the Wasatch Front Water Quality Council for funding research and analyses, including this critique. I also thank Utah Department of Water Quality for allowing me to participate and provide constructive criticism in headwater nutrient criteria development.

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Division of Water Quality Responses to Richards' Comments (April 7, 2019)

David Richards' (Oreohelix Consulting) comments expressed concern about the stressor-response (S-R) models that were used to evaluate changes in the composition of macroinvertebrates and diatoms associated with increasing ambient nutrient concentrations (Technical Support Document, Chapter 6). While many of these concerns are valid, the ramifications are overstated (see detailed responses below). Additional analyses could certainly be conducted to improve those presented in *Technical Support Document: Utah's Nutrient Strategy* (hereafter TSD). However, Utah's Division of Water Quality (UDWQ) does not believe that the evidence currently presented on the role of nutrient enrichment on alterations to structural responses is invalid. Structural responses were one of many different lines of evidence that UDWQ evaluated to derive the proposed numeric nutrient criteria (NNC) for headwater streams. None of the structural responses and related total nitrogen and total phosphorus thresholds discussed in the comments were directly incorporated into the NNC, and even if this line of evidence was completely ignored, it would not substantively change the current proposed criteria.

The primary concern raised in this comment letter is that the composition of stream assemblages (algae and diatoms) may actually be responding to temperature or other naturally occurring physicochemical changes along a longitudinal (i.e., upstream-downstream) gradient. The relative influence of covariates on nutrient stressor-response (S-R) relationships remains a challenge, particularly when these evaluations are conducted at a landscape scale, which is required for the derivation of regional NNC. This is the principal reason that UDWQ's headwater NNC combines nutrient concentrations with ecological responses. Using this approach will help to eliminate both false positive and false negative impairment determinations because problems are identified using empirical evidence of adverse effects. It is possible that any deleterious responses that are identified could be caused by a combination of stressors (e.g., enrichment and habitat degradation), but as the last section of *Proposed Nutrient Criteria: Utah's Headwater Streams* (hereafter Proposal) discusses, UDWQ is committed to more thoroughly evaluating the specific causes of any impairments that are identified.

As reported in the TSD, structural responses to nutrient enrichment were evaluated in a couple of ways. The first uses TITAN models that are intrinsically unable to account for the influence of covariates, but has the advantage of making taxa-specific characterizations of responses to nutrient enrichment. The second approach evaluated RIVPACS model outputs (O/E), which is an integral measure of condition that accounts for covariates. These models make site-specific predictions of expected composition (E) from a stream's physical attributes (covariates), many of which account for longitudinal and temperature differences among streams.

Other concerns raised in these comments are contrary to the underlying intent of establishing regionally applicable NNC for headwater streams. The analysis of structural responses to nutrient at a regional scale—spatial and temporal— requires a broad understanding of the relationship between nutrient enrichment and alterations to the composition of stream biota. The comments in this letter provide many examples of where these relationships may falter with respect to the responses of specific taxa—under specific circumstances—or under site-specific conditions of specific streams. The proposed NNC addresses the uncertainty raised by these considerations by combining nutrients and responses to assess support of moderately enriched streams.

Several suggestions are made throughout the comments about how evaluations of structural responses to nutrient enrichment could be improved. UDWQ is open to future modifications of those proposed in the existing NNC responses if specifics are presented for consideration. The comments present several promising possibilities, but specific changes to proposed response variables are not provided. The proposed NNC provide a structure for combining nutrients with direct measures of adverse effects to aquatic life and recreational uses to address the reality that many headwater streams are naturally protected from the effects of nutrient enrichment. The NNC structure is amendable to the addition of future responses that capture deleterious impacts that are not already included in the proposed rules. The NNC already include ecological responses that are proximate to all known nutrient enrichment pathways toward the degradation of aquatic life uses. However, other more sensitive indicators of these pathways certainly do exist. UDWQ welcomes the addition of any new, and demonstrated, responses to nutrient enrichment that are identified and vetted through a robust scientific and stakeholder process. As illustrated in the specific responses to comments below UDWQ maintains the validity of the existing quantified relationships to structural responses. However, this letter highlights future improvements that could be incorporated into the headwater NNC to improve the protection of these important ecosystems.

Specific Comments

The following section provides detailed responses from UDWQ to comments on the NNC submitted by David Richards. Richards' comments are provided in *blue, italic text*. Responses from UDWQ are in the black text that follows.

Relative Importance of Nutrients and Other Factors

Temperature: Comparison with Richards et al. 2018

It is well known that temperature is the major driver in diatom and macroinvertebrate assemblage structure and occurrences in streams.

Diatom and macroinvertebrate thresholds and assemblage changes shown in Table 7.2 of the UDWQ document are responding to natural changes from headwaters downstream i.e. the river continuum, not specifically to nutrient enrichment.

Richards et al. (2018) conducted TITAN analysis on over 400 macroinvertebrate taxa and 221,240 records from Idaho wadeable streams in relation to water temperature and produced threshold values for all of these taxa. Their paper also reported whether taxa significantly increased or decreased with increased temperatures.

I compared UDWQ's TITAN results for TP and TN (Table 7.3 starting on page 92)vs. Richards et al. (2018) TITAN results for water temperatures. All (100%) of UDWQ's significantly sensitive (decreaser) taxa for TP were also significant (or near significant) decreasers for water temperature reported by Richards et al. (2018) (Table 1). Likewise, all (100%) of UDWQ's significant increaser taxa with increased TP were significant or near significant increaser taxa with increased water temperatures in Richards et al. (2018) (Table 2). There were > 100 taxa that covaried with TP and water temperature as reported by UDWQ and Richards (2018). In addition, many of these taxa were considered significant 'indicator taxa' for temperature by Richards et al. (2108). That is to say, there is a complete, 100% overlap between UDWQ's taxa reported to be either positively or negatively affected by TP and Richards et al. (2018) taxa that responded to

increases and decreases in water temperature. Any threshold values that UDWQ reported for TP were not responding to TP but to temperature, as it is the primary driver in macroinvertebrate assemblages.

A majority of the taxa that UDWQ considered to be decreasers (sensitive to) with increased TP were the EPTs (Ephemeroptera, Plecoptera, and Trichoptera). These are well known cold-water dependent taxa, with the exception of a very few Es' and Ts' that prefer warmer water. Plecoptera are classic cold, well-oxygenated water taxa that prefer faster moving water with unconsolidated substrates. Thus, water temperature and substrate type affect the distribution of Plecoptera more than any other variable, including nutrients.

An experienced aquatic entomologist would look at Table 1 (and page 25 in Ostermiller 2014) and immediately determine that this is a cold-water taxa list and nutrients probably have little secondary effect… There were however, three or four chironomid taxa that Richards et al. (2018) reported as water temperature increasers but UDWQ reported as TP decreasers. Those taxa should be more closely examined, as their occurrences could be affected by nutrients and not just water temperature.

Also, macroinvertebrate assemblage threshold values that UDWQ reported for TP and TN are likely to completely correspond with temperature threshold values reported by Richards et al. (2018). Decreaser taxa sensitive to increased water temperatures had an assemblage level threshold » 20.5 C, the widely accepted temperature transition between cold water and warm water fisheries (Richards et al. 2018). Thus, there is substantial evidence that macroinvertebrates in UDWQ TITAN models responded mostly to temperature and not nutrients. Nutrient assemblage level threshold values reported by UDWQ likely correspond to the temperature threshold values from cold-water to warm-water presented by Richards et al. (2018), nothing more.

[see comment letter for referenced tables]

With respect to the NNC, there are several important considerations that should help to minimize any the concerns raised in these comments. Chief among these is the fact that UDWQ is proposing combined criteria that use a combination of nutrients and responses to make impairment determinations. This means that adverse effects need to be demonstrated before a site is considered impaired. This is important because nutrient concentrations and temperature both increase naturally moving downstream from headwaters. In headwater streams, human-caused increases to temperature and nutrients are caused by many of the same things, and solutions to these problems would likely resolve either issue and lead to improvements in the condition of stream biota. UDWQ has currently elected to exclude biological assessment as NNC responses because keeping them separate allows biological integrity to be assessed independently from causes, which can be determined once degraded conditions are identified. That said, the NNC are also flexible and additional nutrient-specific biological indicators could easily be added should they be developed in the future.

Richards et al. (2018) also used TITAN to identify taxa sensitive to temperature. One weakness of the TITAN analysis used in this investigation to generate temperature responses (like the TITAN model conducted by UDWQ) is that it is unable to account for the influence of covariates. The temperature TITAN model presented by Richards as evidence that UDWQ's nutrient analysis is invalid suffers from some of the same weaknesses. The streams included in the temperature TITAN analysis include a wide breadth of stream sizes and conditions, so the influence of other covariates is as problematic as those presented by UDWQ with respect to nutrients. The invertebrate taxa that are sensitive to increasing temperature in the cited investigation are also sensitive to many different human-caused stressors. It is likely true that some of the sensitive taxa are responding more strongly to increased temperature, whereas others are responding more strongly to nutrient-related alterations (e.g., algae structure, DO deficits, diel DO fluctuations). However, the relative influence of these changes cannot be demonstrated using TITAN models presented by Richards et al., nor those presented by UDWQ in the TSD, because both are correlative.

Autecology: Examples of Taxa-Specific Responses

As an example, Pteronarcella sp. often occurs in highly productive waters as long as they are moderately cold and well oxygenated.

*As a further hypothetical example, although the plecopteran families Chloroperlidae and Taeniopterygidae were evaluated by DWQ to be highly significantly sensitive to TP (0.004 mg L^{-1}; Table 7.3), we would **not** expect to see an increase in abundance of individuals within these two families if TP was reduced in lower elevational, warmer, sediment laden stream settings. They are clearly more sensitive to increased temperatures and stream embeddedness than nutrients.*

Several examples of macroinvertebrates responding to increased temperature gradients and not increased nutrient gradients as proposed by UDWQ can be seen in Table 2. Coenagrionidae (a family of damselflies) are known to mostly occur in warm, slower moving waters. If these conditions are met, then the amount of nutrients in the waters they occur in is not important or only very slightly secondarily important. Likewise, Tricorythodes sp. (Family Ephemeroptera = mayfly), which are almost completely dependent on warmer water environments with finer sediments and lower water velocities, with little response to nutrient levels. There were several snail taxa that UDWQ suggested which significantly increased with increased nutrients (e.g. TP): Physella sp., Planorbidae, Gyraulus sp. Hydrobiidae, and Corbicula (e.g. TN). It is well known that these taxa, other than Hydrobiids, prefer higher temperatures, lower flows, and higher levels of $CaCO_3$ in the water, all of which are more representative of lower elevation streams with lower gradients. However, nutrients do co-vary with these *factors and also tend to be higher in these types of environments. Hydrobiids are a diverse group of snails and can occur in many types of waters including warm springs with low nutrient levels, regardless of increased nutrient levels. One of the likely misidentified hydrobiid was Potamopyrgus antipodarum (New Zealand mudsnail), which is actually not a hydrobiid but in a different family. Potamopyrgus can occur in a wide variety of conditions and its occurrence is more likely due to the locations where it has been introduced rather than from nutrient levels. Even though its population densities are dependent on nutrient levels, population levels and thus detectability of P. antipodarum can fluctuate substantially from year to year and are not nutrient dependent. Caecidotea sp. (a genus of isopods) is most often found in slower, warmer waters. Even though ostracods are a diverse group, UDWQ reported these are sensitive to increased TP. Richards et al. (2018) reported that ostracods were also sensitive to increased water temperatures. One only has to look at macroinvertebrate assemblages in Utah Lake and Farmington Bay of the Great Salt Lake, two water bodies that UDWQ considers nutrient impaired, to realize that their abundances can reach extreme high densities and are primarily governed by water temperature (i.e. they are cold water taxa and occur mostly from late autumn to early spring even though nutrient levels do not vary much annually). In addition, ostracods are typically uncommon and rare in headwater streams.*

These examples of specific taxa responses highlight the value of conducting the TITAN analysis because these relationships would have been potentially obscured using integrative measures of composition (e.g., O/E). UDWQ agrees with the commenter that careful consideration of taxa-specific responses is useful because it can highlight the extent to which nutrients, temperature and other factors may be influencing TITAN model predictions. Many of these examples highlight the potential role of functional feeding groups as an underlying determinant of species distributions. For example, *Pteronarcella sp.* stoneflies are relatively long-lived (bivoltine) shredders that are dependent on leaf litter deposited to the stream. Nutrient enrichment could potentially affect the quantity and quality of this resource via a shift in the trophic state in the stream (Vannote et al. 1980), or more subtly through an increase in heterotrophic production and a subsequent increase in organic matter processing and export of these resources from the ecosystem. Similarly, it should not be surprising that snails increase in response to nutrient enrichment because these organisms feed by scraping algae. The TITAN results indicate that these organisms increase in abundance as nutrients increase, which is what one would predict for organism that depend on increases in benthic production for survival.

These comments also highlight UDWQ's rationale for expanding on the TITAN analysis to include RIVPACS model outputs (O/E). RIVPACS models make predictions of the taxa expected to occur at sites with minimal human-caused disturbance (E) based on stream physical and geographic attributes. The predictors used to make these predictions are descriptors that differentiate longitudinal position along and upstream-downstream river continuum, which accounts for many of the important covariates of concern to the commenter. As documented in the TSD, UDWQ found that nutrient thresholds derived using O/E strongly corresponded to previously established biological impairment thresholds. To be clear, UDWQ does not claim that nutrients are the only stressor with the potential to cause a reduction in O/E, but the strong correspondence with nutrient enrichment suggests that these stressors play an important role in this relationship. For this reason, biological assessment using macroinvertebrates will be maintained independent of NNC.

Diatoms

I also examined UDWQ diatom taxa TITAN results and my conclusions are similar to macroinvertebrate TITAN results: that is, there is no evidence that diatoms respond to nutrients based on the models but most likely were responding to water temperature and other covariates. Any nutrient threshold values for diatoms are also likely to be erroneous and should not be included in criteria development. I have consulted with a phycology lab with experts on Utah's diatoms to help evaluate the TITAN results (Rushforth Phycology, Provo, UT personal communication). Consensus was the diatom assemblage shift for TP using TITAN was a headwaters to lower elevation assemblage shift (i.e. river continuum) and it was not possible to conclude the shift was due to TP.

The NNC combine nutrients with responses to make impairment determinations in moderately enriched streams. Practically speaking, many concerns about the relative importance of covariates and nutrient enrichment are less important using a combined criteria model because assessments require a demonstration of adverse effects. Also, the indicators evaluated in this chapter are not an integral part of the proposed NNC and ignoring this line of evidence entirely would not change the NNC nutrient or response thresholds.

Diatoms are well-documented to be sensitive to nutrient enrichment (Potapova and Charles 2007). Diatoms are primary producing organisms and their growth is frequently limited by TP or TN. Dodds et al. (2002) analyzed changes in benthic algal biomass from 620 sites and found nitrogen and phosphorus to be much more predictive than physical characteristic (including temperature) and major landscape-scale changes associated with different ecoregions. Biomass accrual changes the composition of diatoms from early succession to late succession taxa (Stephenson et al. 1991). Degradation to the composition of diatom assemblages, including reduced diversity, has been demonstrated from experimental nutrient additions (Gudmundsdottir et al. 2013). Hill et al. (2001) found that the second axis of an ordination of diatom composition was related to stream size and nutrient concentration, supporting statements made in previous comments that changes in these conditions are difficult to decouple. UDWQ agrees that changes in habitat, such as increases in stream temperature, are important determinants of diatom assemblage structure, but as these studies—particularly those involving controlled enrichment experiments—demonstrate the role of nutrient enrichment can be equally or more important determinants of the structure of diatom assemblages.

Substrate

Substrate type is also critically important for macroinvertebrate assemblages (Miller et al. 2019).

Several comments highlight the importance of substrate size distribution as an important determinant stream assemblage structure. UDWQ agrees that substrate size and stability are important habitat characteristics. Headwaters typically have larger and more stable substrates than streams lower in headwaters. These conditions favor macroinvertebrate taxa (e.g., EPT) that are known to be sensitive to a wide range of anthropogenic enrichment, including nutrients. The O/E evaluation that UDWQ conducted accounted for factors associated with natural changes in stream substrate size distributions and UDWQ still found nutrients to be strongly associated with degraded conditions as measured with this index.

Analytical Methods

A more useful analysis would have included multivariate methods such as the commonly used non-metric multidimensional scaling along with multivariate tests of significance.

Non-parametric multidimensional scaling (NMDS) cannot simultaneously evaluate changes in in both assemblage composition and potential causative factors. It is possible to conduct an ordination on the composition of stream biota and subsequently relate causative factors to the axes of the ordination, but this analysis only illustrates broad patterns in the relationships between stressors and responses. Instead, UDWQ generally opted to use an alternative multivariate approach, random forests, to quantify the relative importance of nutrients versus naturally occurring covariates throughout the TSD because the technique is better able to quantify the relative influence of each causative variable. RIVPACS models actually use techniques similar to NMDS to differentiate differences among streams on the basis of differences in assemblage structure, which is then followed by discriminant analysis to ascribe natural changes in physical attributes to each compositionally unique group. The analytical usefulness of any analytical approach is dictated by the properties of the underlying data and the underlying questions being addressed. The analyses conducted by UDWQ were appropriate and were also successful in revealing a reasonably strong relationship between nutrient enrichment and the structure of stream biota.

A closer more thorough look at the taxa that were reported as nutrient sensitive should have been a priority by UDWQ. There were several more deficiencies in UDWQ's macroinvertebrate database, as used in TITAN models, and there is a real need for UDWQ to update its taxonomic database.

UDWQ agrees that a more thorough evaluation of indictor taxa would be useful. However, nutrient-specific indicator taxa are not currently included in the proposed criteria for many of the reasons highlighted by the commenter. The only taxa-specific indicators currently available to UDWQ are those derived from TITAN models, which are correlational relationships. Landscape-scale relationships are appropriate for identifying integral changes in composition associated with nutrient enrichment. This is why UDWQ felt comfortable using the aggregate of TITAN prediction thresholds as one line of evidence—among many others—for purposes of establishing TN and TP thresholds. The use of specific taxa as indictors of enrichment requires a more extensive and mechanistic understanding of the autecology of the taxa intended to be indicative of enriched conditions. UDWQ is willing to explore the inclusion of indicator taxa to develop additional response indicators for the NNC in the future.

RIVPACS Models

Similar to the TITAN problems discussed above; RIVPACs macroinvertebrate models may suffered from the inability to account for covariates (e.g. temperature, substrate type), nonconcurrent sample events, and samples collected from streams other than headwater streams (please correct me if only headwater stream data were used in the RIVPAC models or if only data that had concurrent nutrients and macroinvertebrates were used; the methods and data set do not make this clear). Subsequently, the RIVPACs macroinvertebrate results have the same flaws as the TITAN models and should not be used in criteria development.

As mentioned in other responses, RIVPACS models do account for naturally occurring differences in the physical attributes of streams. Non-concurrent sample events are actually beneficial to the accuracy of RIVPACS models because the models substitute time for space. Thus, samples collected over a breadth of environmental conditions are better able to account for year-to-year changes in climatic conditions. O/E has been demonstrated to be an accurate measure of stream condition in numerous investigations and the data collection techniques used by UDWQ are essentially identical to those used in all of these investigations. UDWQ uses O/E as an indicator of aquatic life use support and its use as a nutrient response provided one of the few ways to assess the extent to which nutrient enrichment was associated with an independent measure of aquatic life use support. As a result, UDWQ respectfully disagrees that the use of this indicator, as one line of evidence among many, was inappropriate in NNC development.

Other Metrics for Consideration

There are a wealth of diatom, macroinvertebrate, and fish metrics being used by other agencies, which is known as a multi-metric approach (see Miller et al. 2019, Chapter 15 in Ostermiller et al. 2019, as a start). Over reliance on RIVPACs O/E for assessing streams by UDWQ results in inadequate assessments (Richards 2016a). It appears that there is institutional inertia and reluctance of UDWQ to use metrics other than RIVPACs O/E models for macroinvertebrates.

Several dozen or so metrics were suggested in Miller et al. (2019) Chapter 15. A few of these metrics directly measure the effects of nutrient related increased productivity on fish populations and macroinvertebrate assemblages and are relatively easy to use in the field and in criteria development and implementation.

All biological assessment methods are inevitably more sensitive to some types of stressors than others and RIVPACS and TITAN are not exceptions. TITAN has been demonstrated to be a useful way to establish general S-R thresholds from taxa-specific S-R relationships. O/E has been demonstrated to be sensitive to a breadth of different stressors and is generally considered to be among the more sensitive measures of biological degradation. One reason for this is that the geographic predictors allow the models to make site-specific predictions of expected taxa (E). However, this does not avoid biases resulting from the relative sensitivity of different resident taxa to different types of human-caused stressors.

O/E is not biological integrity but it as an important aspect of it. DWQ agrees that the development of biological assessment tools for additional assemblages would be useful and has taken preliminary steps to accomplish this task. Nevertheless, the use of O/E, which has been repeatedly demonstrated to be a robust indicator of biological degradation, provides a useful way to identify whether a site is biologically degraded. The analyses presented in the TSD demonstrate the O/E biological impairments are far more likely in enriched streams. It is impossible to tell from this analysis if a specific stream is degraded from nutrients or other sometimes correlative factors, however this does not mean that the influence of nutrient enrichment on these demonstrated relationships can be ignored or discounted. The NNC were developed based on the collective information provided by numerous lines of inquiry. The proposed NNC include the combination of stressors and responses to account for uncertainty due to the factors expressed in these comments. No element of the NNC is directly dependent on this line of inquiry and the proposed NNC would remain unchanged if this line of inquiry was completely eliminated from the analysis. As documented in the TSD, UDWQ has been transparent about the relative strengths and weaknesses of each line of evidence used to support the proposed NNC. The weaknesses highlighted by these comments do not substantially highlight anything not already presented in the TSD. The comments also ignore the close correspondence between the enrichment thresholds and independently derived measures of aquatic life use support already integrated into UDWQ biological assessment procedures.

Changes in Taxa Relative Abundances

Ecologists continue to show that environmental changes (e.g. nutrients) can affect ecosystem function well before a change in taxa richness occurs, including relative contributions of individual taxa to ecosystem functions via changes in their abundance or biomass (often measured using evenness and diversity indices) or to changes in assemblage composition (e.g. relative abundance) (Loreau 1998; Fox 2006; Spaak et al. 2017; Fox & Kerr 2012; Suding et al.2008).

In the context of UDWQ nutrient criteria development, this would mean that there is a gradient from most sensitive to least sensitive measures of nutrient impairment from changes in:

1) relative abundances (biomass) of individual taxa (i.e. diatoms, macroinvertebrates, fish) to,

2) species (taxa) composition (i.e. diatoms, macroinvertebrates, fish) to,

3) ecosystem functioning responses (i.e. respiration and primary production).

Obviously, we want to use the most sensitive, early warning metrics available to assess nutrient impairment, e.g. changes in relative abundances. UDWQ already has diatom and macroinvertebrate abundance data and were used to develop TITAN models. It would be fairly easy to develop a change in relative abundance metric(s) for diatoms and macroinvertebrates using this data. I would certainly be willing to participate in the development of these changes in taxa relative abundance metrics with UDWQ.

UDWQ agrees that the most sensitive responses to stream enrichment are desirable. The general progression of relative sensitivity to nutrient enrichment is also supported by the scientific literature: changes in structure generally precede changes in function. However, nutrients are not a traditional stressor because small to moderate increases in nutrients can actually improve most ecological responses at higher trophic levels. From the perspective of aquatic life use protection, the germane question is at what point do changes in ecosystem structure or function degrade important ecological characteristic of stream ecosystems. The data presented in this chapter of the TSD suggest that minor changes to diatom assemblages do not alter the condition of higher trophic levels until the structural changes in stream autotrophs are significant enough to disrupt the competitive advantage of stream biota at higher trophic levels. The degradation of higher trophic levels is the point where nutrient responses represent a potential adverse effect to stream ecosystems. The proposed NNC do not directly integrate structural responses, but they do suggest that the proposed thresholds should be protective against these deleterious effects to higher trophic levels.

Selection of Stream Sites

One of the major problems with UDWQ's TITAN analysis was that presumably, data used were not only from headwater streams but also lower elevation wadeable streams. A quick review of UDWQ's data showed this for both diatoms and macroinvertebrates. Miller et al. (2019) wrote an entire chapter on covariates and uncertainty for the Ostermiller et al. (2019) nutrient document and explicitly addressed this problem. The proper way to use TITAN models would have been to use a subset of the data collected from only headwater streams. This would have reduced the influence of temperature and other River Continuum effects (see Miller et al. 2019).

It is important for the statistical thresholds included in the NNC to be ecologically meaningful, so it was necessary to include a reasonably equal number of low, moderate and highly enriched streams when conducting the analysis. Very limited responses for moderate nutrient enrichment sites were expected because physical covariates common to headwater streams reduce the strength of relationships between nutrient enrichment and ecological responses. Hence, UDWQ will rely on combined criteria because they reduce assessment errors for moderately enriched streams where adverse nutrient effects are possible. In circumstances where the headwater streams have attributes that make them more sensitive to nutrients, these combined criteria will help identify any adverse effects.

Another confounding factor is that UDWQ may have not collected diatom or macroinvertebrate data concurrently with their most recent field collections for nutrients (please correct me if I am wrong). Thus, there is no way to compare diatom and macroinvertebrate assemblage composition from samples collected perhaps 5 or more years prior to collection of nutrient data (i.e. recent nutrient data need to be excluded from analyses if diatoms or macroinvertebrates were not collected concurrently). Other factors, such as drought or storm events, likely have affected diatoms and macroinvertebrate assemblages and the assumption UDWQ may have made in doing so was that nutrient levels during their most recent field season had an effect on diatom and macroinvertebrate assemblages that were *present several years prior. That is, the present somehow influenced the past (see Miller et al. 2019 for a discussion on this error).*

The S-R models for structural responses used chemical and biological data collected over the most recent 8-year period of record. As suggested by the commenter, ambient nutrient concentrations exhibit temporal fluctuations. Collecting samples across several years provides more accurate information about the general degree of enrichment as sites and the extent of structural changes associated with changes in enrichment. It is true that factors such as floods or droughts may have influenced the strength of these S-R relationships for a small subset of samples, which is why UDWQ based the analysis on the greatest number of samples possible. The TN and TP thresholds derived from structural responses are intended to be reflective of general patterns of nutrient enrichment. If the objective of the investigation was to quantify the effects of nutrients at specific streams, the factors described by the commenter would warrant careful consideration. However, such concerns are less important when the relationships are interpreted in aggregate, as was the case for the structural S-R data presented in the TSD.

Taxonomic Resolution

There are also some problems associated with using higher level taxonomic resolution to determine TP and TN effects on macroinvertebrates, even if TITAN models were valid, which they were not. Several researchers have commented on this to UDWQ in the past and Richards (2016b) documented that this is certainly not the case for ammonia. UDWQ (2019) has also acknowledged that taxonomy/phylogeny is not a good predictor of sensitivity to ammonia. In addition, UDWQ's TITAN results for diatoms illustrate this problem (Table 7.3 in Ostermiller et al. 2019). At least three genera showed clear, large, species level sensitives to TP; Cymbella, Nitzchia, and Synedra. Cymbella naviculaformis had a TP threshold = 0.01, whereas C. minuta threshold = 0.609, which was about a 60X difference in sensitivity to TP. Nitzchia incospicua TP threshold = 0.021, wheras N. apiculate = 0.679, a 27X difference in sensitivity. All Cymbella and Nitzchia taxa were decreasers, that is they decreased in abundance with increased TP. However, and even more revealing, Synedra delicatissima was a decreaser with TP sensitivity = 0.013 but S. ulna was an increaser with sensitivity = 0.041. Within a genus of diatoms (Synedra), one species was highly sensitive and decreased with increased TP and another species increased with increased TP.

Based on Richards (2016b), UDWQ (2017), and DWQ TITAN diatom results for TP, I presume nutrient sensitivity is also not predicted by phylogeny. Thus, the use of family or higher-level taxonomy can lead to imprecise estimates of nutrient sensitivity or erroneous, biased, conclusions and care must be taken when using taxonomic levels greater than species level if taxa metrics will be used to develop nutrient criteria.

It is always best to start any biological assessment, or S-R model, with the highest possible taxonomic resolution. UDWQ works with professional laboratories—USU/BLM National Aquatic Monitoring Center (macroinvertebrates) and Rushforth Phycology (diatoms)—to identify all possible organisms to the lowest possible level of taxonomic resolution. Some taxa are difficult to identify to a finer level of resolution until later stages of development or are compromised in sample preservation, so they are reported at a higher level of taxonomic resolution. With respect to the application of these data, there is a tradeoff between the extra information provided by finer taxonomic resolution and the need to fully characterize the resident assemblage. For instance, it might be possible to identify many species within a genus under ideal conditions in late stage of development, but most individuals are reported as genus. In circumstances where taxonomic results show both genus and species level information, it is impossible to tell whether they are two unique taxa, and keeping both in the dataset would intrinsically treat them as unique taxa in subsequent data analysis. UDWQ has spent much time working with taxonomic experts to determine appropriate operational taxonomic units (OTUs) that consider these tradeoffs.

As the comment suggests, taxa designated at higher levels of taxonomic organization can contain individual taxa with varying sensitivity to human-caused stress. Under such circumstances, the strength of S-R relationships for higher levels of taxonomic organization would be weakened. This means that the significant relationships between nutrient enrichment and alterations to the structure of stream biota would be more accurate if the use of lower level taxonomic resolution was possible, which strengthens the interpretation that significant higher-level relationships with nutrient enrichment are meaningful and generalizable. The opposite example, where some species within a genus increase in response to enrichment, while others decrease would result in insignificant S-R relationships. The structural response results described in the TSD explicitly take such tradeoffs into account. The TITAN thresholds are based on an agglomeration of taxa-specific responses, and the predictions of the RIVPACS models are derived from predetermined OTUs that accounted for these tradeoffs. The OTU determinations were made through interactive consultations between the taxonomists and international experts in the application of their results. The thresholds evaluated in this line of evidence of the NNC are the manifestation of these collaborative efforts.

Benchmarks

Designated Beneficial Use

UDWQ headwater stream designated beneficial use is to protect cold-water fisheries and the aquatic food chain they depend on. The Clean Water Act also includes protection and propagation of fisheries and shell fisheries (i.e. mollusks: mussels, clams, and snails) and a 'biological integrity' clause. At this time, it appears that only the literature for fish and macroinvertebrate response to nutrients directly address beneficial use of headwater streams.

Thus there is a real need to focus on fish, macroinvertebrate, and diatom metrics in the development of nutrient criteria. I suggest that until we develop appropriate biotic metrics and get those correct, we put less emphasis on the less responsive metrics such as production and respiration. The other metrics proposed (e.g. primary production, respiration) are less responsive, secondary substitutes for fish, macroinvertebrate, and diatom-based metrics. While we have an improved understanding of macroinvertebrate responses to changes in primary production and respiration, DWQ should not ignore *the need for a robust knowledge of the fish community and the macroinvertebrate assemblages that are explicitly identified as the beneficial use of coldwater fisheries. Obviously, it is easy to measure primary production and respiration and those metrics can certainly supplement a comprehensive macroinvertebrate, diatom, and fish bioassessment program. I am not sure why UDWQ does not use fish, diatom, and macroinvertebrate-based metrics more often or develop these criteria given that the designated beneficial use for headwater streams is to protect cold-water fisheries and the aquatic life they depend on (i.e.macroinvertebrates). I suggest that UDWQ consult more frequently with state fisheries biologists to develop a comprehensive fish bioassessment program.*

UDWQ is open to making future improvement to the NNC and biological assessment program as appropriate. However, in this context these comments are largely out of scope. UDWQ is accepting comments on the current regulation as opposed to ideas on improvements that could be made moving forward. While UDWQ believes the NNC are protective in their current state, this does not mean that improvements won't occur in the future. If this occurs, the NNC can easily accommodate the additional response parameters.

Aquatic life uses in Utah and elsewhere were established to help ensure the protection and maintenance of the biological integrity of waters as mandated by the Clean Water Act. Biological integrity is an integrative construct used to convey a multifaceted concept of ecosystem health. Ecologists often partition biological integrity into structural and functional components, which is reflected in the most widely accepted definition (emphasis added):

> "*The ability to support and maintain a balanced, integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region*" (Karr and Dudley 1981, Karr et al. 1986).

Structural integrity reflects elements of biological degradation that alter the composition and relative abundance of stream biota. Whereas functional integrity elements reflect alterations to elements integral to important ecosystem functions or processes. Ecosystem processes describe the flow of energy through food webs, which is generally measured through the production or consumption of carbon. UDWQ evaluated all of these responses to generate the proposed NNC. The TSD contains an analysis of all of these relationships, which were considered collectively when establishing the proposed NNC. The only exception is alterations to fish assemblages, which were intentionally excluded because UDWQ assumed that any alteration to the structure of fish assemblages would follow more proximate degradation to lower trophic levels that are equally integral to the preservation of aquatic life uses.

Watershed based criteria

It would behoove us to start our bioassessment program at the watershed or mountain range/plateau level, not at a regional level. UDWQ will eventually have to go to the watershed site specific level any way. Why not just start there and save time and money?

It would be extraordinarily resource intensive for UDWQ to derive NNC for every watershed in the state. Given the scale of statewide assessments that UDWQ is required to evaluate, it is important to have tools that focus resources where they are most likely to result in improved water quality. The proposed headwater NNC will allow UDWQ to efficiently identify those watersheds where nutrient inputs are having adverse effects. Once impaired streams are identified, these streams can be targeted for additional site-specific monitoring and assessment efforts as part of TMDL and/or watershed planning processes. Additional data collection throughout targeted, impaired watersheds can be then be used to evaluate all causes of degraded conditions—including potential interactions among multiple stressors—and the relative importance of different nutrient sources. This additional information will help UDWQ and cooperators devise remediation plans are as efficient and effective as possible.

General Comments

*Diatom and macroinvertebrate TITAN models for TN and TP **can not** be used as part of the multiple-lines-of evidence and should be removed from the document and analyses. These models are irrelevant because they did not account for other covariates, including temperature or substrate composition.*

Based on our understanding of macroinvertebrate assemblages, there is no evidence that macroinvertebrates responded to TP as suggested by the TITAN model and there is really no reason for its inclusion in nutrient criteria development. It is misleading at best. Taxa that UDWQ report as sensitive to TN are actually responding to water temperature, sediments, velocity etc. within the river continuum from headwaters downstream.

Unfortunately, the three Structural Response measures; TITAN diatoms, TITAN macroinvertebrates, and perhaps RIVPACs O/E macroinvertebrate models should not be used to help determine threshold criteria for nutrients in headwater streams. However, these models may be useful in the future if only headwater stream data is used and the major covariate, water temperature is accounted for.

UDWQ has put together an admirable report on nutrient criteria for headwater streams. They are to be commended. However, all three of the Structural Responses (TITAN-Diatoms; TITAN Macroinvertebrates; Biological Assessments: O/E) in the multiple-lines-of-evidence are invalid and need to be removed from criteria development. Rational and methods used in the development of headwater stream nutrient criteria will set precedence for other water body nutrient criteria in UT and should be developed using the best science available. Changes in diatom and macroinvertebrate taxa relative abundances should be strongly considered as first responder metrics to help insure that early detection of nutrient impairment can be made.

As the responses to specific comments illustrate, UDWQ is well-aware of the strengths and limitations of this line of inquiry in creating appropriately protective NNC for headwater streams. None of the flaws discussed throughout these comments were unaddressed. The TSD is transparent with respect to the strengths and weaknesses of each line of evidence that were interpreted collectively to establish the proposed NNC. The influence of structural responses was part of this analysis. These comments point toward areas of uncertainty with respect to the interpretation of structural responses to nutrient enrichment. All of these concerns are valid, albeit overstated. UDWQ stands by the NNC, which integrate diverse ecological responses to nutrient enrichment. The close correspondence between structural and functional aspects of biological integrity suggests that the NNC are appropriately protective. The only specific recommendation from the commenter is to eliminate this line of inquiry from the supporting documentation. Doing so would not change the NNC in any way and would be contrary to UDWQ's attempt to publically present all available data and information as rationale for the NNC.

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Recommended Reading

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Smith et al. 2005. Alternative approach for establishing acceptable thresholds on macroinvertebrate community metrics. J. N. Am. Benthol Soc. 24(2): 428-440.

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Friends

FRIENDS of
Great Salt Lake

Protecting the Great Salt Lake Ecosystems through education, research, advocacy and the arts.
150 S. 600 E. Ste 5D
Salt Lake City, Utah 84102

April 8, 2019

Chris Bittner
Utah Division of Water Quality
P.O. Box 144870
Salt Lake City, Utah 84114-4870
cbittner@utah.gov submitted via email

Submitted via Division of Water Quality electronic submission portal also

Re: Public Comment on Proposed Amendments to Standards of Quality for Waters of the State, R317-2 Utah Administrative Code

Dear Mr. Bittner,

Thank you for the opportunity to comment on the proposed amendments to standards of quality for waters of the state R317-2 of the Utah Administrative Code. We make these comments on behalf of FRIENDS of Great Salt Lake.

FRIENDS of Great Salt Lake (FRIENDS) is a non-profit organization that has, as its mission, the preservation and protection of the Great Salt Lake ecosystem as well as Great Salt Lake's watershed, and the organization seeks to increase public awareness and appreciation of the Lake through education, research, advocacy, and the arts. The organization has long been involved in the protection and restoration of Great Salt Lake, its ecosystems and its watershed, advocating for ways in which the public may enjoy these resources by bird-watching, boating, photographing, hiking and studying these natural areas. On behalf of its members, FRIENDS frequently participates in agency processes that affect Great Salt Lake. FRIENDS considers this participation to be critical to its mission and to be valuable as a means of influencing water quality standards that will lead to the protection and preservation of the Greater Great Salt Lake watershed. Some of the water subject to this proposed rule will find its way to the Great Salt Lake. Additionally, the implementation of nutrient water quality criteria will establish a basis upon which the Division of Water Quality may work to establish numeric water quality criteria for Great Salt Lake, including for both nitrogen and phosphorus.

FRIENDS supports the proposed nutrient criteria for headwater streams, and agrees that excessive nutrients in sources of drinking water can degrade both aquatic life and recreational uses of these water bodies. Additionally, FRIENDS understands that the Division of Water Quality has prioritized headwaters for initial development of nutrient water quality criteria and implementing assessment of those criteria. FRIENDS supports the draft criteria as proposed, and encourages the Division of Water Quality to pass the proposed amendment as written.

As the Division of Water Quality proceeds with nutrient water quality criteria for other water bodies of the state, FRIENDS respectfully requests that the agency consider developing numeric water quality standards for both nitrogen and phosphorus for Great Salt Lake. Utah's 2016 Integrated Report contains evidence that Farmington Bay of Great Salt Lake is threatened by excess nutrients. Although Utah's Division of Water Quality did not recommend that Farmington Bay be listed as impaired in its 2016 Integrated Report (IR), there is evidence in the IR demonstrating that Farmington Bay is impaired under Great Salt Lake's narrative criteria for secondary contact recreation activities. Farmington Bay's recreational activities include air boating, kayaking, canoeing, hunting and bird watching. *IR 2016 Ch. 6, Evaluation of Harmful Algal Bloom Data in Farmington Bay, Great Salt Lake,* at 7. Additionally, Antelope Island State Park forms much of Farmington Bay's western shoreline. *Id.* Antelope Island is "one of the most popular Great Salt Lake tourism and recreation destinations". *Id.* The Division of Water Quality evaluated the toxic algal blooms present in Farmington Bay under World Health Organization (WHO) indicators of thresholds for human health risk; and concluded that Farmington Bay exceeds WHO's human health risk indicators. I*d*. Ch. 6 at 8-15. This demonstrates that Farmington Bay is suffering from excessive nutrients, and would benefit from numeric water quality standards for nitrogen and phosphorus.

Thank you for the opportunity to submit these comments. FRIENDS supports the proposed nutrient criteria for headwater streams, and thanks the Division of Water Quality for its work on this issue.

In saline,

Lynn de Freitas, Executive Director

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
Denver, CO 80202-1129
Phone 800-227-8917
www.epa.gov/region8

May 1, 2019

Ref: 8WD-CWQ

Erica Gaddis, Director
Utah Division of Water Quality
195 North 1950 West
PO Box 144870
Salt Lake City, Utah 84114-4870

Re: EPA Comments on Utah's Combined Nutrient Criterion Proposal for Headwater Streams

Dear Dr. Gaddis:

This letter provides the U.S. Environmental Protection Agency (EPA) Region 8 Water Quality Unit comments on the Utah Division of Water Quality's (UDWQ) draft combined nutrient criterion water quality standards (WQS) proposal for Utah's Category 1 and 2 (headwater) streams for the public comment period extending from March 19 to May 3, 2019. The public hearing is scheduled for May 1, 2019. The proposal includes:

1) Proposed Combined Nutrient Criterion: Utah Headwater Streams: Application of Stressor-Response Models and Multiple Lines of Evidence (Proposal);
2) Technical Support Document: Utah Nutrient Strategy: Scientific Investigations to Support Utah's Nutrient Reduction Program (TSD); and
3) Proposed rule language.

BACKGROUND

The UDWQ's proposal includes two components: (1) a recreational use criterion for benthic chlorophyll-a of 125 mg/chl-*a*/m^2, or 49 g/m^2 Ash Free Dry Mass (AFDM), not to be exceeded; and (2) a combined nutrient criterion for protection of aquatic life that is described in more detail below. The EPA comments on the combined nutrient criterion are included below. The EPA has no comments on the recreational use criterion and supports its adoption at this time.

The combined nutrient criterion relies on a combination of numeric nutrient criteria thresholds and ecological indicator responses (i.e., gross primary production (GPP), filamentous algae cover, and ecosystem respiration (ER)) to determine whether nutrients impair the aquatic life uses in headwater streams. These ecological response indicators apply when concentrations of total nitrogen (TN) and total phosphorus (TP) are observed within the following ranges (TN= 0.40-0.80 mg/L and TP=0.035-0.080 mg/L). The proposed ecological response thresholds are: GPP < 6 g $O_2/m^2/d$; Filamentous algae cover: <33%; and ER < 5 g $O_2/m^2/d$. These thresholds are identified in the table located at Appendix A of this letter. The EPA understands that UDWQ is adopting this table (see Appendix A) by reference as part of the proposed rule and therefore, these thresholds and indicators represent the applicable combined nutrient criterion.

The bullets below identify the EPA's summary of UDWQ's proposal for applying the combined nutrient criterion to determine if a waterbody is fully supporting its aquatic life uses:

- If nutrient concentrations are below the lower TN or TP thresholds (TN < 0.40 mg/L or TP < 0.035 mg/L) and all three ecological response thresholds are not exceeded, then aquatic life uses are considered fully supporting for that specific nutrient (either TN or TP).[1]
- If concentrations for either TN or TP are between 0.40-0.80mg/L TN or 0.035-0.080 mg/L TP
    - the waterbody is considered fully supporting of aquatic life uses if data for at least one response indicator are available and measurements for the response indicator(s) are below thresholds;
    - the waterbody is considered not meeting its aquatic life uses ("impaired") if a threshold for any response indicator is exceeded; or
    - the waterbody is considered not assessed ("insufficient data) if all three response indicators are not measured.
- If nutrient concentrations exceed the upper threshold of 0.80 mg/L TN or 0.08 mg/L TP, then the waterbody is considered impaired for aquatic life uses for TN or TP regardless of response indicator results.

GENERAL COMMENTS

The EPA's regulation (40 C.F.R. § 131.11(a)) requires that "criteria must be based on sound scientific rationale and must contain sufficient parameters to protect the designated use." The EPA is offering comments to assist UDWQ in ensuring that Utah's numeric combined nutrient criterion and supporting documentation comply with these WQS requirements. Please note that our comments are preliminary in nature and should not be interpreted as a final EPA decision under Clean Water Act (CWA) § 303(c).

Because Utah's approach gives additional weight to the ecological response indicators, the sensitivity of the response indicators and derivation of their thresholds is important to ensure protection of aquatic life uses.[2] With respect to the combined nutrient criterion, the EPA's technical review identified a number of concerns related to the use of stream metabolism metrics and use of filamentous algae as response indicators for headwater streams that are discussed in detail in Attachment A:

- The process for selecting thresholds for GPP and ER is unclear as is the rationale on how the statistical properties of the deviance reduction analysis supports their ecological significance;
- At many sampling locations, the stream metabolism metrics could not be calculated.
- The analysis does not confirm that GPP and ER are sensitive indicators that will exhibit a response to nutrient pollution in headwater streams;
- Data used to select the stream metabolism indicators and derive criteria were collected at sites that were not demonstrated to be representative of headwater stream conditions;

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[1] See Attachment A, page 16 of this letter for EPA's implementation comment requesting clarification about full support assessment decisions.

[2] See EPA's guidance: Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters. 2013. EPA-820-F-13-039. https://www.epa.gov/sites/production/files/2013-09/documents/guiding-principles.pdf.

- The analysis does not demonstrate a clear link between the stream metabolism thresholds and aquatic life use protection for headwater streams.
- The proposal and TSD currently lack a scientific rationale for the proposed 33% filamentous algae cover threshold; and
- Details should be provided regarding the selection of reference sites and the use of reference site data to derive upper and lower threshold concentrations for TN and TP.

In its detailed comments, the EPA has offered suggestions for additional rationale or analyses could be used to address these concerns before a final technical rationale is submitted to the EPA for review and approval under the CWA § 303(c).

We hope our comments are helpful to UDWQ and the Water Quality Board. We recognize the significant efforts invested by UDWQ and stakeholders and commend UDWQ for its progress in addressing nutrient pollution through a variety of mechanisms. These advancements include: adoption of technology-based limits for TP, completion of TMDLs for TP, initiation of nutrient criteria setting efforts for Utah Lake, and development of a draft combined nutrient criterion. We appreciate UDWQ's efforts to ensure that Utah's draft rulemaking complies with the EPA's water quality standards requirements at 40 C.F.R. Part 131. If there are questions concerning our comments, please contact Tina Laidlaw (406-457-5016). We look forward to working with the parties to address these issues.

Sincerely,

for SS

Sandra D. Spence
Chief, Water Quality Section

cc. Chris Bittner
Standards Coordinator, UDWQ

Jeff Ostermiller
Nutrient Reduction Program Coordinator, UDWQ

ATTACHMENT A - Detailed Comments on Utah's Combined Nutrient Criterion

1. Derivation of metabolic thresholds

The EPA has been unable to replicate the analysis used by UDWQ to establish thresholds for GPP and ER as the information provided does not fully describe how the stream metabolism thresholds were derived. The approach used to derive any water quality criterion or threshold, and their supporting data and methods should be transparent and reproducible.[3]

Chapter 5 (Pages 54-56, TSD) indicates that the proposed GPP and ER thresholds were derived using nonparametric deviance reduction. The rationale for using deviance reduction methods is not clear. First, Figure 5.2 shows a linear relationship among nutrients, GPP, and ER without any obvious change points in the nutrient-metabolism relationship. Given this linear relationship, it is unclear why UDWQ used a change point analysis rather than linear interpolation methods to derive thresholds. Second, it is unclear if the statistically derived change point thresholds for GPP and ER have ecological significance or how they are linked to impacts to aquatic life uses. In fact, UDWQ documented this concern in the 2014 version of the TSD and the thresholds remain unchanged: "Our estimates of GPP and ER thresholds are intrinsically statistical and do not necessarily translate to the health of stream ecosystems."[4,5]

Recommendations

To provide additional clarification and to document the scientific defensibility of the criterion, the EPA recommends revision of the TSD language to more accurately and clearly explain the analyses completed including:

- Providing a step-wise description of the analytical methods used to derive the GPP and ER thresholds. Please provide sufficient detail to ensure the analytical methods can be replicated and the threshold selection process is transparent.
- Documenting how the statistical properties of deviance reduction analysis support the following statement: "Two thresholds were identified; these were expected to provide ecologically meaningful information, with the first threshold corresponding to a departure from the range of natural (reference) conditions, and a second, higher threshold representing an appreciable alteration to GPP or ER processes." (Page 51, TSD).
- Describing whether UDWQ explored the use of linear interpolation methods (either from the literature, reference, or the relationship of these metabolic indicators with other endpoints) to derive the GPP and ER thresholds.
- Explaining the relationship of the statistically-derived nutrient groups identified in Table 5.2 (TSD, page 55) to the nutrient thresholds proposed as criteria in Table 12.1 (TSD, page 139).
- Explaining how the GPP and ER criteria thresholds relate to distinct changes in the aquatic life community, structure or function.

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[3] See EPA Water Quality Standards Handbook, Chapter 3, Section 3.1 Water Quality Criteria. Pages. 2-3. https://www.epa.gov/sites/production/files/2014-10/documents/handbook-chapter3.pdf.

[4] Page 74. 2014 Technical Basis for the Utah's Nutrient Strategy.

[5] See also EPA's January 5, 2017 comments provided to UDWQ "Comments on the Technical Basis for the Utah's Nutrient Strategy."

2. Issues related to calculation of stream metabolism metrics or interpretation of results

Utah's TSD states that calculation of metabolic rates should be routine using typically collected data:

> "DWQ's monitoring and assessment program has practical constraints that were considered when developing the proposed NNC, which were defined to facilitate routine data collection of the parameters necessary for making decisions about support of aquatic life in headwater streams. This means the protection of aquatic life uses will not be impeded by a lack of sufficient data or information necessary to make regulatory decisions." (Page 24, TSD) [emphasis added]
>
> "In addition, there are rare circumstances in which metabolism models cannot accurately calculate GPP and ecosystem respiration (ER), because diel changes in dissolved oxygen (DO) are insufficient for making reliable reaeration estimates." (Page 152, TSD) [emphasis added]

Results from headwater streams sampled in 2015 show that two of the three stream metabolism metrics proposed by UDWQ for their combined criterion could not be calculated at approximately 40% of sites. The inability to calculate stream metabolism metrics at many sites is a practical barrier that limits the utility of these indicators. In these situations, UDWQ must rely on percent filamentous algae to make attainment decisions. In Section 7 of this comment letter, we describe concerns with the protectiveness of the percent filamentous algae threshold. The lack of a clear relationship between the proposed filamentous algae threshold and aquatic life use protection is particularly concerning for the 40% of headwaters sites where attainment decisions will likely be based on this indicator. Since the response indicators serve a critical function in the moderate range of TN and TP values (essentially off-ramping the use of the TN and TP criteria thresholds), it is critical to establish their use, effectiveness and reliability in headwater streams ecosystems.

Additionally, some results presented for individual headwater sites appear to warrant additional clarification:

- Pages 159-160 (TSD) presents ER results for the headwater streams. Raw data[6] reported for the East Fork Virgin River at US89 (Site 4951550) and Huntington Creek (Site 4930585) show positive ER values (0.147 ER at the East Fork Virgin River and 1.525 at Huntington Creek) with comments about the large confidence intervals observed. ER results should be reported as negative, not positive, values because ER reflects the amount of oxygen being consumed. Please explain whether it is appropriate to include these data in Table 13.1 or if these values should be removed.
- Young[7] proposes that low ER values (<0.8 g $O_2/m^2/d$) indicate poor stream health. Based on this information, please explain whether values <0.8 were considered in either deriving the stream metabolism thresholds using the 2010 dataset or in reviewing the 2015 data.

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[6] Excel File. HeadwaterSpecialStudy_SummaryTables_v3_28Sept2017.

[7] Young. R.G., C.D. Matthaei, and C.R. Townsend. 2008. Organic matter breakdown and ecosystem metabolism: functional indicators for assessing river ecosystem health. Journal of the North American Benthological Society, Vol. 27, No. 3, Pages 605-625.

Recommendations

The EPA recommends:

- Reevaluating whether GPP and ER will serve as functional response indicators that can be reliably collected in headwater streams.
- Evaluating whether some of the results presented in the TSD are valid for inclusion.
- Considering the implications of low ER values.
- Providing a copy of Utah's stream metabolism Standard Operating Procedures (SOPs) to the EPA as part of the submission package.

3. Responsiveness of stream metabolism indicators to nutrient pollution in the headwaters

The EPA is concerned that the stream metabolism indicators are not sensitive to nutrients. 40 C.F.R. § 131.11(a) requires that "criteria must be based on sound scientific rationale and must contain sufficient parameters to protect the designated use." (Emphasis added.) The EPA considers response indicators that are sensitive to nutrient pollution as examples of the types of "sufficient parameters" needed to protect the designated use, which for Utah's headwater streams is aquatic life. The EPA's guidance document entitled "Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters"[8] recommends that, for a combined criterion, response indicators should be sensitive to nutrients such that a predictable relationship exists between the two. Response indicator thresholds should be linked to nutrient concentrations and demonstrated to protect uses (i.e., aquatic life uses).[9] Without this quantified relationship, response indicator thresholds may be unable to ensure use protection.

UDWQ examined whether the proposed metabolic indicators responded to nutrients or other potential covariates using Random Forest.[10] Table 5.1 (page 53, TSD) summarizes the results of the Random Forest analysis. "Variables with a larger increase in the mean squared error (MSE) are more important determinants of metabolic rates relative to others." (See page 53, TSD). For GPP, the primary predictors of metabolic rates were channel shading (MSE=104.3), slope (MSE=103.1), and basin slope (MSE=75.3) followed by nutrients (MSE = 72.6 for TN and 73.9 for TP). For ER, channel shading (MSE=69.3), total nitrogen (MSE=69.0), and slope (MSE=63.4) were the most important factors influencing ER.[11] UDWQ notes that they further explored the influence of relevant covariates (stream slope, shading, TN, and TP) for both response indicators to improve the accuracy of the metabolism results:

> "NDR [nonparametric deviance reduction] revealed significant thresholds at ~1% slope for both ER and GPP. GPP and ER thresholds were also found for percent channel shading, where streams with channel shading less than ~11% had greater mean daily rates of GPP (9.3 ± 5.6 to 3.99 ± 4.1) and ER (8.10 ± 5.5 to 4.31 ± 4.1)." (Page 60, TSD)

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[8] Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters. 2013. EPA-820-F-13-039. https://www.epa.gov/sites/production/files/2013-09/documents/guiding-principles.pdf.

[9] See also EPA's November 20, 2014 comments to Utah: "EPA comments on the Technical Basis for Utah's Nutrient Strategy."

[10] Random forest is a decision tree analytical method used for classification or regression.

[11] Note: the values cited here were obtained from Table 5-1. These values differ slightly from the values cited on page 60 of the TSD. The ER increase related to TP had an MSE of 52.1.

These results show that at sampling locations with greater than 1% slope and greater than 11% channel shading these factors have a greater influence than nutrient concentrations on metabolic rates. Information presented in the TSD documented that the majority of the headwater streams sampled in 2015 have slopes that exceed 1% and shading greater than 11%. Therefore, one would expect that the ER and GPP response indicators would have limited utility in signaling nutrient impacts in these headwaters:

> "Canopy cover (shading of the stream channel by riparian vegetation) averaged about 50% but ranged from 3% to 87%. Sites were generally of high gradient, averaging about 5% slope, with a range from < 0.5% to just over 20% among all streams." (page 157, TSD)

The TSD documents the limitations in the relationship between the proposed metabolism indicators and nutrients concentrations:

> "In general, neither GPP nor ER was high in comparison with the broader investigation used to generate S-R relationships." (Page, 158, Chapter 5, TSD). [emphasis added]
>
> "When GPP and ER rates were compared across the range of nutrients that occur throughout Utah, GPP and ER were found to be relatively robust indicators of enrichment, particularly when channel shading and slope were accounted for (Chapter 5). However, in the lower ranges of nutrient concentrations in headwater streams, these responses were not particularly sensitive measures of enrichment. This follow-up investigation did not document a single stream with elevated GPP, and one stream with elevated ER was identified." (Page 163, Chapter 12, TSD). [emphasis added]

Because of the physical characteristics of headwater streams - cooler, lower nutrient concentrations, greater reaeration (due to steeper slopes), and shadier (less GPP) - it's not surprising that the proposed stream metabolism indicators do not respond to increased nutrient concentrations in headwater streams and the data presented do not provide sufficient evidence of a relationship. Information presented in the TSD confirms that, at the 60% of headwater sites where metabolic rates could be calculated, GPP and ER were not sensitive to nutrient pollution. The EPA is concerned that, if GPP and ER are not sensitive to nutrients, use of these indicators and/or the derived thresholds will not serve to confirm nutrient impairments in these streams (see Figure 5.2 on page 9 below).

Recommendations

Based on this information, the EPA recommends:

- Specifying how UDWQ accounted for the influence of channel slope and shading when establishing the GPP and ER thresholds in headwaters.
- Analyzing the 2015 headwaters data to demonstrate that headwater streams are sensitive to nutrient pollution.

4. Representativeness and applicability of metabolic indicators from all streams to headwater streams

Sites sampled in 2010 to develop the combined nutrient criterion differ significantly from headwater streams for which the combined criterion are proposed and the TSD does not clearly demonstrate how these thresholds are protective of headwaters. As discussed above, UDWQ's analysis showed that sampling locations with greater than 1% slope and less than 11% channel shading have a greater influence than nutrient concentrations on metabolic rates. However, UDWQ used data from a statewide study, not headwater streams, to select the proposed response indicators (i.e., GPP and ER), evaluate their sensitivity, and establish thresholds.[12] Streams from the 2010 study were large (average watershed area of 187 mi^2, average discharge of 29 cfs, average width of ~25 feet, average depth of 1.1 feet, average slope of only 1.1%, and average canopy cover of only 27%). (Table 3.2, page 29-30, TSD). Utah conducted additional sampling of headwater sites in 2015; however, data from these events were not considered in the selection of the response indicators or in the derivation of the proposed thresholds. The EPA was not able to locate data summarizing the drainage area, width, depth and slope of these headwater sites to compare to the 2010 study.

Young (2008) notes: "metabolic rates at potentially impacted sites should be compared with rates measured at (more) pristine sites that are characterized by similar stream order and size"[13] [emphasis added]. If there are significant differences in drainage area and stream orders between sites sampled in 2010 compared to headwater streams, then hydrodynamic differences alone between size classes could confound the ability to use data from the 2010 study to establish a protective combined nutrient criterion for headwaters streams.

Recommendations

The EPA recommends:

- Explaining in the TSD how the data used relate to the derivation of headwater streams thresholds and ensure aquatic life protection in headwater streams.
- Adding a table to the TSD that summarizes the drainage area, width, depth, etc. for the headwater sites sampled in 2015.
- Comparing the morphologic and physical characteristics of the 2010 study sites to headwater sites to demonstrate that the streams sampled in 2010 are comparable to headwater streams.
- Using representative data from the target headwater streams to select response indicators and derive protective thresholds or explain why these data are not relevant.

5. Protectiveness of Proposed Thresholds and Link to Aquatic Life Use Protection

The TSD does not clearly link key metabolic indicators that Utah has selected for use in the combined criterion to protection of aquatic life uses in headwater streams. The EPA used Figure 5.2 (Page 60, TSD) to further review the nutrient-metabolism relationship in Utah's headwater streams. The EPA superimposed the following information on the figure:

- Low, medium and high thresholds for TN and TP (orange and red lines)
- Mean GPP and ER values for the low, medium, and high nutrient groups (blue arrows)
- Thresholds for GPP and ER (black hashed lines)
- 2015 metabolism results at headwater streams (blue symbols)

[12] Chapter 5 (TSD).
[13] Young, R. G., C.D. Matthaei, and C.R Townsend.2008. Organic matter breakdown and ecosystem metabolism: functional indicators for assessing river ecosystem health. Journal of the North American Benthological Society, Vol. 27, No. 3. Pages 605-625.

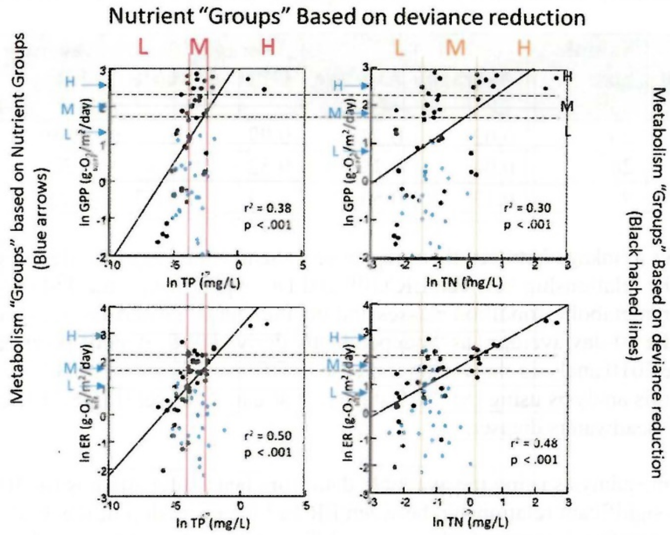

Figure 5.2. Linear relationships between ambient nutrient concentrations (total nitrogen [TN] and total phosphorus [TP]) and gross primary production (GPP, top row) and ecosystem respiration (ER, bottom row)

With this information added to the figure, it is apparent that the proposed ER threshold of 5 g-O_2/m^2/day (Ln value of 1.6) is at or above the *upper* threshold TP value. Because the upper TP threshold is associated with impaired conditions, it is unclear how the proposed ER threshold demonstrates protection of aquatic life uses. In addition, a review of the GPP and ER results observed at Utah's headwater streams (blue symbols) shows that GPP and ER tend to be biased lower at headwater sites, at a given nutrient concentration, than the 2010 study sites. The TSD does not explain how the GPP and ER threshold values developed using the 2010 sites (and not the 2015 headwater sites where these thresholds are applied) are protective of headwater streams aquatic life. This demonstration is key in supporting the proposed thresholds.

To further review the 2015 dataset, the EPA categorized each site based on the nutrient enrichment thresholds identified in Table 12.1 (page 139, TSD). Sites with TN and TP concentrations below the lower thresholds (<0.4 mg/L TN: < 0.035 mg/L TP) were labeled "low"; sites with either TN or TP concentration in the mid-range (TN= 0.40-0.80mg/L and TP=0.035- 0.080 mg/L) were labeled "moderate", and sites with TN or TP concentrations above the upper threshold (>0.80 mg/L TN; >0.080 mg/L TP) were labeled "high". Table 1 below presents the average and maximum values for TN, TP, GPP and ER for each "nutrient enrichment category." These data show that GPP does not clearly increase with increasing nutrient enrichment categories and ER decreases with increasing nutrient enrichment categories (which is the inverse of what we would expect if this indicator was responsive to nutrients). The lack of a predictable response in GPP and ER is problematic given the critical role the ecological response indicators play in the middle range of the TN and TP values for this combined criterion.

Table 1. Summary Statistics for 3 Nutrient Enrichment Categories[14] in Headwaters Streams

Nutrient Enrichment Categories	Sample Size	Average TP	Average TN	Average GPP	Max GPP	Average ER	Max ER
low	20	0.02	0.24	0.99	3	2.69	9.83
moderate	20	0.04	0.35	0.52	1.51	1.32	4.91
high	9	0.13	0.53	1.24	3.37	0.73	1.53

As the means to infer a linkage between these response indicators and aquatic life use protection, UDWQ examined the relationship between ER/GPP and DO. Specifically, the TSD documents the relationship between metabolic condition classes and the number of DO criterion exceedances (excursions below the 30-day average) as "independently derived indicators of potential threats to stream biota."[15] The 2010 analysis showed an increase in DO excursions when ER > 5 g $O_2/m^2/d$. UDWQ performed this analysis using the 2010 statewide streams dataset (Figure 12.3, page 148, TSD) but not for the 2015 headwaters dataset.

The EPA ran the same analysis using the available data from headwater streams (n=30). The EPA's analysis showed no significant relationship between ER and the excursion of the 30-day average DO criterion -only two sampling locations had any probability of exceeding it (probability of 0.27 and 0.19). All other sampling locations showed zero probability of exceeding the 30-day average DO criterion of 6.5 mg/L. We also performed this analysis using the daily minimum DO value of 4 mg/L DO and only one site[16] exceeded that value.

Based on the information in the TSD, UDWQ has not clearly demonstrated that GPP and ER are linked to protection of aquatic life uses in headwater streams as no linkage between exceedance of the DO criterion and GPP or ER (UDWQ's chosen metrics) was established.

Recommendations

The EPA recommends:

- Providing documentation in the TSD that the proposed GPP and ER thresholds will ensure protection of aquatic life uses in headwater streams, particularly in light of the 2015 headwaters data. Specifically, the EPA recommends:
    - Conducting additional stressor-response analyses using only the 2015 headwater data and comparing the thresholds obtained with that analysis to the proposed thresholds for GPP and ER. Providing an explanation as to whether UDWQ evaluated the ER/DO relationship using the 2015 headwaters data and describe the results of that analysis.

6. Other Potential Indicators

UDWQ considered other response indicators in establishing the combined criterion for headwater

[14] See Table 12.1, page 139 of the TSD.
[15] Page 57, TSD.
[16] Salt Creek at USFS boundary (MLID 4995360); probability of exceeding the minimum DO criterion of 6%.

streams, but the rationale for why they were not selected as response indicators is not clearly documented in the TSD. The TSD refers to Utah's analysis of potential biological indicators (i.e., diatoms, macroinvertebrates) to increasing nutrient concentrations which showed a loss of sensitive taxa at nutrient concentrations that were lower than the proposed lower nutrient thresholds. For example, the state's analysis shows loss of sensitive macroinvertebrate and diatom taxa at approximately 0.011 mg/L TP and 0.016 mg/L TP[17] which are much lower concentrations than the proposed TP threshold of 0.035. Similarly, the TSD states: "The overall threshold that captures the TP associated with the most appreciable changes in both tolerant and abundant diatom taxa was at 0.022 mg/L." (Page 89, TSD).

This information suggests substantial changes to community structure, which is indicative of impacts to the aquatic life designated use, are occurring at lower levels than the proposed criterion, at least for TP. The TSD notes that:

> "Allowing nutrient concentrations to achieve levels that result in assemblages dominated by tolerant taxa are likely underprotective." (Page 101, TSD)

Results presented in Chapter 7 (TSD) suggest that changes from sensitive to tolerant communities are occurring at nutrient concentrations below the proposed lower nutrient thresholds. This information suggests that the proposed combined nutrient criterion would likely lead to shifts to more tolerant, and less desirable, taxa – conditions that are not protective of aquatic life and that contradict the stated objectives.

Recommendations

The EPA recommends:

- Exploring the use of diatoms or macroinvertebrates as response indicators for use with the combined criterion. Alternatively, the proposal should include a rationale for not selecting diatoms or macroinvertebrates as potential response indicators for the combined nutrient criterion.

7. Development and selection of the filamentous algal threshold

The proposal and TSD currently lack a clear scientific rationale for the proposed 33% filamentous algae cover threshold proposed to protect aquatic life uses. The EPA's regulation at 40 C.F.R. § 131.11(a) requires that "criteria must be based on sound scientific rationale and must contain sufficient parameters to protect the designated use." UDWQ did not empirically derive the proposed filamentous algae threshold. Instead, the primary basis for the 33% threshold appears to be two studies available in the scientific literature (Biggs 2000, and Welch et al. 1988).[18] Further examination of these papers reveals that the 30% threshold identified in Biggs is based on impacts to aesthetics and trout habitat in New Zealand. The TSD does not include a description of which aspects of Biggs' conclusions are most relevant to Utah's headwater streams. For protection of benthic biodiversity, which should be protected as a component of the aquatic life designated use, it is important to note that Biggs[19] establishes a mean

[17] Page 88, TSD.
[18] Proposal, Page 27.
[19] Page 102. Biggs, B. J. F. 2000. New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams. Report to New Zealand Ministry for the Environment.

monthly chlorophyll-a of 15 mg/m^2 as the threshold necessary -- not the 30% threshold cited in the proposal. In addition, Welch et al. 1988 relates to an aesthetics threshold for percent filamentous algae cover. Welch does not address aquatic life use protection. The proposal does not explain how a threshold based on aesthetics is protective of aquatic life uses.

Beyond the literature citations, the proposal provides the following justification for selecting the 33% threshold:

> "DWQ recommends a criterion of maximum filamentous algae cover of 1/3 of the stream bed. While this number is at the upper end of concentrations that others have suggested as protective of stream aquatic life uses, DWQ has established this threshold as protective of stream conditions because it represents the maximum filamentous algae concentration that is observed on any single collection event." (Proposal, page 27) [emphasis added]

Given the stated paucity of data collected on Utah streams, there is limited information on which to base this statement and demonstrate that the proposed threshold is protective of aquatic life uses in headwater streams.

The EPA's guidance document entitled "Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters"[20] recommends that "[combined] criterion should demonstrate the sensitivity of the response indicator(s) to increased nutrient concentrations and quantify how these nutrient-response linkages will achieve the goal of protecting and maintaining aquatic communities." Chapter 13 of the TSD, page 160, explicitly states that "there was no statistically significant linear relationship between TN or TP and filamentous algae cover." The proposal also cites to the influence of confounding factors on filamentous algae growth: "Others have noted that whether or not filamentous algae cover reaches levels of potential concern is also dependent on other stream characteristics such as canopy cover, stream temperature, stream size, and hydrology (Busse et al. 2006, Dodds and Oakes 2004, Riseng et al. 2004)." (Proposal, page 27). Based on the proposal, it is unclear how UDWQ controlled for confounding factors in the study design used for the independent evaluation of the proposed numeric nutrient criterion (Chapter 13) or in any subsequent analysis.

The EPA also reviewed regionally-relevant studies related to Utah's proposed filamentous algae threshold. For example, the Montana Department of Environmental Quality (DEQ) conducted a dose-response nutrient study on a perennial prairie reference stream. Recognizing that plains streams, even reference sites, generally tend to have a higher degree of human disturbance than montane reference sites (i.e., "least disturbed" compared to "minimally disturbed" reference sites),[21] the EPA examined the Montana study because it offered insights into visually assessed filamentous algae values observed across a nutrient gradient. The EPA's hypothesis was that the visual estimate of filamentous algae observed in prairie reference streams would be greater than estimates from headwater streams because prairie streams are likely to be less shaded, have lower gradients, more impacts, etc. Therefore, the Montana study represented the "upper range" of conditions for filamentous algae that could be applicable to headwater conditions.

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[20] Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters. 2013. EPA-820-F-13-039. https://www.epa.gov/sites/production/files/2013-09/documents/guiding-principles.pdf.

[21] Stoddard, J.L., D.P. Larsen, C. Hawkins, R.K. Johnson, and R.H. Norris. 2006. Setting Expectations for the Ecological Condition of Streams: The Concept of Reference Condition." Ecological Applications 16: 1267-76.

The study used a "Before After Control Impact Paired" study design with an upstream control reach and two downstream low and high dosed reaches. As soluble nutrients were added to the stream over a two-month period, Montana DEQ collected data on several response measures, including visual estimates of filamentous algae. While sampling protocols used to estimate filamentous algae may differ from Utah's sampling methods, results from the Montana study are informative. In 2009 and 2011, years when no dosing occurred (Parts A and C below), data collected at the control reach showed average filamentous algae values ranged from approximately 2% to 9% cover, 2% to 9% in the low dose reach, and 1% to 6% in the high dose reach.[22] In 2010 years where dosing occurred, the maximum average percent cover observed in any reach was 33% in the low dose reach and 17% in the high dose reach.[23]

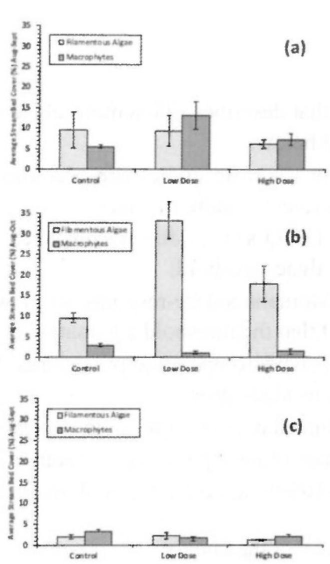

FIGURE 3. Average visually assessed streambed cover by filamentous algae and macrophytes over a common period. Part (a) is 2009 (August–September). Part (b) is 2010 (August–October) during the After period. Part (c) is 2011 (August–September). For each treatment, error bars are one standard deviation of the mean across the indicated time period (see also Table 1 for sampling dates).

These results show that Utah's proposed threshold of 33% exceeds the visual estimates of average percent cover observed in a prairie reference stream during times when nutrients were being added directly to the stream and suggest that Utah's proposed threshold would not adequately protect aquatic life uses in headwater streams. This concept is supported by information presented in the TSD:

> "On average, the maximum filamentous algae cover observed was low but highly variable among study locations (average of 19 ±24; Figure 13.3). At approximately 10% of the study sites (24 of 49) filamentous algae never exceeded 10% during the growing season." (TSD, page 160)

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[22] Page 10. Suplee, M.W., R. Sada, and D.L Feldman. 2019. Aquatic Plant and Dissolved Oxygen Changes in a Reference-Condition Prairie Stream Subjected to Experimental Nutrient Enrichments. Journal of the American Water Resources Association.1-20. https://doi.org/10.1111/1752-1688.12736.

[23] *Ibid.*

[emphasis added]

The sentence should be corrected to read, "At approximately 50% of the study sites (24 of 49) filamentous algae never exceeded 10% during the growing season." [emphasis added] These data from Utah streams, coupled with results from Montana's dose-response study, indicate that a lower filamentous algae threshold is likely needed to protect aquatic life uses.

Lastly, visual estimates for filamentous algae cover can be prone to bias. Therefore, having sampling methods that ensure a systematic approach to sampling is important. There is also no information describing how the proposal evaluated bias in the visual estimates.

Recommendations

The EPA recommends:

- Adding a chapter to the TSD that describes filamentous algae as a response indicator and addresses the issues described below;
- Discussing in the TSD how the scientific studies cited demonstrate that a threshold of 33% filamentous algae cover will protect aquatic life uses;
- Explaining in the TSD how UDWQ's study design controlled for confounding factors in the derivation of the filamentous algae threshold;
- Reconciling the results from Montana's dose-response study with the proposed 33% threshold and demonstrating in the TSD that the threshold adequately protects aquatic life uses;
- Providing a copy of UDWQ's standard operating procedures (SOPs) for determining visual estimates of percent filamentous algae growth;
- Describing how the state evaluated potential bias in the visual estimates;
- Characterizing the percent filamentous algae cover at reference streams in the TSD; and
- Exploring the relationships between percent cover and invertebrate data.

8. Derivation of lower and upper nutrient thresholds

The proposal applies a combined nutrient criterion within a broad range of TN and TP values - ranging from concentrations representative of reference conditions to upper TN and TP values at which impairments to aquatic life are expected. Given the EPA's comments on the sensitivity of the response indicators and protectiveness of the proposed thresholds, UDWQ's proposed approach could allow nutrient concentrations to increase until they reach the upper nutrient thresholds and impact or impair aquatic life.

In addition, the EPA encourages revising the TSD to ensure that the final technical rationale clearly articulates the state's process for selecting the upper and lower nutrient thresholds and addresses the following issues:

- Chapter 11 (TSD) suggests that one line of information used to establish the proposed criteria are frequency distributions from headwater reference streams. Please describe the state's process for identifying reference sites or cite to a separate document that provides this information.

- Pages 126- 127 (Chapter 11, TSD) references a total of 45 reference sites compared to 3861 total samples for TP and 2,947 for predicted TN collected at all headwater sites. Please clarify the total number of reference samples used in the analysis.
- Page 23 (Proposal) states that "The lower concentrations are consistent with the 90th percentile of reference sites, which have been used to support criteria elsewhere." Should this statement be modified to read: "lower concentrations are consistent with the 90th percentile of <u>mean</u> concentrations at reference sites?"

<u>Recommendations</u>

The EPA recommends:

- Explaining how a broad range of nutrient concentrations will ensure protection of aquatic life uses.
- Providing documentation on UDWQ's reference site screening process.
- Clarifying in the TSD and proposal, if needed, the number of reference samples and whether the 90th percentile represents a mean concentration.

9. <u>Full Support Assessment Determinations Based on a Single Response Indicator</u>

As described on page 2 of this letter, UDWQ will in some instances be relying on data from a single response indicator in use attainment decisions. Page 42 (Proposal) states that sites will be considered "to be meeting their aquatic life uses provided that at least one response variable has been measured and no response that has been measured exceeds the established thresholds…In circumstances where a response is required to make an assessment decision, it is not necessary to have data on all response[s] specified in the NNC."

For states using a combined criterion, the EPA recommends relying on data for more than one response indicator to make the decision that a water is fully supporting its aquatic life uses. This approach is especially critical in situations where the response indicators, and their associated thresholds, may not be very sensitive to increases in nutrient concentrations.

Based on the EPA's technical review of the proposed suite of response indicators, none of Utah's proposed response indicators exhibit a strong relationship to nutrients. In addition, because of an inability to calculate GPP and ER at many headwater sites (see page 5 of this letter), the state may have to rely on results for percent filamentous algae cover to make attainment decisions based on a threshold that lacks a clear scientific rationale. Therefore, the EPA recommends modifying the proposal to require that data from all response indicators must be collected and meet the proposed thresholds before a site can be assessed as meeting its aquatic life uses.

10. <u>Criterion Operation and Implementation Comments</u>

In addition, the EPA offers the following set of criterion operation and implementation-related comments for UDWQ's consideration:

- We recommend developing SOPs for making assessment decisions within the combined criterion matrix to clearly document how assessment decisions will be made.

- Because the combined criterion incorporates a *range* of nutrient thresholds, please describe in the proposal the process that the state would use to identify total maximum daily load (TMDL) targets when a waterbody is listed as impaired.
- In the TSD and proposal, please clarify the assessment decision that would occur if TP concentrations exceed the moderate or upper thresholds but TN concentrations do not.
- Please clarify in the TSD and proposal whether both TN and TP concentrations need to be below the lower thresholds for a site to be considered fully supporting its aquatic life uses. The current language in the proposal appears to offer contradictory perspectives. For example, the description in the Proposal (pages 24, 41) specifies that *both* TN *and* TP must be below the lower threshold for a site to be considered meeting its aquatic life uses. In contrast, Tables 4 and 8 (pages 33 and 42, Proposal) suggest "either/or" must be below the specified nutrient concentration before a full support determination can be made. The TSD (pages ES7, 137 and Table 12.1 on page 139) contain similar contradictory information.
- The EPA recommends UDWQ consider placing waters identified within the moderate range of TN and TP, with no available ecological response indicator data, in Category 5 of the Integrated Report until response indicator data are available to confirm the aquatic life use is attained.
- Please describe in the proposal how the proposed combined criterion will ensure protection of downstream uses, especially in instances where nutrient concentrations are allowed to increase to/near the upper thresholds for TN and/or TP.

APPENDIX A

Table 12.1. Numeric Nutrient Criteria and Associated Ecological Responses (Bioconfirmation Criteria) Proposed to Protect Aquatic Life Uses in Antidegradation Category 1 and 2 (UAC R317-2-12)[f] Headwater Perennial Streams

Low Nutrient Enrichment at Headwater Streams: No Ecological Responses		
Summertime Average Nutrients		**Assessment Notes**
TN < 0.40[a,b]	TP < 0.035[a,b]	Fully supporting biological uses if the average of ≥ 4 summertime samples is below the specified nutrient concentration of either TN and TP unless ecological responses specified for moderate enrichment streams are exceeded. Sites with fewer samples will not be assessed for nutrients.

Moderate Nutrient Enrichment at Headwater Streams and Ecological Responses			
Summertime Average Nutrients		**Ecological Response**	**Assessment Notes**
TN 0.40–0.80[a]	TP 0.035–0.080[a]	Plant/Algal Growth[c] < 1/3 or more filamentous algae cover[d,e] OR GPP[c] of < 6 g O_2/m^2/day OR Plant and Microbial Growth ER[c] < 5 g O_2/m^2/day	Headwater streams within this range of nutrient concentrations will be considered impaired (not supporting for nutrients) if any response exceeds defined thresholds. Streams without response data will be listed as having insufficient data and prioritized for additional monitoring if either TN or TP falls within the specified range.

High Nutrient Enrichment at Headwater Streams: No Ecological Responses[e]		
Summertime Average Nutrients		**Assessment Notes**
TN > 0.80[a,b]	TP > 0.080[a,b]	Streams over these thresholds will initially be placed on Utah's Section 303(d) list as threatened. Threatened streams will be further evaluated using additional data such as nutrient responses, biological assessments, or nutrient-related water quality criteria (e.g., pH and DO) both locally and in downstream waters.

Notes: Criteria would be applicable unless more restrictive total maximum daily load (TMDL) targets have been established to ensure the attainment and maintenance of downstream waters. DO = dissolved oxygen, ER = ecosystem respiration, GPP = gross primary production, TN = total nitrogen in mg/L, and TP = total phosphorus in mg/L.

a. Seasonal average of ≥ 4 samples collected during the summertime growing season (June 1–September 30) will not be exceeded. Sites will be assessed using the higher of TN and TP threshold classifications.

b. Response data, when available, will be used to assess aquatic life use support or as evidence for additional site-specific investigations to confirm impairment or derive and promulgate a site-specific exception to these criteria.

c. Daily whole stream metabolism obtained using open-channel methods. Daily values are not to be exceeded on any collection event.

d. Filamentous algae cover means patches of filamentous algae > 1 cm in length or mats > 1 mm thick. Daily values are not to be exceeded at any time during the growing season (June 1–September 30).

e. Quantitative estimates are based on reach-scale averages with at least three measures from different habitat units (i.e., riffle, run) made with quantitative visual estimation methods.

f. Excluded waters identified in UAC R317-2-13.2 (c).

Division of Water Quality Responses to EPA Comments (May 1, 2019)

The United States Environmental Protection Agency (EPA) provided technical comments to Utah's Division of Water Quality (UDWQ) about the proposed headwater numeric nutrient criteria (NNC) and its underlying rationale. EPA did not raise any concerns on the NNC elements intended to protect recreational uses (UAC R317-2-14.7), so the responses to comments focus on those NNC elements intended to be protective of aquatic life uses (UAC R317-2-14.8).

EPA raised several concerns about the ecological relevance of the statistically derived response thresholds and their ability to ensure protection of aquatic life uses in headwater streams. UDWQ addresses specific concerns by expanding on the information provided in the supporting documentation in the Detailed Responses below.

EPA also makes several recommendations which involve requests for additional clarification in supporting materials for the proposed headwater numeric nutrient criteria (NNC). Additional EPA recommendations include providing additional supporting materials such as the Standard Operating Procedures (SOPs) for filamentous algae cover data collection and the approach that UDWQ intends to follow for criteria implementation. While these materials have already undergone extensive technical review, UDWQ appreciates the fresh perspectives provided by stakeholders outside of these discussions. EPA is particularly well suited to highlight circumstances where additional details would provide additional rationale that the proposed criteria align with regulatory water quality standard requirements (40 C.F.R. Part 131). UDWQ has revised the supporting documentation—*Technical Support Document: Utah's Nutrient Strategy* (hereafter TSD) and *Proposed Nutrient Criteria: Utah's Headwater Streams* (hereafter Proposal)—to further clarify the underlying rationale behind the NNC. Additional requested documents will be submitted in conjunction with the rulemaking packet provided to EPA for formal review and approval in accordance with section 303(c) of the Clean Water Act (CWA).

Inclusion of the recommended clarifications in supporting documentation will improve the strength of the underlying rationale. However, the comments do not substantively alter the proposed rules or supporting documentation, nor do they raise concerns about the scientific defensibility of the rules as an important regulatory tool that will help the agency maintain and protect water quality in Utah's headwater streams. The proposed headwater NNC does not remove any existing protections from adverse effects caused by excessive nutrient enrichment. Instead, they establish additional protections that can be used to identify adverse effects of nutrient enrichment. The 2015 confirmation investigation (TSD, Chapter 13) confirmed that the NNC were able to identify headwater streams exhibiting adverse effects of nutrient enrichment.

Many headwater streams have naturally-occurring physical attributes that provide natural protections form the effects of nutrient enrichment and this sometimes obscures otherwise significant stressor-response (S-R) relationships. However, the inability of the NNC to identify adverse effects in these circumstances is not evidence that the criteria lack protections for aquatic life uses; in fact, these observations are evidence that combining nutrients with ecological responses is needed to avoid an unreasonable number of false-positive impairment determinations. The responses included in the NNC facilitate an evaluation of the two most important causal pathways leading to degradation of aquatic life uses. Among all of the responses that UDWQ evaluated in the TSD, these responses were also most easily integrated into routine monitoring and assessment programs.

Detailed Responses

The following section provides detailed responses from UDWQ to comments on the NNC submitted by EPA. EPA comments are provided in *blue, italic text*. Responses from UDWQ are in the black text that follows. In some cases, the sections provided by the commenter are subdivided (capital letters) to facilitate responses to major subtopics. For each section, EPA made specific recommendations to UDWQ, which is followed by actions taken by UDWQ, if any, to fulfill each request.

1. Derivation of metabolic thresholds

1A

The EPA has been unable to replicate the analysis used by UDWQ to establish thresholds for GPP and ER as the information provided does not fully describe how the stream metabolism thresholds were derived. The approach used to derive any water quality criterion or threshold, and their supporting data and methods should be transparent and reproducible.

UDWQ agrees that it is critically important for all analyses to be transparent and reproducible. For these reasons all data were made available to interested parties when draft of support documents were released for comment. The methods in the Stream Metabolism chapter of the TSD have been clarified. UDWQ also recalculated the thresholds to ensure that the thresholds could be replicated. This analysis, along with the underlying data and analytical code, will be provided to EPA—along with other supporting materials—when the NNC are submitted to EPA for approval.

1B

Chapter 5 (Pages 54-56, TSD) indicates that the proposed GPP and ER thresholds were derived using nonparametric deviance reduction. The rationale for using deviance reduction methods is not clear. First, Figure 5.2 shows a linear relationship among nutrients, GPP, and ER without any obvious change points in the nutrient-metabolism relationship. Given this linear relationship, it is unclear why UDWQ used a change point analysis rather than linear interpolation methods to derive thresholds.

As explained in the TSD, TP and TN concentrations below the lowest TP and TN NNC thresholds are indistinguishable from reference conditions. Ecological significance is based on the assumption that reference conditions are fully protective. This assumption is also the basis of EPA's (2000) distribution approaches (see *Frequency Distribution Approaches for Setting Nutrient Criteria* in the TSD). Ecological significance was also explicitly considered for the other thresholds. The cited quote from the TSD is accurate but the statement precedes a discussion about the various evaluations that UDWQ conducted to establish the ecological relevance of the statistical thresholds. UDWQ evaluated ecological significance by comparing the thresholds with related water quality standards and assessment indices. In the case of the metabolism threshold, this was done by comparing ER thresholds with Utah's DO criteria. In addition, UDWQ compared the proposed thresholds against independent investigations reported in the scientific literature.

One way to establish the ecological relevance of statistically-derived groups is to evaluate whether or not the other groups correspond with independently derived measures of stream health in a manner consistent with ecological theory. One problem often attributed to eutrophication is low levels of DO. This occurs because additional nutrients increase the abundance or biomass of autotrophs (plants, algae) and heterotrophs (microbes, fungus). The resulting increase in carbon, coupled with additional macronutrients (N, P) fuels increased decomposition. These macronutrients also increase the abundance of microbes and other organisms that decompose these carbon sources. These organisms all respire, consuming oxygen in the process, which can result in DO concentrations that are low enough to be harmful to stream biota. These low DO problems are often particularly apparent during the nighttime when DO consumption is not offset by oxygen produced via primary production. ER is a direct measure of the oxygen consumption associated with the consumption of the additional carbon made available via higher GPP rates. Utah's DO criteria were derived independently, based on oxygen levels found to be harmful to aquatic life, as opposed to underlying processes (GPP, ER) that cause low DO conditions in streams. However, given the cycle discussed above, it follows that the number of excursions below DO water quality standards should increase predictably from low to high ER groups and this is exactly what was documented in the TSD (pp. 57-60). Importantly, no excursion below the 30-day DO criterion occurred among any of the streams in the low GPP and ER groups that define the ecological boundaries of the headwater NNC. The lack of DO violations in this group, but not higher groups, suggests that the lower thresholds are real and values below those thresholds are protective of aquatic life uses.

Another way that UDWQ established ecological relevance of the stream metabolism groups is by comparing the results presented in the TSD against those reported in the scientific literature. These comparisons are presented in the Discussion section of the metabolism chapter in the TSD (pp. 61-64) and also in the proposal. The GPP and ER thresholds in the proposed criteria align with those proposed by other investigators. As discussed in the TSD, these thresholds are also reflective of the first change point, which UDWQ interprets as the point where background GPP and ER rates can be distinguished from naturally-occurring conditions.

EPA Recommendations and UDWQ Responses

To provide additional clarification and to document the scientific defensibility of the criterion, the EPA recommends revision of the TSD language to more accurately and clearly explain the analyses completed including:

- *Providing a step-wise description of the analytical methods used to derive the GPP and ER thresholds. Please provide sufficient detail to ensure the analytical methods can be replicated and the threshold selection process is transparent.*

UDWQ reviewed early TSD drafts to better understand how the TN, TP and metabolism thresholds were derived. The methods and results of Chapter 5 in the TSD have been revised. UDWQ also recalculated the thresholds to ensure that the thresholds could be replicated. This analysis, along with the underlying data and analytical code, will be provided to EPA—along with other supporting materials—when the NNC are submitted to EPA for approval.

- *Documenting how the statistical properties of deviance reduction analysis support the following statement: "Two thresholds were identified; these were expected to provide ecologically meaningful information, with the first threshold corresponding to a departure from the range of natural (reference) conditions, and a second, higher threshold representing an appreciable alteration to GPP or ER processes." (Page 51, TSD).*

As explained in the TSD, TP and TN concentrations below the lowest TP and TN NNC thresholds are indistinguishable from reference conditions. Statistically, the threshold is reflective of the first significant change point in the relationship between ambient nutrient concentrations and stream metabolic rates. UDWQ assumed that GPP and ER rates below this threshold were reflective of naturally occurring conditions. The assumption that the lowest rates are reflective of natural conditions is similar to *post hoc* reference site selection based on water chemistry, which has been used extensively by EPA and state agencies. Ecological significance is based on the assumption that reference conditions are fully protective. In addition, sites below and above the ER threshold were evaluated against Utah's numeric DO criteria (Proposal, Figure 8) which validated that the lower threshold is protective of potentially stressful DO conditions. The assumption that reference conditions are reflective of natural conditions is also the basis of EPA's (2000) distribution approaches, and a similar analysis conducted by UDWQ that confirm that the nutrient concentrations below the TN and TP concentrations below the lower metabolic thresholds fall within the range of reference conditions. The higher threshold represents the next statistically valid change point in the relationship between nutrient concentrations and stream metabolism, which seemed to distinguish streams with atypically high GPP or ER. The upper thresholds assisted with data interpretation and were otherwise not integral to the NNC.

- *Describing whether UDWQ explored the use of linear interpolation methods (either from the literature, reference, or the relationship of these metabolic indicators with other endpoints) to derive the GPP and ER thresholds.*

UDWQ provided additional details with respect to the underlying rationale behind the analytical methods used to derive the GPP and ER in the responses to section 2C above.

The linear relationship among nutrients and metabolism responses was only apparent after natural log transformations of both nutrients and responses. Hence, these relationships are exponential, not linear. While statistically significant, there was also considerable scatter due to error and the influence of covariates. UDWQ used the linear regression in an exploratory fashion to efficiently confirm that an underlying relationship between the variables could be measured. Once this relationship was confirmed, UDWQ then applied more sophisticated analyses to characterize the relationship and to specifically identify change points.

With respect to additional responses, UDWQ explored the relationship between autochthonous organic matter standing stocks and metabolic rates (TSD, Chapter 6). The relationship between ambient nutrient concentrations and structural responses was not explored in the same way because UDWQ explored these relationships using existing data sources to maximize the sample size and generate the most robust structural response relationships possible. The results of all of these analyses are presented in the TSD (Chapters 2-7).

- *Explaining the relationship of the statistically-derived nutrient groups identified in Table 5.2 (TSD, page 55) to the nutrient thresholds proposed as criteria in Table 12.1 (TSD, page 139).*

Table 5.2 provides the nutrient concentrations that, on average, most strongly distinguished among streams with low, moderate and high metabolic rates. These thresholds were among many that UDWQ used as multiple lines of evidence (see Proposal and TSD, Chapter 12) to inform the nutrient thresholds. UDWQ identified lower nutrient thresholds that were reflective of the upper range of background conditions and then collectively evaluated the nutrient thresholds from all responses to ensure that these lower concentrations would be protective of several different indicators of aquatic life use support. The nutrient thresholds associated with changes in metabolic responses were among the indicators evaluated in this review of the proposed criteria. UDWQ edited the TSD to provide a more thorough explanation of these relationships and discusses the ecological significance of these thresholds in the responses to section 2B of this comment letter.

- *Explaining how the GPP and ER criteria thresholds relate to distinct changes in the aquatic life community, structure or function.*

The TSD discusses linkages among metabolic responses and nutrient enrichment extensively, but UDWQ has provided additional information on the linkages among metabolic responses and aquatic life uses in the responses to comments. In some respects, linkages to ecosystem functions are self-evident because GPP and ER are considered fundamental ecosystem functions. Chapter 2 of the TSD discusses linkages between these indicators, the protection of aquatic life uses, and Utah's water quality standards. Chapter 5 provides additional details on the ecological importance of GPP and ER responses with further elaboration provided in the responses to comment 2A. Linkages between stream metabolic rates and higher trophic levels are intrinsically indirect, but virtually all nutrient-related adverse impacts to the composition of stream assemblages are initiated by increases in autotrophic (GPP) or heterotrophic (ER) production. Hence, many of the nutrient-related alterations to the composition of macroinvertebrates and diatom assemblages documented by UDWQ (TSD, Chapter 7) are indirectly attributable to increases in GPP or ER.

With respect to the specific GPP and ER thresholds, several lines of evidence can be used to establish their ecological relevance. The metabolic thresholds are reflective of the lowest statistically valid change-points associated with ambient nutrient concentrations. UDWQ interpreted this response as an inflection point that distinguishes background GPP and ER rates from those altered by nutrient enrichment. The corresponding TN and TP concentrations are roughly equivalent of the 75^{th} percentile of reference site distributions (TSD, Chapter 11), which provides additional support for the interpretation with respect to the NNC stressor. Biological integrity cannot be measured directly because it is a construct intended to capture many different facets of stream condition. Instead, resource managers have relied on indicators reflective of important aspects of stream condition. After calculating ER thresholds, UDWQ compared ER rates with Utah's DO criteria and found that excursions below the criteria were much more likely above the ER NNC threshold (TSD, Chapter 5). UDWQ also found a significant relationship between nutrients (TN and TP) and standing stocks of autochthonous organic matter (OM). Streams with low levels of autochthonous organic matter were much more likely to show excursions below DO criteria and almost always exhibited ER rates below the proposed ER threshold (TSD, Figure 6.3, panel D). In contrast, the vast majority of streams with high autochthonous OM biomass had ER rates greater than the proposed NNC threshold.

Many studies have demonstrated linkages between stream metabolic rates and various stressors, including nutrients. However, few translate their results into ER or GPP condition classes. Young et al. (2006) suggested that GPP (4 g O_2/m^2/day) and ER values (5.5 g O_2/m^2/day) differentiated streams in good vs. fair condition. These recommendations are quite similar to the lower thresholds derived from Utah streams (GPP of 6 and ER of 5 g O_2/m^2/day). Another study (Izagirre et al. 2008), compared the thresholds proposed by Young to metabolic values obtained from 19 streams in Spain and suggested that the proposed thresholds may be overly conservative because they were exceeded in all of their most oligotrophic and biologically healthy streams (average GPP of 9 g O_2/m^2/day). There are many other causal pathways that could potentially link alteration of GPP and ER rates to degradation of uses (see responses to 3A above). UDWQ was unable to evaluate the ecological relevance of GPP and ER thresholds for every causal pathway, but those that were evaluated demonstrate that the proposed thresholds are appropriately protective. In contrast, data have not been presented that provide evidence that lower rates are needed to be protective of biological uses.

2. *Issues related to calculation of stream metabolism metrics or interpretation of results*

2A

Utah's TSD states that calculation of metabolic rates should be routine using typically collected data:

"DWQ's monitoring and assessment program has practical constraints that were considered when developing the proposed NNC, which were defined to facilitate routine data collection of the parameters necessary for making decisions about support of aquatic life in headwater streams. This means the protection of aquatic life uses will not be impeded by a lack of sufficient data or information necessary to make regulatory decisions." (Page 24, TSD) [emphasis added]

"In addition, there are rare circumstances in which metabolism models cannot accurately calculate GPP and ecosystem respiration (ER), because diel changes in dissolved oxygen (DO) are insufficient for making reliable reaeration estimates." (Page 152, TSD) [emphasis added]

UDWQ's comment about the circumstances where metabolism models could not be generated (or the inability to generate accurate models) should have specified that this is only true in circumstances where minimal GPP and ER do not constitute a threat to aquatic life uses. Circumstances where metabolism models cannot be easily generated are caused by an inability to accurately model an estimate of atmospheric reaeration, due to relatively small diel variations in DO. This typically occurs in streams that are very turbulent, highly unproductive, or have very high rates of atmospheric reaeration. In all such circumstances, both ER and GPP are low, and although unquantified, can be concluded to be below the NNC thresholds. Such circumstances are analogous to non-detects below the criterion in chemical analyses when the concentration of a pollutant could not be measured because concentrations are below the analytical detection limit. Once equipment has been purchased, there is nothing that constrains UDWQ's ability to collect the data necessary to model stream metabolism.

As discussed in more detail in responses to Section 3 of the comment letter, the relatively large number of sites where GPP and ER could not be calculated in the 2015 study is a reflection of the fact that many of these streams have attributes that make them naturally protected from all adverse effects resulting from nutrient enrichment. For example, high channel shading decreases the likelihood of enrichment altering the structure of stream autotrophs and subsequent modification to higher trophic levels in stream food webs or increases in GPP rates. High channel gradients decrease the residence time of nutrients, similarly minimizing enrichment conditions that could alter stream autotrophs. Higher channel gradients also increase reaeration, minimizing diel DO flux in the process. Similar analogies could be made for other covariates. If streams have physical attributes that make them naturally protected from the adverse effects typically caused by nutrient enrichment, the inability to easily measure GPP and ER does not diminish the protectiveness of the headwater criteria; it is simply reflective of a lack of local adverse effects and a demonstration of the value of combined criteria. UDWQ does not believe that it is appropriate to presuppose impaired conditions at moderately enriched streams with naturally-occurring attributes that are protective of adverse effects resulting from nutrient enrichment. The proposed criteria also include upper TN and TP thresholds that do not require responses, so evaluations of enrichment can still be made even if metabolism data are unavailable.

If the NNC were adopted, filamentous algae and metabolism metrics would not be the only responses available to UDWQ for purposes of identifying nutrient-related impairments. Other numeric criteria are routinely evaluated that can be used to identify impairments along several causal paths linking nutrient enrichment to degradation of aquatic life uses. For example, Utah's streams are naturally alkaline (pH > 8) and violations of Utah's upper pH criterion of 9 (UAC R317-2-17) sometimes occur when rates of primary production are high due to reductions in water column CO_2. This increase in pH has been associated with adverse effects to fish and also increases the relative toxicity of ammonia. Similarly, Utah has both acute and chronic DO criteria, which are used to identify adverse nutrient-related effects along related causal paths. Both DO and pH are routinely measured during every sampling event for all of Utah's waters. Utah also routinely conducts biological assessments on streams using O/E, and the TSD (pp. 83-104) linked nutrient enrichment to an increased probability of identifying biologically degraded waters using this assessment method. These proposed NNC also include protections for recreational uses and the associated evaluations of biomass accrual are another response that will be used to evaluate potential deleterious effects of nutrient enrichment, albeit for an alternative designated use.

2B

Results from headwater streams sampled in 2015 show that two of the three stream metabolism metrics proposed by UDWQ for their combined criterion could <u>not</u> be calculated at approximately 40% of sites. The inability to calculate stream metabolism metrics at many sites is a practical barrier that limits the utility of these indicators. In these situations, UDWQ must rely on percent filamentous algae to make attainment decisions. In Section 7 of this comment letter, we describe concerns with the protectiveness of the percent filamentous algae threshold. The lack of a clear relationship between the proposed filamentous algae threshold and aquatic life use protection is particularly concerning for the 40% of headwaters sites where attainment decisions will likely be based on this indicator. Since the response indicators serve a critical function in the moderate range of TN and TP values (essentially off-ramping the use of the TN and TP criteria thresholds), it is critical to establish their use, effectiveness and reliability in headwater streams ecosystems.

UDWQ is not concerned about the relatively high number of streams where metabolism responses could not be calculated because these "non-detects" are reflective of circumstances where elevated GPP and ER are not reflective of adverse conditions (see response to 3A). In many of these cases where metabolism was not calculated from the 2015 data, it may have been possible to generate the data using more sophisticated models. However, UDWQ did not spend the resources to calculate these results because the objective of that investigation was to validate the NNC thresholds, and in that context, it was clear that these sites would fall below GPP and ER thresholds.

2C

Young proposes that low ER values (<0.8 g $O_2/m^2/d$) indicate poor stream health. Based on this information, please explain whether values <0.8 were considered in either deriving the stream metabolism thresholds using the 2010 dataset or in reviewing the 2015 data.

Very low rates of ER can be reflective of poor stream health because they may indicate widespread extirpation of aquatic life or a loss of hydrological connection between surface waters and the hyporheic zone due to significant and widespread sedimentation. UDWQ has not included low ER rates in the proposed NNC for a couple of reasons. First, UDWQ expects that these hypothetical situations are rare among headwater streams because they are typically reported to occur in the most highly degraded streams. The causes of these deleterious responses are generally not attributable to nutrients, so this would be out of scope with respect to the proposed NNC. Low thresholds for ER could potentially be useful as a general indicator of stream health but is unlikely to be useful for identifying nutrient impairments. Other water quality indicators will be more sensitive to widespread loss of aquatic life, and it is unlikely that a low ER component to the criteria would identify an impairment that would not be identified using other routinely collected water quality parameters. Second, as discussed in responses earlier in this section, reliable measures of very low ER rates can be problematic without a direct measure of reaeration. Directly measuring reaeration in the field is a lengthy process and would require an expansion of laboratory capacity with new analytical methods, which are both practical constraints that limit their routine collection.

EPA Recommendations and UDWQ Responses

The EPA recommends:

- *Reevaluating whether GPP and ER will serve as functional response indicators that can be reliably collected in headwater streams.*

  DWQ has reviewed the efficacy of GPP and ER as functional response indicators and have determined that these indicators can reliably be collected through our routine monitoring programs and utilized as designed in the combined criteria framework.

- *Evaluating whether some of the results presented in the TSD are valid for inclusion.*

  DWQ has reviewed the results in the TSD. Two sites have been flagged with respect to metabolism model results. None of these sites had high nutrients, GPP, or ER and therefore, their exclusion from the analysis does not affect the interpretation of study results with respect to the proposed NNC.

- *Considering the implications of low ER values.*

  UDWQ considered the implications of low ER values and provided a more detailed explanation of whether such responses are appropriate for the NNC in the response to section 2C. With the exception of the unusual circumstance of e.g., overt toxicity or very high levels of anthropogenic stress, low ER indicates that nutrients are not causing adverse effects to stream biota. The potential for such overt toxicity is highly unlikely in headwaters, and if such conditions were identified, the cause would not be nutrient-related, so these responses would be an inappropriate addition to nutrient criteria.

- *Providing a copy of Utah's stream metabolism Standard Operating Procedures (SOPs) to the EPA as part of the submission package.*

  The requested documentation will be submitted in conjunction with the rulemaking packet provided to EPA for formal review and approval in accordance with section 303(c) of the CWA.

3. *Responsiveness of stream metabolism indicators to nutrient pollution in the headwaters*

3A

The EPA is concerned that the stream metabolism indicators are not sensitive to nutrients. 40 C.F.R. § 131.11(a) requires that "criteria must be based on sound scientific rationale and must contain sufficient parameters to protect the designated use." (Emphasis added.) The EPA considers response indicators that are sensitive to nutrient pollution as examples of the types of "sufficient parameters" needed to protect the designated use, which for Utah's headwater streams is aquatic life. The EPA's guidance document entitled "Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters" recommends that, for a combined criterion, response indicators should be sensitive to nutrients such that a predictable relationship exists between the two. Response indicator thresholds should be linked to nutrient concentrations and demonstrated to protect uses (i.e., aquatic life uses). Without this quantified relationship, response indicator thresholds may be unable to ensure use protection.

UDWQ divided responses to these comments into several subsections to address major elements of the comments. These responses are likely more detailed than the comment strictly requires because the comment reflects several important themes related to other comments in the letter.

Metabolism Responses are Linked to Nutrient Concentrations

UDWQ demonstrated a predictable relationship among stressors (TN, TP) and all of the responses evaluated, including GPP and ER (see Figure 5.2 in Section 5A of these comments).

Metabolism Responses are Heuristically Linked to Aquatic Life Uses

The central tenet of combined criteria is the simultaneous consideration of nutrient concentrations and all associated responses. Utah's headwater criteria include upper thresholds that do not require responses to assess, which means that the responses are only relevant to moderately enriched streams. Sensitivity (capability of protecting designated uses) should be evaluated in the context of false positive and false negative decisions with false negatives being of greater concern. UDWQ concludes that false negative decisions in the moderate range of nutrient enrichment are unlikely. The headwater NNC includes filamentous algae cover, GPP and ER responses as explicit protections of aquatic life uses and excursion of any one of responses is interpreted as an excursion. Additional implicit responses related to nutrient enrichment responses are also routinely evaluated against independent numeric criteria including DO and pH (which are already evaluated with existing numeric criteria) and biological assessments based O/E macroinvertebrates scores (see also response to Section 2 comments). Consideration was given to adding implicit responses to the proposed NNC, but UDWQ determined—in consultation with regional EPA staff—that retaining their independent evaluation would be more protective of designated uses. If any of these explicit or implicit responses indicate degradation at a moderately enriched stream, it would be considered impaired. It is UDWQ's position that assessments based on the combination of these responses, combined with the upper nutrient thresholds, are sufficient to identify nutrient-related adverse effects in moderately enriched headwater streams. This was confirmed by the 2015 confirmation investigation (TSD, pp. 152-166) where the NNC successfully identified a considerable number of nutrient-related impairments. The combination of nutrients and responses in the NNC is independently protective. The additional responses incorporated into the NNC provide additional lines of evidence that UDWQ can use to identify nutrient-related problems. EPA has provided no evidence in the comment to support the conclusions that NNC "may be unable to support use protection."

Aquatic life uses in Utah and elsewhere were established to help ensure the protection and maintenance of the biological integrity of waters as mandated by the Clean Water Act. Biological integrity is an integrative construct used to convey a multifaceted concept of ecosystem health. Ecologists often partition biological integrity into structural and functional components, which is reflected in the most widely accepted definition (emphasis added):

> "*The ability to support and maintain a balanced, integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region*" (Karr and Dudley 1981, Karr et al. 1986).

Structural integrity reflects elements of biological degradation that alter the composition and relative abundance of stream biota, whereas functional integrity elements reflect alterations to elements integral to important ecosystem functions or processes. Ecosystem processes describe the flow of energy through food webs, which is generally measured through the production or consumption of carbon. GPP and ER are fundamental measurements of these important processes.

GPP and ER are linked to aquatic life uses because they are integral to the construct of biological integrity. This tie to aquatic life use support is an implicit tenet of all state biological assessment programs. For example, Utah assesses aquatic life use support using O/E, which quantifies local extinction of macroinvertebrate taxa resulting from human-caused stressors, other states use similar metrics. EPA has not required Utah, nor other states, to demonstrate that the loss of invertebrate species are "necessary aquatic organisms" because their loss, in and of itself, is considered to diminish central aspects of biological integrity. GPP and ER are similarly linked to aquatic life uses as fundamental mechanistic measures of stream ecosystem functions.

EPA (2010) guidance emphasizes the importance of conceptual models when using stressor-response models to establish NNC. One purpose of these models is to demonstrate the specific causal pathways that link nutrient enrichment to degradation of aquatic life uses (e.g., TSD, Figure 2.1). Linkages between nutrient enrichment and degradation of uses are often complex, often involving several interim steps before deleterious effects to uses occur, and this sometimes involves several different, potentially interrelated, pathways. One way that these models can be used is to visualize how ecological responses—in this case GPP and ER—are integral to the protection of uses. Another way that these models can be used is to identify responses that are as proximate to nutrient enrichment as possible, because these responses are assumed to generate more accurate and sensitive S-R relationships.

GPP and ER are direct measures of fundamentally important ecological alterations to nutrient enrichment and are as proximate to nutrient enrichment as possible. Almost all causal pathways linking nutrient enrichment to aquatic life uses start with increases in the abundance of autotrophs or heterotrophs. Many causal pathways related to autotrophs are caused by increases to primary production rates, which GPP quantifies. Similarly, many heterotrophic responses are caused by increased microbial (e.g., bacteria, fungus) biomass, and while decomposition is not the only a function of these organisms, it is among the most important with respect to the health of stream food webs. ER directly measures rates of organic matter processing, which is particularly important to headwater streams since they are typically net heterotrophic due to most of the energy needed to support life comes from external (allochthonous) sources. Also, excessive ER depletes DO, degrading aquatic life uses. To suggest that GPP and ER are not linked to aquatic life uses ignores the fact that these indicators measure processes that are directly linked to all of the nutrient related causal pathways with the potential to degrade aquatic life uses. Moreover, given that nearly all adverse effects are initially caused by increases in plant and microbial growth, other deleterious effects are unlikely to occur without adverse effects to one of these proximate responses.

Multiple Lines of Evidence Suggests that the GPP and ER Thresholds are Appropriately Protective

Ambient nutrient concentrations for sites below the lower metabolic thresholds are roughly equivalent of the 75th percentile of reference site distributions (TSD, Chapter 11) and UDWQ considers such conditions to be reflective of full support of aquatic life uses (see Section 1 responses for additional details). Reference conditions are integral to the demonstration that NNC derived from frequency distribution approaches are protective, but the approaches are limited with respect to the overarching CWA objective to protect biological integrity. Unfortunately, biological integrity cannot be measured directly because it is a construct that is intended to capture many different facets of stream condition. Instead, resource managers have relied on indicators reflective of important aspects of stream condition. In the case of GPP and ER, the relevance of the NNC thresholds as indicators of important biological integrity components was evaluated in a couple of ways. After calculating ER thresholds, UDWQ compared ER rates with Utah’s DO criteria and found that excursions below the DO criteria were much more likely above the ER NNC threshold (TSD, Chapter 5). UDWQ also found a significant relationship between nutrients (TN and TP) and standing stocks of autochthonous organic matter (OM). Streams with low levels of autochthonous organic matter were much less likely to show excursions below DO criteria, and almost always exhibited ER rates below the proposed ER threshold (TSD, Figure 6.3, panel D). In contrast, the vast majority of streams with high autochthonous OM biomass had ER rates greater than proposed NNC threshold. UDWQ was unable to evaluate the ecological relevance GPP and ER thresholds for every causal pathway, but those that were evaluated support the proposed thresholds as appropriately protective. In contrast, evidence has not been presented from EPA or others that suggest that lower rates are needed to be protective of biological uses.

NNC Derivation Involved an Evaluation of Most Candidate Responses

In 2013, EPA convened a symposium of international experts with the objective of establishing the most appropriate and sensitive responses of nutrient enrichment in streams (EPA 2014). UDWQ reviewed the findings of this symposium and almost all of the responses recommended by these experts were evaluated in the process of establishing the proposed headwater NNC; it remains unclear what additional responses should be added. The only potential responses that UDWQ did not extensively evaluate were algal and nutrient-specific macroinvertebrate metrics, and UDWQ is willing to add these as additional responses to the NNC if empirically-supported thresholds are identified in the future. In the interim, UDWQ maintains that the addition of these NNC to Utah's water quality standards are scientifically sound for protecting waters from the effects of nutrient enrichment, and therefore protective of the support of aquatic life and recreational uses.

3B

UDWQ examined whether the proposed metabolic indicators responded to nutrients or other potential covariates using Random Forest. Table 5.1 (page 53, TSD) summarizes the results of the Random Forest analysis. "Variables with a larger increase in the mean squared error (MSE) are more important determinants of metabolic rates relative to others." (See page 53, TSD). For GPP, the primary predictors of metabolic rates were channel shading (MSE=104.3), slope (MSE=103.1), and basin slope (MSE=75.3) followed by nutrients (MSE = 72.6 for TN and 73.9 for TP). For ER, channel shading (MSE=69.3), total nitrogen (MSE=69.0), and slope (MSE=63.4) were the most important factors influencing ER. UDWQ notes that they further explored the influence of relevant covariates (stream slope, shading, TN, and TP) for both response indicators to improve the accuracy of the metabolism results:

"NDR [nonparametric deviance reduction] revealed significant thresholds at ~1% slope for both ER and GPP. GPP and ER thresholds were also found for percent channel shading, where streams with channel shading less than ~11% had greater mean daily rates of GPP (9.3 ± 5.6 to 3.99 ± 4.1) and ER (8.10 ± 5.5 to 4.31 ± 4.1)." (Page 60, TSD)

These results show that at sampling locations with greater than 1% slope and greater than 11% channel shading these factors have a greater influence than nutrient concentrations on metabolic rates. Information presented in the TSD documented that the majority of the headwater streams sampled in 2015 have slopes that exceed 1% and shading greater than 11%. Therefore, one would expect that the ER and GPP response indicators would have limited utility in signaling nutrient impacts in these headwaters:

"Canopy cover (shading of the stream channel by riparian vegetation) averaged about 50% but ranged from 3% to 87%. Sites were generally of high gradient, averaging about 5% slope, with a range from < 0.5% to just over 20% among all streams." (page 157, TSD)

The TSD documents the limitations in the relationship between the proposed metabolism indicators and nutrients concentrations:

"In general, neither GPP nor ER was high in comparison with the broader investigation used to generate S-R relationships." (Page, 158, Chapter 5, TSD). [emphasis added]

"When GPP and ER rates were compared across the range of nutrients that occur throughout Utah, GPP and ER were found to be relatively robust indicators of enrichment, particularly when channel shading and slope were accounted for (Chapter 5). However, in the lower ranges of nutrient concentrations in headwater streams, these responses were not particularly sensitive measures of enrichment. This follow-up investigation did not document a single stream with elevated GPP, and one stream with elevated ER was identified." (Page 163, Chapter 12, TSD). [emphasis added]

Because of the physical characteristics of headwater streams - cooler, lower nutrient concentrations, greater reaeration (due to steeper slopes), and shadier (less GPP) - it's not surprising that the proposed stream metabolism indicators do not respond to increased nutrient concentrations in headwater streams and the data presented do not provide sufficient evidence of a relationship. Information presented in the TSD confirms that, at the 60% of headwater sites where metabolic rates could be calculated, GPP and ER were not sensitive to nutrient pollution. The EPA is concerned that, if GPP and ER are not sensitive to nutrients, use of these indicators and/or the derived thresholds will not serve to confirm nutrient impairments in these streams (see Figure 5.2 on page 9 below).

A response only needs to be sensitive to enrichment under conditions where a stream is naturally susceptible to the adverse effects that it quantifies. If no response provides evidence of adverse effects, then it is reasonable to conclude that the condition of aquatic life uses in the moderately enriched stream being assessed has not been degraded. The alternative interpretation—implied in this comment: "*will not serve to confirm nutrient impairments in these streams* (emphasis added)"—is to presuppose impairments exist in circumstances where adverse effects have not been demonstrated.

The Random Forest results and related analyses provide additional support for the linkage between nutrient enrichment and stream metabolism. Both TN and TP were among the top 5 explanatory variables for both ER and GPP. The fact that physical characteristics also controlled the magnitude of metabolic responses is not surprising, nor is it problematic from the perspective of ensuring that the NNC are protective of aquatic life uses. Headwater streams that are relatively sensitive to nutrient enrichment (e.g., less channel shading, lower channel gradient) showed an increase in GPP and ER with increasing nutrients. If conditions are amenable to adverse effects and streams are enriched, the potential exists for adverse effects from increased rates of GPP and ER. As discussed in the responses to Section 2 of these comments, the same attributes that make some streams naturally resistant to increases in GPP and ER are also protective of other nutrient responses, i.e., the stream is not impaired. When a stream is moderately enriched and lacks the physical attributes to sufficiently protect against adverse effects, it is possible that other related numeric criteria (e.g., pH, DO) or indicators (e.g., O/E, chl-*a*, filamentous algae cover) would identify nutrient-related problems. If none of these responses indicate adverse effects, then it is reasonable to conclude that the moderately enriched streams had naturally protective attributes and local threats to aquatic life are minimal.

EPA Recommendations and UDWQ Responses

Based on this information, the EPA recommends:

- *Specifying how UDWQ accounted for the influence of channel slope and shading when establishing the GPP and ER thresholds in headwaters.*

The influence of covariates is among the principal reasons for the incorporation of both nutrient and responses in the NNC. Without the incorporation of responses, it would be nearly impossible to identify criteria that were protective of uses in streams where adverse effects are most likely to occur. Approximately half of the moderately enriched streams in the 2015 investigation did not show any indication of adverse effects. Practically speaking, local characteristics like slope and channel shading are difficult to incorporate into regional NNC without compromising their regulatory applicability. The proposed NNC will be applied to steams that do not have nutrient point sources. As a result, the primary regulatory application will be identifying water quality impairments. If a moderately enriched stream has higher slopes or canopy cover this would decrease the likelihood that problems with GPP and ER would manifest. An observation of low GPP and ER in such circumstances demonstrates that these adverse effects do not exist. Conversely, in the physical characteristics of a stream are not naturally protective, the expectation is that thigh rates of GPP and ER would manifest themselves, which is the intent of combining nutrients and ecological responses in the NNC (see also Section 3B responses). As noted in the comments, UDWQ did evaluate the influence of numerous physical characteristics know to control GPP and ER rates and while several were important, TN and TP were also among the top 5 predictor variables. This demonstrates that under the right conditions, nutrient enrichment is an important determinant of these important measures of ecosystem function in streams.

- *Analyzing the 2015 headwaters data to demonstrate that headwater streams are sensitive to nutrient pollution.*

UDWQ did analyze the 2015 data (TSD, Chapter 13) and, as discussed in the responses to comments, these analyses did demonstrate that some headwater streams are sensitive to nutrient enrichment, which the combination of nutrients and responses in the proposed NNC successfully identified. Many of the streams in this study, which focused on streams where previous sampling suggested moderate to high nutrient enrichment, would be considered to be impaired using the proposed NNC. None of these streams would have been identified as impaired using conventional, nutrient-related parameters (e.g. pH, DO). These analyses demonstrated the added protections to aquatic life that these NNC would provide to these important ecosystems.

4. Representativeness and applicability of metabolic indicators from all streams to headwater streams

Sites sampled in 2010 to develop the combined nutrient criterion differ significantly from headwater streams for which the combined criterion are proposed and the TSD does not clearly demonstrate how these thresholds are protective of headwaters. As discussed above, UDWQ's analysis showed that sampling locations with greater than 1% slope and less than 11% channel shading have a greater influence than nutrient concentrations on metabolic rates. However, UDWQ used data from a statewide study, not headwater streams, to select the proposed response indicators (i.e., GPP and ER), evaluate their sensitivity, and establish thresholds. Streams from the 2010 study were large (average watershed area of 187 mi^2, average discharge of 29 cfs, average width of ~25 feet, average depth of 1.1 feet, average slope of only 1.1%, and average canopy cover of only 27%). (Table 3.2, page 29-30, TSD). Utah conducted additional sampling of headwater sites in 2015; however, data from these events were not considered in the selection of the response indicators or in the derivation of the proposed thresholds. The EPA was not able to locate data summarizing the drainage area, width, depth and slope of these headwater sites to compare to the 2010 study.

Young (2008) notes: "metabolic rates at potentially impacted sites should be compared with rates measured at (more) pristine sites that are characterized by similar stream order and size" [emphasis added]. If there are significant differences in drainage area and stream orders between sites sampled in 2010 compared to headwater streams, then hydrodynamic differences alone between size classes could *confound the ability to use data from the 2010 study to establish a protective combined nutrient criterion for headwaters streams.*

Utah's headwaters have fewer enriched sites, particularly at the upper end of ambient nutrient concentrations (i.e., highly enriched streams). Limited responses were expected among moderately enriched headwater streams because they are more likely to have physical attributes that make them naturally protected from adverse effects of nutrient enrichment. In order to avoid missing otherwise ecologically meaningful S-R relationships, it was important to ensure that the derivation of NNC thresholds was made from a dataset with a fairly even number of low, moderate, and highly enriched streams. For example, DO and ER followed a predictable relationship when the underlying data had a sufficient number of streams at the higher end of ambient nutrient concentrations observed in Utah (TSD, Chapter 5), but this relationship was less apparent when data were limited to less enriched and sensitive streams (TSD, Chapter 13). DO deficits are caused by excessive respiration, so the former is likely a more accurate reflection of this S-R relationship. Similarly, a statistically significant relationship between nutrients and stream metabolism (see Figure 5.2 below) becomes obscured when the underlying data are biased toward a higher number of naturally tolerant streams.

EPA Recommendations and UDWQ Responses

The EPA recommends:

- *Explaining in the TSD how the data used relate to the derivation of headwater streams thresholds and ensure aquatic life protection in headwater streams.*

  The first 14 chapters of the TSD (~180 pages) contain an extensive explanation of how the data used relates to the preservation of aquatic life and the application of stressor-response relationships to the protection of headwater streams. UDWQ maintains that this documentation, when combined with the Proposal and additional clarifications provided through the responses to these comments, provides sufficient demonstration that the proposed NNC would be a valuable regulatory tool to address the adverse effects of nutrient pollution in headwater streams.

- *Adding a table to the TSD that summarizes the drainage area, width, depth, etc. for the headwater sites sampled in 2015.*

  UDWQ made a concerted effort to provide all of the data used to conduct all analyses to all stakeholders, including EPA. The results and interpretation of these analyses have been vetted with stakeholders, including a technical review team. The 2015 investigation was intended as a confirmational investigation, with the stated intent of confirming the proposed NNC. The study was not intended to refine existing thresholds and the study design is not amenable to doing so. Physical habitat characteristics of the 2015 investigation are already summarized in the context of interpreting the data presented and study objectives. If EPA needs additional data and information as part of their formal review of the NNC, UDWQ will provide additional, readily available data and information.

- *Comparing the morphologic and physical characteristics of the 2010 study sites to headwater sites to demonstrate that the streams sampled in 2010 are comparable to headwater streams.*

The TSD already summarizes the physical characteristics of headwater streams collected in the 2015 conformational investigations: "Despite the fact that study sites were constrained to headwater streams, they exhibited a fairly wide range of physical characteristics. While sites were all at relatively high elevations (average of ~2,200 m) relative to all streams in Utah, they spanned a fairly wide range of elevation, from 1,580 to 3,040 m. Canopy cover (shading of the stream channel by riparian vegetation) averaged about 50% but ranged from 3% to 87%. Sites were generally of high gradient, averaging about 5% slope, with a range from < 0.5% to just over 20% among all streams. Given these relatively high gradients, it is not surprising that about 80% of sites had relatively coarse substrates (> 50% of measured cobbles were 64–250 mm or larger)." This breadth of physical conditions highlights the importance that UDWQ placed on selecting S-R study sites that encompassed a range of conditions, particularly those where adverse effects of nutrient enrichment are likely to manifest.

- *Using representative data from the target headwater streams to select response indicators and derive protective thresholds or explain why these data are not relevant.*

UDWQ designed the studies to efficiently determine the ecosystem response thresholds. To establish response indicators based on a e.g., random sample design, was anticipated to require an exceptionally large number of samples because of general lack of significant nutrient inputs to cause measurable responses. Category 1 and 2 waters are Utah's most stringent antidegradation tiers and no new discharges are allowed in Category 1 waters. Compared to downstream waters, these waters have little anthropogenic influence. UDWQs expectation was that measurable nutrient impacts will only occur rarely. Hence, UDWQ noted that the headwater sites selected were biased towards the most impacted sites known. The inability to always quantify ER and GPP in some of the headwater streams confirmed the expected lack of adverse nutrient-related ecosystem responses.

5. Protectiveness of Proposed Thresholds and Link to Aquatic Life Use Protection

5A

The TSD does not clearly link key metabolic indicators that Utah has selected for use in the combined criterion to protection of aquatic life uses in headwater streams. The EPA used Figure 5.2 (Page 60, TSD) to further review the nutrient-metabolism relationship in Utah's headwater streams. The EPA superimposed the following information on the figure:

- *Low, medium and high thresholds for TN and TP (orange and red lines)*
- *Mean GPP and ER values for the low, medium, and high nutrient groups (blue arrows)*
- *Thresholds for GPP and ER (black hashed lines)*
- *2015 metabolism results at headwater streams (blue symbols)*

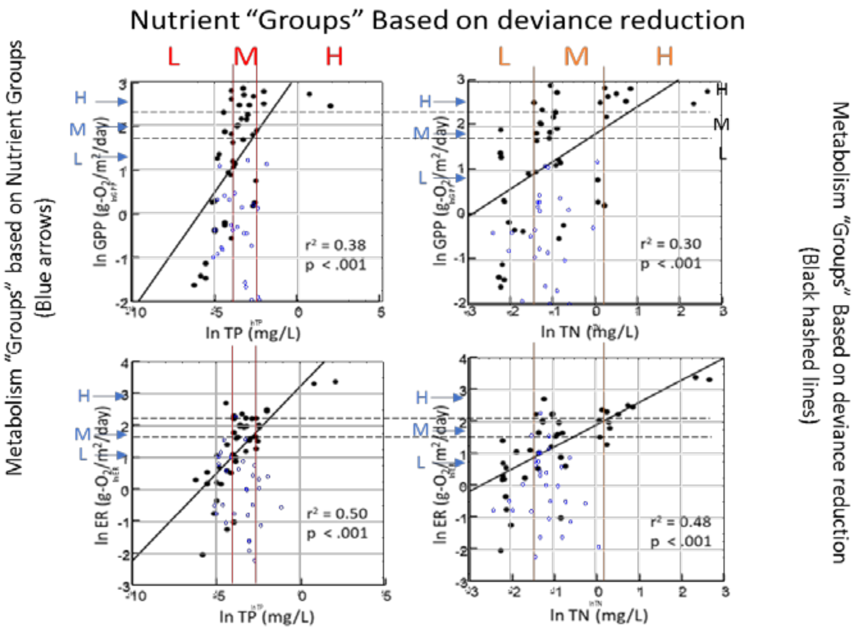

Figure 5.2. Linear relationships between ambient nutrient concentrations (total nitrogen [TN] and total phosphorus [TP]) and gross primary production (GPP, top row) and ecosystem respiration (ER, bottom row).

With this information added to the figure, it is apparent that the proposed ER threshold of 5 g-O_2/m^2/day (Ln value of 1.6) is at or above the upper threshold TP value. Because the upper TP threshold is associated with impaired conditions, it is unclear how the proposed ER threshold demonstrates protection of aquatic life uses.

UDWQ acknowledges that similar to NNC efforts by EPA and other states, infrequent decision errors may occur. With the current state of the science, it is difficult to establish broadly protective N and P criteria when the magnitude of enrichment necessary to elicit adverse effects varies from one stream to the next due to variance in naturally-occurring, local stream attributes. However, UDWQ is unable to duplicate the conclusions of the comment regarding the modified graph.

From the perspective of sensitivity to nutrient enrichment, UDWQ’s analysis on the relationship depicted in the graph focused on the upper left hand corner of the graph because the errors of greatest concern are those where deleterious responses (above the lower horizontal line) are observed, yet the site falls below the lower nutrient threshold (left of the left vertical line). As can be seen in these graphs, the number of potential false negative assessment errors follows: GPP vs. TP = 2-3; ER vs. TP = 1; GPP vs. TN = 1; ER vs. TN = 1. UDWQ does not consider these errors to be evidence that the lower TN and TP criteria are not protective. If GPP or ER were always reliable measures of nutrient impacts, UDWQ would rely on these measures exclusively. The NNC do not assume that all moderately enriched streams will exhibit adverse effects for all responses. Instead, several responses are independently evaluated to identify adverse effects. The data support that the NNC are protective.

Of course, false positive impairment determinations—erroneous impairment conclusions—are also possible. In the context of use protection such errors are less problematic, but they can divert limited restoration resources. In the context of the graph provided by the commenter, these errors may occur for sites that fall to the right of the right vertical line, yet below the lower horizontal line. Sites in this region would be considered to be impaired wholly on the basis of nutrient enrichment, without evidence of adverse effects. However, each pane in the figure depicts a single response and one cannot conclude that this actually a false positive impairment determination until a similar conclusion is made for all NNC response variables. Nevertheless, the data presented in the graphs also suggest that the potential for false positive impairment determinations is likely to be relatively low.

Hypothetically assuming that these sites represent potential false positive decisions, the figure provided by the commenter demonstrates that both false positive and false negative error rates are low. This is one of the primary benefits of combining nutrient concentrations with ecological responses when setting NNC.

5B

In addition, a review of the GPP and ER results observed at Utah's headwater streams (blue symbols) shows that GPP and ER tend to be biased lower at headwater sites, at a given nutrient concentration, than the 2010 study sites. The TSD does not explain how the GPP and ER threshold values developed using the 2010 sites (and not the 2015 headwater sites where these thresholds are applied) are protective of headwater streams aquatic life. This demonstration is key in supporting the proposed thresholds.

UDWQ does not interpret these data to indicate a low bias. The responses were generally lower in the headwater streams than the 2010 statewide streams for similar TP and TN concentrations. As discussed throughout these responses and in the TSD, several known covariates that make streams naturally protective from the effects of nutrient enrichment are more prevalent in headwater streams. Lower responses relative to the TP and TN concentrations represent lower sensitivity to nutrients because of other covariates and are not indicators of bias. Many of the statewide streams from the 2010 sampling lack these protective covariates, and in these cases, the metabolic responses were expected to be higher. A failure to demonstrate a lack of adverse effects at streams with naturally protective physical attributes is not intrinsically problematic. In fact, such inconsistent S-R relationships formed the basis for using a combination of nutrient concentrations and ecological responses to assess moderately enriched streams.

5C

To further review the 2015 dataset, the EPA categorized each site based on the nutrient enrichment thresholds identified in Table 12.1 (page 139, TSD). Sites with TN and TP concentrations below the lower thresholds (<0.4 mg/L TN: < 0.035 mg/L TP) were labeled "low"; sites with either TN or TP concentration in the mid-range (TN= 0.40-0.80mg/L and TP=0.035- 0.080 mg/L) were labeled "moderate", and sites with TN or TP concentrations above the upper threshold (>0.80 mg/L TN; >0.080 mg/L TP) were labeled "high". Table 1 below presents the average and maximum values for TN, TP, GPP and ER for each "nutrient enrichment category." These data show that GPP does not clearly increase with increasing nutrient enrichment categories and ER decreases with increasing nutrient enrichment categories (which is the inverse of what we would expect if this indicator was *responsive to nutrients). The lack of a predictable response in GPP and ER is problematic given the critical role the ecological response indicators play in the middle range of the TN and TP values for this combined criterion.*

Table 1. Summary Statistics for 3 Nutrient Enrichment Categories in Headwaters Streams

Nutrient Enrichment Categories	***Sample Size***	***Average TP***	***Average TN***	***Average GPP***	***Max GPP***	***Average ER***	***Max ER***
low	*20*	*0.02*	*0.24*	*0.99*	*3*	*2.69*	*9.83*
moderate	*20*	*0.04*	*0.35*	*0.52*	*1.51*	*1.32*	*4.91*
high	*9*	*0.13*	*0.53*	*1.24*	*3.37*	*0.73*	*1.53*

The range of nutrient concentrations found among sites from all Utah streams (not just headwaters) demonstrated a relationship among ambient nutrient concentrations and metabolism responses (see Figure 5.2 above). The fact that the relationship weakens among streams with relatively lower nutrients is not surprising because there are fewer sites with the potential for nutrients to exert a measurable influence on metabolism and a relatively higher number of streams with attributes that are naturally protective from the adverse effects of nutrient enrichment. Second, particularly with respect to ER, the maximum values bias group averages. UDWQ discussed the site with the highest ER in the TSD and noted that this site also had the highest filamentous algae cover among all of the sites evaluated, so biological nutrient uptake is one logical explanation for the observed low nutrient concentrations at this site. Third, as the commenter previously noted, many of these streams have physical attributes that make them less susceptible to high GPP and ER rates, which when combined with more susceptible streams would weaken the relationship among metabolic rates and nutrient enrichment. The combination of nutrients and responses is intended to focus on the protection of aquatic life uses in streams at greatest threat to the adverse effects of nutrient enrichment.

5D

As the means to infer a linkage between these response indicators and aquatic life use protection, UDWQ examined the relationship between ER/GPP and DO. Specifically, the TSD documents the relationship between metabolic condition classes and the number of DO criterion exceedances (excursions below the 30-day average) as "independently derived indicators of potential threats to stream biota." The 2010 analysis showed an increase in DO excursions when ER > 5 g $O_2/m^2/d$. UDWQ performed this analysis using the 2010 statewide streams dataset (Figure 12.3, page 148, TSD) but not for the 2015 headwaters dataset.

The EPA ran the same analysis using the available data from headwater streams (n=30). The EPA's analysis showed <u>no</u> significant relationship between ER and the excursion of the 30-day average DO criterion -only two sampling locations had any probability of exceeding it (probability of 0.27 and 0.19). All other sampling locations showed zero probability of exceeding the 30-day average DO criterion of 6.5 mg/L. We also performed this analysis using the daily minimum DO value of 4 mg/L DO and only one site exceeded that value.

Based on the information in the TSD, UDWQ has not clearly demonstrated that GPP and ER are linked to protection of aquatic life uses in headwater streams as no linkage between exceedance of the DO criterion and GPP or ER (UDWQ's chosen metrics) was established.

The differences between the 2010 and 2015 investigations highlight the importance of using a sufficient range of ambient nutrient concentration for purposes of calculating ecologically meaningful response thresholds. ER is a mechanistically sound measure of conditions that lead to DO depressions and is more sensitive than DO. UDWQ interprets the lack of discernible relationship between ER and DO in headwaters stream as confirming the known insensitivity of DO for identifying adverse effects in moderately enriched streams. The 2010 data defined the relationship between ER and DO which was used to establish a protective threshold. The threshold is protective because it was based on streams that lack many of the protective covariates of the headwater streams.

EPA Recommendations and UDWQ Responses

The EPA recommends:

- *Providing documentation in the TSD that the proposed GPP and ER thresholds will ensure protection of aquatic life uses in headwater streams, particularly in light of the 2015 headwaters data. Specifically, the EPA recommends:*
    - *Conducting additional stressor-response analyses using only the 2015 headwater data and comparing the thresholds obtained with that analysis to the proposed thresholds for GPP and ER. Providing an explanation as to whether UDWQ evaluated the ER/DO relationship using the 2015 headwaters data and describe the results of that analysis.*

As discussed in the TSD (Chapters 1-7), the initial S-R investigation was intended to evaluate whether several proposed indicators of nutrient enrichment not previously collected were viable response parameters, and if so, whether thresholds derived from these parameters and existing data could be used to generate NNC for Utah streams. Given these study objectives, UDWQ collected data that encompassed the breath of ambient nutrient concentrations observed among Utah streams. The underlying assumption was that ecologically meaningful thresholds cannot be derived using data that were biased with respect to the known distribution of ambient nutrient concentrations. Ultimately, the results of this investigation were considered collectively to identify a combination of nutrient concentrations and responses that could be used to protect headwater streams from the effects of nutrient enrichment.

After proposing the NNC that combined nutrient and responses, the next step was an evaluation of whether or not the combination of nutrients and responses in the proposed criteria was adequately protective of headwater streams. As noted in responses to this section and Section 4, this confirmation exercise was conducted in 2015. Sites for this investigation were selected from those headwater streams that historical data suggested were moderately or highly enriched. Nutrients and responses were collected and UDWQ concluded that the combination of nutrients and responses in the NNC successfully identified those headwater streams where aquatic life uses were at greatest threat to nutrient enrichment (i.e., they had lower slopes or less channel shading than similarly enriched streams).

An alternative study design would have been to collect ambient nutrient concentrations and responses from as many headwater reference sites as possible to obtain a more robust estimate of background conditions. These data could then be used to better define the upper limits of naturally-occurring ecological responses. However, these data could not be used to determine whether departures from reference conditions constituted an adverse effect on aquatic life uses. As a result, this line of inquiry would not result in appreciably different thresholds or responses than those already proposed. To date, no stakeholder has presented defensible alternatives to the proposed NNC, despite all underlying data being made available. If alternative thresholds or responses were presented, UDWQ would be willing to consider alterations to the proposed NNC.

6. Other Potential Indicators

6A

UDWQ considered other response indicators in establishing the combined criterion for headwater streams, but the rationale for why they were not selected as response indicators is not clearly documented in the TSD.

Numerous candidate ecological responses were evaluated (TSD, Chapters 3-7), including: nutrient limitation, nutrient saturation, stream metabolism (GPP, ER), autochthonous organic matter standing stocks, diatom taxa composition, macroinvertebrate taxa composition, and macroinvertebrate biological assessment indices. In fact, the collective responses include virtually all of the responses recommended by an EPA expert panel that was convened to recommend the best ecological responses for purposes of assessing nutrient enrichment (EPA 2000). As described in the TSD and throughout the proposal, all responses were used as lines of evidence to for the primary nutrient thresholds to ensure that consideration was given for as many nutrient-related adverse effects as possible. As discussed in the TSD (pp. 145-151), this approach also allowed UDWQ to ensure that the proposed criteria included those responses that could be most easily incorporated into routine monitoring and assessment activities conducted by the agency and cooperators.

As discussed in the TSD (pp. 145-151), the proposed NNC ultimately included several responses that were the most direct measures of the two principal adverse effects of nutrient enrichment: increases in autotrophic and heterotrophic production. Other responses were not included in the proposed NNC because their routine collection was impractical (e.g., organic matter standing stocks) or because they are already routinely and independently evaluated (e.g., O/E, DO, pH). Metabolism, filamentous algae cover, and benthic algal biomass (for recreational uses) are all new responses incorporated into the proposed headwater NNC, and each has strengths and weaknesses. Beyond those already evaluated, the only additional response the UDWQ could potentially incorporate into the criteria would be diatom-based biological assessment metrics. UDWQ has not currently developed these assessment tools, so these would need to be incorporated once these tools have been developed and vetted with stakeholders.

6B

The TSD refers to Utah's analysis of potential biological indicators (i.e., diatoms, macroinvertebrates) to increasing nutrient concentrations which showed a loss of sensitive taxa at nutrient concentrations that were lower than the proposed lower nutrient thresholds. For example, the state's analysis shows loss of sensitive macroinvertebrate and diatom taxa at approximately 0.011 mg/L TP and 0.016 mg/L TP *which are much lower concentrations than the proposed TP threshold of 0.035. Similarly, the TSD states: "The overall threshold that captures the TP associated with the most appreciable changes in both tolerant and abundant diatom taxa was at 0.022 mg/L." (Page 89, TSD).*

This information suggests substantial changes to community structure, which is indicative of impacts to the aquatic life designated use, are occurring at lower levels than the proposed criterion, at least for TP. The TSD notes that:

"Allowing nutrient concentrations to achieve levels that result in assemblages dominated by tolerant taxa are likely underprotective." (Page 101, TSD)

Results presented in Chapter 7 (TSD) suggest that changes from sensitive to tolerant communities are occurring at nutrient concentrations below the proposed lower nutrient thresholds. This information suggests that the proposed combined nutrient criterion would likely lead to shifts to more tolerant, and less desirable, taxa – conditions that are not protective of aquatic life and that contradict the stated objectives.

The loss of highly sensitive taxa does not necessarily constitute an impairment to aquatic life uses. If numeric criteria are not violated, the point where departure from reference condition constitutes an impairment is a policy decision. It is widely acknowledged that an expectation of pristine environmental conditions is an unrealistic environmental objective. An acknowledgement of the importance of practical constraints in setting environmental objectives is intrinsic to all biological assessment programs.

TITAN identifies three thresholds: sensitive taxa, tolerant taxa, and taking both sensitive and tolerant responses into consideration (All). These thresholds provide additional lines of evidence with respect to TP concentrations that may be protective of aquatic life uses; however, they are one line of evidence among many and should not be interpreted in isolation of others. The comment is correct that the average threshold for the two most sensitive diatom responses is below the TP threshold proposed in the NNC. However, this is only true for the most sensitive of diatom taxa, which collectively revealed a threshold of 0.016 mg/L (95% confidence intervals = 0.010-0.022). Taking uncertainty into account, the proposed phosphorus threshold falls within the overall TITAN predictions: 0.022 mg/L (95% confident intervals = 0.010-0.047). Among all of the lines of evidence that UDWQ evaluated, these are the only thresholds that fall below lower nutrient thresholds. The tolerant taxa TITAN response threshold of .042 mg/L (95^{th} confidence intervals 0.027 – 0.051) was what UDWQ was referring to when making the statement about being under-protective (as quoted by the commenter), and this threshold is above the lower TP threshold proposed in the NNC.

The diatom TITAN analyses do suggest some statistically significant changes to this assemblage may occur at TP concentrations slightly below the proposed NNC thresholds, although ecologically significant effects are not predicted. TITAN thresholds only capture changes to those taxa that demonstrate statistically significant predictable changes along a stressor gradient. Many taxa did not change predictably with increasing TP, and presumably remain unchanged, so "substantial changes" at these concentrations are undetectable. The first significant change point for all other responses, including the macroinvertebrate O/E index that UDWQ uses for conducting biological assessments, falls above the proposed lower TP threshold. This suggests that the potential minor changes in diatom composition at the lower two diatom thresholds are not sufficient to alter the higher trophic levels or nutrient-related ecosystem functions. As noted in the TSD, the algae composition most likely to degrade uses is a regime shift from streams where benthic production is predominantly based on diatoms to one dominated by filamentous algae (See also responses to Section 6 comments) because these regime shifts often lead to habitat degradation and appreciable alterations of stream food webs. These types of changes are closely aligned with the protections afforded by Utah's aquatic life use descriptions, which specify that cold or warm water fish be protected, "including necessary aquatic organisms in their food chain" (UAC R317-2-6.3). Importantly, the lower diatom threshold for TP is below the 75th percentile of reference site TP concentrations which suggests a marked increase in false positive impairment determinations.

UDWQ has substantial diatom data and ultimately intends to develop biological assessment methods using this assemblage. Development of these analytical approaches will require sufficient resources. Once draft methods are available, it would be necessary to solicit stakeholder input before they are used to inform regulatory decisions. Once fully vetted, diatom responses could conceivably be included as additional responses indicators in a revised NNC. However, it is more likely that UDWQ would apply the methods independently, because (1) nutrients are not the only pollutants known to degrade diatom assemblages and (2) independent assessments would ultimately be more protective of designated uses.

EPA Recommendations and UDWQ Responses

The EPA recommends:
Exploring the use of diatoms or macroinvertebrates as response indicators for use with the combined criterion. Alternatively, the proposal should include a rationale for not selecting diatoms or macroinvertebrates as potential response indicators for the combined nutrient criterion.

As indicated on p. 88 in Chapter 7 of the TSD "Diatom compositional changes could only be evaluated for TP. TITAN revealed thresholds for eight diatom taxa that significantly decreased in abundance and occurrence in response to increasing TP concentrations (Figure 7.1)." While TITAN is useful for identifying response thresholds, the approach cannot be used to establish response thresholds that can be used for conducting assessments on streams not included in the analysis (see also response to comments in this Section). Diatoms were not selected because, based on the available data, thresholds could not be determined for TN, and because UDWQ has not currently developed diatom biological assessment tools.

Macroinvertebrate assessment scores could have been added as an additional response in the NNC, but DWQ opted to continue to keep these assessments independent due to the integrative nature of biological assessments. As discussed on p. 98 in Chapter 7 of the TSD, there was a significant relationship between nutrients and O/E scores: "Macroinvertebrate O/E scores decreased with increasing nutrients. A significant, albeit weak, linear relationship was observed among macroinvertebrate O/E scores and TN ($n = 68$, $r^2 = 0.302$, $p < 0.001$) and TP ($n = 243$, $r^2 = 0.294$, $p < 0.001$). The weakness in the relationship may be evidence of other stressors and natural gradients that are expected in structural responses because the effects of nutrients are indirect. For this reason, DWQ has incorporated functional responses with more direct linkages to nutrients into stressor-response (S-R) models directed toward NCC development." Macroinvertebrate biological assessments will continue to be conducted and the response indicators in the NNC will be integrated into biological assessment data collection activities. Keeping these assessments independent will allow UDWQ to better assess the relative influence of all stressors, including TN and TP, on the structure of stream biota.

7. Development and selection of the filamentous algal threshold

7A

The proposal and TSD currently lack a clear scientific rationale for the proposed 33% filamentous algae cover threshold proposed to protect aquatic life uses. The EPA's regulation at 40 C.F.R. § 131.11(a) requires that "criteria must be based on sound scientific rationale and must contain sufficient parameters to protect the designated use." UDWQ did not empirically derive the proposed filamentous algae threshold. Instead, the primary basis for the 33% threshold appears to be two studies available in the scientific literature (Biggs 2000, and Welch et al. 1988). Further examination of these papers reveals that the 30% threshold identified in Biggs is based on impacts to aesthetics and trout habitat in New Zealand.

The TSD does not include a description of which aspects of Biggs' conclusions are most relevant to Utah's headwater streams. For protection of benthic biodiversity, which should be protected as a component of the aquatic life designated use, it is important to note that Biggs establishes a mean monthly chlorophyll-a of 15 mg/m^2 as the threshold necessary -- not the 30% threshold cited in the proposal. In addition, Welch et al. 1988 relates to an aesthetics threshold for percent filamentous algae cover. Welch does not address aquatic life use protection. The proposal does not explain how a threshold based on aesthetics is protective of aquatic life uses.

It is true that one focus of these review papers identifies a decline in aesthetics and nuisance conditions degrading recreational uses. One possible reason is that recreational uses are likely more sensitive to filamentous algae growth than aquatic life uses. However, Biggs (2000) also discusses detrimental effects on aquatic life resulting from extensive filamentous algae throughout his review—loosely captured in summary tables as "aesthetics and trout habitat"—including: impairment of fish spawning, habitat degradation, reduction in fish feeding activity, reductions in fish populations, increases to pH and related increases in ammonia toxicity, and the potential for hypoxia. UDWQ is concerned that prolonged enrichment, particularly when combined with stabilization of flow via water diversions or impoundments, can cause streams to shift from diatom-based food webs to a state where the majority (i.e., >50%) of the stream bed is covered in filamentous algae. Such shifts have been observed in Utah streams and these prolonged periods of extensive filamentous algae blooms are considered to be an important indicator of eutrophication with a multitude of potential adverse effects to stream biota. UDWQ set an indicator that specifies that filamentous algae shall not exceed ⅓ cover to be protective against dominance of this growth form (see also response to section 3B). This section of the response to comments summarizes some of the important linkages to aquatic life uses discussed by Biggs (2000) and UDWQ has also included additional information on the linkage in the TSD.

Extensive and long-lived filamentous algae blooms can degrade stream habitat in several ways. First, the structure of these algae mats are known to trap suspended sediment, which can fill interstitial spaces in cobble-bedded streams. This diminishes the quantity and quality of macroinvertebrate habitat because they frequently reside in these interstitial spaces. Extensive algal mats also slow the flow of water, which can increase stream temperature in areas exposed to sunlight. Increases in water temperature can have adverse metabolic effects on macroinvertebrates because these organisms are ectotherms, with body temperatures dictated by their surrounding environments. Higher stream temperatures also decrease DO saturation, which can be detrimental to stream biota.

Another adverse effect of a regime shift to a condition where filamentous algae blooms are extensive (i.e., >50% cover) is the alteration of stream food webs. For most stream macroinvertebrates, diatoms are a preferable food resource because they are higher in lipids and more easily digestible than filamentous algae. Some algal piercing taxa are specialized in feeding on filamentous algae and they will replace less specialized taxa when algal mats are present. However, these taxa are also less likely to actively drift, which can be detrimental to the feeding efficiency of trout and other fish. Decreases of trout abundance in streams dominated by filamentous algae have been documented and this may be due, in part, to shifts in the taxonomic composition of lower trophic levels. In mesotrophic streams, the loss of actively drifting stream insects is less severe because algal mats are more short-lived, allowing time for recolonization of these insects. Another impact of excessive filamentous algae growth is a reduction in the grazing efficiency of macroinvertebrates. Top down control of algal biomass through grazing has been well-documented in streams where stream autotrophs consist primarily of diatoms (the natural condition of Utah headwater stream), but these biotic controls on excessive benthic production are less effective once filamentous algae are the dominant forms of these ecosystems.

Extensive mats of filamentous algae also exacerbate other water quality parameters that have been demonstrated to be deleterious to aquatic life uses. Higher rates of primary production are associated with increases in pH, with the potential to negatively affect the condition of fish and indirectly affect all aquatic biota by increasing the toxicity of ammonia that may be present at higher concentrations in nutrient enriched streams. The resulting higher biomass of autotrophs can cause appreciable increases in the diel flux of DO, which has been attributed to biological degradation. The accrual of autochthonous carbon in streams with extensive filamentous algae mats can be considerable, especially when nutrient concentrations are high because episodic sloughing decreases and filamentous algae mats become longer and thicker due to increases in nutrient diffusion into the mats. In Utah, decreases in stream temperatures will ultimately result in algal senescence, which allows the carbon tied up in these mats to be more available to stream heterotrophs, increasing ER, which has the potential to cause hypoxic conditions (Suplee et al. 2019). Another advantage of measuring filamentous algae cover during the growing season as a nutrient response is the ability to identify the potential for late-season deleterious hypoxia.

The natural state of headwater streams in Utah is a state where stream autotrophs primarily consist of diatoms. UDWQ included filamentous algae as a response variable based on the knowledge that regime shift to autotrophs dominated structurally in filamentous form is undesirable, from the perspective of both recreational and aquatic life uses. Existing scientific evidence establishes clear linkages between nutrient enrichment and adverse effects on both of these uses.

As this review illustrates, enough is understood about the deleterious impacts of extensive filamentous algae blooms to reasonably conclude that dominance of this growth form in headwater stream constitutes a threat to aquatic life uses. A more precise estimate of exactly how high seasonal maximum algae growth can go before these adverse effects occur is limited by the available data. As Biggs (2000) states, "*effects on water quality and ecosystem degradation are only moderately well quantified, and a number of cause-effect assumptions in this linkage need further testing.*" It would be useful for EPA to take a leadership role in helping to fill these data gaps because filamentous algae cover is an important nutrient response that could be easily and inexpensively be integrated into state monitoring programs.

7B

Beyond the literature citations, the proposal provides the following justification for selecting the 33% threshold:

"DWQ recommends a criterion of maximum filamentous algae cover of 1/3 of the stream bed. While this number is at the upper end of concentrations that others have suggested as protective of stream aquatic life uses, DWQ has established this threshold as protective of stream conditions because it represents the maximum filamentous algae concentration that is observed on any single collection event." (Proposal, page 27) [emphasis added]

Given the stated paucity of data collected on Utah streams, there is limited information on which to base this statement and demonstrate that the proposed threshold is protective of aquatic life uses in headwater streams.

The derivation of the filamentous algae NNC threshold was semi-quantitative. UDWQ has provided evidence to support that nutrients must be controlled to prevent filamentous algae from becoming the dominant form of benthic autotrophs, which is defined as >50%. As discussed elsewhere in responses to this section, this is because extensive algal blooms are more likely to be associated with nutrient enrichment and also because they represent a greater threat to aquatic life uses. Given this determination, any value less than 50% is considered to be protective. Filamentous algae blooms can occur in relatively unenriched streams with stable flows, but they tend to have a more limited spatial and temporal extent. To avoid making too many false impairment determinations due to natural filamentous algae accumulations, UDWQ used 20% to demarcate an upper limit of naturally-occurring conditions. UDWQ met with a technical review team and the consensus was that a NNC response to maintain filamentous algae cover lower than ⅓ of the stream, a value approximately midway between 20-50%, was the most appropriate way to balance false positive and false negative decision errors. The supporting documents have been updated with additional clarification

7C

The EPA's guidance document entitled "Guiding Principles on an Optional Approach for Developing and Implementing a Numeric Nutrient Criterion that Integrates Causal and Response Parameters" recommends that "[combined] criterion should demonstrate the sensitivity of the response indicator(s) to increased nutrient concentrations and quantify how these nutrient-response linkages will achieve the goal of protecting and maintaining aquatic communities." Chapter 13 of the TSD, page 160, explicitly states that "there was no statistically significant linear relationship between TN or TP and filamentous algae cover." The proposal also cites to the influence of confounding factors on filamentous algae growth: "Others have noted that whether or not filamentous algae cover reaches levels of potential concern is also dependent on other stream characteristics such as canopy cover, stream temperature, *stream size, and hydrology (Busse et al. 2006, Dodds and Oakes 2004, Riseng et al. 2004)." (Proposal, page 27). Based on the proposal, it is unclear how UDWQ controlled for confounding factors in the study design used for the independent evaluation of the proposed numeric nutrient criterion (Chapter 13) or in any subsequent analysis.*

The quantity of filamentous algae is mechanistically related to nutrient concentrations, although this relationship was not apparent in the available data. The proliferation of filamentous algae is among the oldest biological indicator of nutrient enrichment in streams. As streams become enriched, it is increasingly likely that proliferations of filamentous algae will occur. UDWQ interprets a dominance (>50%) of filamentous algae to be a strong indicator of nutrient impairment with a low potential for false positive impairment determinations. The converse interpretation, concluding that a stream without filamentous algae is in an oligotrophic state, is not an appropriate interpretation of the data. As highlighted in the TSD and other responses to comments, local stream characteristics exert controls on algal accrual. Flooding frequency is particularly important because scouring can reset algal accrual. Hence, it is difficult to reliably link low levels of filamentous algae to oligotrophic stream conditions. To reduce the probability of making these false negative impairment determinations based on filamentous algae, the thresholds in the NNC are expressed as "not to be exceeded" values, with a minimum recommended monitoring frequency of once per month. The implementation of filamentous algae at sites with moderate levels of nutrient enrichment is not intended to address the situations where natural factors prevent proliferations of extensive algae growth. However, when present, extensive filamentous algae cover is, in and of itself, a reflection of degraded aquatic life uses.

7D

The EPA also reviewed regionally-relevant studies related to Utah's proposed filamentous algae threshold. For example, the Montana Department of Environmental Quality (DEQ) conducted a dose-response nutrient study on a perennial prairie reference stream. Recognizing that plains streams, even reference sites, generally tend to have a higher degree of human disturbance than montane reference sites (i.e., "least disturbed" compared to "minimally disturbed" reference sites), the EPA examined the Montana study because it offered insights into visually assessed filamentous algae values observed across a nutrient gradient. The EPA's hypothesis was that the visual estimate of filamentous algae observed in prairie reference streams would be greater than estimates from headwater streams because prairie streams are likely to be less shaded, have lower gradients, more impacts, etc. Therefore, the Montana study represented the "upper range" of conditions for filamentous algae that could be applicable to headwater conditions.

UDWQ again reviewed the findings of the Montana study in response to this comment. Based on the information provided in this study, UDWQ does not support that the prairie streams are closely representative of the "upper range" for filamentous algae in Utah headwater streams. Prairie streams have some physical attributes that potentially make them more susceptible to nutrients. However, these streams also typically have smaller substrate size, particularly in slower runs and pools, which tends to favor macrophytes over accumulation of filamentous algae. This is important because the investigators note that most of the filamentous algae growth occurred in riffles, which tend to have larger, more stable substrate. The vast majority of Utah's headwater streams have larger, more stable substrates, which make accumulations of extensive algal mats more likely. Moreover, on average, riffles only comprised 15% of the stream reach, further limiting the spatial extent of filamentous algae mats observed in the Montana investigation. Again, Utah's headwater streams have a higher proportion of stream reaches in riffles and runs, which makes direct comparison with the Montana investigation problematic. As reported in the TSD, UDWQ collected filamentous algae data at 49 headwater streams located throughout Utah. Filamentous algae cover at these streams peaked at 95% cover, with 16% of streams exceeding the 1/3 threshold proposed by the headwater NNC. Clearly the filamentous algae cover data reported in the Montana study is not reflective of the "upper range" applicable to Utah's headwater streams, because empirical data collected from Utah headwater streams demonstrate that more extensive filamentous algae mats occur in the streams the NNC are intended to protect.

Another interesting observation from the Montana investigation is that it demonstrated many of the same deleterious responses discussed elsewhere in these responses to comments. This investigation clearly demonstrated that filamentous algae cover increases in response to nutrient enrichment. The stream that received the higher nutrient dosing had much higher daily maximum DO concentrations in comparison to the control, and modestly lower daily minimum concentrations, which suggests increases to both GPP and ER rates, which the researchers link to degradation of aquatic life. The high dose stream also exhibited decline in DO below water quality standards, which the authors of the investigation attributed to the respiration of the additional carbon during the senescence of filamentous algae. In their words (Suplee et al. 2019, emphasis added), "*A consistent finding across the whole-stream enrichment literature is that increased nutrients increase algal primary productivity and standing crop of a stream and, accordingly, we monitored the floral community. Enrichment effects on the benthic algae of this prairie stream were consistent with this nearly universal finding, and the degree of changes was largely in alignment with our dosing levels."*

7E

Lastly, visual estimates for filamentous algae cover can be prone to bias. Therefore, having sampling methods that ensure a systematic approach to sampling is important. There is also no information describing how the proposal evaluated bias in the visual estimates.

Detailed standard operating procedures (SOPs) were written prior to data collection and all field crews were trained together to ensure that they had interpreted the methods similarly. To address the potential for sampling error, the SOP requires measurement to be taken from three transects running perpendicular to stream flow and located in riffles and runs—where filamentous algae cover is more likely to occur. Along each transect, 10 measurement of filamentous algae cover are made upstream and downstream in each of 4-6 habitat units. Each measurement of the presence or absence of filamentous algae is made using a line intersect method, which is a method commonly used to quantify plant cover in vegetative surveys. This protocol resulted in >240 measures of filamentous algae cover from each stream, which is a sample size that should be more than sufficient to minimize observation bias.

EPA Recommendations and UDWQ Responses

The EPA recommends:

- *Adding a chapter to the TSD that describes filamentous algae as a response indicator and addresses the issues described below;*

UDWQ added some of the material from the responses to this Section to Chapter 12 of the TSD.

- *Discussing in the TSD how the scientific studies cited demonstrate that a threshold of 33% filamentous algae cover will protect aquatic life uses;*

Additions to the TSD include a more thorough description of the underlying rationale for the selection of the 33% threshold (see also response to Section 7B).

- *Explaining in the TSD how UDWQ's study design controlled for confounding factors in the derivation of the filamentous algae threshold;*

The revisions to the TSD include a more thorough description of the underlying rationale for the selection of the 33% threshold (see also response to Section 7B).

- *Reconciling the results from Montana's dose-response study with the proposed 33% threshold and demonstrating in the TSD that the threshold adequately protects aquatic life uses;*

Please see response to Section 7D. UDWQ did not revise the SOP to incorporate the information because the study is not directly applicable and the resulting arguments only further support the information already presented, as modified, in the TSD.

- *Providing a copy of UDWQ's standard operating procedures (SOPs) for determining visual estimates of percent filamentous algae growth;*

The SOPs were developed prior to collection of the data, revised after being vetted in preliminary field testing and will be submitted in conjunction with the rulemaking packet provided to EPA for formal review and approval in accordance with section 303(c) of the CWA.

- *Describing how the state evaluated potential bias in the visual estimates;*

Bias is minimized through the use of collection techniques that are easily repeatable. UDWQ used a derivation of line-intersect, transect measurements that are widely used to quantify plant cover in vegetative surveys. To ensure the methods are repeatable, detailed standard operating procedures (SOPs) are provided and all field crews were trained together to ensure that they had interpreted the methods similarly. UDWQ will also work with cooperators interested in collecting these types of data to minimize the potential for bias. Another important factor that limits the bias of any measurement is sample size. As stated in the TSD, filamentous algae cover was calculated from >240 field measurements, which were collected on each collection event.

- *Characterizing the percent filamentous algae cover at reference streams in the TSD; and*

Due to the confirmational nature of the 2015 investigation, which focused on data collection in moderate to highly enriched headwater streams, UDWQ does not have the data necessary to conduct the requested analysis. However, UDWQ agrees that a thorough investigation of background filamentous algae cover would be useful to the scientific community and will endeavor to help fill this important gap as additional data become available through implementation of the NNC.

- *Exploring the relationships between percent cover and invertebrate data.*

There are currently insufficient co-located samples to evaluate these relationships. However, UDWQ is integrating collection of filamentous algae cover into routine biological assessment data collection activities, so these analyses can be conducted in the future.

8. Derivation of lower and upper nutrient thresholds

The proposal applies a combined nutrient criterion within a broad range of TN and TP values - ranging from concentrations representative of reference conditions to upper TN and TP values at which impairments to aquatic life are expected. Given the EPA's comments on the sensitivity of the response indicators and protectiveness of the proposed thresholds, UDWQ's proposed approach could allow nutrient concentrations to increase until they reach the upper nutrient thresholds and impact or impair aquatic life.

As discussed in these responses, UDWQ supports that the combined criteria used to evaluate waters moderately enriched by nutrients are sufficiently protective because of the multiple lines of evidence. The potential for false negative impairment determinations is further limited in occurrence and extent by having the upper thresholds. However, the primary purpose of the upper thresholds is to conserve monitoring resources by rapidly and efficiently identifying impaired sites and to protect downstream uses.

EPA Recommendations and UDWQ Responses

The EPA recommends:

- *Explaining how a broad range of nutrient concentrations will ensure protection of aquatic life uses.*

Chapter 12 of the TSD has an extensive discussion of the rationale behind the NCC and evidence that the combination of nutrients and responses is protective of aquatic life uses. The response parameters included in the TSD are only applicable to moderately enriched streams. The NNC specify that a violation of any response in moderately enriched streams is sufficient to consider a stream to be impaired. If adverse effects are not observed at moderately enriched streams, it likely means that the stream has physical attributes that reduce its sensitivity to nutrient enrichment. Under such circumstances, there is little reason to believe that moderate enrichment will "impact or impair aquatic life." The commenter does not present any data that demonstrates that the combination of nutrients and responses in the NNC miss adverse effects of nutrient enrichment on aquatic life uses.

- *Providing documentation on the reference site screening process.*

The reference site selection process was developed prior to collection of the data and will be submitted in conjunction with the rulemaking packet provided to EPA for formal review and approval in accordance with section 303(c) of the CWA.

- *Clarifying in the TSD and proposal, if needed, the number of reference samples and whether the 90th percentile represents a mean concentration.*

The TSD (Chapter 12) already summarizes the number of samples used for calculating growing season averages (see *Data Compilation* section in *Methods*). In addition, data used to conduct the analysis of reference sites were made available to stakeholders, including EPA. The NNC specify that nutrient concentrations are to be based on the average concentration of TN and TP over the growing season. As a result, UDWQ treated the reference site data similarly. For each reference site, the average of all available samples, collected during the growing season, over the nine-year period of record, were calculated (see Table 11.1). The averages among all reference sites were then used to determine percentiles (see Table 11.2) . The TSD and Proposal have been updated to more clearly state the percentiles were derived from growing season averages.

9. *Full Support Assessment Determinations Based on a Single Response Indicator*

As described on page 2 of this letter, UDWQ will in some instances be relying on data from a single response indicator in use attainment decisions. Page 42 (Proposal) states that sites will be considered "to be meeting their aquatic life uses provided that at least one response variable has been measured and no response that has been measured exceeds the established thresholds…In circumstances where a response is required to make an assessment decision, it is not necessary to have data on all response[s] specified in the NNC."

For states using a combined criterion, the EPA recommends relying on data for more than one response indicator to make the decision that a water is fully supporting its aquatic life uses. This approach is especially critical in situations where the response indicators, and their associated thresholds, may not be very sensitive to increases in nutrient concentrations.

Based on the EPA's technical review of the proposed suite of response indicators, none of Utah's proposed response indicators exhibit a strong relationship to nutrients. In addition, because of an inability to calculate GPP and ER at many headwater sites (see page 5 of this letter), the state may have to rely on results for percent filamentous algae cover to make attainment decisions based on a threshold that lacks a clear scientific rationale. Therefore, the EPA recommends modifying the proposal to require that data from all response indicators must be collected and meet the proposed thresholds before a site can be assessed as meeting its aquatic life uses.

While EPA guidance of combined criteria recommends the inclusion of an assessment matrix, this is not a requirement of the CWA and associated regulations. UDWQ typically provides specifics with respect to the interpretation of standards in the Integrated Report's Assessment Methods. In this case, the agency agreed that an exception was appropriate due to the nuances intrinsic to combined criteria. The assessment decision rules that are part of the NNC were policy decisions made in consultation with stakeholders.

The circumstances described by the commenter are those where either TN or TP indicate moderate enrichment and evidence exists that adverse effects do not occur in the stream. Importantly, in such circumstances there would also be no evidence that deleterious responses have occurred. UDWQ is comfortable making a full support determination in these circumstances unless other nutrient-related criteria (e.g., pH, DO) identify adverse effects to aquatic life uses. The decision to consider such sites to be fully supporting aquatic life uses was made to maximize agency resources. The alternative to a full-support listing decision would be assessing the site as having insufficient data (Assessment Category 3), which obligates the agency to collect follow-up data. Given that collection of response data is somewhat resource intensive, prioritization of data collection at these low-nutrient sites over those that are moderately enriched streams or without any nutrient data is not sound planning. More importantly, such diversions of limited resources would diminish the ability of UDWQ to ensure the statewide protection of all headwater streams. As demonstrated by the 2015 pilot investigation, the proposed NNC will allow UDWQ to identify headwater streams at greatest threat to nutrient enrichment.

EPA Recommendations and UDWQ Responses

Therefore, the EPA recommends modifying the proposal to require that data from all response indicators must be collected and meet the proposed thresholds before a site can be assessed as meeting its aquatic life uses.

The decision rules were policy decisions that were made in consultation with stakeholders. UDWQ intends to routinely collect data to support all of the ecosystem responses to improve the accuracy of the assessment decisions. However, each individual ecosystem response has been demonstrated to be sufficiently robust to support an assessment decision of full support unless other water quality indicators demonstrate adverse effects. It is also worth noting that the converse is also true; the NNC specify that an excursion of a single response threshold is sufficient to make a determination of impaired conditions. The assessment decision rules in the proposal have not been modified.

10. Criterion Operation and Implementation Comments

In addition, the EPA offers the following set of criterion operation and implementation-related comments for UDWQ's consideration:

- *We recommend developing SOPs for making assessment decisions within the combined criterion matrix to clearly document how assessment decisions will be made.*

  UDWQ revised the TSD and Proposal to provide clarification with respect to how assessments will be conducted. UDWQ previously documented how the criteria will be implemented for assessments in Tables 4 and 8 and accompanying text in the proposal. In addition, Table 8 is explicitly incorporated into the rule. Additional ongoing clarifications can continue to be provided in the methods associated with the *Integrated Report*.

- *Because the combined criterion incorporates a range of nutrient thresholds, please describe in the proposal the process that the state would use to identify total maximum daily load (TMDL) targets when a waterbody is listed as impaired.*

UDWQ has not developed implementation methods for TMDLs because TMDL targets will be based on achieving the criteria. UDWQ considers both the lower and middle tiers equally to be supporting beneficial uses and acceptable as TMDL targets. TMDL targets will therefore depend on site-specific relationships between nutrient concentrations and ecological responses. Detailed TMDL guidance will be developed in consultation with stakeholders prior to the NNC being used to make impairment determinations in the *Integrated Report*.

- *In the TSD and proposal, please clarify the assessment decision that would occur if TP concentrations exceed the moderate or upper thresholds but TN concentrations do not.*

A minimum of 4 samples are required to calculate growing season TN and TP averages for assessment purposes. Broadly, the NNC intend final assessment decision would be made based on the extent to which nutrient enrichment threatens aquatic life, so DWQ would base its overall assessment on the worse-case scenario. Table 2.14.8 in R317-2 shows the criteria, and if all of the required conditions within a tier are met, the criteria are being met. Therefore, a site must meet both TN and TP thresholds to be considered meeting the tier-specific criteria. As specified in Table 2.14.8, if TP concentrations exceed the lower threshold but TN concentrations do not, ecological response data are required to evaluate the TP exceedance. If TP concentrations are above 0.08 mg/L, the site is considered to be not meeting the criteria, regardless of TN concentrations.

- *Please clarify in the TSD and proposal whether both TN and TP concentrations need to be below the lower thresholds for a site to be considered fully supporting its aquatic life uses. The current language in the proposal appears to offer contradictory perspectives. For example, the description in the Proposal (pages 24, 41) specifies that both TN and TP must be below the lower threshold for a site to be considered meeting its aquatic life uses. In contrast, Tables 4 and 8 (pages 33 and 42, Proposal) suggest "either/or" must be below the specified nutrient concentration before a full support determination can be made. The TSD (pages ES7, 137 and Table 12.1 on page 139) contain similar contradictory information.*

The requirements specified in rule are consistent and clear. As required by proposed Table 2.1.4.8 in R317-2, both TN and TP concentrations must be below the lower thresholds for a site to be considered fully supporting as indicated by the "and."

- *The EPA recommends UDWQ consider placing waters identified within the moderate range of TN and TP, with no available ecological response indicator data, in Category 5 of the Integrated Report until response indicator data are available to confirm the aquatic life use is attained.*

As shown in Table 12.1 of the TSD, waters without any response indicator data will be assessed as having insufficient data: "Streams without response data will be listed as having insufficient data and prioritized for additional monitoring if either TN or TP falls within the specified range." UDWQ's approach is consistent with the EPA's 2013 Guiding Principles for biocriteria that state: "If a causal parameter is significantly exceeded but no response parameters are exceeded, then the state should pursue additional studies to determine whether site-specific criteria are appropriate."

- *Please describe in the proposal how the proposed combined criterion will ensure protection of downstream uses, especially in instances where nutrient concentrations are allowed to increase to/near the upper thresholds for TN and/or TP.*

Implementing these criteria will be a vast improvement to protect and restore downstream uses considering that mid-to lower elevation streams currently lack numeric nutrient criteria. In most cases, the most sensitive downstream uses are likely to be lakes or reservoirs. UDWQ currently assesses these waterbodies using several nutrient-related responses, including: trophic state index (TSI), DO, pH and the relative abundance of cyanobacteria. In addition, UDWQ conducts biological assessments in locations downstream of headwaters. These biological assessments have been documented in the TSD to be sensitive to nutrient enrichment. Any impairments that are identified would be addressed through TMDLs, which may require nutrient reductions that are more stringent than otherwise needed for the prevention of adverse effects in headwater streams.

U.S. EPA Comments on non-nutrient criteria

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
1595 Wynkoop Street
DENVER, CO 80202-1129
Phone 800-227-8917
http://www.epa.gov/region08

May 2, 2019

Ref: 8WD-CWQ

Christopher Bittner
Utah Division of Water Quality
195 North 1950 West
P.O. Box 144870
Salt Lake City, Utah 84114-4870

Re: EPA Comments on Utah's Proposed Revisions to Water Quality Standards

Dear Mr. Bittner:

This letter provides the U.S. Environmental Protection Agency (EPA) Region 8 Water Quality Unit comments on the Utah Division of Water Quality's (UDWQ) proposed revisions to R317-2, *Standards of Quality for Waters of the State* adding:

- Silver Creek site-specific total dissolved solids criterion;
- Jordan River site-specific ammonia criteria;
- Sheep Creek drinking water use; and
- Corrections to Aquatic Life and Human Health statewide criteria.

The EPA offers these comments in response to the UDWQ's public comment opportunity on proposed revisions to R317-2 from March 19 to May 3, 2019.[1] Our review addresses the information and supporting materials included in the notice and the UDWQ website. The public hearing for the proposed revisions to water quality standards (WQS) is scheduled for May 1, 2019.

The EPA's Water Quality Standards Regulation (40 C.F.R. Part 131) specifies the requirements for revisions to water quality standards.[2] The EPA is offering comments to assist UDWQ in ensuring that Utah's proposed revisions and supporting documentation comply with these WQS requirements before revisions are adopted by the Utah Water Quality Board (Board). Please note that our comments are preliminary in nature and should not be interpreted as a final EPA decision under Clean Water Act (CWA) § 303(c).

[1] The EPA is transmitting comments in a separate letter addressing the UDWQ proposal to add numeric nutrient criteria to headwater streams (Category 1 and 2) statewide.
[2] See also EPA's Water Quality Standards Handbook, section 3.1 available at: https://www.epa.gov/sites/production/files/2014-10/documents/handbook-chapter3.pdf.

GENERAL COMMENTS

The EPA has discussed the proposed WQS revisions with UDWQ and with other parties involved with the individual proposals. We appreciate UDWQ and others discussing complex details of these proposals, the significant preliminary work done to characterize and document these water quality issues, and the thoughtful analyses addressing potential resolutions. As a part of its public outreach the UDWQ posted summaries of each water quality issue as well as in-depth analyses and supporting materials for the more technical water quality questions. These proposals and supporting documents are clear and of an appropriate technical scope and depth to address each water quality issue. Generally, we concur that it is reasonable and appropriate to consider whether the proposed WQS revisions are warranted (i.e., the proposed revisions appear to be appropriate WQS considerations for the given water quality issue.) Below are comments identifying our outstanding questions and concerns.

SPECIFIC COMMENTS

The EPA offers no specific comments to the addition of the drinking water use to Sheep Creek, a tributary to the Blacksmith Fork and tributaries. The three other proposed revisions are addressed below.

Silver Creek Site-Specific Total Dissolved Solids Criterion

UDWQ proposes a site-specific water quality criterion for Total Dissolved Solids (TDS) protecting agricultural uses in a portion of the Silver Creek watershed, as follows:

> A site-specific total dissolved solids (TDS) criterion to protect the agricultural designated use is proposed for a portion of Silver Creek, Summit County. Specifically, a maximum TDS criterion of 1,900 mg/L is proposed for Silver Creek and tributaries from Tollgate Creek to headwaters.
>
> [In R317-2, *Standards of Quality for Waters of the State* add to] R317-2-14. Numeric Criteria Table 2.14.1 FOOTNOTE: (4) Silver Creek and tributaries, Summit County, from confluence with Tollgate Creek to headwaters maximum 1,900 mg/L.[3]

The proposed revision to the Silver Creek TDS criterion is supported by *Criteria Support Document: Use and Value Assessment and Site-specific Criteria for Total Dissolved Soils (TDS): Silver Creek, Version 2.1*. The document provides a use and value demonstration (see 40 C.F.R. § 131.10(k)(3)) documenting UDWQ's consideration of the use and value of Silver Creek water for agricultural purposes within the Silver Creek watershed from Tollgate Creek to its headwaters. It also provides UDWQ's rationale in developing the site-specific TDS criterion as protective of the agricultural use in this portion of the Silver Creek watershed, pursuant to 40 C.F.R. § 131.10(g)(3). UDWQ proposes splitting the segment into Silver Creek 1: Weber River confluence to Tollgate Creek; and Silver Creek 2: Tollgate Creek to Silver Creek headwaters. The site-specific 1,900 mg/L TDS criterion would apply year-round as an instantaneous maximum only to Silver Creek 2, while the statewide 1,200 mg/L TDS would remain in place in Silver Creek 1.

The document finds winter road salting to be the principal anthropogenic TDS loading in this portion of Silver Creek. Human safety concerns currently make this an irreversible human caused condition per 40 C.F.R. § 131.10(g)(3).

> After determining that road salt was the primary source of the anthropogenic portion of TDS loadings to Silver Creek, local and state road maintenance agencies were contacted and their best management practices (BMPs) reviewed. BMPs are currently being implemented (primarily liquid potassium chloride

[3] See: *Water Quality Standards Revisions Supporting Documentation* Proposed Amendments to R317-2-13, and R317-2-14, Standards of Quality for Waters of the State Published in the April 1, 2019 Utah Bulletin, Section 3.

pre-treatment of roads, sweeping and metered application) but salt application on private properties remains unregulated. The governmental agencies emphasized the importance of road salting for public safety. This road salting to protect human life and health is considered an irreversible human-caused condition.[4]

The EPA reviewed the proposal and Criteria Support Document, and from our perspective it appears that the proposal is appropriate for this water quality issue. The document clearly presents and analyzes the TDS data for Silver Creek; and the rationale for splitting Silver Creek into assessment units 1 and 2 with a higher agricultural use TDS criterion for Segment 2. The EPA concurs that anthropogenic winter road salting in the upper Silver Creek watershed appears to be the dominant source of TDS in Segment 2, and that current technology and safety considerations make this manmade condition currently unable to be remedied. Hence, the proposal appears to be an appropriate option addressing the current TDS water quality issue.

However, the EPA is concerned that Silver Creek TDS concentrations may be an issue in the future. The state and municipal stakeholders may want to consider a range of options that could help reduce TDS loading into Silver Creek designed towards mitigating further TDS water quality issues. Given the projected near-term population growth in Park County (see Figure 18, Criteria Support Document); the potential future (post-2024) loss of Judge Tunnel water that is effectively diluting the TDS problem (see Figures 30-32, and Table 6); and the evolution of road salting technology we suggest an expanded road salting awareness and control program throughout the upper Silver Creek watershed. Significant load reductions may become achievable through conservative use of road salt products (particularly from private snow removal and traction control operations) and continued, and updated, Best Management Practices (BMPs) from municipal and state operations. We also recommend performing a TDS loading analysis identifying principal road salt entry locations and timing within the watershed, which could be used to prioritize further road salt management, recapture and other upgraded BMPs over time. We are concerned that without further controls TDS loading may increase to levels that could further impact the agricultural uses of Silver Creek water. The Water Quality Board may wish to consider scheduling further road salt management activities and controls in conjunction with adoption of the site-specific TDS criterion or in connection with future triennial reviews.

Jordan River Site-Specific Ammonia Criteria

UDWQ proposes site-specific ammonia criteria protecting warm water aquatic life uses in portions of Mill Creek, Jordan River and the Surplus Canal, as follows:

[R317-2, *Standards of Quality for Waters of the State* add to] R317-2-14, Table 2.14.2, Footnote 9
(9a) The thirty-day average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average, the chronic criterion calculated using the following equations.
Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River, Fish Early Life Stages are Present:
mg/l as N (Chronic) = $0.9405 * ((0.0278/(1+10^{7.688-pH})) + ((1.1994/(1+10^{pH-7.6888}))) * MIN(6.920,(7.547*10^{0.028*(20-T)}))$
Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River, Fish Early Life Stages are Absent:

[4] *Ibid.*

mg/L as N (chronic) = 09.405 * (((0.0278/(1+10^(7.688-pH))+(1.1994/(1+10^(pH-7.688)))) * (7.547*10^(0.028*(20-MAX (T,7))))

$$mg/L\ as\ N\ (chronic) = 09.405 * (((0.0278/(1+10^{7.688-pH}))+(1.1994/(1+10^{pH-7.688}))) * (7.547*10^{0.028*(20-MAX(T,7))}))$$

(9b) The one-hour average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average the acute criterion calculated using the following equations.

Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River:

$$mg/l\ as\ N\ (Acute) = 0.729 * (((0.0114/(1+10^{7.204-pH}))+(1.6181/(1+10^{pH-7.204}))) * MIN(51.93,(62.15*10^{0.036*(20-T)}))$$

The proposed ammonia criteria vary with water temperature and pH, and the chronic ammonia equations vary by months when early life stages of fish are expected to occur in the affected stream reaches.

The proposed revision to the Mill Creek and Jordan River ammonia criteria is supported by *Criteria Support Document: Site-specific criteria based on recalculated aquatic life water quality criteria for ammonia for a segment of Mill Creek and the Jordan River, Salt Lake County, Utah.* The document provides UDWQ's rationale in developing the site-specific ammonia criteria based on the absence of unionid mussels and salmonids (trout) in the affected segment pursuant to EPA recommendations (see: *Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater*, 2013).[5] The site-specific ammonia criteria would apply to portions of Mill Creek, Jordan River and the Surplus Canal as described above.

UDWQ's public notice notes unionid mussels and trout were not observed in the affected reaches and not anticipated to recolonize these waters within the reasonable planning horizon:

> Unionid mussels have not been discovered in recent surveyed portions of the Jordan River, but historically they were documented to be present in tributaries and were likely present in the Jordan River. Today, this segment of the Jordan River is biologically and chemically degraded as indicated by the water quality impairments identified in Utah's Integrated Report. The mussels rely on a fish host to complete their life cycle and questions remain regarding the suitability of the fish that are present to serve as hosts. There is no evidence that these mussels are present in the identified portions of Mill Creek, Jordan River, Surplus canal, or surrounding watersheds. Therefore, these mussels are unlikely to return within a reasonable planning horizon without human intervention. Efforts to restore the Jordan River are ongoing but are unlikely to be sufficient to support the potential reintroduction of unionid mussels within the reasonable planning horizon of the next 30 years. The Utah Division of Wildlife supports this conclusion and they are responsible for identifying, protecting and reintroducing unionid mussels in Utah waters.

While evidence exists of historic occurrence of unionids and salmonids at the site[6] and both species occur in distant hydrologically-connected water bodies, no live individuals were found at the site despite multiple sampling methods and attempts. While definitive "absence" is difficult to establish and unionids and salmonids may recolonize water bodies as habitat and water quality improvements occur, it appears that unionids and salmonids do not currently occur at the site.[7]

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[5] EPA 822-R-18-002, April 2013. See also Appendix N. Site Specific Criteria for Ammonia. Available at: https://www.epa.gov/wqc/aquatic-life-criteria-ammonia.

[6] See *Criteria Support Document: Site-specific criteria based on recalculated aquatic life water quality criteria for ammonia for a segment of Mill Creek and the Jordan River, Salt Lake County, Utah*; and supporting 2014-2017 Oreohelix freshwater mollusk surveys.

[7] Per *Utah Implementation Guidance for the 2013 USEPA Ammonia Criteria for the Protection of Aquatic Life*, Utah Division of Water Quality, 2017; and EPA guidance in *Technical Support Document for Conducting and Reviewing*

However, uncertainty remains about the potential for unionids and salmonids to recolonize this site, especially given the challenges of predicting future habitat and water quality conditions. The Board may find utility in having continued water quality data and habitat assessments for this site, as well as summaries of those data and site conditions when conducting future triennial reviews. The EPA recommends that regular water quality and periodic unionid and salmonid sampling be continued at the site, perhaps as a requirement of the associated National Pollutant Discharge Elimination System permit for the affected facility. Such data and site condition summaries could help inform the Board's future triennial reviews and water quality protection decisions.

The current absence of unionid mussels and salmonids in the Mill Creek, Jordan River and Surplus Canal segments affords a recalculation of the EPA ammonia criteria recommendation at this site, and it appears UDWQ followed EPA guidance documents appropriately in this recalculation.[5] The EPA notes that there appears to be a typographical error in the chronic ammonia equation for fish early life stages are present above:

… $1.1994/(1+10^{pH-7.688\underline{8}})$ …

We recommend that the extra 8 should be removed before the chronic ammonia equation for fish early life stages present is adopted by the Board.

The EPA also notes that the *Criteria Support Document: Site-specific criteria based on recalculated aquatic life water quality criteria for ammonia for a segment of Mill Creek and the Jordan River, Salt Lake County, Utah*, under Mollusk Surveys (p. 2) cites "historic" occurrence as "pre-1978". Given that the *Utah Implementation Guidance for the 2013 USEPA Ammonia Criteria for the Protection of Aquatic Life*, Utah Division of Water Quality, 2017 treats any occurrence before November 28, 1975 as "historic" we assume the Criteria Support Document use of 1978 in Mollusk Surveys paragraphs 2 and 3 are typographical errors. We recommend revising those 1978 dates to November 28, 1975 in a revised final version of the Criteria Support Document before adoption by the Board.

Corrections to Aquatic Life and Human Health Criteria Statewide

UDWQ proposes to correct errors that were unintentionally adopted by the Board in the 2018 revision of the statewide aquatic life and human health criteria. The EPA supports the proposed corrections to these errors. We note that the UDWQ public notice Attachment 4, Human Health Criteria Corrections and Intended Revisions for the Utah 2018 WQS Revision table appears to contain an error for butylbenzyl phthalate:

CAS	Pollutant	Organism +Water	Organism only	
85-68-7	Butylbenzyl Phthalate	0.010	0.010	Add significant figure

To be consistent with EPA's current human health criteria recommendations the proposed criteria for Organism + Water and for Organism Only should both be 0.10 ug/l. While states and tribes may adopt criteria more stringent than EPA recommendations it appears that these may contain typographical errors. We recommend these values be reviewed and if necessary revised before adoption by the Board.

Freshwater Mussel Occurrence Surveys for the Development of Site-specific Water Quality Criteria for Ammonia, 2013. EPA 800-R-13-003. Available at: https://www.epa.gov/wqc/aquatic-life-criteria-ammonia.

Conclusion

In its specific comments, the EPA has offered suggestions for revisions before a final WQS proposal and supporting rationale are adopted by the Board and submitted to the EPA for review and approval under the CWA § 303(c). We hope our comments are helpful to UDWQ and the Water Quality Board. We appreciate UDWQ's efforts to ensure that Utah's draft rulemaking complies with the EPA's water quality standards requirements at 40 C.F.R. Part 131. If there are questions concerning our comments, please contact George Parrish (303-312-7027). We look forward to working with UDWQ to address these issues.

Sincerely,

for Sandra D. Spence
Chief, Water Quality Section

DWQ Responses to EPA Comments - Non Nutrient Criteria

1. Silver Creek site-specific total dissolved solids (TDS) criterion:
TDS concentrations may continue to increase in the future in Silver Creek. Additional actions are recommended to address these potential increases.

DWQ shares the concern regarding future development in the Silver Creek Watershed contributing to further increases in TDS concentrations. DWQ's Watershed Protection Section will continue to work with local stakeholders to alert them to threat to water quality from continued TDS inputs to Silver Creek and provide technical support to develop effective management strategies.

2. Jordan River site-specific ammonia criteria:
The chronic site-specific ammonia criterion has an additional significant figure that appears to be a typographical error.

DWQ agrees and will correct the typographical error shown in strikeout font below.

> Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River, Fish Early Life Stages are Present: mg/l as N (Chronic) = $0.9405 * ((0.0278/(1+10^{7.688-pH})) + ((1.1994/(1+10^{pH-7.688\cancel{8}}))) * MIN(6.920,(7.547*10^{0.028*(20-T)})))$

3. Human Health criteria for butylbenzyl phthalate:
The water + organism and water-only human health criteria for butylbenzyl phthalate should be 0.1 µg/L and not 0.01 µg/L.

DWQ agrees and will correct the typographical error for butylbenzyl phthalate for the human health criteria in Table 2.14.6. Both the organism + water and water only criteria will be 0.1 µg/L.

Public Hearing Attendance

PUBLIC HEARING ON PROPOSED AMENDMENTS TO THE
DEFINITIONS, R317-1-1 and
STANDARDS OF QUALITY FOR WATERS OF THE STATE,
R317-2, UTAH ADMINISTRATIVE CODE
UDEQ Board Room,
195 N. 1950 W
Salt Lake City, UT
May 1, 2019
6:00 – 7:00 p.m.

NAME/ AFFILIATION (Please Print)	**ADDRESS/ E-MAIL**
1.	
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NO ATTENDANCE

Attachment 3
Supporting Documentation for Headwaters Numeric Nutrient Criteria

Proposed Nutrient Criteria: Utah Headwater Streams: https://documents.deq.utah.gov/water-quality/standards-technical-services/DWQ-2019-006505.pdf

Technical Support Document: https://documents.deq.utah.gov/water-quality/standards-technical-services/DWQ-2019-006461.pdf

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Water Quality Standards Revisions Supporting Documentation
Proposed Amendments to R317-1, Definitions and R317-2, Standards of Quality for Waters of the State Published in the April 1, 2019 Utah Bulletin

Note: This document is intended as a companion document to the information published in the April 1, 2019 Utah Bulletin. This document provides supplemental information for a subset of the proposed amendments to R317-1 and R317-2 described in the April 1, 2019 Utah Bulletin. Additional information on the proposed headwaters nutrient criteria and a copy of the markup submitted for publication in the Utah Bulletin are also available on the DWQ website http://www.waterquality.utah.gov/rules/rulechange.htm. The information in the Utah Bulletin prevails should any unintentional discrepancies occur between these documents and the Utah Bulletin

Comments will be accepted until 5:00 PM, May 3, 2019. Comments should be mailed to Christopher Bittner, Utah Division of Water Quality, P.O. Box 144870, SLC, UT 84114-4870 or e-mailed to cbittner@utah.gov. Comments can be received by phone at 801-536-4371. Comments will also be accepted at the public hearing. The public hearings will be preceded by one hour for DWQ staff to provide additional information and answer general questions. The public hearings to receive comments will be held for a minimum of one hour at the following time and location:

PUBLIC HEARING DATE	TIME	LOCATION
Wednesday, May 1, 2019	6:00 PM	Utah Department of Environmental Quality Multi-State Agency Office Building, Board Room 195 N. 1950 W Salt Lake City, UT 84116

Proposed Standards Revisions

1) In R317-1-1, Definitions, the proposed change is to define “Ecosystem Respiration”, “Filamentous Algae Cover”, and “Gross Primary Production”. These terms are only used in Section R317-2-14, proposed Tables 2.14.7 and 2.14.8. These specific changes are identified in companion document: DWQ-2019-002321.

2) In R317-2-10, Laboratory and Field Analyses, a clause was added to provide flexibility of field methods that are different than Division of Water Quality standard procedures. These specific changes are identified in companion document: DWQ-2019-002322.

3) In R317-2-14, Numeric Criteria, Table 2.14.7 was added for nutrient criteria applicable to Antidegradation Category 1 and 2 waters statewide. These criteria are needed to ensure that Utah’s headwaters continue to deliver high quality water to, for instance, drinking water.

Nitrogen and phosphorus (nutrients) criteria were developed and applied to Category 1 and Category 2 waters in new Tables 2.14.7 and 2.14.8. These specific changes are identified in companion document: DWQ-2019-002322.

Summary of Proposed Nutrient Criteria for Headwater Streams

The following summary includes excerpts from *Proposed Nutrient Criteria: Utah Headwater Streams, March 2019* (See Attachment 1). This document provides additional details on the background and rationale for the proposed numeric nutrient criteria (NNC), including: (i) a summary of the underlying scientific investigations used to establish NNC thresholds, (ii) a rationale for the thresholds that were selected, and (iii) considerations for integration of the criteria into existing DWQ programs. A companion document, *Technical Support Document: Utah's Nutrient Reduction Program*, provides details with respect to the scientific underpinnings of the NNC. This document is readily accessible at this location or click link for pdf: https://deq.utah.gov/legacy/pollutants/n/nutrients/headwater-criteria.htm

Tiered NNC are proposed to protect aquatic life uses in headwater streams that place streams into one of three enrichment tiers depending on whether or not ambient nutrient concentrations exceed either of two nutrient concentration thresholds (Table 1). Under this proposal, the lower criteria of 0.4 mg/L for total nitrogen (TN) and 0.035 mg/L for total phosphorus (TP) differentiate between low and moderate enrichment streams. A higher threshold of 0.80 mg/L for TN and 0.080 mg/L for TP differentiates between moderate and high enrichment streams. Moderate enrichment streams, with nutrient concentrations between the upper and lower thresholds, require measures of ecological condition to determine whether or not enrichment is impairing or threatening the designated uses of the stream.

Nutrients can degrade aquatic life uses via mechanisms related to increased growth of plants/algae (autotrophs) and/or microbes/fungi (heterotrophs). DWQ selected bioconfirmation criteria (ecological responses) to address both mechanisms. In the case of plant/algae growth, two ecological responses are not-to-be-exceeded over a season at any headwater stream: (1) a daily gross primary production (GPP) rate higher than 6 g O_2/m^2/day or (2) an aerial percent filamentous algae cover exceeding 1/3 of the stream bed. Linkages among microbes/fungi, nutrients, and aquatic life uses are less well understood, in part because these processes are more difficult to observe or measure. However, it is possible to measure ecosystem respiration (ER), which captures the net metabolic activities of all stream biota. DWQ proposes a not-to-be-exceeded seasonal rate for ER of 5 g O_2/m^2/day.

Nutrients can also degrade recreation uses. To protect these uses DWQ proposes a not-to-be-exceeded benthic algae concentration of 125 mg/chlorophyll-*a* (chl-*a*)/m^2, or the equivalent 49 g ash free dry mass (AFDM)/m^2. These criteria are supported by the responses from a survey of Utah citizens who were asked whether streams with varying amounts of benthic algae cover represented "desirable" or "undesirable" conditions. These recommended criteria fall just below the point where the proportion of undesirable responses start to increase and should therefore be protective of recreation from the perspective of degraded aesthetics or other factors influencing recreational use decisions.

These NNC will apply to headwater streams that are currently protected as Antidegradation Category 1 and 2 waters (R317-2-3, Figure 1). These streams consist of waters that the Board has previously determined to be "of exceptional recreational or ecological significance or have been determined to be a State or National resource requiring protection" (R317-2-3). New point source discharges of wastewater are prohibited in Category 1 waters. New point sources are allowed in Category 2 waters, but the discharge cannot degrade water quality. The proposed criteria will not affect any permitted discharges.

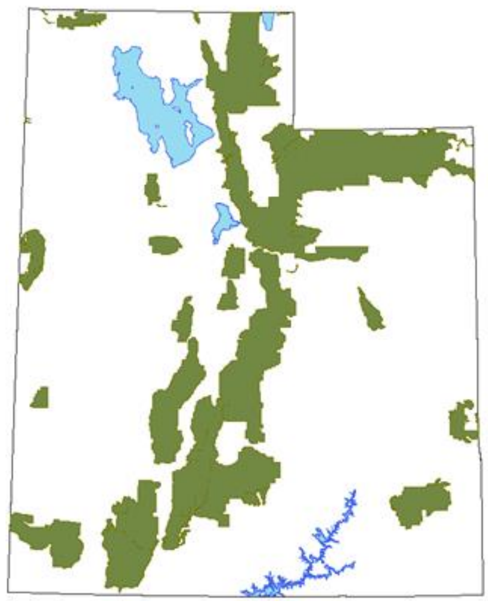


Figure 1. This map depicts Utah's Antidegradation Category 1 and 2 boundaries in green. Division of Water Quality is proposing regional nitrogen and phosphorus numeric criteria for these waters (headwaters) prior to developing numeric nutrient criteria for all waters of the state.

Category 1 and 2 waters are identified in R317-2-12 and include, among others, all stream segments within United States Forest Service (USFS) boundaries, which encompass approximately 8.2 million acres, over 15% of the acreage in Utah. The only Category 1 or 2 streams excluded from these criteria are three small sections of stream, totaling approximately nine river miles. These sections of streams have permitted facilities that were grandfathered an exclusion to the prohibition of discharges in current water quality regulations. Finally, due to the many nuances that can occur incorporating and interpreting this type of criteria, we are referencing in the proposed rule, Table 8: "Decision Matrix That Will Be Used to Assess Support of Headwater Aquatic Life Uses for Nutrient-related Water Quality Problems" found in Attachment 1, *Proposed Nutrient Criteria: Utah Headwater Streams, March 2019*. This table specifies formal water quality assessment decisions depending upon the nutrient tier and ecological responses of the headwater stream being assessed.

Table 1. Numeric Nutrient Criteria and Associated Ecological Responses (Bioconfirmation Criteria) Proposed to Protect Aquatic Life Uses in Antidegradation Category 1 and 2 (UAC R317-2-12)[f] Headwater Perennial Streams

Low Nutrient Enrichment at Headwater Streams: No Ecological Responses			
Summertime Average Nutrients		Assessment Notes	
TN < 0.40[a,b]	TP < 0.035[a,b]	Fully supporting aquatic life uses if the average of ≥ 4 summertime samples is below the specified nutrient concentration of TN and TP unless ecological responses specified for moderate enrichment streams are exceeded that would result in a biological assessment impairment, cause unknown. Sites with fewer samples will not be assessed for nutrients.	
Moderate Nutrient Enrichment at Headwater Streams and Ecological Responses			
Summertime Average Nutrients		Ecological Response	Assessment Notes
TN 0.40– 0.80[a]	TP 0.035– 0.080[a]	Plant/Algal Growth[c] < 1/3 or more filamentous algae cover[d,e] OR GPP[c] of < 6 g O_2/m^2/day or ER[c] of < 5 g O_2/m^2/day	Headwater streams within this range of nutrient concentrations will be considered impaired (not supporting for nutrients) if <u>any</u> response exceeds defined thresholds. Streams <u>without response data</u> will be listed as having <u>insufficient data</u> and prioritized for additional monitoring if either TN or TP falls within the specified range.
High Nutrient Enrichment at Headwater Streams: No Ecological Responses			
Summertime Average Nutrients		Assessment Notes	
TN > 0.80[a,b]	TP > 0.080[a,b]	Streams over these thresholds will initially be placed on Utah's Section 303(d) list as threatened. Threatened streams will be further evaluated using additional data such as nutrient responses, biological assessments, or nutrient-related water quality criteria (e.g., pH and DO) both locally and in downstream waters.	

<u>Notes</u>: Criteria are applicable during the index period of algae growth through senescence unless more restrictive total maximum daily load (TMDL) targets have been established to ensure the attainment and maintenance of downstream waters. DO = dissolved oxygen, ER = ecosystem respiration, GPP = gross primary production, TN = total nitrogen in mg/L, and TP = total phosphorus in mg/L.

a. Seasonal average of ≥ 4 samples collected during the index period will not be exceeded. Sites will be assessed using the higher of TN and TP threshold classifications.

b. Response data, when available, will be used to assess aquatic life use support or as evidence for additional site-specific investigations to confirm impairment or derive and promulgate a site-specific exception to these criteria.

c. Daily whole stream metabolism obtained using open-channel methods. Daily values are not to be exceeded on any collection event.

d. Filamentous algae cover means patches of filamentous algae (> 1 cm in length or mats > 1 mm thick). Not to be exceeded daily stream average, based on at least 3 transects perpendicular to stream flow and spatially dispersed along a reach of at least 50 meters.

e. Quantitative estimates are based on reach-scale averages with at least three measures from different habitat units (i.e., riffle, run) made with quantitative visual estimation methods.

f. Excluded waters identified in UAC R317-2-14, Footnotes for Table 2.14.7 and Table 2.14.8.

ATTACHMENT 1

Proposed Nutrient Criteria: Utah Headwater Streams, March 2019

Available at this location or click link for pdf:
https://deq.utah.gov/legacy/pollutants/n/nutrients/headwater-criteria.htm
DWQ-2019-00234

ATTACHMENT 4

Supporting Documentation for Sheep Creek drinking water use, Silver Creek total dissolved solids, Jordan River ammonia, and human health criteria

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY
WATER QUALITY

Water Quality Standards Revisions Supporting Documentation
Proposed Amendments to R317-2-13, and R317-2-14, Standards of Quality for Waters of the State Published in the April 1, 2019 Utah Bulletin

Note: This document is intended as a companion document to the information published in the April 1, 2019 Utah Bulletin. This document provides supplemental information for a subset of the proposed amendments to R317-2 described in the April 1, 2019 Utah Bulletin. Additional information on the proposed headwaters nutrient criteria and a copy of the markup submitted for publication in the Utah Bulletin are also available on the DWQ website. The information in the Utah Bulletin prevails should any unintentional discrepancies occur between these documents and the Utah Bulletin

Comments will be accepted until 5:00 p.m., May 3, 2019. Comments should be mailed to Christopher Bittner, Utah Division of Water Quality, P.O. Box 144870, SLC, Utah 84114-4870 or e-mailed to cbittner@utah.gov. Comments can be received by phone at 801-536-4371. Comments will also be accepted at the public hearing. The public hearings will be preceded by one hour for DWQ staff to provide additional information and answer general questions. The public hearings to receive comments will be held for a minimum of one hour at the following time and location:

PUBLIC HEARING DATE	TIME	LOCATION
Wednesday, May 1, 2019	6:00 PM	Utah Department of Environmental Quality Multi-State Agency Office Building, Board Room 195 N. 1950 W Salt Lake City, UT 84116

Proposed Standards Revisions

1) Addition of the Class 1C drinking water use to Sheep Creek, Cache County; page 2 and Attachment 1.

2) Revised aquatic life ammonia criteria for portions of Mill Creek, Jordan River, and Surplus Canal, Salt Lake County; page 2 and Attachment 2

3) Revised agricultural use total dissolved solids criterion for a portion of Silver Creek, Summit County; page 4 and Attachment 3

4) Corrections to aquatic life cadmium criteria and human health criteria, statewide; page 5 and Attachment 4

1. Addition of Class 1C drinking water use to portions of the Blacksmith Fork and tributaries from the confluence with Left Hand Fork Blacksmith Fork to headwaters, Cache County. The homeowners association petitioned for this change and the change is supported by the Utah Division of Drinking Water. Their request and a watershed map delineating the proposed change is provided as Attachment 1. The proposed changes to R317-2-13. are:

Blacksmith Fork and tributaries, from confluence with Logan River to headwaters except as listed below		2B 3A	4
Sheep Creek and tributaries from confluence with Blacksmith Fork River to headwaters.	1C	2B 3A	4

2. The following summary is based on the data and findings presented in the *Criteria Support Document: Site-specific criteria based on recalculated aquatic life water quality criteria for ammonia for a segment of Mill Creek and the Jordan River, Salt Lake County, Utah* provided as Attachment 2. Site-specific ammonia criteria for the protection of aquatic life for Mill Creek and a segment of the Jordan River, Salt Lake County are proposed. The criteria apply to Mill Creek from I-15 to the Jordan River, the Jordan River from Mill Creek to 900 South and the Surplus Canal from the Jordan River to 900 South. The proposed criteria are based on the latest scientific information recommended by the EPA (2013). The site-specific criteria are based on the absence of unionid mussels and salmonids (trout) as presented in Appendix N of EPA (2013).

   Unionid mussels have not been discovered in recent surveyed portions of the Jordan River, but historically they were documented to be present in tributaries and were likely present in the Jordan River. Today, this segment of the Jordan River is biologically and chemically degraded as indicated by the water quality impairments identified in Utah's Integrated Report. The mussels rely on a fish host to complete their life cycle and questions remain regarding the suitability of the fish that are present to serve as hosts. There is no evidence that these mussels are present in the identified portions of Mill Creek, Jordan River, Surplus canal, or surrounding watersheds. Therefore, these mussels are unlikely to return within a reasonable planning horizon without human intervention. Efforts to restore the Jordan River are ongoing but are unlikely to be sufficient to support the potential reintroduction of unionid mussels within the reasonable planning horizon of the next 30 years. The Utah Division of Wildlife supports this conclusion and they are responsible for identifying, protecting and reintroducing unionid mussels in Utah waters.

   The current designated uses are to protect warm water aquatic life and do not include salmonids. Additionally, there is no evidence that salmonids reside in this reach of Mill Creek or this reach of Jordan River or Surplus Canal. Therefore, neither unionid mussels nor salmonids are residents for the purpose of determining the ammonia criteria.

In addition to the presence/absence of unionid mussels and salmonids, the ammonia criteria consider the presence of the early life stages of fish, temperature and pH. Early life stages of fish can be more sensitive to ammonia at certain temperatures and pH. When early life stages are more sensitive to ammonia toxicity, the criteria are more stringent for the months that they are present. UDWQ protects for early life stages of fish for those applicable months for which they are likely to occur in the identified reaches of Mill Creek, Jordan River, and Surplus Canal.

As shown in the highlighted font below, the proposed criteria are expressed as mathematical equations that include both pH and temperature:

R317-2-14, Table 2.14.2, Footnote 9

(9a) The thirty-day average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average, the chronic criterion calculated using the following equations.

Fish Early Life Stages are Present:

mg/l as N (Chronic) = $((0.0577/(1+10^{7.688\text{-pH}})) + (2.487/(1+10^{\text{pH-}7.688}))) * \text{MIN}(2.85, 1.45*10^{0.028*(25\text{-T})})$

Fish Early Life Stages are Absent:

mg/l as N (Chronic) = $((0.0577/(1+10^{7.688\text{-pH}})) + (2.487/(1+10^{\text{pH-}7.688}))) * 1.45*10^{0.028*(25\text{-MAX(T,7)})})$

Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River, Fish Early Life Stages are Present:

mg/l as N (Chronic) = $0.9405 * ((0.0278/(1+10^{7.688\text{-pH}})) + ((1.1994/(1+10^{\text{pH-}7.6888}))) * \text{MIN}(6.920,(7.547*10^{0.028*(20\text{-T})})))$

Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River, Fish Early Life Stages are Absent:

mg/L as N (chronic) = $09.405 * (((0.0278/(1+10^{7.688\text{-pH}}))+(1.1994/(1+10^{\text{pH-}7.688}))) * (7.547*10^{0.028*(20\text{-MAX (T,7)})})$

(9b) The one-hour average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average the acute criterion calculated using the following equations.

Class 3A:

mg/l as N (Acute) = $(0.275/(1+10^{7.204\text{-pH}})) + (39.0/1+10^{\text{pH-}7.204}))$

Class 3B, 3C, 3D:

mg/l as N (Acute) = $0.411/(1+10^{7.204\text{-pH}})) + (58.4/(1+10^{\text{pH-}7.204}))$

Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River:

mg/l as N (Acute) = $0.729 * (((0.0114/(1+10^{7.204\text{-pH}}))+(1.6181/(1+10^{\text{pH-}7.204}))) * \text{MIN}(51.93,(62.15*10^{0.036*(20\text{-T})}))$

In addition, the highest four-day average within the 30-day period should not exceed 2.5 times the chronic criterion. The "Fish Early Life Stages are Present" 30-day average total ammonia criterion will be applied by default unless it is determined by the Director, on a site-specific basis, that it is appropriate to apply the "Fish Early Life Stages are Absent" 30-day average criterion for all or some portion of the year. At a minimum, the "Fish Early Life Stages are Present" criterion will apply from the beginning of spawning through the end of the early life stages. Early life stages include the pre-hatch embryonic stage, the post-hatch free embryo or yolk-sac fry stage, and the larval stage for the species of fish expected to occur at the site. The Director will consult with the Division of Wildlife Resources in making
such determinations. The Division will maintain information regarding the waterbodies and time periods where application of the "Early Life Stages are Absent" criterion is determined to be appropriate.

The table below shows an example of the existing and proposed ammonia water quality criteria at a pH of 8.0 and a water temperature of 24°C.

Comparison of Existing Ammonia Criteria to Proposed Criteria at a pH of 8.0 and Temperature of 24°C, Jordan River Segment, Salt Lake County		
	Existing Criteria, (mg/L)	**Proposed Criteria, (mg/L)**
1-hour average	8.4	7.5
30-day average (mg/L) when early life stages of fish present	1.3	2.3
30-day average, when early life stages of fish absent	1.3	2.3

3. The summary below is based on the data and findings presented in the *Criteria Support Document: Use and Value Assessment and Site-specific Criteria for Total Dissolved Soils (TDS): Silver Creek, Version 2.1* provided as Attachment 3. A site-specific total dissolved solids (TDS) criterion to protect the agricultural designated use is proposed for a portion of Silver Creek, Summit County. Specifically, a maximum TDS criterion of 1,900 mg/L is proposed for Silver Creek and tributaries from Tollgate Creek to headwaters.

   Road salting in the Park City area is impacting the water quality of Silver Creek by increasing the concentrations of TDS. The water quality of Silver Creek is also adversely impacted by water diversions and metals contamination from the historic mining activities in the Park City area.

The TDS criterion is intended to protect the agricultural uses of Silver Creek water. After determining that road salt was the primary source of the anthropogenic portion of TDS loadings to Silver Creek, local and state road maintenance agencies were contacted and their best management practices (BMPs) reviewed. BMPs are currently being implemented (primarily liquid potassium chloride pre-treatment of roads, sweeping and metered application) but salt application on private properties remains unregulated. The governmental agencies emphasized the importance of road salting for public safety. This road salting to protect human life and health is considered an irreversible human-caused condition.

After considering all of the current and likely future irrigation practices with Silver Creek water and researching the salt tolerances of the irrigated crops, staff concluded that a higher criterion will protect the agricultural uses. The irrigation uses in this reach are primarily for moderately salt-tolerant pasture grasses. Staff is proposing to change the TDS criterion from 1,200 mg/L to 1,900 mg/L. Although a criterion higher than 1,900 mg/L would likely still be protective of the agricultural uses, limiting the criterion to 1,900 mg/L will support the continued attainment of the 1,200 mg/L criterion downstream.

The following changes to R317-2-13.4 Weber River Basin are recommended by staff.
(a) Weber River Drainage
Weber River and tributaries, from Stoddard diversion to Headwaters, except as listed below
1C 2B 3A 4
Silver Creek and tributaries, from confluence with Weber River to below the confluence with Tollgate Creek
1C 2B 3A 4
Silver Creek and tributaries, from confluence with Tollgate Creek to Headwaters 1C 2B 3A 4*

R317-2-14. Numeric Criteria Table 2.14.1
FOOTNOTE: (4)
Silver Creek and tributaries, Summit County, from confluence with Tollgate Creek to headwaters maximum 1,900 mg/L.

4. In 2018, the Water Quality Board updated several statewide criteria and not all of the changes were made as intended. With the exception of the correction of the aquatic life cadmium criteria in Table 2.14.2, all other corrections are for human health criteria in Tables 2.14.1 and 2.14.6. Attachment 3 is a list of the criteria to be corrected.

ATTACHMENT 1

ATTACHMENT 1: Addition of Class 1C to Sheep Creek, Cache County

ATTACHMENT 1

Sheep Creek Cove Homeowners, Assn. Inc.
4602 W 4950 S
Hooper, UT 84315
February 13, 2017

Ms. Erica Gaddis, Director
Utah Division of Water Quality
P.O. Box 144870
Salt Lake City, UT 84114-4870

Dear Ms. Gaddis:

The Sheep Creek Cove Homeowners Association, Inc. located in Cache County is requesting that Sheep Creek receive a new classification as a Class 1 category water under UAC R317-2. Sheep Creek is part of the Blacksmith Fork Drainage and the property involved with the HOA is located six miles south of Hardware Ranch off the Ant Flat Road.

The following details are included for your use:

Assessment Unit Name: Black Smiths Fork - 2
Assessment Unit Description: Blacksmith Fork and tributaries from confluence with Left Hand Fork Blacksmith Fork to headwaters
Assessment Unit ID: UT16010203-018_00

The Homeowners Association is in the process of obtaining design approval for a culinary water filtration system with the Utah Department of Environmental Quality Drinking Water. This system will augment our existing spring-fed culinary water system which has insufficient flow.

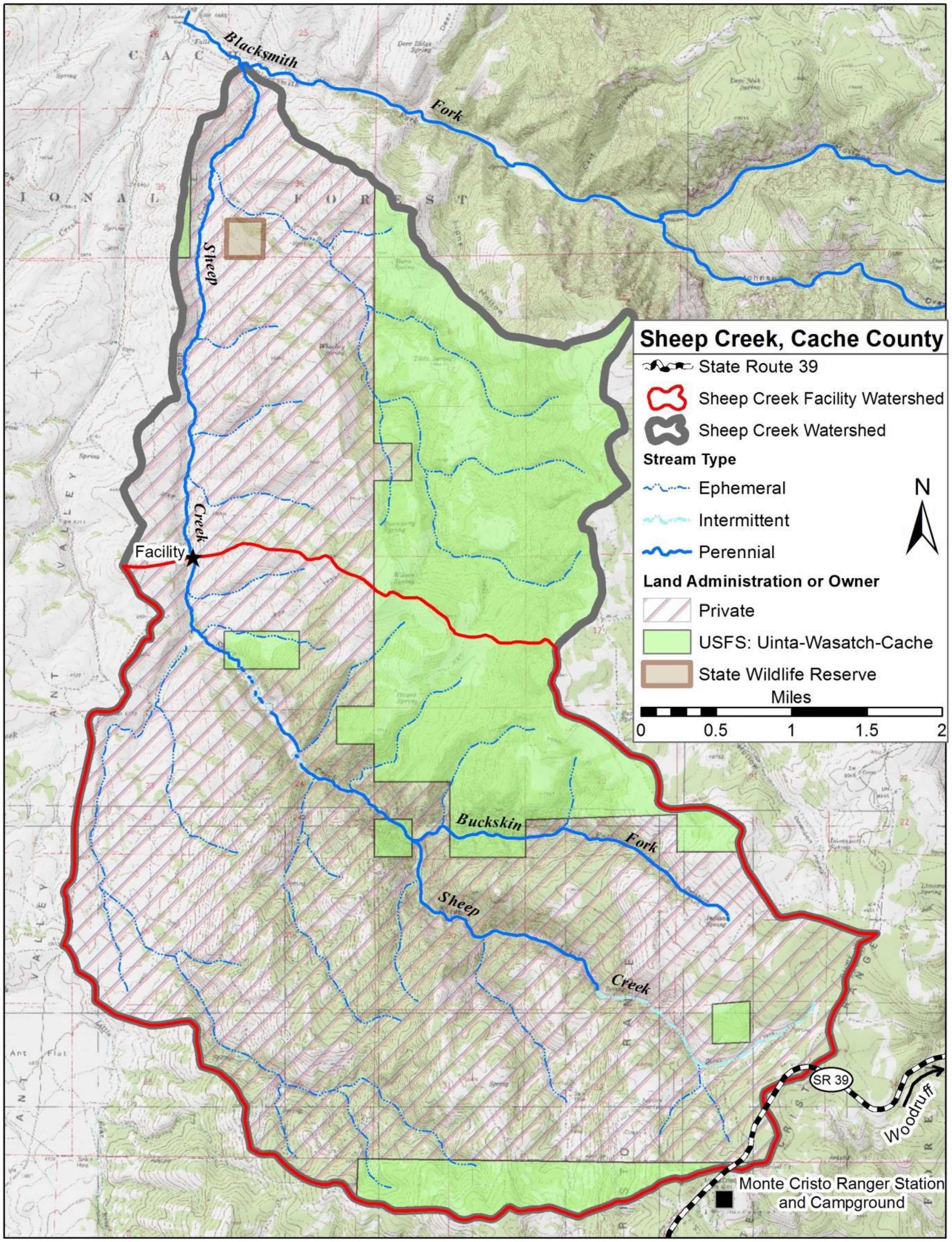
Please let us know if other/additional materials are needed to exact this classification.

Sincerely,

David A. Prevedel, Director
Sheep Creek Cove Homeowners Assn. Inc.

cc: Deidre Beck

ATTACHMENT 1



ATTACHMENT 2

Criteria Support Document: Site-specific criteria based on recalculated aquatic life water quality criteria for ammonia for a segment of Mill Creek and the Jordan River, Salt Lake County, Utah

Available at https://deq.utah.gov/water-quality/guidance-water-quality-standards
DWQ-2018-013091

ATTACHMENT 3

Criteria Support Document: Use and Value Assessment and Site-specific Criteria for Total Dissolved Soils (TDS): Silver Creek, Version 2.2

Available at https://deq.utah.gov/water-quality/guidance-water-quality-standards
DWQ-2019-013090

ATTACHMENT 4

ATTACHMENT 4: Criteria Corrections

ATTACHMENT 4
Criteria Corrections

In the summer of 2018, the Water Quality Board adopted revisions to Utah's human health criteria. The U.S. Environmental Protection Agency identified several discrepancies between the criteria that the supporting documents indicated would be adopted and the criteria that were actually adopted. The U.S. Environmental Protection Agency also identified some additional inconsistencies where MCL-only criteria were not moved from Table 2.14.6 to Table 2.14.1 Class 1C. The table below summarizes the proposed corrections.

The chronic cadmium criterion equation will be corrected as follows:

CADMIUM $CF * e^{(0.7977*\ln(hardness)-3.909)}$

The corrections to the Class 1C criteria in Table 2.14.1 and the human health criteria in Table 2.14.6 are shown in the following table.

ATTACHMENT 4

Human Health Criteria Corrections and Intended Revisions From the Utah 2018 Water Quality Standards Revisions				
CAS	**Pollutant**	**Organism +Water**	**Organism only**	**Explanation**
57-12-5	Cyanide	4	400	Criteria not updated as intended
107-02-8	Acrolein	3		Delete significant figure
117-81-7	Bis(2-Ethylhexyl)Phthalate		0.37	Criteria updated but more stringent than EPA (2015)
85-68-7	Butylbenzyl Phthalate	0.010	0.010	Add significant figure
108-90-7	Chlorobenzene		800	Incorrect CAS # and organism only not updated
124-48-1	Chlorodibromomethane	0.80	21	Criteria not updated as intended
67-66-3	Chloroform	60	2000	Criteria not updated as intended
75-27-4	Dichlorobromomethane	0.95	27	Criteria not updated as intended
74-83-9	Methyl Bromide	100		Old criteria not deleted, result 47100
205-99-2	Benzo(b)fluoranthene		0.0013	Criteria not updated as intended
111-44-4	Bis(2-chloroethylether)			Correct CAS
218-01-9	Chrysene	0.12	0.13	Criteria not updated as intended
53-70-3	Dibenz(a,h)anthracene	0.00012	0.00013	Criteria not updated as intended
91-94-1	3,3-Dichlorobenzidine	0.049		Add significant figure ,revised more stringent than EPA (2015)
84-66-2	Diethyl Phthalate			Correct CAS
121-14-2	2,4-Dinitrotoluene	0.049		Correct criteria, revised less stringent than EPA (2015)
122-66-7	1,2-Diphenylhydrazine	0.03	0.2	Criteria not updated as intended
67-72-1	Hexachloroethane	0.1	0.1	Criteria not updated as intended
621-64-7	N-nitrosodi-n-propylamine	0.0050		Add significant figure to be consistent, no changes were made to act on
120-82-1	1,2,4-Trichlorobenzene	0.071		Add significant figure, revised more stringent than EPA (2015)
319-84-6	Alpha_BHC		0.00039	More stringent than EPA (2015)

ATTACHMENT 4

Human Health Criteria Corrections and Intended Revisions From the Utah 2018 Water Quality Standards Revisions				
319-85-7	Beta-BHC	0.0080		Add significant figure
57-74-9	Chlordane	0.00031		Add significant figure, revised more stringent than EPA (2015)
50-29-2	DDT	0.000030		Revised less stringent than EPA
72-20-8	Endrin		0.03	Old criterion not deleted
8001-35-2	Toxaphene	0.00070		Add significant figure
1912-24-9	Atrazine	3.0		MCL only, moved to Table 2.14.1, need to delete from 2.14.6
75-99-0	Dalapon			MCL only, moved to Table 2.14.1, need to delete from 2.14.6
156-59-2	Dichloroethylene (cis-1,2)			MCL only, move to Table 2.14.1
85-00-7	Diquat			MCL only, moved to Table 2.14.1, need to delete from 2.14.6
1071-83-6	Glyphosate			MCL only, move to Table 2.14.1
1330-20-7	Xylenes			MCL only, move to Table 2.14.1
542-88-1	Bis(2-chloro1methylether)			Delete duplicated entry
108-60-1	Bis(2-chloromethylethylether			Delete duplicated entry
930-55-2	N-Nitrosopyrrolidine			Correct spelling
72-43-5	Methoxychlor			Delete MCL label

ATTACHMENT 5
Utah Bulletin Mark-up of Proposed Amendments

UTAH STATE BULLETIN

OFFICIAL NOTICES OF UTAH STATE GOVERNMENT
Filed March 02, 2019, 12:00 a.m. through March 15, 2019, 11:59 p.m.

Number 2019-7
April 01, 2019

Nancy L. Lancaster, Managing Editor

The *Utah State Bulletin (Bulletin)* is an official noticing publication of the executive branch of Utah state government. The Office of Administrative Rules, part of the Department of Administrative Services, produces the *Bulletin* under authority of Section 63G-3-402.

The Portable Document Format (PDF) version of the *Bulletin* is the official version. The PDF version of this issue is available at https://rules.utah.gov/. Any discrepancy between the PDF version and other versions will be resolved in favor of the PDF version.

Inquiries concerning the substance or applicability of an administrative rule that appears in the *Bulletin* should be addressed to the contact person for the rule. Questions about the *Bulletin* or the rulemaking process may be addressed to: Office of Administrative Rules, PO Box 141007, Salt Lake City, Utah 84114-1007, telephone 801-538-3003. Additional rulemaking information and electronic versions of all administrative rule publications are available at https://rules.utah.gov/.

The information in this *Bulletin* is summarized in the *Utah State Digest (Digest)* of the same volume and issue number. The *Digest* is available by e-mail subscription or online. Visit https://rules.utah.gov/ for additional information.

Office of Administrative Rules, Salt Lake City 84114

Utah state bulletin.
Semimonthly.
1. Delegated legislation--Utah--Periodicals. 2. Administrative procedure--Utah--Periodicals.
I. Utah. Office of Administrative Rules.

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Appendix 2: Regulatory Impact to Non-Small Businesses
No non-small businesses are expected to be impacted by this rulemaking. This rule exempts gasoline dispensing facilities from the permitting process, as they are already regulated under an existing rule. There are no anticipated costs or benefits due to this rule.

The Executive Director of the Department of Environmental Quality, Alan Matheson, has reviewed and approved this fiscal analysis.

R307. Environmental Quality, Air Quality.
R307-401. Permit: New and Modified Sources.
R307-401-10. Source Category Exemptions.

The source categories described in R307-401-10 are exempt from the requirement to obtain an approval order found in R307-401-5 through R307-401-8. The general provisions in R307-401-4 shall apply to these sources.

(1) Fuel-burning equipment in which combustion takes place at no greater pressure than one inch of mercury above ambient pressure with a rated capacity of less than five million BTU per hour using no other fuel than natural gas or LPG or other mixed gas that meets the standards of gas distributed by a utility in accordance with the rules of the Public Service Commission of the State of Utah, unless there are emissions other than combustion products.

(2) Comfort heating equipment such as boilers, water heaters, air heaters and steam generators with a rated capacity of less than one million BTU per hour if fueled only by fuel oil numbers 1 - 6,

(3) Emergency heating equipment, using coal or wood for fuel, with a rated capacity less than 50,000 BTU per hour.

(4) Exhaust systems for controlling steam and heat that do not contain combustion products.

(5) A well site as defined in 40 CFR 60.5430a, including centralized tank batteries, that is not a major source as defined in R307-101-2, and is registered with the Division as required by R307-505.

(6) A gasoline dispensing facility as defined in 40 CFR 63.11132 that is not a major source as defined in R307-101-2. These sources shall comply with the applicable requirements of R307-328 and 40 CFR 63 Subpart CCCCCC: National Emission Standards for Hazardous Air Pollutants for Source Category: Gasoline Dispensing Facilities.

KEY: air pollution, permits, approval orders, greenhouse gases
Date of Enactment or Last Substantive Amendment: [~~March 5, 2018~~]2019
Notice of Continuation: May 15, 2017
Authorizing, and Implemented or Interpreted Law: 19-2-104(3)(q); 19-2-108

Environmental Quality, Water Quality
R317-1-1
Definitions

NOTICE OF PROPOSED RULE
(Amendment)
DAR FILE NO.: 43585
FILED: 03/15/2019

RULE ANALYSIS

PURPOSE OF THE RULE OR REASON FOR THE CHANGE: Definitions are proposed for Ecosystem Respiration, Filamentous Algae Cover, and Gross Primary Production. These terms are only used in Section R317-2-14, proposed Tables 2.14.7 and 2.14.8.

SUMMARY OF THE RULE OR CHANGE: Definitions are added for key terms that are proposed in another filing for Section R317-2-14. Amendments are proposed to Section R317-2-14, Tables 2.14.7 and 2.14.8. (EDITOR'S NOTE: The proposed amendment to Rule R317-2 is under Filing No. 43586 in this issue, April 1, 2019, of the Bulletin.)

STATUTORY OR CONSTITUTIONAL AUTHORIZATION FOR THIS RULE: 40 CFR Part 131 and Title 19, Chapter 5

ANTICIPATED COST OR SAVINGS TO:
♦ THE STATE BUDGET: The purpose of the proposed definitions is to provide clarity. The definitions have no cost impact on state agencies.
♦ LOCAL GOVERNMENTS: The purpose of the proposed definitions is to provide clarity. The definitions have no cost impact on local governments.
♦ SMALL BUSINESSES: The purpose of the proposed definitions is to provide clarity. The definitions have no cost impact on small businesses.
♦ PERSONS OTHER THAN SMALL BUSINESSES, BUSINESSES, OR LOCAL GOVERNMENTAL ENTITIES: The purpose of the proposed definitions is to provide clarity. The definitions have no cost impact on other persons.

COMPLIANCE COSTS FOR AFFECTED PERSONS: There are no estimable additional compliance costs for affected persons.

COMMENTS BY THE DEPARTMENT HEAD ON THE FISCAL IMPACT THE RULE MAY HAVE ON BUSINESSES: The proposed definitions will provide clarity for businesses and fiscal impacts will be neutral.

THE FULL TEXT OF THIS RULE MAY BE INSPECTED, DURING REGULAR BUSINESS HOURS, AT:
ENVIRONMENTAL QUALITY
WATER QUALITY
DEQ, THIRD FLOOR
195 N 1950 W
SALT LAKE CITY, UT 84116
or at the Office of Administrative Rules.

DIRECT QUESTIONS REGARDING THIS RULE TO:
♦ Judy Etherington by phone at 801-536-4344, by FAX at 801-536-4301, or by Internet E-mail at jetherington@utah.gov

INTERESTED PERSONS MAY PRESENT THEIR VIEWS ON THIS RULE BY SUBMITTING WRITTEN COMMENTS NO LATER THAN AT 5:00 PM ON 05/03/2019

INTERESTED PERSONS MAY ATTEND A PUBLIC HEARING REGARDING THIS RULE:
♦ 05/01/2019 06:00 PM, MASOB, 195 N 1950 W, DEQ Board Room, Salt Lake City, UT

THIS RULE MAY BECOME EFFECTIVE ON: 05/22/2019

AUTHORIZED BY: Erica Gaddis, Director

Appendix 1: Regulatory Impact Summary Table*

Fiscal Costs	FY 2019	FY 2020	FY 2021
State Government	$0	$0	$0
Local Government	$0	$0	$0
Small Businesses	$0	$0	$0
Non-Small Businesses	$0	$0	$0
Other Person	$0	$0	$0
Total Fiscal Costs:	**$0**	**$0**	**$0**
Fiscal Benefits			
State Government	$0	$0	$0
Local Government	$0	$0	$0
Small Businesses	$0	$0	$0
Non-Small Businesses	$0	$0	$0
Other Persons	$0	$0	$0
Total Fiscal Benefits:	**$0**	**$0**	**$0**
	$0	$0	$0
Net Fiscal Benefits:	**$0**	**$0**	**$0**

***This table only includes fiscal impacts that could be measured. If there are inestimable fiscal impacts, they will not be included in this table. Inestimable impacts for State Government, Local Government, Small Businesses and Other Persons are described above. Inestimable impacts for Non-Small Businesses are described below.**

Appendix 2: Regulatory Impact to Non-Small Businesses
The purpose of the proposed definitions is to provide clarity. The definitions have no cost impact on non-small businesses.

R317. Environmental Quality, Water Quality.
R317-1. Definitions and General Requirements.
R317-1-1. Definitions.

Note that some definitions are repeated from statute to provide clarity to readers.

"Assimilative Capacity" means the difference between the numeric criteria and the concentration in the waterbody of interest where the concentration is less than the criterion.

"Biological assessment" means an evaluation of the biological condition of a water body using biological surveys and other direct measurements of composition or condition of the resident living organisms.

"Biological criteria" means numeric values or narrative descriptions that are established to protect the biological condition of the aquatic life inhabiting waters that have been given a certain designated aquatic life use.

"Board" means the Utah Water Quality Board.

"BOD" means 5-day, 20 degrees C. biochemical oxygen demand.

"Body Politic" means the State or its agencies or any political subdivision of the State to include a county, city, town, improvement district, taxing district or any other governmental subdivision or public corporation of the State.

"Building sewer" means the pipe which carries wastewater from the building drain to a public sewer, a wastewater disposal system or other point of disposal. It is synonymous with "house sewer".

"CBOD" means 5-day, 20 degrees C., carbonaceous biochemical oxygen demand.

"Challenging Party" means a Person who has or is seeking a permit in accordance with Title 19, Chapter 5, the Utah Water Quality Act and chooses to use the independent peer review process to challenge a Proposal as defined in Subsection 19-5-105.3(1)(a).

"COD" means chemical oxygen demand.

"Conflict of Interest" means a Person who has any financial or other interest which has the potential to negatively affect services to the Division or Challenging Party because it could impair the individual's objectivity or it could create an unfair competitive advantage for any Person or organization.

"Deep well" means a drinking water supply source which complies with all the applicable provisions of the State of Utah Public Drinking Water rules.

"Digested sludge" means sludge in which the volatile solids content has been reduced by at least 38% using a suitable biological treatment process.

"Director" means the Director of the Division of Water Quality.

"Division" means the Utah State Division of Water Quality.

"Domestic wastewater" means a combination of the liquid or water-carried wastes from residences, business buildings, institutions, and other establishments with installed plumbing facilities, together with those from industrial establishments, and with such ground water, surface water, and storm water as may be present. It is synonymous with the term "sewage".

"Ecosystem respiration (ER)" means the spatially explicit rate of organic degradation derived from open channel, diel stream oxygen models.

"Effluent" means the liquid discharge from any unit of a wastewater treatment works, including a septic tank.

"Existing Uses" means those uses actually attained in a water body on or after November 28, 1975, whether or not they are included in the water quality standards.

"Expert" means a person with technical expertise, knowledge, or skills in a subject matter of relevance to a specific water quality investigation, HISA, or Proposal including persons from other regulatory agencies, academia, or the private sector.

"Filamentous Algae Cover" means patches of filamentous algae greater than 1 cm in length or mats greater than 1 mm thick, expressed as the proportion of visible stream bed where it is observed and where it is not.

"Gross primary production" means the spatially explicit rate of autotrophic biomass formation derived from open channel, diel stream oxygen models.

"Human-induced stressor" means perturbations directly or indirectly caused by humans that alter the components, patterns, and/or processes of an ecosystem.

"Human pathogens" means specific causative agents of disease in humans such as bacteria or viruses.

"Highly Influential Scientific Assessment (HISA)" means a Scientific Assessment developed by the Division or an external Person, that has material relevance to a decision by the Division, and the Director determines could have a significant financial impact on either the public or private sector or is novel, controversial, or precedent-setting, and is not a new or renewed permit issued to a Person.

"Independent Peer Review" means scientific review conducted on request from a Challenging Party in accordance with Section 19-5-105.3 and is a subcategory of Independent Scientific Review.

"Independent Scientific Review" means any technical or scientific review conducted by Experts in an area related to the material being reviewed who were not directly or indirectly involved with the development of the material to be reviewed and who do not have a real or perceived conflict of interest. When an Independent Peer Review is conducted, the conditions in Subsection 19-5-105.3(5) shall apply.

"Industrial wastes" means the liquid wastes from industrial processes as distinct from wastes derived principally from dwellings, business buildings, institutions and the like. It is synonymous with the term "industrial wastewater".

"Influent" means the total wastewater flow entering a wastewater treatment works.

"Great Salt Lake impounded wetland" means wetland ponds which have been formed by dikes or berms to control and retain the flow of freshwater sources in the immediate proximity of Great Salt Lake.

"Large underground wastewater disposal system" means the same type of device as an onsite wastewater system except that it is designed to handle more than 5,000 gallons per day of domestic wastewater, or wastewater that originates in multiple dwellings, commercial establishments, recreational facilities, schools, or any other underground wastewater disposal system not covered under the definition of an onsite wastewater system. The Division controls the installation of such systems.

"Onsite wastewater system" means an underground wastewater disposal system for domestic wastewater which is designed for a capacity of 5,000 gallons per day or less and is not designed to serve multiple dwelling units which are owned by separate owners except condominiums and twin homes. It usually consists of a building sewer, a septic tank and an absorption system.

"Operating Permit" is a State issued permit issued to any wastewater treatment works covered under Rules R317-3 or R317-5 with the following exceptions:

A. Any wastewater treatment permitted under Ground Water Quality Protection Rule R317-6.

B. Any wastewater treatment permitted under Underground Injection Control (UIC) Program Rule R317-7.

C. Any wastewater treatment permitted under Utah Pollutant Discharge Elimination System (UPDES) Rule R317-8.

D. Any wastewater treatment permitted under Approvals and Permits for a Water Reuse Project Rule R317-13.

E. Any wastewater treatment permitted by a Local Health Department under Onsite Wastewater Systems Rule R317-4.

"Person" means any individual, trust, firm, estate, company, corporation, partnership, association, state, state or federal agency or entity, municipality, commission, or political subdivision of a state.

"Point source" means any discernible, confined and discrete conveyance including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flow from irrigated agriculture.

"Pollution" means such contamination, or other alteration of the physical, chemical, or biological properties of any waters of the state, or such discharge of any liquid, gaseous or solid substance into any waters of the state as will create a nuisance or render such waters harmful or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.

"Proposal" means any science-based initiative proposed by the division on or after January 1, 2016, that would financially impact a Challenging Party and that would:

A. change water quality standards;

B. develop or modify total maximum daily load requirements;

C. modify wasteloads or other regulatory requirements for permits; or

D. change rules or other regulatory guidance. A Proposal is not an individual permit issued to a Person, nor is it a technology based limit applied in accordance with Effluent limitations, 33 U.S.C. Sec. 1311, National pollutant discharge elimination system, 33 U.S.C. Sec. 1342, and Information and guidelines, 33 U.S.C. Sec. 1314.

"Regulatory requirements" for permits means the methods or policies used by the Division to derive permit limits such as wasteload analyses, reasonable potential determinations, whole effluent toxicity policy, interim permitting guidance, antidegradation reviews, or Technology Based Nutrient Effluent Limit requirements.

"Scientific Assessment" means an evaluation of a body of credible scientific or technical knowledge that synthesizes scientific literature, data analysis and interpretation, and models, and includes any assumptions used to bridge uncertainties in the available information.

"Scientific basis" means empirical data or other scientific findings, conclusions, or assumptions used as the justification for a rule, regulatory guidance, or a regulatory tool.

"Scientifically necessary to protect the designated beneficial uses of a waterbody" as referenced in Subsection 19-5-105.3(8) means a Technology Based Nutrient Effluent Limit that under current and future growth projections, will:

A. prevent circumstances that would cause or contribute to an impairment of any designated or existing use in the receiving water or downstream water bodies based on Utah's water quality standards, Section R317-2-7; or

B. improve water quality conditions that are causing or contributing to any existing impairment in the receiving water or downstream water bodies, as defined by Utah's water quality standards, Section R317-2-7.

"Sewage" is synonymous with the term "domestic wastewater".

"Shallow well" means a well providing a source of drinking water which does not meet the requirements of a "deep well".

"Sludge" means the accumulation of solids which have settled from wastewater. As initially accumulated, and prior to treatment, it is known as "raw sludge".

"SS" means suspended solids.

"Technology Based Nutrient Effluent Limit" means maximum nutrient limitations based on the availability of technology to achieve the limitations, rather than based on a water quality standard or a total maximum daily load.

Total Maximum Daily Load (TMDL) means the maximum amount of a particular pollutant that a waterbody can receive and still meet state water quality standards, and an allocation of that amount to the pollutant's sources.

"Treatment works" means any plant, disposal field, lagoon, dam, pumping station, incinerator, or other works used for the purpose of treating, stabilizing or holding wastes. (Section 19-5-102).

"TSS" means total suspended solids.

"Underground Wastewater Disposal System" means a system for underground disposal of domestic wastewater. It includes onsite wastewater systems and large underground wastewater disposal systems.

"Use Attainability Analysis" means a structured Scientific Assessment of the factors affecting the attainment of the uses specified in Section R317-2-6. The factors to be considered in such an analysis include the physical, chemical, biological, and economic use removal criteria as described in 40 CFR 131.10(g) (1-6).

"Wastes" means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (Section 19-5-102).

"Wastewater" means sewage, industrial waste or other liquid substances which might cause pollution of waters of the state. Intercepted ground water which is uncontaminated by wastes is not included.

"Waters of the state" means all streams, lakes, ponds, marshes, water-courses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon this state or any portion thereof, except that bodies of water confined to and retained within the limits of private property, and which do not develop into or constitute a nuisance, or a public health hazard, or a menace to fish and wildlife, shall not be considered to be "waters of the state" under this definition (Section 19-5-102).

"Water Quality Based Effluent Limit (WQBEL)" means an effluent limitation that has been determined necessary to ensure that water quality standards in a receiving body of water will not be violated.

KEY: TMDL, water pollution
Date of Enactment or Last Substantive Amendment: [~~May 24, 2018~~]2019
Notice of Continuation: August 30, 2017
Authorizing, and Implemented or Interpreted Law: 19-5

Environmental Quality, Water Quality
R317-2
Standards of Quality for Waters of the State

NOTICE OF PROPOSED RULE
(Amendment)
DAR FILE NO.: 43586
FILED: 03/15/2019

RULE ANALYSIS

PURPOSE OF THE RULE OR REASON FOR THE CHANGE: This rule is being changed to update formatting; correct errors; add a potable water designated use to Sheep Creek requested by a homeowners association; revise the total dissolved solids criterion for Silver Creek to resolve the existing water quality impairment; update the aquatic life ammonia criteria for a section of the Jordan River to be less stringent; provide flexibility for field methods in Section R317-2-10; and apply nutrient criteria to specific Category 1 and Category 2 waters to protect the recreational and aquatic life uses.

SUMMARY OF THE RULE OR CHANGE: LABORATORY AND FIELD ANALYSES: In Section R317-2-10, a clause was added to provide flexibility of field methods that are different than Division of Water Quality standard procedures. SHEEP CREEK USE CHANGE: The Class 1C designated use (drinking water source) was applied to Sheep Creek, Cache County based on a request from a homeowners association and the Utah Division of Drinking Water. SILVER CREEK TDS CRITERION: The total dissolved solids (TDS) criterion was revised for upper Silver Creek in Summit County from 1,200 mg/L to 1,900 mg/L in Table 2.14.1. JORDAN RIVER AMMONIA CRITERIA: The aquatic life criteria for ammonia for segments of the Jordan River, Surplus Canal, and Mill Creek, Salt Lake County were changed based on updated information regarding the toxicity of ammonia and studies characterizing the aquatic life in these segments in Table 2.14.2. NUTRIENT CRITERIA: In Section R317-2-14 (Numeric Criteria), new Table 2.14.7 was added for nutrient criteria applicable to Antidegradation Category 1 and 2 waters statewide. These criteria are needed to ensure that Utah's headwaters continue to deliver high quality water to, for instance, drinking water. Nitrogen and phosphorus (nutrients) criteria were developed and applied to Category 1 and Category 2 waters in new Tables 2.14.7 and 2.14.8. UPDATES AND CORRECTIONS: In Section R317-2-14, Tables 2.14.1 and 2.14.6, several corrections were made to the statewide human health criteria. The aquatic life cadmium chronic criterion formula was corrected. The corrections to Tables 2.14.1, 2.14.2 and 2.14.6 were because the 2018 revisions (Utah State Bulletin, No. 2018-7, April 1, 2018, Filing No. 42691) were not implemented as intended.

STATUTORY OR CONSTITUTIONAL AUTHORIZATION FOR THIS RULE: 40 CFR Part 131 and Title 19, Chapter 5

MATERIALS INCORPORATED BY REFERENCE:

♦ Adds Table 8, Decision Matrix That Will Be Used to Assess Support of Headwater Aquatic Life Uses for Nutrient-related Water Quality Problems, "Proposed Nutrient Criteria: Utah Headwater Streams", published by Utah Division of Water Quality, 03/01/2019

ANTICIPATED COST OR SAVINGS TO:

♦ THE STATE BUDGET: SUMMARY: No direct costs will be incurred by state agencies because no state agency is a constrained party. The Utah Division of Water Quality will incur indirect costs that are estimated to be a one-time cost of $6,400 and aggregate annual costs of $4,500 over the next 3 years ($8,000/year of increased costs associated with nutrient criteria monitoring offset by $6,500/year of cost savings associated with reduced monitoring on Silver Creek). These costs will be absorbed through agency process efficiencies. LABORATORY AND FIELD ANALYSES: The proposed revision to Section R317-2-10 Laboratory and Field Analyses is cost neutral or will cause indirect costs for state agencies. The indirect costs would be to the Division of Water Quality for the staff time required to review the alternative methods allowed by the proposed revision. The indirect costs are inestimable because no data is available regarding how many alternative methods may be proposed by entities external to the Division of Water Quality. Currently, this type of request is infrequent but is estimated to require 120 hours of staff time at $100/hr for review should any methods be submitted for approval. No requests are anticipated over the next three years. SHEEP CREEK USE CHANGE: The addition of the Class 1C use to Sheep Creek is cost neutral because no additional resources are required for its implementation. SILVER CREEK TDS CRITERION: The proposed TDS criterion for upper Silver Creek will result in ongoing indirect benefits of $6,500 annually for the Utah Division of Water Quality, which is deducted from annual costs for purposes of overall evaluation of these proposed changes to this rule. These savings are based on the resolution of the existing TDS water quality impairment and an elimination of 8 sampling trips per year, 8 hours per trip specifically for TDS measurements, at $100/hr. JORDAN RIVER AMMONIA CRITERIA: The proposed ammonia criteria for segments of the Jordan River, Surplus Canal, and Mill Creek are cost neutral because no additional resources will be required for their implementation. NUTRIENT CRITERIA: The proposed nutrient criteria in Section R317-2-14 will result in net one-time and ongoing indirect costs to the Division of Water Quality. The one-time costs will be to update the use classifications and criteria in various internal systems. The one-time indirect fiscal impacts will be $1,400 assuming four hours to update each of the four databases at $100/hr and $5,000 for 5 new probes to measure ecosystem respiration and gross primary production. Anticipated ongoing indirect costs are for the implementation of new sampling and analysis methods to support assessment of the proposed nutrient criteria and are estimated to be $24,000 over the next 3 years ($8,000/year). The nutrient criteria require new measures of gross primary production, ecosystem respiration and filamentous algae. Costs are dependent on the number of sites sampled which depends on the available existing resources. Additional labor costs associated with the collection of requisite data is estimated based on an average of 40 site visits and an additional 0.5 hourS for a field crew of 2 on each visitation; and 4 hours for one staff for calculating and processing the gross primary production and ecosystem respiration data for approximately 10 sites annually, resulting in an annual expense of approximately $8,000. If water quality impairments are identified by the nutrient criteria, the Division of Water Quality will incur inestimable indirect costs to further investigate and if appropriate, restore the impaired water quality. Long term costs to the Division of Water Quality to address nutrient-related impairments are also inestimable because actions taken are situational and often deferred by state or federal grants. The proposed nutrient criteria in Section R317-2-14 may result in indirect inestimable costs to state of Utah land management agencies. These agencies are not constrained parties, but water quality nutrient impairments could potentially result in increased costs associated with nutrient management. However, these impacts are unlikely to be significant because the affected activities have to occur in an area co-located with an impaired stream and have been demonstrated to be contributing to the impairment as a source of nitrogen or phosphorus to the stream. Further, implementation measures to address nonpoint sources of pollution are voluntary and are often offset by state and federal nonpoint source grants. New impairments resulting from the proposed nutrient criteria are not anticipated over the next three years, because the Division of Water Quality has a biannual reporting cycle for making impairment determinations, with the first report relevant to these criteria planned for 2022. Plans to restore impairments cannot be developed or implemented until impaired waters are identified. As a result, immediate costs associated with new impairments are anticipated to be neutral, exceptions being inestimable. Once impairment decisions are ultimately made, additional indirect costs are inestimable, but likely to be relatively small in size and scope. Based on currently available data, approximately 10-15% of the affected streams may ultimately be classified as impaired, meaning water quality does not meet the proposed nutrient criteria, but these estimates are statistical and additional indirect expense increases, if any, are expected to vary considerably on a case-by-case basis. Even for potentially affected activities that are co-located on an impaired stream, increased indirect costs are not inevitable. Impairment determinations trigger additional investigations that are conducted by the Utah Division of Water Quality or other interested parties. Only after the additional investigations, is a final determination made regarding impairment and sources of nutrient pollution. For those activities ultimately found to be contributing to a nutrient-related impairment as a source of nitrogen and phosphorus, costs are inestimable because there are generally many ways that their contribution to the impairment can be resolved, some of which may be revenue neutral. Given the relatively small number of anticipated impairments and the voluntary nature of implementation measures, the proposed nutrient criteria will be revenue neutral. UPDATES AND CORRECTIONS: There are no costs or benefits associated with the remaining updates and corrections to Section R317-2-14.

♦ LOCAL GOVERNMENTS: SUMMARY: The impact of these proposed changes on local governments are inestimable benefits. LABORATORY AND FIELD ANALYSES: Local governments are not constrained parties for the proposed revision to Section R317-2-10 because local governments are not required to conduct field analyses. For indirect effects to local governments, the proposed revision is cost neutral or will have inestimable benefits. The proposed revision provides optional flexibility on acceptable analytical methods that the Division of Water Quality is willing to use to interpret water quality regulations. Presumably, local governments will only exercise this option to submit alternative methods for agency approval if it is cost neutral or a benefit. No data is available to estimate the frequency or specifics of these potential requests. SHEEP CREEK USE CHANGE: The impacts are neutral for the addition of the Class 1C use to Sheep Creek in Section R317-2-13 because no local governments are constrained or affected. SILVER CREEK TDS CRITERION: The Snyderville Basin Water Reclamation District (District) and Park City are the constrained parties for the proposed site-specific TDS criterion. The proposed TDS criterion is less stringent than the existing criterion and will result in benefits that are inestimable. Under the existing TDS criterion, additional treatment to comply was estimated by the District to be $120,873,000 in capital costs and $2,710,000 for annual operating costs using 2013 dollars. The estimates did not include disposal of the brine waste that would be generated by the treatment process which is expected to be a significant additional cost. These treatment cost estimates are expected to meet the threshold that would cause widespread social and economic harm for compliance. Treatment is not required above this social and economic harm threshold under either federal or Utah requirements. The actual realized benefits are inestimable because the economic analyses are unavailable to calculate an accurate cost savings; that is, based on avoiding economic harm, how much the District would have had to spend for compliance; but the proposed changes would result in considerable savings to the District. The impacts to the other constrained party, Park City, are neutral because their permitted discharges are below the existing TDS criterion and are unaffected by the change in rule. JORDAN RIVER AMMONIA CRITERIA: The Central Valley Water Reclamation Facility (CVWRF) is the only constrained local government affected by the Jordan River, Surplus Canal, and Mill Creek ammonia criteria in Section R317-2-14. The proposed ammonia criteria are less stringent than the existing criteria and will result in inestimable compliance benefits. Less stringent criteria will result in less stringent effluent limits but ammonia effluent limits are also dependent on quantity of water available for dilution, ambient ammonia concentrations in the receiving waters, pH of the receiving waters, and temperature of the receiving waters. These other factors may result in higher or lower effluent limits but in all cases, the effluent limits will be less stringent than they would be under the existing ammonia criteria and under newly promulgated federal ammonia criteria. Over the next three years, the indirect cost impacts are anticipated to be neutral. However, under the less stringent proposed ammonia criteria, CVWRF anticipates delaying or avoiding significant future capital and operational costs that could be required for the treatment of ammonia compared to the existing ammonia criteria. For instance, capital costs for aeration tank and blower capacity expansion required to meet a lower ammonia criteria are estimated to be $10,000,000 to $15,000,000. NUTRIENT CRITERIA: Local governments are not constrained parties for the proposed nutrient criteria in Tables 2.14.7 and 2.14.8 because this rule does not apply to any stream that receives a municipal discharge. All 29 of Utah's counties include some Category 1 or Category 2 waters. Indirect impacts will be neutral or inestimable benefits. The inestimable indirect benefits are based on the potential future avoidance of additional treatment costs for drinking water or obtaining alternative sources of drinking water because of adverse nutrient-related impacts. Many nutrient-related effects have been demonstrated to have adverse impacts to recreation, so municipalities with economies that are heavily dependent on outdoor recreation may experience inestimable benefits if these rules prevent or diminish these problems. UPDATES AND CORRECTIONS: The proposed revisions to Table 2.14.6 are statewide, therefore publicly-owned treatment works are constrained parties. Local governments that operate sewer collection systems only, having no treatment works, may be indirectly affected. The impacts for both direct and indirect impacts are neutral because no local government currently has limits for these specific pollutants and this status is not expected to change.

♦ SMALL BUSINESSES: SUMMARY: The impact of these proposed changes on small businesses are neutral or will result in inestimable costs. LABORATORY AND FIELD ANALYSES: Small businesses are not constrained parties for the proposed revision to Section R317-2-10 Laboratory and Field Analyses because small businesses are not required to conduct field analyses. For indirect effects to small businesses, the proposed revision is cost neutral or will have inestimable benefits. The proposed revision provides optional flexibility. Presumably, small businesses will only exercise these options if they are cost neutral or a benefit. No data is available to estimate the frequency or specifics of these potential requests. SHEEP CREEK USE CHANGE: The impacts are neutral for the addition of the Class 1C use to Sheep Creek in Section R317-2-13 because no small businesses are constrained or affected. SILVER CREEK TDS CRITERION: No small businesses are constrained by the proposed Silver Creek TDS criteria in Section R317-2-14 and direct effects are neutral because no small businesses have TDS effluent limits for the affected waters. Small businesses discharging to publically-owned treatment works may be affected indirectly if they discharge high levels of TDS. These indirect costs are inestimable because no small businesses currently have pretreatment limits for TDS. JORDAN RIVER AMMONIA CRITERIA: No small businesses are constrained by the proposed Jordan River ammonia criteria in Section R317-2-14 and direct effects are neutral because no small businesses have ammonia effluent limits for the affected waters. Small businesses discharging to CVWRF may be affected indirectly if they discharge high levels of ammonia. These indirect costs are inestimable because no small businesses currently discharging to CVWRF have pretreatment limits for ammonia. NUTRIENT CRITERIA: Small businesses are not constrained parties by the proposed nutrient criteria in Section R317-2-14. Small businesses could be impacted by indirect costs due to actions by federal or state land management agencies. These agencies grant leases and permits (hereafter in this section, permits refers to both) for small businesses to conduct activities such as recreation, oil and gas exploration and production, mining, timber harvesting, and grazing on state or federal lands. The land management agencies may elect to modify their leasing or permitting programs to implement best management practices (BMPs) if the activity is determined to cause or contribute to a nutrient impairment and these modifications may result in neutral impacts or increased indirect costs to the permittees. However, these impacts are unlikely to be significant because the affected permitted activities would have to occur in an area co-located with an impaired stream and have been demonstrated to be contributing to the impairment as a source of nitrogen or phosphorus to the stream. Further, implementation measures to address nonpoint sources of pollution are voluntary and are often offset by state and federal nonpoint source grants. New impairments resulting from the proposed nutrient criteria are not anticipated over the next three years, because the Division of Water Quality has a biannual reporting cycle for making impairment determinations, with the first report relevant to these criteria planned for 2022. Plans to restore impairments cannot be developed or implemented until impaired waters are identified. As a result, immediate costs associated with new impairments are anticipated to be neutral, exceptions being inestimable. Once impairment decisions are ultimately made, additional indirect costs to permittees are inestimable, but likely to be relatively small in size and scope. Based on currently available data, approximately 10-15% of the affected streams may ultimately be classified as impaired, defined as water quality not meeting the proposed nutrient criteria, but these estimates are statistical and additional indirect expense increases, if any, are expected to vary considerably on a case-by-case basis. Even for potentially affected permittees that are co-located on an impaired stream, increased indirect costs are not inevitable. Impairment determinations trigger additional investigations that are conducted by the Utah Division of Water Quality or other interested parties. Only after the additional investigations, is a final determination made regarding impairment and sources of nutrient pollution. For those permittees ultimately found to be contributing to a nutrient-related impairment as a source of nitrogen and phosphorus, costs are inestimable because there are generally many ways that their contribution to the impairment can be resolved, some of which may be revenue neutral. Costs for other remediation options are often offset through state and federal grants. Interested parties will generally evaluate all possible solutions when crafting restoration plans, and will attempt to select the most cost-effective solutions that are likely to lead to desired water quality improvements. Given the relatively small number of anticipated impairments and the voluntary nature of implementation measures, the proposed nutrient criteria are most likely to be revenue neutral. UPDATES AND CORRECTIONS: There are no costs or benefits associated with the remaining updates and corrections to Section R317-2-14.

♦ PERSONS OTHER THAN SMALL BUSINESSES, BUSINESSES, OR LOCAL GOVERNMENTAL ENTITIES: SUMMARY: The impact of these proposed changes are neutral or will result in inestimable indirect costs for other persons. LABORATORY AND FIELD ANALYSES: Other persons are not constrained parties for the proposed revision to Section R317-2-10 Laboratory and Field Analyses because they are not required to conduct field analyses. SHEEP CREEK USE CHANGE: Indirect impacts are neutral or positive for the addition of the Class 1C use to Sheep Creek in Section R317-2-13 because no persons are constrained. The residents comprising the homeowners association that requested change may have indirect savings because of costs avoided for water treatment or for health care costs from ingesting contaminated drinking water. These indirect savings are inestimable because these are potential future savings since the affected waters currently meet the drinking water requirements. The indirect cost impacts will be neutral for the affected homeowners association that requested the change because the creek currently is meeting the Class 1C requirements. SILVER CREEK TDS CRITERION: The proposed TDS criterion for Silver Creek in Section R317-2-14 does not affect any other persons. JORDAN RIVER AMMONIA CRITERIA: The proposed ammonia criteria for the Jordan River in Section R317-2-14 do not affect any other persons. NUTRIENT CRITERIA: No constrained other persons are affected by the proposed nutrient criteria in Section R317-2-14. Other persons could be impacted by indirect costs due to actions by state or federal land management agencies. These agencies grant leases and permits (hereafter in this section, permits refers to both) for other persons to conduct activities such as recreation, oil and gas exploration and production, mining, timber harvesting, and grazing on state or federal lands. The land management agency may elect to modify their leasing or permitting programs to implement BMPs if the activity is determined to cause or contribute to a nutrient impairment and these modifications may result in neutral impacts or increased indirect costs to the permittees. However, these impacts are unlikely to be significant because the affected permitted activities would have to occur in an area co-located with an impaired stream and have been demonstrated to be contributing to the impairment as a source of nitrogen or phosphorus to the stream. Further, implementation measures to address nonpoint sources of pollution are voluntary and are often offset by state and federal nonpoint source grants. New impairments resulting from the proposed nutrient criteria are not anticipated over the next three years, because the Division of Water Quality has a biannual reporting cycle for making impairment determinations, with the first report relevant to these criteria planned for 2022. Plans to restore impairments cannot be developed or implemented until impaired waters are identified. As a result, immediate costs associated with new impairments are anticipated to be neutral, exceptions being inestimable. Once impairment decisions are ultimately made, additional indirect costs to permitted other persons are inestimable, but likely to be relatively small in size and scope. Based on currently available data, approximately 10-15% of the affected streams may ultimately be classified as impaired, meaning water quality is not meeting the proposed nutrient criteria, but these estimates are statistical and additional indirect expense increases, if any, are expected to vary considerably on a case-by-case basis. Even for potentially affected permitted persons that are co-located on an impaired stream, increased indirect costs are not inevitable. Impairment determinations trigger additional investigations that are conducted by the Utah Division of Water Quality or other interested parties. Only after the additional investigations, is a final determination made regarding impairment and sources of nutrient pollution. For those persons ultimately found to be contributing to a nutrient-related impairment as a source of nitrogen and phosphorus, costs are inestimable because there are generally many ways that their contribution to the impairment can be resolved, some of which may be revenue neutral. Costs of other remediation options with the potential to increase indirect costs are often offset through state and federal grants. Interested parties will generally evaluate all possible solutions when crafting restoration plans, and will attempt to select the most cost-effective solutions that are likely to lead to desired water quality improvements. Given the relatively small number of anticipated impairments and the voluntary nature of implementation measures, the proposed nutrient criteria are most likely to be revenue neutral. UPDATES AND CORRECTIONS: No other affected persons are identified for the remaining proposed changes.

COMPLIANCE COSTS FOR AFFECTED PERSONS: No estimable additional compliance costs are expected for affected persons.

COMMENTS BY THE DEPARTMENT HEAD ON THE FISCAL IMPACT THE RULE MAY HAVE ON BUSINESSES: For most of these proposed revisions, the fiscal impacts are revenue neutral or will result in modest cost savings for businesses. The proposed nutrient criteria have the potential to increase indirect costs for a small percentage of permittees on state or federal lands, although the amount cannot be estimated at this time. The Department is aware of these potential cost increases and is committed to working with interested parties to develop implementation approaches that minimize increases in indirect costs to the greatest extent possible.

THE FULL TEXT OF THIS RULE MAY BE INSPECTED, DURING REGULAR BUSINESS HOURS, AT:

ENVIRONMENTAL QUALITY
WATER QUALITY
DEQ, THIRD FLOOR
195 N 1950 W
SALT LAKE CITY, UT 84116
or at the Office of Administrative Rules.

DIRECT QUESTIONS REGARDING THIS RULE TO:
♦ Judy Etherington by phone at 801-536-4344, by FAX at 801-536-4301, or by Internet E-mail at jetherington@utah.gov

INTERESTED PERSONS MAY PRESENT THEIR VIEWS ON THIS RULE BY SUBMITTING WRITTEN COMMENTS NO LATER THAN AT 5:00 PM ON 05/03/2019

INTERESTED PERSONS MAY ATTEND A PUBLIC HEARING REGARDING THIS RULE:
♦ 05/01/2019 06:00 PM, MASOB, 195 N 1950 W, DEQ Board Room, Salt Lake City, UT

THIS RULE MAY BECOME EFFECTIVE ON: 05/22/2019

AUTHORIZED BY: Erica Gaddis, Director

Appendix 1: Regulatory Impact Summary Table*

Nutrient Criteria			
Fiscal Costs	FY 2019	FY 2020	FY 2021
State Government	$8,000	$14,400	$8,000
Local Government	$0	$0	$0
Small Businesses	$0	$0	$0
Non-Small Businesses	$0	$0	$0
Other Person	$0	$0	$0
Total Fiscal Costs:	$8,000	$14,400	$8,000

Fiscal Benefits			
State Government	$0	$0	$0
Local Government	$0	$0	$0
Small Businesses	$0	$0	$0
Non-Small Businesses	$0	$0	$0
Other Persons	$0	$0	$0
Total Fiscal Benefits:	**$0**	**$0**	**$0**
Net Fiscal Benefits:	**($8,000)**	**($14,400)**	**($8,000)**

Proposed rule changes excluding nutrient criteria			
Fiscal Costs	**FY 2019**	**FY 2020**	**FY 2021**
State Government	$0	$0	$0
Local Government	$0	$0	$0
Small Businesses	$0	$0	$0
Non-Small Businesses	$0	$0	$0
Other Person	$0	$0	$0
Total Fiscal Costs:	**$0**	**$0**	**$0**
Fiscal Benefits			
State Government	$6,500	$6,500	$6,500
Local Government	$0	$0	$0
Small Businesses	$0	$0	$0
Non-Small Businesses	$0	$0	$0
Other Persons	$0	$0	$0
Total Fiscal Benefits:	**$6,500**	**$6,500**	**$6,500**
Net Fiscal Benefits:	**$6,500**	**$6,500**	**$6,500**

***This table only includes fiscal impacts that could be measured. If there are inestimable fiscal impacts, they will not be included in this table. Inestimable impacts for State Government, Local Government, Small Businesses and Other Persons are described above. Inestimable impacts for Non-Small Businesses are described below.**

Appendix 2: Regulatory Impact to Non-Small Businesses

The impact of these proposed changes are neutral or will result in inestimable indirect costs for non-small businesses. LABORATORY AND FIELD ANALYSES: Non-small businesses are not constrained parties for the proposed revision to Section R317-2-10 because non-small businesses are not required to conduct field analyses. For indirect effects to non-small businesses, the proposed revision is cost neutral or will have inestimable benefits. The proposed revision provides optional flexibility. Presumably, non-small businesses will only exercise these options if they are cost neutral or a benefit. No data is available to estimate the frequency or specifics of these potential requests. SHEEP CREEK USE CHANGE: The impacts are neutral for the addition of the Class 1C use to Sheep Creek in Section R317-2-13 because no non-small businesses are constrained or affected. SILVER CREEK TDS CRITERIA: The proposed revisions to Table 2.14.6 are neutral because no non-small businesses have effluent limits for TDS discharges to Silver Creek. Non-small businesses discharging to publically-owned treatment works may be affected indirectly if they discharge high levels of TDS. These indirect costs are inestimable because no non-small businesses discharging to the Silver Creek Water Reclamation Facility currently have pretreatment limits for TDS. JORDAN RIVER AMMONIA CRITERIA: No non-small businesses are constrained by the proposed Jordan River ammonia criteria in Section R317-2-14 and direct effects are neutral because no non-small businesses have ammonia effluent limits for the affected waters. Non-small businesses discharging to Central Valley Water Reclamation Facility may be affected indirectly if they discharge high levels of ammonia. These indirect costs are inestimable because no non-small businesses currently discharging to CVWRF have pretreatment limits for ammonia. NUTRIENT CRITERIA: State and Federal land management agencies are not constrained parties for the proposed nutrient criteria in Section R317-2-14, nor are other non-small businesses. Non-small businesses could be impacted by indirect costs due to actions by federal or state land management agencies. These agencies grant leases and permits (hereafter in this section, permits refers to both) for non-small businesses to conduct activities such as recreation, oil and gas exploration and production, mining, timber harvesting and grazing on state or federal lands. The land management agencies may elect to modify their leasing or permitting programs to implement best management practices (BMPs) if the activity is determined to cause or contribute to a nutrient impairment. These modifications may result in neutral impacts or increased indirect costs to the permittees. However, these impacts are unlikely to be significant because the affected permitted activities would have to occur in an area co-located with an impaired stream and have been demonstrated to be contributing to the impairment as a source of nitrogen or phosphorus to the stream. Further, implementation measures to address nonpoint sources of pollution are voluntary and are often offset by state and federal nonpoint source grants. New impairments resulting from the proposed nutrient criteria are not anticipated over the next three years, because the Division of Water Quality has a biannual reporting cycle for making impairment determinations, with the first report relevant to these criteria planned for 2022. Plans to restore impairments cannot be developed or implemented until impaired waters are identified. As a result, immediate costs associated with new impairments are anticipated to be neutral, exceptions being inestimable. Once impairment decisions are ultimately made, additional indirect costs to non-small business permittees are inestimable, but likely to be relatively small in size and scope. Based on currently available data, approximately 10-15% of the affected streams may ultimately be classified as impaired (water quality not meeting the proposed nutrient criteria), but these estimates are statistical and additional indirect expense increases, if any, are expected to vary considerably on a case-by-case basis. Even for potentially affected non-small business permittees that are co-located on an impaired stream, increased indirect costs are not inevitable. Impairment determinations trigger additional investigations that are conducted by the Utah Division of Water Quality or other interested parties. Only after the additional investigations, is a final determination made regarding impairment and sources of nutrient pollution. For those non-small businesses ultimately found to be contributing to a nutrient-related impairment as a source of nitrogen and phosphorus, costs are inestimable because there are generally many ways that their contribution to the impairment can be resolved, some of which may be revenue neutral. Costs for other remediation options are often offset through state and federal grants. Interested parties will generally evaluate all possible solutions when crafting restoration plans, and will attempt to select the most cost-effective solutions that are likely to lead to desired water quality improvements. Given the relatively small number of anticipated impairments and the voluntary nature of implementation measures, the proposed nutrient criteria are most likely to be revenue neutral. UPDATES AND CORRECTIONS: There are no costs associated with the remaining updates and corrections to Section R317-2-14.

R317. Environmental Quality, Water Quality.
R317-2. Standards of Quality for Waters of the State.
R317-2-10. Laboratory and Field Analyses.

10.1 Laboratory Analyses

All laboratory examinations of samples collected to determine compliance with these regulations shall be performed in accordance with standard procedures as approved by the Director by the Utah Office of State Health Laboratory<u>,</u> or by a laboratory certified by the Utah Department of Health.

10.2 Field Analyses

All field analyses to determine compliance with these rules shall be conducted in accordance with standard procedures specified by the Utah Division of Water Quality<u> or with methods approved by the Director</u>.

R317-2-13. Classification of Waters of the State (see R317-2-6).

[~~a. Colorado River Drainage~~
~~13.1 Upper Colorado River Basin~~
]<u>13.1 Upper Colorado River Basin</u>
<u>a. Colorado River Drainage</u>

TABLE

Paria River and tributaries, from state line to headwaters			2B			3C	4
All tributaries to Lake Powell except as listed below:			2B		3B		4
Tributaries to Escalante River from confluence with Boulder Creek to headwaters, including Boulder Creek			2B	3A			4
Dirty Devil River and tributaries, from Lake Powell to Fremont River			2B			3C	4
Deer Creek and tributaries, from confluence with Boulder Creek to headwaters			2B	3A			4
Freemont River and tributaries from confluence with Muddy Creek to Capitol Reef National Park, except as listed below:	1C		2B			3C	4
Pleasant Creek and tributaries, from confluence with Fremont River to East boundary of Capitol Reef National Park			2B			3C	4
Pleasant Creek and tributaries, from East boundary of Capitol Reef National Park to headwaters	1C		2B	3A			
Fremont River and tributaries, through Capitol Reef National Park to headwaters	1C	2A		3A			4
Muddy Creek and tributaries, from Confluence with Fremont River to Highway U-10 crossing, except as listed below			2B			3C	4
Muddy Creek from confluence with Fremont River to confluence with Ivie Creek			2B			3C	4*
Muddy Creek and tributaries from the confluence with Ivie Creek to U-10			2B			3C	4*
Ivie Creek and its tributaries from the confluence with Muddy Creek to the confluence with Quitchupah Creek			2B			3C	4*
Ivie Creek and its tributaries from the confluence with Quitchapah Creek to U-10, except as listed below:			2B			3C	4*
Quitchupah Creek from the confluence with Ivie Creek to U-10			2B			3C	4*
Quitchupah Creek and tributaries, from Highway U-10 crossing to headwaters			2B	3A			4
Ivie Creek and tributaries, from Highway U-10 to headwaters			2B	3A			4
Muddy Creek and tributaries, from Highway U-10 crossing to headwaters	1C		2B	3A			4
San Juan River and tributaries from Lake Powell to state line except as listed below:	1C	2A			3B		4
Johnson Creek and tributaries, from confluence with Recapture Creek to headwaters	1C		2B	3A			4
Verdure Creek and tributaries, from Highway US-191 crossing to headwaters			2B	3A			4
North Creek and tributaries, from confluence with Montezuma Creek to headwaters	1C		2B	3A			4
South Creek and tributaries, from confluence with Montezuma Creek to headwaters	1C		2B	3A			4

Spring Creek and tributaries, from confluence with Vega Creek to headwaters			2B	3A				4
Montezuma Creek and tributaries, from U.S. Highway 191 to headwaters	1C		2B	3A				4
Colorado River and tributaries, from Lake Powell to state line except as listed below:	1C	2A			3B			4
Indian Creek and tributaries, through Newspaper Rock State Park to headwaters	1C		2B	3A				4
Kane Canyon Creek and tributaries, from confluence with Colorado River to headwaters			2B			3C		4
Mill Creek and tributaries, from confluence with Colorado River to headwaters	1C	2A		3A				4
Castle Creek from confluence with the Colorado River to Seventh Day Adventist Diversion	1C	2A			3B			4*
Onion Creek from the confluence with Colorado River to road crossing above Stinking Springs	1C	2A			3B			4*
Dolores River and tributaries, from confluence with Colorado River to state line			2B			3C		4
Roc Creek and tributaries, from confluence with Dolores River to headwaters			2B	3A				4
LaSal Creek and tributaries from state line to headwaters			2B	3A				4
Lion Canyon Creek and tributaries, from state line to headwaters			2B	3A				4
Little Dolores River and tributaries, from confluence with Colorado River to state line			2B			3C		4
Bitter Creek and tributaries, from confluence with Colorado River to headwaters			2B			3C		4

(*) Site-specific criteria are associated with this use.

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13.3 Bear River Basin
a. Bear River Drainage

TABLE

Bear River and tributaries, from Great Salt Lake to Utah-Idaho border, except as listed below:		2B		3B		3D	4
Perry Canyon Creek from U.S. Forest boundary to headwaters		2B	3A				4
Box Elder Creek from confluence with Black Slough to Brigham City Reservoir (Mayor's Pond)		2B			3C		4
Box Elder Creek, from Brigham City Reservoir (Mayor's Pond) to headwaters		2B	3A				4
Salt Creek from confluence with Bear River to Crystal Hot Springs		2B		3B		3D	
Malad River and tributaries, from confluence with Bear River to state line		2B			3C		
Little Bear River and tributaries, from Cutler Reservoir to headwaters, except as listed below:		2B	3A			3D	4
South Fork Spring Creek from confluence with Pelican Pond Slough Stream to U.S. Highway 89		2B	3A			3D	4*
Logan River and tributaries, from Cutler Reservoir to headwaters		2B	3A			3D	4
Blacksmith Fork and tributaries, from confluence with Logan River to headwaters, except as listed below		2B	3A				4
Sheep Creek and tributaries from Confluence with Blacksmith Fork River to headwaters	1C	2B	3A				4
Newton Creek and tributaries, from Cutler Reservoir to Newton Reservoir		2B	3A				4
Clarkston Creek and tributaries, from Newton Reservoir to headwaters		2B	3A				4
Birch Creek and tributaries, from confluence with Clarkston Creek to headwaters		2B	3A				4
Summit Creek and tributaries, from confluence with Bear River to headwaters		2B	3A				4
Cub River and tributaries, from confluence with Bear River to state line, except as listed below:		2B		3B			4
High Creek and tributaries from confluence with Cub River to headwaters		2B	3A				4
All tributaries to Bear Lake from Bear Lake to headwaters, except as listed below		2B	3A				4
Swan Springs tributary to Swan Creek	1C	2B	3A				
Bear River and tributaries in Rich County		2B	3A				4
Bear River and tributaries, from Utah-Wyoming state line to headwaters (Summit County)		2B	3A				4

Mill Creek and tributaries, from state line to headwaters (Summit County)		2B	3A			4

(*) Site-specific criteria are associated with this use.

13.4 Weber River Basin
a. Weber River Drainage

TABLE

Willard Creek, from Willard Bay Reservoir to headwaters		2B	3A			4
Weber River, from Great Salt Lake to Slaterville diversion, except as listed below:		2B		3C	3D	4
Four Mile Creek from Interstate 15 to headwaters		2B	3A			4
Weber River and tributaries, from Slaterville diversion to Stoddard diversion, except as listed below		2B	3A			4
Ogden River and tributaries, from confluence with Weber River to Pineview Dam, except as listed below:		2A	3A			4
Wheeler Creek from confluence with Ogden River to headwaters	1C	2B	3A			4
All tributaries to Pineview Reservoir	1C	2B	3A			4
Strongs Canyon Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A			4
Burch Creek and tributaries, from Harrison Boulevard in Ogden to Headwaters	1C	2B	3A			
Spring Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A			4
Weber River and tributaries, from Stoddard diversion to headwaters, except as listed below	1C	2B	3A			4
Silver Creek and tributaries, from the confluence with Weber River to below the confluence with Tollgate Creek	1C	2B	3A			4
Silver Creek and tributaries, from confluence with Tollgate Creek to headwaters	1C	2B	3A			4*

13.5 Utah Lake-Jordan River Basin
a. Jordan River Drainage

TABLE

Jordan River, from Farmington Bay to North Temple Street, Salt Lake City		2B	3B*		3D	4
State Canal, from Farmington Bay to confluence with the Jordan River		2B	3B*		3D	4
Jordan River, from North Temple Street in Salt Lake City to confluence with Little Cottonwood Creek		2B	3B*			4
Surplus Canal from Great Salt Lake to the diversion from the Jordan River		2B	3B*		3D	4
Jordan River from confluence with Little Cottonwood Creek to Narrows Diversion		2B	3A			4
Jordan River, from Narrows Diversion to Utah Lake	1C	2B	3B			4
City Creek, from Memory Park in Salt Lake City to City Creek Water Treatment Plant		2B	3A			
City Creek, from City Creek Water Treatment Plant to headwaters	1C	2B	3A			
Red Butte Creek and tributaries, from Liberty Park pond inlet to Red Butte Reservoir		2B	3A			4
Red Butte Creek and tributaries, from Red Butte Reservoir to headwaters	1C	2B	3A			
Emigration Creek and tributaries, from 1100 East in Salt Lake City to headwaters		2B	3A			4
Parleys Creek and tributaries, from 1300 East in Salt Lake City to Mountain Dell Reservoir	1C	2B	3A			
Parleys Creek and tributaries, from Mountain Dell Reservoir to headwaters	1C	2B	3A			
Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15		2B		3C*		4
Mill Creek (Salt Lake County) and tributaries, from Interstate 15 to headwaters		2B	3A			4
Big Cottonwood Creek and tributaries, from confluence with Jordan River to Big Cottonwood Water Treatment Plant		2B	3A			4
Big Cottonwood Creek and tributaries from Big Cottonwood Water Treatment Plant to headwaters	1C	2B	3A			
Deaf Smith Canyon Creek and tributaries	1C	2B	3A			4
Little Cottonwood Creek and tributaries, from confluence with Jordan River to Metropolitan Water Treatment Plant		2B	3A			4
Little Cottonwood Creek and tributaries, from Metropolitan Water Treatment Plant to headwaters	1C	2B	3A			
Bells Canyon Creek and tributaries, from Lower Bells Canyon Reservoir to headwaters	1C	2B	3A			
Little Willow Creek and tributaries, from Draper Irrigation Company diversion to headwaters	1C	2B	3A			

Big Willow Creek and tributaries, from Draper Irrigation Company diversion to headwaters	1C	2B 3A		
South Fork of Dry Creek and tributaries, from Draper Irrigation Company diversion to headwaters	1C	2B 3A		
All permanent streams on east slope of Oquirrh Mountains (Coon, Barneys, Bingham, Butterfield, and Rose Creeks)		2B	3D	4
Kersey Creek from confluence of C-7 Ditch to headwaters		2B	3D	

(*) Site-specific criteria are associated with this use.

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R317-2-14. Numeric Criteria.

TABLE 2.14.1
NUMERIC CRITERIA FOR DOMESTIC,
RECREATION, AND AGRICULTURAL USES

Parameter	Domestic Source	Recreation and Aesthetics		Agri-culture
	1C(1)	2A	2B	4
BACTERIOLOGICAL (30-DAY GEOMETRIC MEAN) (NO.)/100 ML) (7)				
E. coli	206	126	206	
MAXIMUM (NO.)/100 ML) (7)				
E. coli	668	409	668	
PHYSICAL				
pH (RANGE)	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0
Turbidity Increase (NTU)		10	10	
METALS (DISSOLVED, MAXIMUM MG/L) (2)				
Arsenic	0.01			0.1
Barium	1.0			
Beryllium	<0.004			
Cadmium	0.01			0.01
Chromium	0.05			0.10
Copper				0.2
Lead	0.015			0.1
Mercury	0.002			
Selenium	0.05			0.05
Silver	0.05			
INORGANICS (MAXIMUM MG/L)				
Bromate	0.01			
Boron				0.75
Chlorite	<1.0			
Fluoride	4.0			
Nitrates as N	10			
Total Dissolved Solids (4)				1200
	RADIOLOGICAL			
(MAXIMUM pCi/L)				
Gross Alpha	15			15
Gross Beta	4 mrem/yr	Radium 226, 228		
(Combined)	5			
Strontium 90	8			
Tritium	20000			
Uranium	30			
ORGANICS (MAXIMUM UG/L)				
2,4-D 94-75-7	70			
2,4,5-TP 93-72-1	10			
Alachlor 15972-60-8	2			
Atrazine 1912-24-9	3			
Carbofuran 1563-66-2	40			
Dichloroethylene (cis-1,2) 156-59-2	70			
Dalapon 75-99-0	200			
Di(2ethylhexl)adipate 103-23-1	400			
Dibromochloropropane 96-12-8	0.2			
Dinoseb 88-85-7	7			
Diquat 85-00-7	20			
Endothall 145-73-3	100			
Ethylene Dibromide 106-93-4	0.05			
Glyphosate 1071-83-6	700			
Xylenes 1330-20-7	10,000			
POLLUTION INDICATORS (5)				
BOD (MG/L)	5	5	5	
Nitrate as N (MG/L)	4	4		
Total Phosphorus as P (MG/L)(6)	0.05	0.05		

FOOTNOTES:

(1) See also numeric criteria for water and organism in Table 2.14.6.

(2) The dissolved metals method involves filtration of the sample in the field, acidification of the sample in the field, no digestion process in the laboratory, and analysis by approved laboratory methods for the required detection levels.

(3) Reserved

(4) SITE SPECIFIC STANDARDS FOR TOTAL DISSOLVED SOLIDS (TDS)

Blue Creek and tributaries, Box Elder County, from Bear River Bay, Great Salt Lake to Blue Creek Reservoir:
March through October daily maximum 4,900 mg/l and an average of 3,800 mg/l; November through February daily maximum 6,300 mg/l and an average of 4,700 mg/l. Assessments will be based on TDS concentrations measured at the location of STORET 4960740.

Blue Creek Reservoir and tributaries, Box Elder County, daily maximum 2,100 mg/l;

Castle Creek from confluence with the Colorado River to Seventh Day Adventist Diversion: 1,800 mg/l;

Cottonwood Creek from the confluence with Huntington Creek to Highway U-57: 3,500 mg/l;

Ferron Creek from the confluence with San Rafael River to Highway U-10: 3,500 mg/l;

Huntington Creek and tributaries from the confluence with Cottonwood Creek to Highway U-10: 4,800 mg/l;

Ivie Creek and its tributaries from the confluence with Muddy Creek to the confluence with Quitchupah Creek: 3,800 mg/l provided that total sulfate not exceed 2,000 mg/l to protect the livestock watering agricultural existing use;

Ivie Creek and its tributaries from the confluence with Quitchupah Creek to Highway U-10: 2,600 mg/l;

Lost Creek from the confluence with Sevier River to U.S. National Forest boundary: 4,600 mg/l;

Muddy Creek and tributaries from the confluence with Ivie Creek to Highway U-10: 2,600 mg/l;

Muddy Creek from confluence with Fremont River to confluence with Ivie Creek: 5,800 mg/l;

North Creek from the confluence with Virgin River to headwaters: 2,035 mg/l;

Onion Creek from the confluence with Colorado River to road crossing above Stinking Springs: 3000 mg/l;

Brine Creek-Petersen Creek, from the confluence with the Sevier River to Highway U-119 Crossing: 9,700 mg/l;

Price River and tributaries from confluence with Green River to confluence with Soldier Creek: 3,000 mg/l;

Price River and tributaries from the confluence with Soldier Creek to Carbon Canal Diversion: 1,700 mg/l;

Quitchupah Creek and tributaries from the confluence with Ivie Creek to Highway U-10: 3,800 mg/l provided that total sulfate not exceed 2,000 mg/l to protect the livestock watering agricultural existing use;

Rock Canyon Creek from the confluence with Cottonwood Creek to headwaters: 3,500 mg/l;

San Pitch River from below Gunnison Reservoir to the Sevier River: 2,400 mg/l;

San Rafael River from the confluence with the Green River to Buckhorn Crossing: 4,100 mg/l;

San Rafael River from the Buckhorn Crossing to the confluence with Huntington Creek and Cottonwood Creek: 3,500 mg/l;

Sevier River between Gunnison Bend Reservoir and DMAD Reservoir: 1,725 mg/l;

Sevier River from Gunnison Bend Reservoir to Crafts Lake: 3,370 mg/l;

Silver Creek and tributaries, Summit County, from confluence with Tollgate Creek to headwaters: maximum 1,900 mg/L.

South Fork Spring Creek from confluence with Pelican Pond Slough Stream to U.S. Highway 89 1,450 mg/l (Apr.-Sept.) 1,950 mg/l (Oct.-March)

Virgin River from the Utah/Arizona border to Pah Tempe Springs: 2,360 mg/l

(5) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded. These indicators are superseded by numeric criteria in waters where promulgated.

(6) Total Phosphorus as P (mg/l) indicator for lakes and reservoirs shall be 0.025.

(7) Where the criteria are exceeded and there is a reasonable basis for concluding that the indicator bacteria E. coli are primarily from natural sources (wildlife), e.g., in National Wildlife Refuges and State Waterfowl Management Areas, the criteria may be considered attained provided the density attributable to non-wildlife sources is less than the criteria. Exceedences of E. coli from nonhuman nonpoint sources will generally be addressed through appropriate Federal, State, and local nonpoint source programs.

Measurement of E. coli using the "Quanti-Tray 2000" procedure is approved as a field analysis. Other EPA approved methods may also be used.

For water quality assessment purposes, up to 10% of representative samples may exceed the 668 per 100 ml criterion (for 1C and 2B waters) and 409 per 100 ml (for 2A waters). For small datasets, where exceedences of these criteria are observed, follow-up ambient monitoring should be conducted to better characterize water quality.

TABLE 2.14.2
NUMERIC CRITERIA FOR AQUATIC WILDLIFE(8)

Parameter	Aquatic Wildlife				
	3A	3B	3C	3D	5
PHYSICAL					
Total Dissolved Gases	(1)	(1)			
Minimum Dissolved Oxygen (MG/L) (2)(2a)					
30 Day Average	6.5	5.5	5.0	5.0	
7 Day Average	9.5/5.0	6.0/4.0			
Minimum	8.0/4.0	5.0/3.0	3.0	3.0	
Max. Temperature(C)(3)	20	27	27		
Max. Temperature Change (C)(3)	2	4	4		
pH (Range)(2a)	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	
Turbidity Increase (NTU)	10	10	15	15	
METALS (4) (DISSOLVED, UG/L)(5)					
Aluminum					
4 Day Average (6)	87	87	87	87	
1 Hour Average	750	750	750	750	
Arsenic (Trivalent)					
4 Day Average	150	150	150	150	
1 Hour Average	340	340	340	340	
Cadmium (7)					
4 Day Average	0.72	0.72	0.72	0.72	
1 Hour Average	1.8	1.8	1.8	1.8	
Chromium (Hexavalent)					
4 Day Average	11	11	11	11	
1 Hour Average	16	16	16	16	
Chromium (Trivalent) (7)					
4 Day Average	74	74	74	74	
1 Hour Average	570	570	570	570	
Copper (7)					
4 Day Average	9	9	9	9	
1 Hour Average	13	13	13	13	
Cyanide (Free)					
4 Day Average	5.2	5.2	5.2		
1 Hour Average	22	22	22	22	
Iron (Maximum)	1000	1000	1000	1000	
Lead (7)					
4 Day Average	2.5	2.5	2.5	2.5	
1 Hour Average	65	65	65	65	
Mercury					
4 Day Average	0.012	0.012	0.012	0.012	
Nickel (7)					

4 Day Average	52	52	52	52
1 Hour Average	468	468	468	468
Selenium				
4 Day Average	4.6	4.6	4.6	4.6
1 Hour Average	18.4	18.4	18.4	18.4
Selenium (14) Gilbert Bay (Class 5A) Great Salt Lake Geometric Mean over Nesting Season (mg/kg dry wt)				12.5
Silver				
1 Hour Average (7)	3.2	3.2	3.2	3.2
Tributyltin				
4 Day Average	0.072	0.072	0.072	0.072
1 Hour Average	0.46	0.46	0.46	0.46
Zinc (7)				
4 Day Average	120	120	120	120
1 Hour Average	120	120	120	120
INORGANICS (MG/L) (4)				
Total Ammonia as N (9)				
30 Day Average	(9a)	(9a)	(9a)	(9a)
1 Hour Average	(9b)	(9b)	(9b)	(9b)
Chlorine (Total Residual)				
4 Day Average	0.011	0.011	0.011	0.011
1 Hour Average	0.019	0.019	0.019	0.019
Hydrogen Sulfide (Undissociated, Max. UG/L)	2.0	2.0	2.0	2.0
Phenol(Maximum)	0.01	0.01	0.01	0.01
RADIOLOGICAL (MAXIMUM pCi/L)				
ORGANICS (UG/L) (4)				
Acrolein				
4 Day Average	3.0	3.0	3.0	3.0
1 Hour Average	3.0	3.0	3.0	3.0
Aldrin				
1 Hour Average	1.5	1.5	1.5	1.5
Carbaryl				
4 Day Average	2.1	2.1	2.1	2.1
1 Hour Average	2.1	2.1	2.1	2.1
Chlordane				
4 Day Average	0.0043	0.0043	0.0043	0.0043
1 Hour Average	1.2	1.2	1.2	1.2
Chlorpyrifos				
4 Day Average	0.041	0.041	0.041	0.041
1 Hour Average	0.083	0.083	0.083	0.083
4,4' -DDT				
4 Day Average	0.0010	0.0010	0.0010	0.0010
1 Hour Average	0.55	0.55	0.55	0.55
Diazinon				
4 Day Average	0.17	0.17	0.17	0.17
1 Hour Average	0.17	0.17	0.17	0.17
Dieldrin				
4 Day Average	0.056	0.056	0.056	0.056
1 Hour Average	0.24	0.24	0.24	0.24
Alpha-Endosulfan				
4 Day Average	0.056	0.056	0.056	0.056
1 Hour Average	0.11	0.11	0.11	0.11
beta-Endosulfan				
4 Day Average	0.056	0.056	0.056	0.056
1 Day Average	0.11	0.11	0.11	0.11
Endrin				
4 Day Average	0.036	0.036	0.036	0.036
1 Hour Average	0.086	0.086	0.086	0.086
Heptachlor				
4 Day Average	0.0038	0.0038	0.0038	0.0038
1 Hour Average	0.26	0.26	0.26	0.26
Heptachlor epoxide				
4 Day Average	0.0038	0.0038	0.0038	0.0038
1 Hour Average	0.26	0.26	0.26	0.26
Hexachlorocyclohexane (Lindane)				
4 Day Average	0.08	0.08	0.08	0.08
1 Hour Average	1.0	1.0	1.0	1.0
Methoxychlor (Maximum)	0.03	0.03	0.03	0.03
Mirex (Maximum)	0.001	0.001	0.001	0.001
Nonylphenol				
4 Day Average	6.6	6.6	6.6	6.6
1 Hour Average	28.0	28.0	28.0	28.0
Parathion				
4 Day Average	0.013	0.013	0.013	0.013
1 Hour Average	0.066	0.066	0.066	0.066
PCBs				
4 Day Average	0.014	0.014	0.014	0.014
Pentachlorophenol (11)				
4 Day Average	15	15	15	15
1 Hour Average	19	19	19	19
Toxaphene				
4 Day Average	0.0002	0.0002	0.0002	0.0002
1 Hour Average	0.73	0.73	0.73	0.73
POLLUTION INDICATORS (10)				
Gross Alpha (pCi/L)	15	15	15	15
Gross Beta (pCi/L)	50	50	50	50
BOD (MG/L)	5	5	5	5
Nitrate as N (MG/L)	4	4	4	
Total Phosphorus as P(MG/L) (12)	0.05	0.05		

FOOTNOTES:

(1) Not to exceed 110% of saturation.

(2) These limits are not applicable to lower water levels in deep impoundments. First number in column is for when early life stages are present, second number is for when all other life stages present.

(2a) These criteria are not applicable to Great Salt Lake impounded wetlands. Surface water in these wetlands shall be protected from changes in pH and dissolved oxygen that create significant adverse impacts to the existing beneficial uses. To ensure protection of uses, the Director shall develop reasonable protocols and guidelines that quantify the physical, chemical, and biological integrity of these waters. These protocols and guidelines will include input from local governments, the regulated community, and the general public. The Director will inform the Water Quality Board of any protocols or guidelines that are developed.

(3) Site Specific Standards for Temperature

Kens Lake: From June 1st - September 20th, 27 degrees C.

(4) Where criteria are listed as 4-day average and 1-hour average concentrations, these concentrations should not be exceeded more often than once every three years on the average.

(5) The dissolved metals method involves filtration of the sample in the field, acidification of the sample in the field, no digestion process in the laboratory, and analysis by EPA approved laboratory methods for the required detection levels.

(6) The criterion for aluminum will be implemented as follows:

Where the pH is equal to or greater than 7.0 and the hardness is equal to or greater than 50 ppm as $CaCO_3$ in the receiving water after mixing, the 87 ug/l chronic criterion (expressed as total recoverable) will not apply, and aluminum will be regulated based on compliance with the 750 ug/l acute aluminum criterion (expressed as total recoverable).

(7) Hardness dependent criteria. 100 mg/l used. Conversion factors for ratio of total recoverable metals to dissolved metals must also be applied. In waters with a hardness greater than 400 mg/l as $CaCO_3$, calculations will assume a hardness of 400 mg/l as $CaCO_3$. See Table 2.14.3 for complete equations for hardness and conversion factors.

(8) See also numeric criteria for organism only in Table 2.14.6.

(9) The following equations are used to calculate Ammonia criteria concentrations:

(9a) The thirty-day average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average, the chronic criterion calculated using the following equations.

Fish Early Life Stages are Present:

mg/l as N (Chronic) = $((0.0577/(1+10^{7.688-pH})) + (2.487/(1+10^{pH-7.688}))) * MIN(2.85, 1.45*10^{0.028*(25-T)})$ Fish Early Life Stages are [–]Absent:

mg/l as N (Chronic) = $((0.0577/(1+10^{7.688-pH})) + (2.487/(1+10^{pH-7.688}))) * 1.45*10^{0.028*(25-MAX(T,7))}$

Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River, Fish Early Life Stages are Present:

mg/l as N (Chronic) = $0.9405 * ((0.0278/(1+10^{7.688-pH})) + ((1.1994/(1+10^{pH-7.6888}))) * MIN(6.920,(7.547*10^{0.028*(20-T)})))$

Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River, Fish Early Life Stages are Absent:

mg/L as N (chronic) = $09.405 * (((0.0278/(1+10^{7.688-pH}))+(1.1994/(1+10^{pH-7.688}))) * (7.547*10^{0.028*(20-MAX(T,7))})$

(9b) The one-hour average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average the acute criterion calculated using the following equations.

Class 3A:

mg/l as N (Acute) = $(0.275/(1+10^{7.204-pH})) + (39.0/1+10^{pH-7.204}))$

Class 3B, 3C, 3D:

mg/l as N (Acute) = $0.411/(1+10^{7.204-pH})) + (58.4/(1+10^{pH-7.204}))$

Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15, Jordan River from 900 South Street to confluence with Mill Creek, Surplus Canal from 900 South Street to diversion from the Jordan River:

mg/l as N (Acute) = $0.729 * (((0.0114/(1+10^{7.204-pH}))+(1.6181/(1+10^{pH-7.204}))) * MIN(51.93,(62.15*10^{0.036*(20-T)}))$

In addition, the highest four-day average within the 30-day period should not exceed 2.5 times the chronic criterion. The "Fish Early Life Stages are Present" 30-day average total ammonia criterion will be applied by default unless it is determined by the Director, on a site-specific basis, that it is appropriate to apply the "Fish Early Life Stages are Absent" 30-day average criterion for all or some portion of the year. At a minimum, the "Fish Early Life Stages are Present" criterion will apply from the beginning of spawning through the end of the early life stages. Early life stages include the pre-hatch embryonic stage, the post-hatch free embryo or yolk-sac fry stage, and the larval stage for the species of fish expected to occur at the site. The Director will consult with the Division of Wildlife Resources in making such determinations. The Division will maintain information regarding the waterbodies and time periods where application of the "Early Life Stages are Absent" criterion is determined to be appropriate.

(10) Investigation should be conducted to develop more information where these levels are exceeded.

(11) pH dependent criteria. pH 7.8 used in table. See Table 2.14.4 for equation.

(12) Total Phosphorus as P (mg/l) as a pollution indicator for lakes and reservoirs shall be 0.025. These indicators are superseded by numeric criteria in waters where promulgated.

(13) Reserved

(14) The selenium water quality standard of 12.5 (mg/kg dry weight) for Gilbert Bay is a tissue based standard using the complete egg/embryo of aquatic dependent birds using Gilbert Bay based upon a minimum of five samples over the nesting season. Assessment procedures are incorporated as a part of this standard as follows:

Egg Concentration Triggers: DWQ Responses

Below 5.0 mg/kg: Routine monitoring with sufficient intensity to determine if selenium concentrations within the Great Salt Lake ecosystem are increasing.

5.0 mg/kg: Increased monitoring to address data gaps, loadings, and areas of uncertainty identified from initial Great Salt Lake selenium studies.

6.4 mg/kg: Initiation of a Level II Antidegradation review by the State for all discharge permit renewals or new discharge permits to Great Salt Lake. The Level II Antidegradation review may include an analysis of loading reductions.

9.8 mg/kg: Initiation of preliminary TMDL studies to evaluate selenium loading sources.

12.5 mg/kg and above: Declare impairment. Formalize and implement TMDL.

Antidegradation

Level II Review procedures associated with this standard are referenced at R317-2-3.5.C.

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TABLE 2.14.6
LIST OF HUMAN HEALTH CRITERIA (CONSUMPTION)

Chemical Parameter and CAS #	Water and Organism (ug/L)	Organism Only (ug/L)
	Class 1C	Class 3A,3B,3C,3D
Antimony 7440-36-0	5.6	640
Arsenic 7440-38-2	A	A
Beryllium 7440-41-7	C	C
Chromium III 16065-83-1	C	C
Chromium VI 18540-29-9	C	C
Copper 7440-50-8	1,300	
Mercury 7439-97-6	A	A
Nickel 7440-02-0	610	4,600
Selenium 7782-49-2	170	4,200
Thallium 7440-28-0	0.24	0.47
Zinc 7440-66-6	7,400	26,000
Free Cyanide 57-12-5	[~~140~~]4	[~~140~~]400
Asbestos 1332-21-4	7 million Fibers/L	

2,3,7,8-TCDD Dioxin 1746-01-6	5.0 E -9 B	5.1 E-9 B
Acrolein 107-02-8	3[~~.0~~]	400
Acrylonitrile 107-13-1	0.061	7.0
[~~Atrazine 1912-24-9~~	~~3.0~~	
]Benzene 71-43-2	2.1 B	51 B
Bromoform 75-25-2	7.0 B	120 B
Carbon Tetrachloride 56-23-5	0.4 B	5 B
Chlorobenzene [~~57-12-5~~]108-90-7	100 MCL	[~~1,600~~]800
Chlorodibromomethane 124-48-1	[~~0.40~~]0.80 B	[~~13~~]21 B
Chloroform 67-66-3	[~~5.7~~]60 B	[~~470~~]2,000 B
[~~Dalapon 75-99-0~~	~~200~~	
]Dichlorobromomethane 75-27-4	[~~0.55~~]0.95 B	[~~17~~]27 B
1,2-Dichloroethane 107-06-2	9.9 B	[~~650~~]2,000 B
1,1-Dichloroethylene 75-35-4	300 MCL	20,000
[~~Dichloroethylene (cis 1,2) 156-59-2~~	~~70~~	
~~Diquat 231-36-7~~	~~20~~	
]1,2-Dichloropropane 78-87-5	0.90 B	31 B
1,3-Dichloropropene 542-75-6	0.27	12
Ethylbenzene 100-41-4	68	130
[~~Glyphosate 1071-83-6~~	~~700~~	
]Methyl Bromide 74-83-9	[~~47100~~]100	10,000
Methylene Chloride 75-09-2	20 B	1,000 B
1,1,2,2-Tetrachloroethane 79-34-5	0.2 B	3 B
Tetrachloroethylene 127-18-4	10 B	29 B
Toluene 108-88-3	57	520
1,2 -Trans-Dichloroethylene 156-60-5	100 MCL	4,000
1,1,1-Trichloroethane 71-55-6	10,000 MCL	200,000
1,1,2-Trichloroethane 79-00-5	0.55 B	8.9 B
Trichloroethylene 79-01-6	0.6 B	7 B
Vinyl Chloride 75-01-4	0.022	1.6
[~~Xylenes 1330-20-7~~	~~10,000~~	
]2-Chlorophenol 95-57-8	30	800
2,4-Dichlorophenol 120-83-2	10	60
2,4-Dimethylphenol 105-67-9	100	3,000
2-Methyl-4,6-Dinitrophenol 534-52-1	2	30
2,4-Dinitrophenol 51-28-5	10	300
3-Methyl-4-Chlorophenol 59-50-7	500	2,000
Pentachlorophenol 87-86-5	0.03 B	0.04 B
Phenol 108-95-2	4,000	300,000
2,4,5-Trichlorophenol 95-95-4	300	600
2,4,6-Trichlorophenol 88-06-2	1.5 B	2.8 B
Acenaphthene 83-32-9	70	90
Anthracene 120-12-7	300	400
Benzidine 92-87-5	0.00014 B	0.011 B
BenzoaAnthracene 56-55-3	0.0012 B	0.0013 B
BenzoaPyrene 50-32-8	0.00012 B	0.00013 B
BenzobFluoranthene 205-99-2	0.0012 B	[~~0.018~~]0.0013 B
BenzokFluoranthene 207-08-9	0.012 B	0.013 B
Bis2-Chloro1methylether 542-88-1	0.00015	0.017
Bis2-Chloro1methylethylether 108-60-1	200 B	4000
Bis2-ChloroethylEther 111-44-4[0]_	0.030 B	2.2 B
[~~Bis2-Chloro1methylether 542-88-1~~	~~0.00015~~	~~0.017~~
~~Bis2-Chloro1methylethylether 108-60-1~~	~~200 B~~	~~4000~~
]Bis2-ChloroisopropylEther 39638-32-9	1,400	65,000
Bis2-EthylhexylPhthalate 117-81-7	0.32 B	[~~0.037~~]0.37 B
Butylbenzyl Phthalate 85-68-7	[~~0.1~~]0.10	[~~0.1~~]0.10
2-Chloronaphthalene 91-58-7	800	1,000
Chrysene 218-01-9	[~~0.0038~~]0.12 B	[~~0.018~~]0.13 B
Dibenzoa,hAnthracene 53-70-3	[~~0.0038~~]0.00012 B	[~~0.018~~]0.00013 B
1,2-Dichlorobenzene 95-50-1	1,000	3,000
1,3-Dichlorobenzene 541-73-1	7	10
1,4-Dichlorobenzene 106-46-7	300	900
3,3-Dichlorobenzidine 91-94-1	[~~0.04~~]0.049 B	0.15 B
Diethyl Phthalate 84[~~64~~]-66-2	600	600
Dimethyl Phthalate 131-11-3	2,000	2,000
Di-n-Butyl Phthalate 84-74-2	20	30
2,4-Dinitrotoluene 121-14-2	[~~0.49~~]0.049 B	1.7 B
Dinitrophenols 25550-58-7	10	1,000
1,2-Diphenylhydrazine 122-66-7	[~~0.036~~]0.03 B	[~~0.20~~]0.2 B
Fluoranthene 206-44-0	20	20
Fluorene 86-73-7	50	70
Hexachlorobenzene 118-74-1	0.000079 B	0.000079 B
Hexachlorobutadiene 87-68-3	0.01 B	0.01 B
Hexachloroethane 67-72-1	[~~1.4~~]0.1 B	[~~3.3~~]0.1 B
Hexachlorocyclopentadiene 77-47-4	4	4
Ideno 1,2,3-cdPyrene 193-39-5	0.0012 B	0.0013 B
Isophorone 78-59-1	34 B	1,800 B
Nitrobenzene 98-95-3	10	600
N-Nitrosodiethylamine 55-18-5	0.0008 B	1.24 B
N-Nitrosodimethylamine 62-75-9	0.00069 B	3.0 B
N-Nitrosodi-n-Propylamine 621-64-7	0.0050 B	0.51 B
N-Nitrosodiphenylamine 86-30-6	3.3 B	6.0 B
[~~N-Nitrosoyrrolidine~~]N-Nitrosopyrrolidine 930-55-2	0.016 B	34 B
Pentachlorobenzene 608-93-5	0.1	0.1
Pyrene 129-00-0	20	30
1,2,4-Trichlorobenzene 120-82-1	[~~0.07~~]0.071 MCL	0.076
Aldrin 309-00-2	0.00000077 B	0.00000077 B
alpha-BHC 319-84-6	0.00036 B	[~~0.000050~~]0.00039 B
beta-BHC 319-85-7	[~~0.008~~]0.0080 B	0.014 B
gamma-BHC (Lindane) 58-89-9	4.2 MCL	4.4
Hexachlorocyclohexane (HCH) Technical 608-73-1	0.0066	0.010
Chlordane 57-74-9	[~~0.00030~~]0.00031 B	0.00032 B
4,4-DDT 50-29-3	[~~0.000032~~]0.000030 B	0.000030 B
4,4-DDE 72-55-9	0.000018 B	0.000018 B
4,4-DDD 72-54-8	0.00012 B	0.00012 B
Dieldrin 60-57-1	0.0000012 B	0.0000012 B
alpha-Endosulfan 959-98-8	20	30
beta-Endosulfan 33213-65-9	20	40
Endosulfan Sulfate 1031-07-8	20	40
Endrin 72-20-8	0.03	[~~0.060~~]0.03
Endrin Aldehyde 7421-93-4	1	1
Heptachlor 76-44-8	0.0000059 B	0.0000059 B
Heptachlor Epoxide 1024-57-3	0.000032 B	0.000032 B
Methoxychlor 72-43-5	0.02 [~~MCL~~]	0.02
Polychlorinated Biphenyls (PCBs) 1336-36-3	0.000064 B,D	0.000064 B,D
Toxaphene 8001-35-2	[~~0.0007~~]0.00070 B	0.00071 B

[~~Footnotes~~]FOOTNOTES:

A. See Table 2.14.2

B. Based on carcinogenicity of 10-6 risk.

C. EPA has not calculated a human criterion for this contaminant. However, permit authorities should address this contaminant in NPDES permit actions using the State's existing narrative criteria for toxics

D. This standard applies to total PCBs.

TABLE 2.14.7
NUTRIENT CRITERIA FOR CLASSES 2A and 2B (1)

Nutrient Parameters	Criteria
Periphyton	125 mg/m2 chlorophyll-a
	or
	49 g/m2 ash free dry mass

FOOTNOTES:
(1)Applicable to all Category 1 and Category 2 streams with the following exceptions: Quitchupah Creek through Convulsion Canyon from U. S. Forest Service boundary upstream to East Spring Canyon headwaters; North Fork of Quitchupah Creek from the U. S. Forest Service boundary upstream to its confluence with South Fork; Huntington Creek from U. S. Forest Service boundary to confluence with Crandall Creek and Crandall Creek to headwaters.

TABLE 2.14.8
NUTRIENT CRITERIA FOR CLASSES 3A, 3B, 3C, and 3D(1)

Nutrient Parameters	Criteria(2)
Total Phosphorus	0.035 mg/L)(3), and
Total Nitrogen	0.40 mg/L)(3),
	or
Total Phosphorus	0.080 mg/L(3), and
Total Nitrogen	0.80 mg/L(3), and
Filamentous Algae	33% cover(4), or
Gross Primary Production	6 g O2/m2-day(5), or
Ecosystem Respiration	5 g O2/m2-day(5)

FOOTNOTES:
(1)Applicable to all Category 1 and Category 2 streams with the following exceptions: Quitchupah Creek through Convulsion Canyon from U. S. Forest Service boundary upstream to East Spring Canyon headwaters; North Fork of Quitchupah Creek from the U. S. Forest Service boundary upstream to its confluence with South Fork; Huntington Creek from U. S. Forest Service boundary to confluence with Crandall Creek and Crandall Creek to headwaters.
(2)For water quality assessments, Table 8, Decision Matrix That Will Be Used to Assess Support of Headwater Aquatic Life Uses for Nutrient-related Water Quality Problems, "Proposed Nutrient Criteria: Utah Headwater Streams", Utah Division of Water Quality, March, 2019 is incorporated by reference.
(3)Not to be exceeded seasonal average for the index period of algal growth through senescence.
(4)Not to be exceeded average based on at least 3 transects perpendicular to stream flow and spatially dispersed along a reach of at least 50 meters
(5) Not to be exceeded during the index period of algal growth through senescence.

KEY: water pollution, water quality standards
Date of Enactment or Last Substantive Amendment: [July 2, 2018]2019
Notice of Continuation: September 26, 2017[-1317, 1329]
Authorizing, and Implemented or Interpreted Law: 19-5; FWPCA 33 USC 1251, 1311-1317, 1329

Health, Disease Control and Prevention, Health Promotion
R384-203
Prescription Drug Database Access

NOTICE OF PROPOSED RULE
(Amendment)
DAR FILE NO.: 43562
FILED: 03/04/2019

RULE ANALYSIS

PURPOSE OF THE RULE OR REASON FOR THE CHANGE: This rule is required in Subsection 58-37f-301(2)(f) and there have been amendments to this code since the rule was established. In addition, clarifications have been made to the application process.

SUMMARY OF THE RULE OR CHANGE: This rule is required in Subsection 58-37f-301(2)(f) and there have been amendments to this code since the rule was established. The code has changed from Subsection 58-37f-301(2)(f) to Subsection 58-37f-301(2)(e), the definition of "research facility" has expanded, and clarifications related to the application process are being made.

STATUTORY OR CONSTITUTIONAL AUTHORIZATION FOR THIS RULE: Subsection 58-37f-301(2)(e)

ANTICIPATED COST OR SAVINGS TO:
♦ THE STATE BUDGET: These rule changes are administrative and do not impact the current state budget.
♦ LOCAL GOVERNMENTS: These rule changes are administrative and do not impact local governments.
♦ SMALL BUSINESSES: These rule changes are administrative and do not impact small businesses.
♦ PERSONS OTHER THAN SMALL BUSINESSES, BUSINESSES, OR LOCAL GOVERNMENTAL ENTITIES: These rule changes are administrative and do not impact other persons.

COMPLIANCE COSTS FOR AFFECTED PERSONS: There are no compliance costs associated with these rule changes. These rule changes are administrative.

COMMENTS BY THE DEPARTMENT HEAD ON THE FISCAL IMPACT THE RULE MAY HAVE ON BUSINESSES: There will be no fiscal impact to businesses because the changes are administrative rather than substantive.

THE FULL TEXT OF THIS RULE MAY BE INSPECTED, DURING REGULAR BUSINESS HOURS, AT:
HEALTH
DISEASE CONTROL AND PREVENTION, HEALTH PROMOTION
CANNON HEALTH BLDG
288 N 1460 W
SALT LAKE CITY, UT 84116-3231
or at the Office of Administrative Rules.

DIRECT QUESTIONS REGARDING THIS RULE TO:
♦ Anna Fondario by phone at 801-538-6201, or by Internet E-mail at afondario@utah.gov or mail PO Box 142107, Salt Lake City, UT 84114-2107

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KEY: [~~expedited, negotiations, penalty, settlement~~]TMDL, water pollution
Date of Enactment or Last Substantive Amendment: [~~January 1~~], 2018
Notice of Continuation: August 30, 2017
Authorizing, and Implemented or Interpreted Law: 19-5

Environmental Quality, Water Quality
R317-2
Standards of Quality for Waters of the State

NOTICE OF PROPOSED RULE
(Amendment)
DAR FILE NO.: 42691
FILED: 03/15/2018

RULE ANALYSIS

PURPOSE OF THE RULE OR REASON FOR THE CHANGE: This rule is being changed to correct errors, eliminate requirements that are unnecessary, address comments and recommendations received during the Triennial Reviews of the Water Quality Standards, and comply with Federal requirements.

SUMMARY OF THE RULE OR CHANGE: In Sections R317-2-3.3 and R317-2-11, the public notice and comment periods were extended to provide the public more time to review and comment on sometimes complicated proposals. In Section R317-2-3.5, the requirement that permitted discharges to Class 1C (potable water) waters always conduct a Level II antidegradation review is proposed to be deleted. Level II antidegradation reviews are still required for permitted discharges to Class 1C waters for new permits and for any increases in concentration or effluent loads for existing permits because of previous revisions to these rules. In Section R317-2-13, the recreation uses for Mill Creek in Grand County and Utah Lake in Utah County are proposed to be changed from infrequent primary and secondary contact recreation to frequent primary and secondary contact recreation (Class 2A) because people commonly swim in these waters. This change was requested by the local watershed group and endorsed by the federal land management agency. Descriptions of the waters with site-specific criteria in Section R317-2-14 were added to Section R317-2-13 with an asterisk identifying the affected use. These were added for the convenience of the users. This is a nonsubstantive change because no uses or criteria are revised. The Class 1C drinking water use is added to Grove and Battle Creeks in Utah County at the request of American Fork City. The affected waters are used as a source for drinking water. The aquatic life use is changed from Class 3D (waterfowl, shorebirds and their food chain) to Class 3A (cold water species of game fish, other cold water aquatic life and their food chain) based on an investigation of aquatic life present. In Table 2.14.1, deletion of the temperature-dependent criterion for fluoride for the Class 1C potable water use is proposed to be replaced with the current USEPA drinking water maximum contaminant level. The criteria for several pollutants are proposed to be moved from Table 2.14.6 to Table 2.14.1. The criteria in Table 2.14.6 are human health criteria and these pollutants do not have current USEPA human health criteria but do have USEPA maximum contaminant levels. In Table 2.14.2, the cadmium criteria for aquatic life use Classes 3A-3D are updated. The revised criteria are more stringent for the acute and less stringent for the chronic criterion when compared to the existing Utah criteria. New criteria for carbaryl, a carbamate pesticide, are proposed. Utah does not currently have any numeric criteria for carbaryl. In footnotes for Table 2.14.1, the site-specific total dissolved solids criterion for Quitchupah Creek is revised to include tributaries that were inadvertently omitted when the standard was promulgated. The water quality in one of the tributaries was misidentified as being impaired because of the omission. The site-specific total dissolved solids criterion for the Sevier River from Gunnison Bend Reservoir to Clear Lake: 3,370 mg/l is corrected to Crafts Lake because Clear Lake is not on the Sevier River. In Table 2.14.2, corrections were made to the table values for the chronic ammonia criteria, fish early life stages absent, and the acute silver criteria. The table values are based on equations in the water quality standards are unchanged. In Table 2.14.6, the human health criteria were reviewed and updated as required by federal regulations. Most of the pollutants listed in this table are affected. Some pollutants and criteria are proposed to be moved to Table 2.14.1. Pollutants listed that do not have current USEPA-recommended human health criteria or existing Utah criteria are proposed to be deleted. Criteria with available updated USEPA human health criteria are updated. The new criteria, and most of the updated criteria, are more stringent than the existing criteria; but, some are less stringent. Informational footnotes were added to Tables 2.14.1 and 2.14.2 to alert the user that criteria in Table 2.14.6 also apply to the uses in these tables (nonsubstantive change).

STATUTORY OR CONSTITUTIONAL AUTHORIZATION FOR THIS RULE: 33 U.S.C. 1251 and 33 U.S.C. 1311-1317 and 33 U.S.C. 1329 and 40 CFR Part 131 and Title 19, Chapter 5

ANTICIPATED COST OR SAVINGS TO:

♦ THE STATE BUDGET: For impacts that were estimable, aggregate fiscal cost savings over the next three years for the state will be $29,480. The Utah Division of Water Quality is the only constrained party for the proposed public participation revisions in Sections R317-2-3 and R317-2-11 and both the direct and indirect fiscal impacts will be neutral because the changes only extend the time required for the public comment period. The indirect fiscal impacts for other state agencies will be neutral because the length of the comment and review period should not affect the costs if these agencies choose to comment. The indirect non-fiscal impacts will inestimably be positive because the additional time provided will either have no impact or a beneficial impact by providing additional time for review and comment. The proposed revisions to Section R317-2-3 will result in indirect positive recurring fiscal impacts to the Utah Division of Water Quality because the 26 existing UPDES permits that discharge to Class 1C waters will no longer have to submit redundant Level II antidegradation reviews every 5 years at permit renewal. These reviews are estimated to require 4 hours of staff time at $90/hour for each review resulting in an annual average savings of $1,872 for the first 3 years evaluated or $9,360 over 5 years. The proposed revisions will result in direct positive fiscal impacts to the Utah Division of Wildlife Resources by avoiding the need to submit a Level II antidegradation review every 5 years at permit renewal. The cost impacts are estimated to be an annual savings of $288 over the first 3 years based on an estimated 16 hours of staff time at $90/hour or $1,440 every 5 years. The proposed changes to Section R317-2-13 will have one-time and potentially recurring indirect fiscal costs to the Utah Division of Water Quality. The one-time costs will be to update the use classifications in various internal systems. The one-time indirect fiscal impacts will be $1,400 assuming 4 hours to update each of the 4 databases at $90/hour. The proposed change in Section R317-2-13 for Mill Creek from infrequent primary and secondary contact recreation to frequent primary and secondary contact recreation will not have direct recurring fiscal or non-fiscal impacts to the Utah Division of Water Quality because the water quality support status will be unchanged. The change in use in Section R317-2-13 for Utah Lake may cause recurring indirect fiscal impacts that are inestimable. Based on the currently available data, the water quality of Utah Lake may or may not be categorized as impaired during the next or future assessment cycles which would trigger a TMDL (total maximum daily load) investigation which would have recurring indirect fiscal impacts. These impacts are unknown because the impairment and potential sources of the impairment cannot currently be identified. The proposed addition of the Class 1C potable water use in Section R317-2-13 to Battle and Grove Creeks will have inestimable indirect non-fiscal benefits for the Division of Drinking Water because they supported the change to protect these creeks as drinking water sources. The proposed changes in Section R317-2-14 will have one-time indirect fiscal impacts to the Utah Division of Water Quality. These one-time impacts will be to update the use classifications in various internal systems. The one-time indirect fiscal impact will be $2,800 assuming 8 hours to update each of the 4 databases at $90/hour. The proposed change for the Quitchupah Creek site-specific total dissolved solids criterion in Table 2.14.1 will have recurring indirect fiscal benefits to the Utah Division of Water Quality. With the change, the Division will avoid the need for follow-up sampling and analyses to investigate a tributary to Quitchupah Creek that was inadvertently omitted from the previously promulgated site-specific total dissolved solids standard. Fiscal benefits will be $10,000/yr based on 80 hours of staff time at $90/hour and $2,800 in direct costs for transportation lodging and laboratory analyses.

♦ LOCAL GOVERNMENTS: For impacts that were estimable, aggregate fiscal cost savings over the next three years for local governments will be $12,672. The indirect fiscal impacts for local governments of the proposed public participation revisions in Sections R317-2-3 and R317-2-11 will be neutral because the length of the comment and review period should not affect the costs if they choose to comment. The indirect non-fiscal impacts with be inestimably positive because the additional time provided will either have no impact or a beneficial impact by providing additional time for review and comment. The proposed revisions to Section R317-2-3.5 will result in direct cost savings by avoiding the need to submit a Level II antidegradation review every 5 years at permit renewal for 11 Utah Pollution Discharge Elimination System permits. The impacts will be an annual savings of $384 per permit for 11 permits based on an estimated 16 hours of staff time at $120/hour every 5 years. The annual savings is $4,224 each year or $12,672 for 3 years and $21,120 over 5 years. For the City of American Fork, Indirect inestimable non-fiscal savings are anticipated for the use changes to Grove and Battle Creeks because American Fork City requested the change and the changes will assist in protecting their potable water source. The proposed revisions to Table 2.14.6 are neutral because to no local government currently has limits for these pollutants and this status is not expected to change. The proposed revision to Table 2.14.2 to change to less stringent chronic cadmium criteria may have indirect positive impacts to Park City but these impacts are inestimable. Cadmium concentrations will still require treatment under the new criteria but the cost of treatment may decrease. Park City is not currently meeting the cadmium treatment requirements because of economic hardship and the change in criteria will not affect treatment requirements over the next three years.

♦ SMALL BUSINESSES: For impacts that were estimable, aggregate fiscal cost savings over the next 3 years for small businesses will be $3,456. For the proposed public participation revisions, small businesses are not constrained parties. The indirect fiscal impacts for small businesses will be neutral because the length of the comment and review period should not affect the costs if they choose to comment. The indirect non-fiscal impacts with be inestimably positive because the additional time provided will either have no impact or a beneficial impact by providing additional time for review and comment. The proposed revisions to Section R315-2-3.5 will result in direct positive fiscal impacts by avoiding the need to submit a Level II antidegradation review every 5 years at permit renewal for 3 permittees. The savings will be $1,920 384 per permit based on an estimated 16 hours of staff time at $120/hour every 5 years. Over 5 years, the 3 permittees will save $5,760 or $1,152 annually and $3,456 over 3 years. For the proposed revisions to Grove, Battle, and Mill Creeks in Section R317-2-13, no small businesses will be impacted because no discharge permits are issued for these waters. For the proposed classification change for Utah Lake in Section R317-2-13, the fiscal impacts to eight publicly-owned treatment plant permittees will be neutral because the discharge requirements will not be affected because the discharges are already meeting the new numeric criteria associated with the proposed change in use. Indirect non-fiscal impacts are possible for the three livestock operators identified in the Utah Department of Workforce Services Firm Find but these impacts are inestimable. For any impacts to occur, the water quality of Utah Lake would have to be impaired for E. coli under the changed use but not the existing use designation, a future total maximum daily load would have to conclude that these specific agricultural sources are a significant contributor to the impairment, and the owners would have to elect to voluntarily implement best management practices to address these sources. The proposed changes to Section R317-2-14 result in more stringent criteria for benzene, benzo(a)pyrene, and some phenols which are limited to one discharge permit. The proposed changes have the potential to result in indirect negative fiscal impacts but the potential and magnitude are inestimable. A waste load allocation needs to be evaluated to determine if and how much permit limits for these pollutants will change. Resulting changes to the permit limits may require different or additional water treatment but absent an engineering study, the impacts and associated costs are inestimable.

♦ PERSONS OTHER THAN SMALL BUSINESSES, BUSINESSES, OR LOCAL GOVERNMENTAL ENTITIES: For impacts that were estimable, aggregate fiscal cost savings over the next 3 years for these persons will be $1,152. For the proposed public participation revisions, these persons are not constrained parties. Indirect fiscal impacts for these persons will be neutral because the length of the comment and review period will not affect the costs if they choose to comment. The indirect non-fiscal impacts with be inestimably positive because the additional time provided will either have no impact or a beneficial impact by providing additional time for review and comment. The proposed revisions to Section R317-2-3 will result in direct positive fiscal impacts by avoiding the need to submit a Level II antidegradation review every 5 years at permit renewal for Capitol Reef National Park. The impacts will be an annual savings of $384 based on an estimated 16 hours of staff time at $120/hour every 5 years. The savings over 3 years will be $1,152 and $1,920 over 5 years. The proposed revisions to Section R317-2-14 may result in inestimable indirect cost to other persons that discharge wastewater to publicly-owned treatment works. These persons may be subject to additional pretreatment requirements imposed by the treatment works or the Division of Water Quality to ensure that the treatment works comply with their permit limits. The potential indirect costs are inestimable because no readily available data regarding the specific pollutants or current or potential future pretreatment limits are available.

COMPLIANCE COSTS FOR AFFECTED PERSONS: No additional compliance costs for affected persons.

COMMENTS BY THE DEPARTMENT HEAD ON THE FISCAL IMPACT THE RULE MAY HAVE ON BUSINESSES: The fiscal impacts of these proposed revisions will result in modest cost savings for businesses.

THE FULL TEXT OF THIS RULE MAY BE INSPECTED, DURING REGULAR BUSINESS HOURS, AT:

ENVIRONMENTAL QUALITY
WATER QUALITY
DEQ, THIRD FLOOR
195 N 1950 W
SALT LAKE CITY, UT 84116
or at the Office of Administrative Rules.

DIRECT QUESTIONS REGARDING THIS RULE TO:
♦ Judy Etherington by phone at 801-536-4344, by FAX at 801-536-4301, or by Internet E-mail at jetherington@utah.gov

INTERESTED PERSONS MAY PRESENT THEIR VIEWS ON THIS RULE BY SUBMITTING WRITTEN COMMENTS NO LATER THAN AT 5:00 PM ON 05/01/2018

INTERESTED PERSONS MAY ATTEND A PUBLIC HEARING REGARDING THIS RULE:
♦ 04/11/2018 06:00 PM, UDEQ, 195 N 1950 W, Salt Lake City, UT
♦ 04/13/2018 05:00 PM, Uintah County Library, Vernal, UT
♦ 04/16/2018 06:00 PM, Grand County Library, Moab, UT
♦ 04/17/2018 06:00 PM, Washington County Library, St. George, UT

THIS RULE MAY BECOME EFFECTIVE ON: 06/01/2018

AUTHORIZED BY: Erica Gaddis, Director

Appendix 1: Regulatory Impact Summary Table*

	FY 2018	FY 2019	FY 2020
Fiscal Costs			
State Government	$7,000	$0	$0
Local Government	$0	$0	$0
Small Businesses	$0	$0	$0
Non-Small Businesses	$0	$0	$0
Other Person	$0	$0	$0
Total Fiscal Costs:	**$7,000**	**$0**	**$0**
Fiscal Benefits			
State Government	$12,160	$12,160	$12,160
Local Government	$4,224	$4,224	$4,224
Small Businesses	$1,152	$1,152	$1,152
Non-Small Businesses	$768	$768	$768
Other Persons	$384	$384	$384
Total Fiscal Benefits:	**$18,688**	**$18,688**	**$18,688**
Net Fiscal Benefits:	$11,688	$18,688	$18,688

***This table only includes fiscal impacts that could be measured. If there are inestimable fiscal impacts, they will not be included in this table. Inestimable impacts for State Government, Local Government, Small Businesses and Other Persons are described above. Inestimable impacts for Non-Small Businesses are described below.**

Appendix 2: Regulatory Impacts
For impacts that were estimable, aggregate fiscal cost savings over the next three years for non-small businesses will be $2,304.

The proposed revisions to the public participation requirements will result in inestimable positive non-fiscal impacts because the additional time provided will either have no impact or a beneficial impact by providing additional time for review and comment.

The changes to the antidegradation review requirements in Section R317-2-3 will result in direct positive fiscal impacts by avoiding the need to submit a Level II antidegradation review every 5 years at permit renewal for 2 permits. The impacts will be an annual savings of $384 per permit per year based on an estimated 16 hours of staff time at $120/hour every 5 years. Net annual savings are $768, $2,304 over 3 years and $3804 over 5 years.

No constrained parties were identified that would be affected by the proposed revisions to Section R317-2-13.

The proposed revisions to Section R317-2-14 may have direct and indirect fiscal impacts that are inestimable for two permittees. One of the discharges is currently inactive but the permit does include effluent limits that could be affected by the proposed revisions to Table 2.14.6. The fiscal impacts are inestimable because current effluent data are unavailable. The other discharge permit currently has a monitoring limit for cadmium but the savings of the proposed change are inestimable until cadmium effluent concentrations are assessed at permit renewal. The revisions may result in inestimable indirect cost to non-small businesses that discharge wastewater to publically owned treatment works. These businesses may be subject to additional pretreatment requirements imposed by the treatment works or the Division of Water Quality to ensure that the treatment works comply with their permit limits. The potential indirect costs are inestimable because no readily available data regarding the specific pollutants or current or potential future pretreatment limits are available.

The head of the Department of Environmental Quality, Alan Matheson, has reviewed and approved this fiscal analysis.

R317. Environmental Quality, Water Quality.
R317-2. Standards of Quality for Waters of the State.
R317-2-1A. Statement of Intent.

Whereas the pollution of the waters of this state constitute a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life, and impairs domestic, agricultural, industrial, recreational and other legitimate beneficial uses of water, and whereas such pollution is contrary to the best interests of the state and its policy for the conservation of the water resources of the state, it is hereby declared to be the public policy of this state to conserve the waters of the state and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses; to provide that no waste be discharged into any waters of the state without first being given the degree of treatment necessary to protect the legitimate beneficial uses of such waters; to provide for the prevention, abatement and control of new or existing water pollution; to place first in priority those control measures directed toward elimination of pollution which creates hazards to the public health; to insure due consideration of financial problems imposed on water polluters through pursuit of these objectives; and to cooperate with other agencies of the state, agencies of other states and the federal government in carrying out these objectives.

R317-2-1B. Authority.

These standards are promulgated pursuant to Sections 19-5-104 and 19-5-110.

R317-2-1C. Triennial Review.

The water quality standards shall be reviewed and updated, if necessary, at least once every three years. The Director will seek input through a cooperative process from stakeholders representing state and federal agencies, various interest groups, and the public to develop a preliminary draft of changes. Proposed changes will be presented to the Water Quality Board for information. Informal public meetings may be held to present preliminary proposed changes to the public for comments and suggestions. Final proposed changes will be presented to the Water Quality Board for approval and authorization to initiate formal rulemaking. Public hearings will be held to solicit formal comments from the public. The Director will incorporate appropriate changes and return to the Water Quality Board to petition for formal adoption of the proposed changes following the requirements of the Utah Rulemaking Act, Title 63G, Chapter 3.

R317-2-2. Scope.

These standards shall apply to all waters of the state and shall be assigned to specific waters through the classification procedures prescribed by Sections 19-5-104(5) and 19-5-110 and R317-2-6.

R317-2-3. Antidegradation Policy.

3.1 Maintenance of Water Quality

Waters whose existing quality is better than the established standards for the designated uses will be maintained at high quality unless it is determined by the Director, after appropriate intergovernmental coordination and public participation in concert with the Utah continuing planning process, allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. However, existing instream water uses shall be maintained and protected. No water quality degradation is allowable which would interfere with or become injurious to existing instream water uses.

In those cases where potential water quality impairment associated with a thermal discharge is involved, the antidegradation policy and implementing method shall be consistent with Section 316 of the Federal Clean Water Act.

3.2 Category 1 Waters

Waters which have been determined by the Board to be of exceptional recreational or ecological significance or have been determined to be a State or National resource requiring protection, shall be maintained at existing high quality through designation, by the Board after public hearing, as Category 1 Waters. New point source discharges of wastewater, treated or otherwise, are prohibited in such segments after the effective date of designation. Protection of such segments from pathogens in diffuse, underground sources is covered in R317-5 and R317-7 and the rules for Individual Wastewater Disposal Systems (R317-501 through R317-515). Other diffuse sources (nonpoint sources) of wastes shall be controlled to the extent feasible through implementation of best management practices or regulatory programs.

Discharges may be allowed where pollution will be temporary and limited after consideration of the factors in R317-2-3.5.b.4., and where best management practices will be employed to minimize pollution effects.

Waters of the state designated as Category 1 Waters are listed in R317-2-12.1.

3.3 Category 2 Waters

Category 2 Waters are designated surface water segments which are treated as Category 1 Waters except that a point source discharge may be permitted provided that the discharge does not degrade existing water quality. Discharges may be allowed where pollution will be temporary and limited after consideration of the factors in R317-2-.3.5.b.4., and where best management practices will be employed to minimize pollution effects. Waters of the state designated as Category 2 Waters are listed in R317-2-12.2.

3.4 Category 3 Waters

For all other waters of the state, point source discharges are allowed and degradation may occur, pursuant to the conditions and review procedures outlined in Section 3.5.

3.5 Antidegradation Review (ADR)

An antidegradation review will determine whether the proposed activity complies with the applicable antidegradation requirements for receiving waters that may be affected.

An antidegradation review (ADR) may consist of two parts or levels. A Level I review is conducted to insure that existing uses will be maintained and protected.

Both Level I and Level II reviews will be conducted on a parameter-by-parameter basis. A decision to move to a Level II review for one parameter does not require a Level II review for other parameters. Discussion of parameters of concern is those expected to be affected by the proposed activity.

Antidegradation reviews shall include opportunities for public participation, as described in Section 3.5e.

a. Activities Subject to Antidegradation Review (ADR)

1. For all State waters, antidegradation reviews will be conducted for proposed federally regulated activities, such as those under Clean Water Act Sections 401 (FERC and other Federal actions), 402 (UPDES permits), and 404 (Army Corps of Engineers permits). The Director may conduct an ADR on any projects with the potential for major impact on the quality of waters of the state. The review will determine whether the proposed activity complies with the applicable antidegradation requirements for the particular receiving waters that may be affected.

2. For Category 1 Waters and Category 2 Waters, reviews shall be consistent with the requirement established in Sections 3.2 and 3.3, respectively.

3. For Category 3 Waters, reviews shall be consistent with the requirements established in this section

b. An Anti-degradation Level II review is not required where any of the following conditions apply:

1. Water quality will not be lowered by the proposed activity or for existing permitted facilities, water quality will not be further lowered by the proposed activity, examples include situations where:

(a) the proposed concentration-based effluent limit is less than or equal to the ambient concentration in the receiving water during critical conditions; or

(b) a UPDES permit is being renewed and the proposed effluent concentration and loading limits are equal to or less than the concentration and loading limits in the previous permit; or

(c) a UPDES permit is being renewed and new effluent limits are to be added to the permit, but the new effluent limits are based on maintaining or improving upon effluent concentrations and loads that have been observed, including variability; or

2. Assimilative capacity (based upon concentration) is not available or has previously been allocated, as indicated by water

quality monitoring or modeling information. This includes situations where:

(a) the water body is included on the current 303(d) list for the parameter of concern; or

(b) existing water quality for the parameter of concern does not satisfy applicable numeric or narrative water quality criteria; or

(c) discharge limits are established in an approved TMDL that is consistent with the current water quality standards for the receiving water (i.e., where TMDLs are established, and changes in effluent limits that are consistent with the existing load allocation would not trigger an antidegradation review).

Under conditions (a) or (b) the effluent limit in an UPDES permit may be equal to the water quality numeric criterion for the parameter of concern.

3. Water quality impacts will be temporary and related only to sediment or turbidity and fish spawning will not be impaired,

4. The water quality effects of the proposed activity are expected to be temporary and limited. As general guidance, CWA Section 402 general discharge permits, CWA Section 404 general permits, or activities of short duration, will be deemed to have a temporary and limited effect on water quality where there is a reasonable factual basis to support such a conclusion. Factors to be considered in determining whether water quality effects will be temporary and limited may include the following:

(a) Length of time during which water quality will be lowered.

(b) Percent change in ambient concentrations of pollutants of concern

(c) Pollutants affected

(d) Likelihood for long-term water quality benefits to the segment (e.g., dredging of contaminated sediments)

(e) Potential for any residual long-term influences on existing uses.

(f) Impairment of the fish spawning, survival and development of aquatic fauna excluding fish removal efforts.

c. Anti-degradation Review Process

For all activities requiring a Level II review, the Division will notify affected agencies and the public with regards to the requested proposed activity and discussions with stakeholders may be held. In the case of Section 402 discharge permits, if it is determined that a discharge will be allowed, the Director will develop any needed UPDES permits for public notice following the normal permit issuance process.

The ADR will cover the following requirements or determinations:

1. Will all Statutory and regulatory requirements be met?

The Director will review to determine that there will be achieved all statutory and regulatory requirements for all new and existing point sources and all required cost-effective and reasonable best management practices for nonpoint source control in the area of the discharge. If point sources exist in the area that have not achieved all statutory and regulatory requirements, the Director will consider whether schedules of compliance or other plans have been established when evaluating whether compliance has been assured. Generally, the "area of the discharge" will be determined based on the parameters of concern associated with the proposed activity and the portion of the receiving water that would be affected.

2. Are there any reasonable less-degrading alternatives?

There will be an evaluation of whether there are any reasonable non-degrading or less degrading alternatives for the proposed activity. This question will be addressed by the Division based on information provided by the project proponent. Control alternatives for a proposed activity will be evaluated in an effort to avoid or minimize degradation of the receiving water. Alternatives to be considered, evaluated, and implemented to the extent feasible, could include pollutant trading, water conservation, water recycling and reuse, land application, total containment, etc.

For proposed UPDES permitted discharges, the following list of alternatives should be considered, evaluated and implemented to the extent feasible:

(a) innovative or alternative treatment options

(b) more effective treatment options or higher treatment levels

(c) connection to other wastewater treatment facilities

(d) process changes or product or raw material substitution

(e) seasonal or controlled discharge options to minimize discharging during critical water quality periods

(f) pollutant trading

(g) water conservation

(h) water recycle and reuse

(i) alternative discharge locations or alternative receiving waters

(j) land application

(k) total containment

(l) improved operation and maintenance of existing treatment systems

(m) other appropriate alternatives

An option more costly than the cheapest alternative may have to be implemented if a substantial benefit to the stream can be realized. Alternatives would generally be considered feasible where costs are no more than 20% higher than the cost of the discharging alternative, and (for POTWs) where the projected per connection service fees are not greater than 1.4% of MAGHI (median adjusted gross household income), the current affordability criterion now being used by the Water Quality Board in the wastewater revolving loan program. Alternatives within these cost ranges should be carefully considered by the discharger. Where State financing is appropriate, a financial assistance package may be influenced by this evaluation, i.e., a less polluting alternative may receive a more favorable funding arrangement in order to make it a more financially attractive alternative.

It must also be recognized in relationship to evaluating options that would avoid or reduce discharges to the stream, that in some situations it may be more beneficial to leave the water in the stream for instream flow purposes than to remove the discharge to the stream.

3. Does the proposed activity have economic and social importance?

Although it is recognized that any activity resulting in a discharge to surface waters will have positive and negative aspects, information must be submitted by the applicant that any discharge or increased discharge will be of economic or social importance in the area.

The factors addressed in such a demonstration may include, but are not limited to, the following:

(a) employment (i.e., increasing, maintaining, or avoiding a reduction in employment);

(b) increased production;
(c) improved community tax base;
(d) housing;
(e) correction of an environmental or public health problem; and
(f) other information that may be necessary to determine the social and economic importance of the proposed surface water discharge.

4. The applicant may submit a proposal to mitigate any adverse environmental effects of the proposed activity (e.g., instream habitat improvement, bank stabilization). Such mitigation plans should describe the proposed mitigation measures and the costs of such mitigation. Mitigation plans will not have any effect on effluent limits or conditions included in a permit (except possibly where a previously completed mitigation project has resulted in an improvement in background water quality that affects a water quality-based limit). Such mitigation plans will be developed and implemented by the applicant as a means to further minimize the environmental effects of the proposed activity and to increase its socio-economic importance. An effective mitigation plan may, in some cases, allow the Director to authorize proposed activities that would otherwise not be authorized.

5. Will water quality standards be violated by the discharge?

Proposed activities that will affect the quality of waters of the state will be allowed only where the proposed activity will not violate water quality standards.

6. Will existing uses be maintained and protected?

Proposed activities can only be allowed if "existing uses" will be maintained and protected. No UPDES permit will be allowed which will permit numeric water quality standards to be exceeded in a receiving water outside the mixing zone. In the case of nonpoint pollution sources, the non-regulatory Section 319 program now in place will address these sources through application of best management practices to ensure that numeric water quality standards are not exceeded.

7. If a situation is found where there is an existing use which is a higher use (i.e., more stringent protection requirements) than that current designated use, the Director will apply the water quality standards and anti-degradation policy to protect the existing use. Narrative criteria may be used as a basis to protect existing uses for parameters where numeric criteria have not been adopted. Procedures to change the stream use designation to recognize the existing use as the designated use would be initiated.

d. Special Procedures for Drinking Water Sources

[~~An Antidegradation Level II Review will be required by the Director for discharges to waters with a Class 1C drinking water use assigned.~~
] Depending upon the locations of the discharge and its proximity to downstream drinking water diversions, additional treatment or more stringent effluent limits or additional monitoring, beyond that which may otherwise be required to meet minimum technology standards or in stream water quality standards, may be required by the Director in order to adequately protect public health and the environment. Such additional treatment may include additional disinfection, suspended solids removal to make the disinfection process more effective, removal of any specific contaminants for which drinking water maximum contaminant levels (MCLs) exists, and/or nutrient removal to reduce the organic content of raw water used as a source for domestic water systems.

Additional monitoring may include analyses for viruses, Giardia, Cryptosporidium, other pathogenic organisms, and/or any contaminant for which drinking water MCLs exist. Depending on the results of such monitoring, more stringent treatment may then be required.

The additional treatment/effluent limits/monitoring which may be required will be determined by the Director after consultation with the Division of Drinking Water and the downstream drinking water users.

e. Public Notice

The public will be provided notice and an opportunity to comment on the conclusions of all completed antidegradation reviews. When possible, public notice on the antidegradation review conclusions will be combined with the public notice on the proposed permitting or certifying action. In the case of UPDES permits, public notice will be provided through the normal permitting process, as all draft permits are public noticed for 30 days, and public comment solicited, before being issued as a final permit. The Statement of Basis for the draft UPDES permit will contain information on how the ADR was addressed including results of the Level I and Level II reviews. In the case of Section 404 permits from the Corps of Engineers, the Division of Water Quality will develop any needed 401 Certifications and the public notice may be published in conjunction with the US Corps of Engineers public notice procedures. Other permits requiring a Level II review will receive a separate public notice according to the normal State public notice procedures. The public will be provided notice and an opportunity to comment whenever substantive changes are made to the implementation procedures referenced in Subsection R317-2-3.5.f.

f. Implementation Procedures

The Director shall establish reasonable protocols and guidelines (1) for completing technical, social, and economic need demonstrations, (2) for review and determination of adequacy of Level II ADRs and (3) for determination of additional treatment requirements. Protocols and guidelines will consider federal guidance and will include input from local governments, the regulated community, and the general public. The Director will inform the Water Quality Board of any protocols or guidelines that are developed.

R317-2-4. Colorado River Salinity Standards.

In addition to quality protection afforded by these rules to waters of the Colorado River and its tributaries, such waters shall be protected also by requirements of "Proposed Water Quality Standards for Salinity including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System, June 1975" and a supplement dated August 26, 1975, entitled "Supplement, including Modifications to Proposed Water Quality Standards for Salinity including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System, June 1975", as approved by the seven Colorado River Basin States and the U.S. Environmental Protection Agency, as updated by the 1978 Revision and the 1981, 1984, 1987, 1990, 1993, 1996, 1999, 2002, 2005, 2008, and 2011 reviews of the above documents.

R317-2-5. Mixing Zones.

A mixing zone is a limited portion of a body of water, contiguous to a discharge, where dilution is in progress but has not yet resulted in concentrations which will meet certain standards for all pollutants. At no time, however, shall concentrations within the mixing zone be allowed which are acutely lethal as determined by bioassay or other approved procedure. Mixing zones may be delineated for the purpose of guiding sample collection procedures and to determine permitted effluent limits. The size of the chronic mixing zone in rivers and streams shall not to exceed 2500 feet and the size of an acute mixing zone shall not exceed 50% of stream width nor have a residency time of greater than 15 minutes. Streams with a flow equal to or less than twice the flow of a point source discharge may be considered to be totally mixed. The size of the chronic mixing zone in lakes and reservoirs shall not exceed 200 feet and the size of an acute mixing zone shall not exceed 35 feet. Domestic wastewater effluents discharged to mixing zones shall meet effluent requirements specified in R317-1-3.

5.1 Individual Mixing Zones. Individual mixing zones may be further limited or disallowed in consideration of the following factors in the area affected by the discharge:

a. Bioaccumulation in fish tissues or wildlife,

b. Biologically important areas such as fish spawning/nursery areas or segments with occurrences of federally listed threatened or endangered species,

c. Potential human exposure to pollutants resulting from drinking water or recreational activities,

d. Attraction of aquatic life to the effluent plume, where toxicity to the aquatic life is occurring.

e. Toxicity of the substance discharged,

f. Zone of passage for migrating fish or other species (including access to tributaries), or

g. Accumulative effects of multiple discharges and mixing zones.

R317-2-6. Use Designations.

The Board as required by Section 19-5-110, shall group the waters of the state into classes so as to protect against controllable pollution the beneficial uses designated within each class as set forth below. Surface waters of the state are hereby classified as shown in R317-2-13.

6.1 Class 1 -- Protected for use as a raw water source for domestic water systems.

a. Class 1A -- Reserved.

b. Class 1B -- Reserved.

c. Class 1C -- Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water

6.2 Class 2 -- Protected for recreational use and aesthetics.

a. Class 2A -- Protected for frequent primary contact recreation where there is a high likelihood of ingestion of water or a high degree of bodily contact with the water. Examples include, but are not limited to, swimming, rafting, kayaking, diving, and water skiing.

b. Class 2B -- Protected for infrequent primary contact recreation. Also protected for secondary contact recreation where there is a low likelihood of ingestion of water or a low degree of bodily contact with the water. Examples include, but are not limited to, wading, hunting, and fishing.

6.3 Class 3 -- Protected for use by aquatic wildlife.

a. Class 3A -- Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.

b. Class 3B -- Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain.

c. Class 3C -- Protected for nongame fish and other aquatic life, including the necessary aquatic organisms in their food chain.

d. Class 3D -- Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain.

e. Class 3E -- Severely habitat-limited waters. Narrative standards will be applied to protect these waters for aquatic wildlife.

6.4 Class 4 -- Protected for agricultural uses including irrigation of crops and stock watering.

6.5 Class 5 -- The Great Salt Lake.

a. Class 5A Gilbert Bay

Geographical Boundary -- All open waters at or below approximately 4,208-foot elevation south of the Union Pacific Causeway, excluding all of the Farmington Bay south of the Antelope Island Causeway and salt evaporation ponds.

Beneficial Uses -- Protected for frequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain.

b. Class 5B Gunnison Bay

Geographical Boundary -- All open waters at or below approximately 4,208-foot elevation north of the Union Pacific Causeway and west of the Promontory Mountains, excluding salt evaporation ponds.

Beneficial Uses -- Protected for infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain.

c. Class 5C Bear River Bay

Geographical Boundary -- All open waters at or below approximately 4,208-foot elevation north of the Union Pacific Causeway and east of the Promontory Mountains, excluding salt evaporation ponds.

Beneficial Uses -- Protected for infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain.

d. Class 5D Farmington Bay

Geographical Boundary -- All open waters at or below approximately 4,208-foot elevation east of Antelope Island and south of the Antelope Island Causeway, excluding salt evaporation ponds.

Beneficial Uses -- Protected for infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain.

e. Class 5E Transitional Waters along the Shoreline of the Great Salt Lake Geographical Boundary -- All waters below approximately 4,208-foot elevation to the current lake elevation of the open water of the Great Salt Lake receiving their source water from naturally occurring springs and streams, impounded wetlands, or facilities requiring a UPDES permit. The geographical areas of these transitional waters change corresponding to the fluctuation of open water elevation.

Beneficial Uses -- Protected for infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain.

R317-2-7. Water Quality Standards.

7.1 Application of Standards

a. The numeric criteria listed in R317-2-14 shall apply to each of the classes assigned to waters of the State as specified in R317-2-6. It shall be unlawful and a violation of these rules for any person to discharge or place any wastes or other substances in such manner as may interfere with designated uses protected by assigned classes or to cause any of the applicable standards to be violated, except as provided in R317-1-3.1.

b. At a minimum, assessment of the beneficial use support for waters of the state will be conducted biennially and available for a 30-day period of public comment and review. Monitoring locations and target indicators of water quality standards shall be prioritized and published yearly. For water quality assessment purposes, up to 10 percent of the representative samples may exceed the minimum or maximum criteria for dissolved oxygen, pH, E. coli, total dissolved solids, and temperature, including situations where such criteria have been adopted on a site-specific basis.

c. Site-specific standards may be adopted by rulemaking where biomonitoring data, bioassays, or other scientific analyses indicate that the statewide criterion is over or under protective of the designated uses or where natural or un-alterable conditions or other factors as defined in 40 CFR 131.10(g) prevent the attainment of the statewide criteria as prescribed in Subsections R317-2-7.2, and R317-2-7.3, and Section R317-2-14.

7.2 Narrative Standards

It shall be unlawful, and a violation of these rules, for any person to discharge or place any waste or other substance in such a way as will be or may become offensive such as unnatural deposits, floating debris, oil, scum or other nuisances such as color, odor or taste; or cause conditions which produce undesirable aquatic life or which produce objectionable tastes in edible aquatic organisms; or result in concentrations or combinations of substances which produce undesirable physiological responses in desirable resident fish, or other desirable aquatic life, or undesirable human health effects, as determined by bioassay or other tests performed in accordance with standard procedures; or determined by biological assessments in Subsection R317-2-7.3.

7.3 Biological Water Quality Assessment and Criteria

Waters of the State shall be free from human-induced stressors which will degrade the beneficial uses as prescribed by the biological assessment processes and biological criteria set forth below:

a. Quantitative biological assessments may be used to assess whether the purposes and designated uses identified in R317-2-6 are supported.

b. The results of the quantitative biological assessments may be used for purposes of water quality assessment, including, but not limited to, those assessments required by 303(d) and 305(b) of the federal Clean Water Act (33 U.S.C. 1313(d) and 1315(b)).

c. Quantitative biological assessments shall use documented methods that have been subject to technical review and produce consistent, objective and repeatable results that account for methodological uncertainty and natural environmental variability.

d. If biological assessments reveal a biologically degraded water body, specific pollutants responsible for the degradation will not be formally published (i.e., Biennial Integrated Report, TMDL) until a thorough evaluation of potential causes, including nonchemical stressors (e.g., habitat degradation or hydrological modification or criteria described in 40 CFR 131.10 (g)(1 - 6) as defined by the Use Attainability Analysis process), has been conducted.

R317-2-8. Protection of Downstream Uses.

All actions to control waste discharges under these rules shall be modified as necessary to protect downstream designated uses.

R317-2-9. Intermittent Waters.

Failure of a stream to meet water quality standards when stream flow is either unusually high or less than the 7-day, 10-year minimum flow shall not be cause for action against persons discharging wastes which meet both the requirements of R317-1 and the requirements of applicable permits.

R317-2-10. Laboratory and Field Analyses.

10.1 Laboratory Analyses

All laboratory examinations of samples collected to determine compliance with these regulations shall be performed in accordance with standard procedures as approved by the Director by the Utah Office of State Health Laboratory or by a laboratory certified by the Utah Department of Health.

10.2 Field Analyses

All field analyses to determine compliance with these rules shall be conducted in accordance with standard procedures specified by the Utah Division of Water Quality.

R317-2-11. Public Participation.

Public notices and public hearings will be held for the consideration, adoption, or amendment of the classifications of waters and standards of purity and quality. Public notices shall be published at least twice in a newspaper of general circulation in the area affected at least 30 days prior to any public hearing. The notice will be posted on a State public notice website at least 45 days before any hearing and a notice will be mailed at least 30 days before any hearing to the chief executive of each political subdivision and other potentially affected persons.[~~to review all proposed revisions of water quality standards, designations and classifications, and public meetings may be held for consideration of discharge requirements set to protect water uses under assigned classifications.~~]

R317-2-12. Category 1 and Category 2 Waters.

12.1 Category 1 Waters.

In addition to assigned use classes, the following surface waters of the State are hereby designated as Category 1 Waters:

a. All surface waters geographically located within the outer boundaries of U.S. National Forests whether on public or private lands with the following exceptions:

1. Category 2 Waters as listed in R317-2-12.2.

2. Weber River, a tributary to the Great Salt Lake, in the Weber River Drainage from Uintah to Mountain Green.

b. Other surface waters, which may include segments within U.S. National Forests as follows:

1. Colorado River Drainage

Calf Creek and tributaries, from confluence with Escalante River to headwaters.

Sand Creek and tributaries, from confluence with Escalante River to headwaters.

Mamie Creek and tributaries, from confluence with Escalante River to headwaters.

Deer Creek and tributaries, from confluence with Boulder Creek to headwaters (Garfield County).

Indian Creek and tributaries, through Newspaper Rock State Park to headwaters.

2. Green River Drainage

Price River (Lower Fish Creek from confluence with White River to Scofield Dam.

Range Creek and tributaries, from confluence with Green River to headwaters.

Strawberry River and tributaries, from confluence with Red Creek to headwaters.

Ashley Creek and tributaries, from Steinaker diversion to headwaters.

Jones Hole Creek and tributaries, from confluence with Green River to headwaters.

Green River, from state line to Flaming Gorge Dam.

Tollivers Creek, from confluence with Green River to headwaters.

Allen Creek, from confluence with Green River to headwaters.

3. Virgin River Drainage

North Fork Virgin River and tributaries, from confluence with East Fork Virgin River to headwaters.

East Fork Virgin River and tributaries from confluence with North Fork Virgin River to headwaters.

4. Kanab Creek Drainage

Kanab Creek and tributaries, from irrigation diversion at confluence with Reservoir Canyon to headwaters.

5. Bear River Drainage

Swan Creek and tributaries, from Bear Lake to headwaters.

North Eden Creek, from Upper North Eden Reservoir to headwaters.

Big Creek and tributaries, from Big Ditch diversion to headwaters.

Woodruff Creek and tributaries, from Woodruff diversion to headwaters.

6. Weber River Drainage

Burch Creek and tributaries, from Harrison Boulevard in Ogden to headwaters.

Hardscrabble Creek and tributaries, from confluence with East Canyon Creek to headwaters.

Chalk Creek and tributaries, from Main Street in Coalville to headwaters.

Weber River and tributaries, from Utah State Route 32 near Oakley to headwaters.

7. Jordan River Drainage

City Creek and tributaries, from City Creek Water Treatment Plant to headwaters (Salt Lake County).

Emigration Creek and tributaries, from Hogle Zoo to headwaters (Salt Lake County).

Red Butte Creek and tributaries, from Foothill Boulevard in Salt Lake City to headwaters.

Parley's Creek and tributaries, from 13th East in Salt Lake City to headwaters.

Mill Creek and tributaries, from Wasatch Boulevard in Salt Lake City to headwaters.

Big Cottonwood Creek and tributaries, from Wasatch Boulevard in Salt Lake City to headwaters.

Little Willow Creek and tributaries, from diversion to headwaters (Salt Lake County.)

Bell Canyon Creek and tributaries, from Lower Bells Canyon Reservoir to headwaters (Salt Lake County).

South Fork of Dry Creek and tributaries, from Draper Irrigation Company diversion to headwaters (Salt Lake County).

8. Provo River Drainage

Upper Falls drainage above Provo City diversion (Utah County).

Bridal Veil Falls drainage above Provo City diversion (Utah County).

Lost Creek and tributaries, above Provo City diversion (Utah County).

9. Sevier River Drainage

Chicken Creek and tributaries, from diversion at canyon mouth to headwaters.

Pigeon Creek and tributaries, from diversion to headwaters.

East Fork of Sevier River and tributaries, from Kingston diversion to headwaters.

Parowan Creek and tributaries, from Parowan City to headwaters.

Summit Creek and tributaries, from Summit City to headwaters.

Braffits Creek and tributaries, from canyon mouth to headwaters.

Right Hand Creek and tributaries, from confluence with Coal Creek to headwaters.

10. Raft River Drainage

Clear Creek and tributaries, from state line to headwaters (Box Elder County).

Birch Creek (Box Elder County), from state line to headwaters.

Cotton Thomas Creek from confluence with South Junction Creek to headwaters.

11. Western Great Salt Lake Drainage

All streams on the south slope of the Raft River Mountains above 7000' mean sea level.

Donner Creek (Box Elder County), from irrigation diversion to Utah-Nevada state line.

Bettridge Creek (Box Elder County), from irrigation diversion to Utah-Nevada state line.

Clover Creek, from diversion to headwaters.

All surface waters on public land on the Deep Creek Mountains.

12. Farmington Bay Drainage

Holmes Creek and tributaries, from Highway US-89 to headwaters (Davis County).

Shepard Creek and tributaries, from Haight Bench diversion to headwaters (Davis County).

Farmington Creek and tributaries, from Haight Bench Canal diversion to headwaters (Davis County).

Steed Creek and tributaries, from Highway US-89 to headwaters (Davis County).

12.2 Category 2 Waters.

In addition to assigned use classes, the following surface waters of the State are hereby designated as Category 2 Waters:

a. Green River Drainage

Deer Creek, a tributary of Huntington Creek, from the forest boundary to 4800 feet upstream.

Electric Lake.

R317-2-13. Classification of Waters of the State (see R317-2-6).

a. Colorado River Drainage

13.1 Upper Colorado River Basin

TABLE

[Paria River and tributaries, from state line to headwaters		2B	3C	4
]Paria River and tributaries, from state line to headwaters		2B	3C	4
[All tributaries to Lake Powell, except as listed below		2B	3B	4
]All tributaries to Lake Powell except as listed below:		2B	3B	4
[Tributaries to Escalante River from confluence with Boulder Creek to headwaters, including Boulder Creek		2B	3A	4
] Tributaries to Escalante River from confluence with Boulder Creek to headwaters, including Boulder Creek		2B	3A	4
[Dirty Devil River and tributaries, from Lake Powell to Fremont River		2B	3C	4
] Dirty Devil River and tributaries, from Lake Powell to Fremont River		2B	3C	4
[Deer Creek and tributaries, from confluence with Boulder Creek to headwaters		2B	3A	4
] Deer Creek and tributaries, from confluence with Boulder Creek to headwaters		2B	3A	4
[Fremont River and tributaries, from confluence with Muddy Creek to Capitol Reef National Park, except as listed below	1C	2B	3C	4
]Freemont River and tributaries from confluence with Muddy Creek to Capitol Reef National Park, except as listed below:	1C	2B	3C	4
[Pleasant Creek and tributaries, from confluence with Fremont River to East boundary of Capitol Reef National Park		2B	3C	4
] Pleasant Creek and tributaries, from confluence with Fremont River to East boundary of Capitol Reef National Park		2B	3C	4
[Pleasant Creek and tributaries, from East boundary of Capitol Reef National Park to headwaters	1C	2B	3A	
] Pleasant Creek and tributaries, from East boundary of Capitol Reef National Park to headwaters	1C	2B	3A	
[Fremont River and tributaries, through Capitol Reef National Park to headwaters	1C	2A	3A	4
]Fremont River and tributaries, through Capitol Reef National Park to headwaters	1C	2A	3A	4
[Muddy Creek and tributaries, from confluence with Fremont River to Highway U-10 crossing, except as listed below		2B	3C	4
]Muddy Creek and tributaries, from Confluence with Fremont River to Highway U-10 crossing, except as listed below		2B	3C	4
Muddy Creek from confluence with Fremont River to confluence with Ivie Creek		2B	3C	4*
Muddy Creek and tributaries from the confluence with Ivie Creek to U-10		2B	3C	4*
Ivie Creek and its tributaries from the confluence with Muddy Creek to the confluence with Quitchupah Creek		2B	3C	4*
Ivie Creek and its tributaries from the confluence with Quitchapah Creek to U-10, except as listed below:		2B	3C	4*
Quitchupah Creek from the confluence with Ivie Creek to U-10		2B	3C	4*
Quitchupah Creek and. tributaries, from Highway U-10 crossing to headwaters		2B	3A	4
Ivie Creek and tributaries, from Highway U-10 to headwaters		2B	3A	4
[Quitchupah Creek and Tributaries, from Highway U-10 crossing to headwaters		2B	3A	4
Ivie Creek and tributaries, from Highway U-10 to headwaters		2B	3A	4
Muddy Creek and tributaries, from Highway U-10 crossing to headwaters	1C	2B	3A	4
]Muddy Creek and tributaries, from Highway U-10 crossing to headwaters	1C	2B	3A	4
[San Juan River and Tributaries, from Lake Powell to state line except As listed below:	1C	2A	3B	4
]San Juan River and tributaries from Lake Powell to state line except as listed below:	1C	2A	3B	4
[Johnson Creek and tributaries, from confluence with Recapture Creek to headwaters	1C	2B	3A	4
] Johnson Creek and tributaries, from confluence with Recapture Creek to headwaters	1C	2B	3A	4
[Verdure Creek and tributaries, from Highway US-191 crossing to headwaters		2B	3A	4
] Verdure Creek and tributaries, from Highway US-191 crossing to headwaters		2B	3A	4

[~~North Creek and tributaries, from confluence with Montezuma Creek to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
] North Creek and tributaries, from confluence with Montezuma Creek to headwaters	1C	2B	3A	4
[~~South Creek and tributaries, from confluence with Montezuma Creek to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
] South Creek and tributaries, from confluence with Montezuma Creek to headwaters	1C	2B	3A	4
[~~Spring Creek and tributaries, from confluence with Vega Creek to headwaters~~		~~2B~~	~~3A~~	~~4~~
] Spring Creek and tributaries, from confluence with Vega Creek to headwaters		2B	3A	4
[~~Montezuma Creek and tributaries, from U.S. Highway 191 to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
] Montezuma Creek and tributaries, from U.S. Highway 191 to headwaters	1C	2B	3A	4
[~~Colorado River and tributaries, from Lake Powell to state line except as listed below~~	~~1C~~	~~2A~~	~~3B~~	~~4~~
]Colorado River and tributaries, from Lake Powell to state line except as listed below:	1C	2A	3B	4
[~~Indian Creek and tributaries, through Newspaper Rock State Park to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
] Indian Creek and tributaries, through Newspaper Rock State Park to headwaters	1C	2B	3A	4
[~~Kane Canyon Creek and tributaries, from confluence with Colorado River to headwaters~~		~~2B~~	~~3C~~	~~4~~
] Kane Canyon Creek and tributaries, from confluence with Colorado River to headwaters		2B	3C	4
[~~Mill Creek and tributaries, from confluence with Colorado River to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
] Mill Creek and tributaries, from confluence with Colorado River to headwaters	1C	2A	3A	4
Castle Creek from confluence with the Colorado River to Seventh Day Adventist Diversion	1C	2A	3B	4*
Onion Creek from the confluence with Colorado River to road crossing above Stinking Springs	1C	2A	3B	4*
[~~Dolores River and tributaries, from confluence with Colorado River to state line~~		~~2B~~	~~3C~~	~~4~~
] Dolores River and tributaries, from confluence with Colorado River to state line		2B	3C	4
[~~Roc Creek and tributaries, from confluence with Dolores River to headwaters~~		~~2B~~	~~3A~~	~~4~~
] Roc Creek and tributaries, from confluence with Dolores River to headwaters		2B	3A	4
[~~LaSal Creek and tributaries, from state line to headwaters~~		~~2B~~	~~3A~~	~~4~~
] LaSal Creek and tributaries from state line to headwaters		2B	3A	4
[~~Lion Canyon Creek and tributaries, from state line to headwaters~~		~~2B~~	~~3A~~	~~4~~
] Lion Canyon Creek and tributaries, from state line to headwaters		2B	3A	4
[~~Little Dolores River and tributaries, from confluence with Colorado River to state line~~		~~2B~~	~~3C~~	~~4~~
] Little Dolores River and tributaries, from confluence with Colorado River to state line		2B	3C	4
[~~Bitter Creek and tributaries, from confluence with Colorado River to headwaters~~		~~2B~~	~~3C~~	~~4~~
] Bitter Creek and tributaries, from confluence with Colorado River to headwaters		2B	3C	4

(*) Site-specific criteria are associated with this use.

b. Green River Drainage

TABLE

Green River and tributaries, from confluence with Colorado River to state line, except as listed below:[-]	1C	2A	3B	4
[~~Thompson Creek and tributaries from Interstate Highway 70 to headwaters~~		~~2B~~	~~3C~~	~~4~~
] Thompson Creek and tributaries from Interstate 70 to headwaters		2B	3C	4
[~~San Rafael River and tributaries, from confluence with Green River to confluence with Ferron Creek~~		~~2B~~	~~3C~~	~~4~~
] San Rafael River and tributaries from confluence with Green River to confluence with Ferron Creek, except as listed below:		2B	3C	
San Rafael River from the confluence with the Green River to Buckhorn Crossing		2B	3C	4*
San Rafael River from Buckhorn Crossing to the confluence with Huntington Creek and Cottonwood Creek		2B	3C	4*
[~~Ferron Creek and tributaries, from confluence with San Rafael River to Millsite Reservoir~~		~~2B~~	~~3C~~	~~4~~
~~Ferron Creek and tributaries, from Millsite Reservoir to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
] Ferron Creek and tributaries,				

from confluence with San Rafael River to Millsite Reservoir, except as listed below: 2B 3C 4

Ferron Creek from the confluence with San Rafael River to Highway 10 2B 3C 4*

Ferron Creek and tributaries, from Millsite Reservoir to headwaters 1C 2B 3A 4

[Huntington Creek and tributaries, from confluence with Cottonwood Creek to Highway U-10 crossing 2B 3C 4
] Huntington Creek and tributaries, from confluence with Cottonwood Creek to Highway U-10 crossing 2B 3C 4*

[Huntington Creek and tributaries, from Highway U-10 crossing to headwaters 1C 2B 3A 4
] Huntington Creek and tributaries from Highway U-10 crossing to headwaters 1C 2B 3A 4

[Cottonwood Creek and tributaries, from confluence with Huntington Creek to Highway U-57 crossing 2B 3C 4
] Cottonwood Creek and tributaries from confluence with Huntington Creek to Highway U-57 crossing, except as listed below: 2B 3C 4

Cottonwood Creek from the confluence with Huntington Creek to U-57 2B 3C 4*

Rock Canyon Creek from the confluence with Cottonwood Creek to headwaters 2B 3C 4*

[Cottonwood Creek and tributaries, from Highway U-57 crossing to headwaters 1C 2B 3A 4
] Cottonwood Creek and tributaries from Highway U-57 crossing to headwaters 1C 2B 3A 4

[Cottonwood Canal, Emery County 1C 2B 3E 4
] Cottonwood Canal, Emery County 1C 2B 3E 4

[Price River and tributaries, from confluence with Green River to Carbon Canal Diversion at Price City Golf Course 2B 3C 4

Except as listed below
] Price River and tributaries, from confluence with Green River to Carbon Canal Diversion at Price City Golf Course, except as listed below 2B 3C 4

Price River and tributaries from confluence with Green River to confluence with Soldier Creek 2B 3C 4*

Price River and tributaries from the confluence with Soldier Creek to Carbon Canal Diversion 2B 3C 4*

[Grassy Trail Creek and tributaries, from Grassy Trail Creek Reservoir to headwaters 1C 2B 3A 4
] Grassy Trail Creek and tributaries, from Grassy Trail Creek Reservoir to headwaters 1C 2B 3A 4

[Price River and tributaries, from Carbon Canal Diversion at Price City Golf Course to Price City Water Treatment Plant intake. 2B 3A 4
] Price River and tributaries, from Carbon Canal Diversion at Price City Golf Course to Price City Water Treatment Plant intake 2B 3A 4

[Price River and tributaries, from Price City Water Treatment Plant intake to headwaters 1C 2B 3A 4
] Price River and tributaries, from Price City Water Treatment Plant intake to headwaters 1C 2B 3A 4

[Range Creek and tributaries, from confluence with Green River to Range Creek Ranch 2B 3A 4
] Range Creek and tributaries, from confluence with Green River to Range Creek Ranch 2B 3A 4

[Range Creek and tributaries, from Range Creek Ranch to headwaters 1C 2B 3A 4
] Range Creek and tributaries, from Range Creek Ranch to headwaters 1C 2B 3A 4

[Rock Creek and tributaries, from confluence with Green River to headwaters 2B 3A 4
] Rock Creek and tributaries, from confluence with Green River to headwaters 2B 3A 4
[Nine Mile Creek and tributaries, from confluence with Green River to headwaters 2B 3A 4
]
Nine Mile Creek and tributaries, from confluence with Green River to headwaters 2B 3A 4

[Pariette Draw and tributaries, from confluence with Green River to headwaters 2B 3B 3D 4
] Pariette Draw and tributaries, from confluence with Green River to headwaters 2B 3B 3D 4

[Willow Creek and tributaries (Uintah County), from confluence with Green River to headwaters 2B 3A 4
] Willow Creek and tributaries (Uintah County), from confluence with Green River to headwaters 2B 3A 4

[White River and tributaries, from confluence with Green River to state line, except as listed below 2B 3B 4
] White River and tributaries, from confluence with Green River to state line, except as listed below: 2B 3B 4

[Bitter Creek and Tributaries from White River to Headwaters		2B 3A		4
] Bitter Creek and tributaries from White River to headwaters		2B 3A		4
[Duchesne River and tributaries, from confluence with Green River to Myton Water Treatment Plant intake, except as listed below		2B 3B		4
] Duchesne River and tributaries, from confluence with Green River to Myton Water Treatment Plant intake, except as listed below		2B 3B		4
[Uinta River and tributaries, From confluence with Duchesne River to Highway US 40 crossing		2B 3B		4
] Uinta River and tributaries from confluence with Duchesne River to U.S. Highway 40 crossing		2B 3B		4
[Uinta River and tributaries, From Highway US-4- crossing to headwaters		2B 3A		4
] Uinta River and tributaries, from U.S. Highway 40 crossing		2B 3A		4
[Power House Canal from Confluence with Uinta River to headwaters		2B 3A		4
] Power House Canal from confluence with Uinta River to headwaters		2B 3A		4
[Whiterocks River and Canal, From Tridell Water Treatment Plant to Headwaters	1C	2B 3A		4
] Whiterocks River and Canal, from Tridell Water Treatment Plant to headwaters	1C	2B 3A		4
[Duchesne River and tributaries, from Myton Water Treatment Plant intake to headwaters	1C	2B 3A		4
] Duchesne River and tributaries, from Myton Water Treatment Plant intake to headwaters	1C	2B 3A		4
[Lake Fork River and tributaries, from confluence with Duchesne River to headwaters	1C	2B 3A		4
] Lake Fork River and tributaries, from confluence with Duchesne River to headwaters	1C	2B 3A		4
[Lake Fork Canal from Dry Gulch Canal Diversion to Moon Lake	1C	2B	3E	4
] Lake Fork Canal from Dry Gulch Canal Diversion to Moon Lake	1C	2B	3E	4
[Dry Gulch Canal, from Myton Water Treatment Plant to Lake Fork Canal	1C	2B	3E	4
] Dry Gulch Canal, from Myton Water Treatment Plant to Lake Fork Canal	1C	2B	3E	4
[Ashley Creek and tributaries, from confluence with Green River to Steinaker diversion		2B 3B		4
] Ashley Creek and tributaries, from confluence with Green River to Steinaker diversion		2B 3B		4
[Ashley Creek and tributaries, from Steinaker diversion to headwaters	1C	2B 3A		4
] Ashley Creek and tributaries, from Steinaker diversion to headwaters	1C	2B 3A		4
[Big Brush Creek and tributaries, from confluence with Green River to Tyzack (Red Fleet) Dam		2B 3B		4
] Big Brush Creek and tributaries from confluence with Green River to Tyzack (Red Fleet) Dam		2B 3B		4
[Big Brush Creek and tributaries, from Tyzack (Red Fleet) Dam to headwaters	1C	2B 3A		4
] Big Brush Creek and tributaries, from Tyzack (Red Fleet) Dam to headwaters	1C	2B 3A		4
[Jones Hole Creek and tributaries, from confluence with Green River to headwaters		2B 3A		
] Jones Hole Creek and tributaries from confluence with Green River to headwaters		2B 3A		
[Diamond Gulch Creek and tributaries, from confluence with Green River to headwaters		2B 3A		4
] Diamond Gulch Creek and tributaries, from confluence with Green River to headwaters		2B 3A		4
[Pot Creek and tributaries, from Crouse Reservoir to headwaters		2B 3A		4
] Pot Creek and tributaries, from Crouse Reservoir to headwaters		2B 3A		4
[Green River and tributaries, from Utah Colorado state line to Flaming Gorge Dam except as listed below:		2A 3A		4
]Green River and tributaries, from Utah-Colorado state line to Flaming Gorge Dam, except as listed below:		2A 3A		4
[Sears Creek and tributaries, Daggett County		2B 3A		
] Sears Creek and tributaries, Daggett County		2B 3A		
[Tolivers Creek and tributaries, Daggett County		2B 3A		
] Tolivers Creek and tributaries, Daggett County		2B 3A		
[Red Creek and tributaries, from confluence with Green River to state line		2B 3C		4
] Red Creek and tributaries, from confluence with Green River to state line		2B 3C		4
[Jackson Creek and				

~~tributaries, Daggett County~~		~~2B~~	~~3A~~	
] Jackson Creek and tributaries, Daggett County		2B	3A	
[~~Davenport Creek and tributaries, Daggett County~~		~~2B~~	~~3A~~	
] Davenport Creek and tributaries, Daggett County		2B	3A	
[~~Goslin Creek and tributaries, Daggett County~~		~~2B~~	~~3A~~	
] Goslin Creek and tributaries, Daggett County		2B	3A	
[~~Gorge Creek and tributaries, Daggett County~~		~~2B~~	~~3A~~	
] Gorge Creek and tributaries, Daggett County		2B	3A	
[~~Beaver Creek and tributaries, Daggett County~~		~~2B~~	~~3A~~	
] Beaver Creek and tributaries, Daggett County		2B	3A	
[~~O-Wi-Yu-Kuts Creek and tributaries, Daggett County~~		~~2B~~	~~3A~~	
] O-Wi-Yu-Kuts Creek and tributaries, Daggett County		2B	3A	
Tributaries to Flaming Gorge Reservoir, except as listed below		2B	3A	4
[~~Birch Spring Draw and tributaries, from Flaming Gorge Reservoir to headwaters~~		~~2B~~	~~3C~~	~~4~~
] Birch Spring Draw and tributaries, from Flaming Gorge Reservoir to headwaters		2B	3C	4
[~~Spring Creek and tributaries, from Flaming Gorge Reservoir to headwaters~~		~~2B~~	~~3A~~	
] Spring Creek and tributaries, from Flaming Gorge Reservoir to headwaters		2B	3A	
[~~All Tributaries of Flaming Gorge Reservoir from Utah Wyoming state line to headwaters~~		~~2B~~	~~3A~~	~~4~~
]All tributaries of Flaming Gorge Reservoir from Utah-Wyoming state line to headwaters		2B	3A	4

(*) Site-specific criteria are associated with this use.

13.2 Lower Colorado River Basin

a. Virgin River Drainage

TABLE

Beaver Dam Wash and tributaries, from Motoqua to headwaters		2B	3B	4
[~~Virgin River and tributaries from state line to Quail Creek diversion except as listed below~~		~~2B~~	~~3B~~	~~4~~
]Virgin River and tributaries, from state line to Quail Creek diversion, except as listed below:		2B	3B	4
Virgin River from the Utah-Arizona border to Pah Tempe Springs		2B	3B	4*
Virgin River from the Utah-Arizona border to Pah Tempe Springs		2B	3B	4*
[~~Santa Clara River from confluence with Virgin River to Gunlock Reservoir~~	~~1C~~	~~2B~~	~~3B~~	~~4~~
] Santa Clara River from confluence with Virgin River to Gunlock Reservoir	1C	2B	3B	4
[~~Santa Clara River and tributaries, from Gunlock Reservoir to headwaters~~		~~2B~~	~~3A~~	~~4~~
] Santa Clara River and tributaries, from Gunlock Reservoir to headwaters		2B	3A	4
[~~Leed's Creek, from confluence with Quail Creek to headwaters~~		~~2B~~	~~3A~~	~~4~~
] Leeds Creek from confluence with Quail Creek to headwaters		2B	3A	4
[~~Quail Creek from Quail Creek Reservoir to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
] Quail Creek from Quail Creek Reservoir to headwaters	1C	2B	3A	4
[~~Ash Creek and tributaries, from confluence with Virgin River to Ash Creek Reservoir~~		~~2B~~	~~3A~~	~~4~~
] Ash Creek and tributaries, from confluence with Virgin River to Ash Creek Reservoir		2B	3A	4
[~~Ash Creek and tributaries, From Ash Creek Reservoir to headwaters~~		~~2B~~	~~3A~~	~~4~~
] Ash Creek and tributaries, from Ash Creek Reservoir to headwaters		2B	3A	4
[~~Virgin River and tributaries, from the Quail Creek diversion to headwaters, except as listed below~~	~~1C~~	~~2B~~	~~3C~~	~~4~~
]Virgin River and tributaries, from the Quail Creek diversion to headwaters, except as listed below:	1C	2B	3C	4
North Creek, from the confluence with Virgin River to headwaters	1C	2B	3C	4*
[~~North Fork Virgin River and tributaries~~	~~1C~~	~~2A~~	~~3A~~	~~4~~
] North Fork Virgin River and tributaries	1C	2A	3A	4
Kolob Creek, from confluence with Virgin River to headwaters		2B	3A	4
[~~East Fork Virgin River, from town of Glendale to headwaters~~		~~2B~~	~~3A~~	~~4~~
] East Fork Virgin River, from town of Glendale to headwaters		2B	3A	4
[~~Kolob Creek, from confluence with Virgin River to headwaters~~		~~2B~~	~~3A~~	~~4~~
]				

(*) Site-specific criteria are associated with this use.

b. Kanab Creek Drainage

TABLE

[~~Kanab Creek and tributaries, from state line to irrigation diversion at confluence with Reservoir Canyon~~		~~2B~~			~~3C~~		~~4~~
]Kanab Creek and tributaries, from state line to irrigation diversion at confluence with Reservoir Canyon		2B			3C		4
[~~Kanab Creek and tributaries, from irrigation diversion at confluence with Reservoir Canyon to headwaters~~		~~2B~~	~~3A~~				~~4~~
]Kanab Creek and tributaries, from irrigation diversion at confluence with Reservoir Canyon to headwaters		2B	3A				4
Johnson Wash and tributaries, from state line to confluence with Skutumpah Canyon		2B			3C		4
[~~Johnson Wash and tributaries, from confluence with Skutumpah Canyon to headwaters~~		~~2B~~	~~3A~~				~~4~~
]Johnson Wash and tributaries, from confluence with Skutumpah Canyon to headwaters		2B	3A				4

13.3 Bear River Basin

a. Bear River Drainage

TABLE

Bear River and tributaries, from Great Salt Lake to Utah-Idaho border, except as listed below:		2B		3B		3D	4
[~~Perry Canyon Creek from U.S. Forest boundary to headwaters~~		~~2B~~	~~3A~~				~~4~~
] Perry Canyon Creek from U.S. Forest boundary to headwaters		2B	3A				4
[~~Box Elder Creek from confluence with Black Slough to Brigham City Reservoir (the Mayor's Pond)~~		~~2B~~			~~3C~~		~~4~~
] Box Elder Creek from confluence with Black Slough to Brigham City Reservoir (Mayor's Pond)		2B			3C		4
[~~Box Elder Creek, from Brigham City Reservoir (the Mayor's Pond) to headwaters~~		~~2B~~	~~3A~~				~~4~~
] Box Elder Creek, from Brigham City Reservoir (Mayor's Pond) to headwaters		2B	3A				4
[~~Salt Creek, from confluence with Bear River to Crystal Hot Springs~~		~~2B~~		~~3B~~		~~3D~~	
] Salt Creek from confluence with Bear River to Crystal Hot Springs		2B		3B		3D	
[~~Malad River and tributaries, from confluence with Bear River to state line~~		~~2B~~			~~3C~~		
] Malad River and tributaries, from confluence with Bear River to state line		2B			3C		
[~~Little Bear River and tributaries, from Cutler Reservoir to headwaters~~		~~2B~~	~~3A~~			~~3D~~	~~4~~
] Little Bear River and tributaries, from Cutler Reservoir to headwaters, except as listed below:		2B	3A			3D	4
South Fork Spring Creek from confluence with Pelican Pond Slough Stream to U.S. Highway 89		2B	3A			3D	4*
[~~Logan River and tributaries, from Cutler Reservoir to headwaters~~		~~2B~~	~~3A~~			~~3D~~	~~4~~
] Logan River and tributaries, from Cutler Reservoir to headwaters		2B	3A			3D	4
[~~Blacksmith Fork and tributaries, from confluence with Logan River to headwaters~~		~~2B~~	~~3A~~				~~4~~
] Blacksmith Fork and tributaries, from confluence with Logan River to headwaters		2B	3A				4
[~~Newton Creek and tributaries, from Cutler Reservoir to Newton Reservoir~~		~~2B~~	~~3A~~				~~4~~
] Newton Creek and tributaries, from Cutler Reservoir to Newton Reservoir		2B	3A				4
[~~Clarkston Creek and tributaries, from Newton Reservoir to headwaters~~		~~2B~~	~~3A~~				~~4~~
] Clarkston Creek and tributaries, from Newton Reservoir to headwaters		2B	3A				4
[~~Birch Creek and tributaries, from confluence with Clarkston Creek to headwaters~~		~~2B~~	~~3A~~				~~4~~
] Birch Creek and tributaries, from confluence with Clarkston Creek to headwaters		2B	3A				4
[~~Summit Creek and tributaries, from confluence with Bear River to headwaters~~		~~2B~~	~~3A~~				~~4~~
] Summit Creek and tributaries, from confluence with Bear River to headwaters		2B	3A				4
[~~Cub River and tributaries, from confluence with Bear River to state line, except as listed below:~~		~~2B~~		~~3B~~			~~4~~
] Cub River and tributaries, from confluence with Bear River to state line, except as listed below:		2B		3B			4
[~~High Creek and tributaries, from confluence with Cub River to headwaters~~		~~2B~~	~~3A~~				~~4~~
] High Creek and tributaries from confluence with Cub River to headwaters		2B	3A				4
All tributaries to Bear Lake from Bear Lake to headwaters, except as listed below		2B	3A				4
Swan Springs tributary to Swan Creek	1C	2B	3A				
Bear River and tributaries in Rich County		2B	3A				4

Bear River and tributaries, from Utah-Wyoming state line to headwaters (Summit County)		2B	3A			4
Mill Creek and tributaries, from state line to headwaters (Summit County)		2B	3A			4

(*) Site-specific criteria are associated with this use.

13.4 Weber River Basin
a. Weber River Drainage

TABLE

Willard Creek, from Willard Bay Reservoir to headwaters		2B	3A			4
[Weber River, from Great Salt Lake to Slaterville diversion, except as listed below:		2B		3C	3D	4
]Weber River, from Great Salt Lake to Slaterville diversion, except as listed below:		2B		3C	3D	4
Four Mile Creek from Interstate[-]_15 [T]to headwaters		2B	3A			4
Weber River and tributaries, from Slaterville diversion to Stoddard diversion, except as listed below		2B	3A			4
Ogden River and tributaries, [F]from confluence with Weber River [T]to Pineview Dam, except as listed [B]below[-]:		2A	3A			4
[Wheeler Creek from Confluence with Ogden River to headwaters	1C	2B	3A			4
] Wheeler Creek from confluence with Ogden River to headwaters	1C	2B	3A			4
[All tributaries to Pineview Reservoir	1C	2B	3A			4
] All tributaries to Pineview Reservoir	1C	2B	3A			4
Strongs Canyon Creek and [T]tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A			4
Burch Creek and tributaries, from Harrison Boulevard in Ogden to Headwaters	1C	2B	3A			
Spring Creek and tributaries, [F]from U.S. National Forest [B]boundary to headwaters	1C	2B	3A			4
[Weber River and tributaries, from Stoddard diversion to headwaters	1C	2B	3A			4
]Weber River and tributaries, from Stoddard diversion to headwaters	1C	2B	3A			4

13.5 Utah Lake-Jordan River Basin
a. Jordan River Drainage

TABLE

[Jordan River, from Farmington Bay to North Temple Street, Salt Lake City		2B	3B *		3D	4
]Jordan River, from Farmington Bay to North Temple Street, Salt Lake City		2B	3B*		3D	4
[State Canal, from Farmington Bay to confluence with the Jordan River		2B	3B *		3D	4
]State Canal, from Farmington Bay to confluence with the Jordan River		2B	3B*		3D	4
[Jordan River, from North Temple Street in Salt Lake City to confluence with Little Cottonwood Creek		2B	3B *			4
]Jordan River, from North Temple Street in Salt Lake City to confluence with Little Cottonwood Creek		2B	3B*			4
[Surplus Canal from Great Salt Lake to the diversion from the Jordan River		2B	3B *		3D	4
]Surplus Canal from Great Salt Lake to the diversion from the Jordan River		2B	3B*		3D	4
[Jordan River from confluence with Little Cottonwood Creek to Narrows Diversion		2B	3A			4
]Jordan River from confluence with Little Cottonwood Creek to Narrows Diversion		2B	3A			4
[Jordan River, from Narrows Diversion to Utah Lake	1C	2B	3B			4
]Jordan River, from Narrows Diversion to Utah Lake	1C	2B	3B			4
[City Creek, from Memory Park in Salt Lake City to City Creek Water Treatment Plant		2B	3A			
]City Creek, from Memory Park in Salt Lake City to City Creek Water Treatment Plant		2B	3A			
City Creek, from City Creek Water Treatment Plant to headwaters	1C	2B	3A			
[Red Butte Creek and tributaries from Liberty Park pond inlet to Red Butte Reservoir		2B	3A			4
]Red Butte Creek and tributaries, from Liberty Park pond inlet to Red Butte Reservoir		2B	3A			4
[Red Butte Creek and tributaries, from Red Butte Reservoir to headwaters	1C	2B	3A			
]Red Butte Creek and tributaries, from Red Butte Reservoir to headwaters	1C	2B	3A			
[Emigration Creek and tributaries, from 1100 East in Salt Lake City to headwaters		2B	3A			4
]Emigration Creek and tributaries, from 1100 East in Salt Lake City to headwaters		2B	3A			4
[Parley's Creek and tributaries, from 1300 East in Salt Lake City to Mountain Dell Reservoir	1C	2B	3A			
]Parleys Creek and tributaries, from 1300 East in Salt Lake City to Mountain Dell Reservoir	1C	2B	3A			
[Parley's Creek and tributaries, from Mountain Dell Reservoir to						

headwaters	1C	2B 3A		
]Parleys Creek and tributaries, from Mountain Dell Reservoir to headwaters	1C	2B 3A		
[Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate Highway 15		2B	3C	4
]Mill Creek (Salt Lake County) from confluence with Jordan River to Interstate 15		2B	3C	4
[Mill Creek (Salt Lake County) and tributaries from Interstate Highway 15 to headwaters		2B 3A		4
]Mill Creek (Salt Lake County) and tributaries, from Interstate 15 to headwaters		2B 3A		4
[Big Cottonwood Creek and tributaries, from confluence with Jordan River to Big Cottonwood Water Treatment Plant		2B 3A		4
]Big Cottonwood Creek and tributaries, from confluence with Jordan River to Big Cottonwood Water Treatment Plant		2B 3A		4
[Big Cottonwood Creek and tributaries, from Big Cottonwood Water Treatment Plant to headwaters	1C	2B 3A		
]Big Cottonwood Creek and tributaries from Big Cottonwood Water Treatment Plant to headwaters	1C	2B 3A		
Deaf Smith Canyon Creek and tributaries	1C	2B 3A		4
[Little Cottonwood Creek and tributaries, from confluence with Jordan River to Metropolitan Water Treatment Plant		2B 3A		4
]Little Cottonwood Creek and tributaries, from confluence with Jordan River to Metropolitan Water Treatment Plant		2B 3A		4
Little Cottonwood Creek and tributaries, from Metropolitan Water Treatment Plant to headwaters	1C	2B 3A		
Bells Canyon Creek and tributaries, from [l]Lower Bell['']s Canyon [r]Reservoir to headwaters	1C	2B 3A		
[Little Willow Creek and tributaries, from Draper Irrigation Company diversion to headwaters	1C	2B 3A		
]Little Willow Creek and tributaries, from Draper Irrigation Company diversion to headwaters	1C	2B 3A		
Big Willow Creek and tributaries, from Draper Irrigation Company diversion to headwaters	1C	2B 3A		
South Fork of Dry Creek and tributaries, from Draper [ ]Irrigation Company diversion to headwaters	1C	2B 3A		
[All permanent streams on east slope of Oquirrh Mountains (Coon, Barney's, Bingham, Butterfield, and Rose Creeks)		2B	3D	4
]All permanent streams on east slope of Oquirrh Mountains (Coon, Barneys, Bingham, Butterfield, and Rose Creeks)		2B	3D	4
Kersey Creek from confluence of C-7 Ditch to headwaters		2B	3D	

[* Site specific criteria for dissolved oxygen. See Table 2.14.5.
](*) Site-specific criteria are associated with this use.

b. Provo River Drainage

TABLE

[Provo River and tributaries, from Utah Lake to Murdock diversion		2B 3A		4
]Provo River and tributaries, from Utah Lake to Murdock Diversion		2B 3A		4
[Provo River and tributaries, from Murdock Diversion to headwaters, except as listed below	1C	2B 3A		4
]Provo River and tributaries, from Murdock Diversion to headwaters, except as listed below:	1C	2B 3A		4
Upper Falls drainage above Provo City diversion	1C	2B 3A		
Bridal Veil Falls drainage above Provo City diversion	1C	2B 3A		
Lost Creek and tributaries above Provo City diversion	1C	2B 3A		

c. Utah Lake Drainage

TABLE

[Dry Creek and tributaries (above Alpine), from U.S. National Forest boundary to headwaters		2B 3A		4
]Dry Creek and tributaries (above Alpine), from U.S. National Forest boundary to headwaters		2B 3A		4
[American Fork Creek and tributaries, from diversion at mouth of American Fork Canyon to headwaters		2B 3A		4
]American Fork Creek and tributaries, from diversion at mouth of American Fork Canyon to headwaters		2B 3A		4
[Spring Creek and tributaries, from Utah Lake near Lehi to headwaters		2B 3A		4
]Spring Creek and tributaries, from Utah Lake near Lehi to headwaters		2B 3A		4
[Lindon Hollow Creek and tributaries, from Utah Lake to headwaters		2B	3B	4
]Lindon Hollow Creek and tributaries, from Utah Lake to headwaters		2B	3B	4
Grove Creek from Murdock Diversion to headwaters	1C	2B 3A		
Battle Creek from Murdock Diversion to Headwaters	1C	2B 3A		

[~~Rock Canyon Creek and tributaries (East of Provo) from U.S. National Forest boundary to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
]Rock Canyon Creek and tributaries (East of Provo), from U.S. National Forest boundary to headwaters	1C	2B	3A	4
Mill Race (except from Interstate [~~Highway~~]15 to the Provo City WWTP discharge) and tributaries, from Utah Lake to headwaters		2B	3B	4
Mill Race from Interstate 15[~~Highway~~] [~~15~~]to the Provo City wastewater treatment plant discharge		2B	3B	4
[~~Spring Creek and tributaries from Utah Lake (Provo Bay) to 50 feet upstream from the east boundary of the Industrial Parkway Road Right-of-way~~		~~2B~~	~~3B~~	~~4~~
]Spring Creek and tributaries, from Utah Lake (Provo Bay) to 50 feet upstream from the east boundary of the Industrial Parkway Road Right-of-way		2B	3B	4
[~~Tributary to Spring Creek (Utah County) which receives the Springville City WWTP effluent from confluence with Spring Creek to headwaters~~		~~2B~~	~~3D~~	~~4~~
]Tributary to Spring Creek (Utah County) which receives the Springville City WWTP effluent from confluence with Spring Creek to headwaters		2B	3D	4
[~~Spring Creek and tributaries from 50 feet upstream from the east boundary of the Industrial Parkway Road right of way to the headwaters~~		~~2B~~	~~3A~~	~~4~~
]Spring Creek and tributaries from 50 feet upstream from the east boundary of the Industrial Parkway Road right-of-way to the headwaters		2B	3A	4
Ironton Canal from Utah Lake (Provo Bay) to the east boundary of the Denver and Rio Grande Western Railroad right-of-way		2B	3C	4
[~~Ironton Canal from the east boundary of the Denver and Rio Grande Western Railroad right-of-way to the point of diversion from Spring Creek~~		~~2B~~	~~3A~~	~~4~~
]Ironton Canal from the east boundary of the Denver and Rio Grande Western Railroad right-of-way to the point of diversion from Spring Creek		2B	3A	4
[~~Hobble Creek and tributaries, from Utah Lake to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Hobble Creek and tributaries, from Utah Lake to headwaters		2B	3A	4
[~~Dry Creek and tributaries from Utah Lake (Provo Bay) to Highway US 89~~		~~2B~~	~~3E~~	~~4~~
]Dry Creek and tributaries, from Utah Lake (Provo Bay) to U.S. Highway 89		2B	3E	4
[~~Dry Creek and tributaries from Highway US 89 to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Dry Creek and tributaries, from U.S. Highway 89 to headwaters		2B	3A	4
[~~Spanish Fork River and tributaries, from Utah Lake to diversion at Moark Junction~~		~~2B~~	~~3B 3D~~	~~4~~
]Spanish Fork River and tributaries, from Utah Lake to diversion at Moark Junction		2B	3B 3D	4
[~~Spanish Fork River and tributaries, from diversion at Moark Junction to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Spanish Fork River and tributaries, from diversion at Moark Junction to headwaters		2B	3A	4
Benjamin Slough and tributaries, from Utah Lake to headwaters, except as listed below		2B	3B	4
[~~Beer Creek (Utah County) from 4850 West (in NE1/4NE1/4 sec. 36, T.8 S., R.1 E.) to headwaters~~		~~2B~~	~~3C~~	~~4~~
] Beer Creek (Utah County) from 4850 West (in NE1/4NE1/4 sec. 36, T.8.S., R.1.E.) to headwaters		2B	3C	4
[~~Salt Creek, from Nephi diversion to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Salt Creek from Nephi diversion to headwaters		2B	3A	4
[~~Currant Creek, from mouth of Goshen Canyon to Mona Reservoir~~		~~2B~~	~~3A~~	~~4~~
]Currant Creek from mouth of Goshen Canyon to Mona Reservoir		2B	3A	4
[~~Currant Creek, from Mona Reservoir to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Currant Creek from Mona Reservoir to headwaters		2B	3A	4
[~~Peteetneet Creek and tributaries, from irrigation diversion above Maple Dell to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Peteetneet Creek and tributaries, from irrigation diversion above Maple Dell to headwaters		2B	3A	4
[~~Summit Creek and tributaries (above Santaquin), from U.S. National Forest boundary to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Summit Creek and tributaries (above Santaquin), from U.S. National Forest boundary to headwaters		2B	3A	4
[~~All other permanent streams entering Utah Lake~~		~~2B~~	~~3B~~	~~4~~
]All other permanent streams entering Utah Lake		2B	3B	4

13.6 Sevier River Basin
a. Sevier River Drainage

TABLE

[~~Sevier River and tributaries from Sevier Lake to Gunnison Bend Reservoir to U.S.National Forest boundary except as listed below~~	~~2B~~	~~3C~~	~~4~~
]Sevier River and tributaries, from Sevier Lake to Gunnison Bend Reservoir to U.S. National Forest boundary, except as listed below:	2B	3C	4
Sevier River from Gunnison Bend Reservoir to Clear Lake	2B	3C	4*
[~~Beaver River and tributaries from Minersville City to headwaters~~	~~2B~~	~~3A~~	~~4~~
] Beaver River and tributaries, from Minersville City to headwaters	2B	3A	4
[~~Little Creek and tributaries, From irrigation diversion to Headwaters~~	~~2B~~	~~3A~~	~~4~~
] Little Creek and tributaries, from irrigation diversion to headwaters	2B	3A	4
[~~Pinto Creek and tributaries, From Newcastle Reservoir to Headwaters~~	~~2B~~	~~3A~~	~~4~~
] Pinto Creek and tributaries, from Newcastle Reservoir to headwaters	2B	3A	4
Coal Creek and tributaries	2B	3A	4
Summit Creek and tributaries	2B	3A	4
Parowan Creek and tributaries	2B	3A	4
[~~Tributaries to Sevier River from Sevier Lake to Gunnison Bend Reservoir from U.S. National Forest boundary to headwaters, including:~~	~~2B~~	~~3A~~	~~4~~
]Tributaries to Sevier River from Sevier Lake to Gunnison Bend Reservoir from U.S. National Forest boundary to headwaters, including:	2B	3A	4
[-] Pioneer Creek and tributaries, [-] Millard County_	2B	3A	4
[-] Chalk Creek and tributaries, [-] Millard County_	2B	3A	4
[-] Meadow Creek and tributaries, [-] Millard County_	2B	3A	4
[-] Corn Creek and tributaries, [-] Millard County_	2B	3A	4
Sevier River and tributaries, below U.S. National Forest boundary from Gunnison Bend Reservoir to Annabella Diversion, except as listed below	2B	3B	4
Sevier River between Gunnison Bend Reservoir and DMAD Reservoir	2B	3B	4*
[~~Oak Creek and tributaries, Millard County~~	~~2B~~	~~3A~~	~~4~~
] Oak Creek and tributaries Millard County	2B	3A	4
[~~Round Valley Creek and tributaries, Millard County~~	~~2B~~	~~3A~~	~~4~~
] Round Valley Creek and tributaries, Millard County	2B	3A	4
[~~Judd Creek and tributaries, Juab County~~	~~2B~~	~~3A~~	~~4~~
] Judd Creek and tributaries, Juab County	2B	3A	4
[~~Meadow Creek and tributaries, Juab County~~	~~2B~~	~~3A~~	~~4~~
] Meadow Creek and tributaries, Juab County	2B	3A	4
[~~Cherry Creek and tributaries Juab County~~	~~2B~~	~~3A~~	~~4~~
] Cherry Creek and tributaries, Juab County	2B	3A	4
[~~Tanner Creek and tributaries, Juab County~~	~~2B~~	~~3E~~	~~4~~
] Tanner Creek and tributaries, Juab County	2B	3E	4
Baker Hot Springs, Juab County	2B	3D	4
[~~Chicken Creek and tributaries, Juab County~~	~~2B~~	~~3A~~	~~4~~
] Chicken Creek and tributaries, Juab County	2B	3A	4
[~~San Pitch River and tributaries, from confluence with Sevier River to Highway U-132 crossing except As listed below:~~	~~2B~~	~~3C 3D~~	~~4~~
] San Pitch River and tributaries, from confluence with Sevier River to Highway U-132 crossing, except as listed below:	2B	3C 3D	4
San Pitch River from below Gunnison Reservoir to the Sevier River	2B	3C 3D	4*
[~~Twelve Mile Creek (South Creek) and tributaries, from U.S. Forest Service boundary to headwaters~~	~~2B~~	~~3A~~	~~4~~
] Twelve Mile Creek (South Creek) and tributaries, from U.S. National Forest boundary to headwaters	2B	3A	4
Six Mile Creek and tributaries, Sanpete County	2B	3A	4
[~~Manti Creek (South Creek) and tributaries, from U.S. Forest Service boundary to headwaters~~	~~2B~~	~~3A~~	~~4~~
] Manti Creek (South Creek) and tributaries, from U.S. National Forest boundary to headwaters	2B	3A	4
[~~Ephraim Creek (Cottonwood Creek) and tributaries, from U.S. Forest Service to headwaters~~	~~2B~~	~~3A~~	~~4~~
] Ephraim Creek (Cottonwood Creek) and tributaries, from U.S. National Forest to headwaters	2B	3A	4

[~~Oak Creek and tributaries, from U.S. Forest Service boundary near Spring City to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Oak Creek and tributaries, from U.S. National Forest boundary near Spring City to headwaters		2B	3A	4
[~~Fountain Green Creek and tributaries, from U.S. Forest Service boundary to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Fountain Green Creek and tributaries, from U.S. National Forest boundary to headwaters		2B	3A	4
[~~San Pitch River and tributaries, from Highway U-132 crossing to headwaters~~		~~2B~~	~~3A~~	~~4~~
]San Pitch River and tributaries, from Highway U-132 crossing to headwaters		2B	3A	4
Lost Creek from the confluence with Sevier River to U.S. National Forest boundary		2B	3C 3D	4*
Brine Creek-Petersen Creek from the confluence with the Sevier River to Highway U-119 Crossing		2B	3C 3D	4*
[~~Tributaries to Sevier River from Gunnison Bend Reservoir to Annabelle Diversion from U.S. National Forest boundary to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Tributaries to Sevier River from Gunnison Bend Reservoir to Annabella diversion from U.S. National Forest boundary to headwaters		2B	3A	4
[~~Sevier River and tributaries, from Annabella diversion to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Sevier River and tributaries, from Annabella diversion to headwaters		2B	3A	4
[~~Monroe Creek and tributaries, from diversion to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Monroe Creek and tributaries, from diversion to headwaters		2B	3A	4
[~~Little Creek and tributaries, from irrigation diversion to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Little Creek and tributaries, from irrigation diversion to headwaters		2B	3A	4
[~~Pinto Creek and tributaries, from Newcastle Reservoir to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Pinto Creek and tributaries, from Newcastle Reservoir to headwaters		2B	3A	4
Coal Creek and tributaries		2B	3A	4
Summit Creek and tributaries		2B	3A	4
Parowan Creek and tributaries		2B	3A	4
Duck Creek and tributaries	1C	2B	3A	4

(*) Site-specific criteria are associated with this use.

13.7 Great Salt Lake Basin

a. Western Great Salt Lake Drainage

TABLE

Grouse Creek and tributaries, Box Elder County		2B	3A	4
Muddy Creek and tributaries, Box Elder County		2B	3A	4
Dove Creek and tributaries, Box Elder County		2B	3A	4
Pine Creek and tributaries, Box Elder County		2B	3A	4
Rock Creek and tributaries, Box Elder County		2B	3A	4
Fisher Creek and tributaries, Box Elder County		2B	3A	4
Dunn Creek and tributaries, Box Elder County		2B	3A	4
[~~Indian Creek and tributaries, Box Elder County~~		~~2B~~	~~3A~~	~~4~~
]Indian Creek and tributaries, Box Elder County		2B	3A	4
[~~Tenmile Creek and tributaries, Box Elder County~~		~~2B~~	~~3A~~	~~4~~
]Tenmile Creek and tributaries, Box Elder County		2B	3A	4
[~~Curlew (Deep) Creek, Box Elder County~~		~~2B~~	~~3A~~	~~4~~
]Curlew (Deep) Creek, Box Elder County		2B	3A	4
[~~Blue Creek and tributaries, from Great Salt Lake to Blue Creek Reservoir~~		~~2B~~	~~3D~~	~~4~~
]Blue Creek and tributaries, Box Elder County, from Bear River Bay, Great Salt Lake to Blue Creek Reservoir		2B	3D	4*
[~~Blue Creek and tributaries, from Blue Creek Reservoir to headwaters~~		~~2B~~	~~3B~~	~~4~~
]Blue Creek and tributaries from Blue Creek Reservoir to headwaters		2B	3B	4*
[~~All perennial streams on the east slope of the Pilot Mountain Range~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
]All perennial streams on the east slope of the Pilot Mountain Range	1C	2B	3A	4
[~~Donner Creek and tributaries, from irrigation diversion to Utah Nevada state line~~		~~2B~~	~~3A~~	~~4~~
]Donner Creek and tributaries, from irrigation diverion to Utah-Nevada state line		2B	3A	4
[~~Bettridge Creek and tributaries, from irrigation diversion to Utah Nevada state line~~		~~2B~~	~~3A~~	~~4~~
]Bettridge Creek and tributaries, from irrigation diverion to Utah-Nevada state line		2B	3A	4
[~~North Willow Creek and tributaries, Tooele County~~		~~2B~~	~~3A~~	~~4~~

]North Willow Creek and tributaries, Tooele County		2B	3A				4
[~~South Willow Creek and tributaries, Tooele County~~		~~2B~~	~~3A~~				~~4~~
]South Willow Creek and tributaries, Tooele County		2B	3A				4
Hickman Creek and tributaries, Tooele County		2B	3A				4
Barlow Creek and tributaries, Tooele County		2B	3A				4
Clover Creek and tributaries, Tooele County		2B	3A				4
Faust Creek and tributaries, Tooele County		2B	3A				4
Vernon Creek and tributaries, Tooele County		2B	3A				4
Ophir Creek and tributaries, Tooele County		2B	3A				4
[~~Soldier Creek and Tributaries from the Drinking Water Treatment Facility Headwaters, Tooele County~~	~~1C~~	~~2B~~	~~3A~~				~~4~~
]Soldier Creek and tributaries, from the Drinking Water Treamtent Facility to headwaters, Tooele County	1C	2B	3A				4
Settlement Canyon Creek and tributaries, Tooele County		2B	3A				4
[~~Middle Canyon Creek and tributaries, Tooele County~~		~~2B~~	~~3A~~				~~4~~
]Middle Canyon Creek and tributaries, Tooele County		2B	3A				4
Tank Wash and tributaries, Tooele County		2B	3A				4
Basin Creek and tributaries, Juab and Tooele Counties		2B	3A				4
Thomas Creek and tributaries, Juab County		2B	3A				4
[~~Indian Farm Creek and tributaries, Juab County~~		~~2B~~	~~3A~~				~~4~~
]Indian Farm Creek and tributaries, Juab County		2B	3A				4
[~~Cottonwood Creek and tributaries, Juab County~~		~~2B~~	~~3A~~				~~4~~
]Cottonwood Creek and tributaries, Juab County		2B	3A				4
Red Cedar Creek and tributaries, Juab County		2B	3A				4
Granite Creek and tributaries, Juab County		2B	3A				4
Trout Creek and tributaries, Juab County		2B	3A				4
Birch Creek and tributaries, Juab County		2B	3A				4
[~~Deep Creek and tributaries, from Rock Spring Creek to headwaters, Juab and Tooele Counties~~		~~2B~~	~~3A~~				~~4~~
]Deep Creek and tributaries, from Rock Spring Creek to headwaters, Juab and Tooele Counties		2B	3A				4
Cold Spring, Juab County		2B			3C	3D	
Cane Spring, Juab County		2B			3C	3D	
[~~Lake Creek, from Garrison (Pruess) Reservoir to Nevada state line~~		~~2B~~	~~3A~~				~~4~~
]Lake Creek, from Garrison (Pruess) Reservoir to Nevada state line		2B	3A				4
Snake Creek and tributaries, Millard County		2B		3B			4
Salt Marsh Spring Complex, Millard County		2B	3A				
Twin Springs, Millard County		2B		3B			
Tule Spring, Millard County		2B			3C	3D	
Coyote Spring Complex, Millard County		2B			3C	3D	
[~~Hamblin Valley Wash and tributaries, from Nevada state line to headwaters (Beaver and Iron Counties)~~		~~2B~~				~~3D~~	~~4~~
]Hamblin Valley Wash and tributaries, from Nevada state line to headwaters (Beaver and Iron Counties)		2B				3D	4
[~~Indian Creek and tributaries, Beaver County, from Indian Creek Reservoir to headwaters~~		~~2B~~	~~3A~~				~~4~~
]Indian Creek and tributaries, Beaver County, from Indian Creek Reservoir to headwaters		2B	3A				4
Shoal Creek and tributaries, Iron County		2B	3A				4

(*) Site-specific criteria are associated with this use.

b. Farmington Bay Drainage

TABLE

[~~Corbett Creek and tributaries, from Highway to headwaters~~		~~2B~~	~~3A~~		~~4~~
]Corbett Creek and tributaries, from Highway to headwaters		2B	3A		4
[~~Kays Creek and tributaries, from Farmington Bay to U.S. National Forest boundary~~		~~2B~~		~~3B~~	~~4~~
]Kays Creek and tributaries, from Farmington Bay to U.S. National Forest boundary		2B		3B	4
North Fork Kays Creek and tributaries, from U.S. National Forest boundary to headwaters		2B	3A		4
Middle Fork Kays Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A		4
South Fork Kays Creek and					

tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A	4
Snow Creek and tributaries		2B	3C	4
[~~Holmes Creek and tributaries, from Farmington Bay to U.S. National Forest boundary~~		~~2B~~	~~3B~~	~~4~~
]Holmes Creek and tributaries, from Farmington Bay to U.S. National Forest boundary		2B	3B	4
Holmes Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A	4
[~~Baer Creek and tributaries, from Farmington Bay to Interstate Highway 15~~		~~2B~~	~~3C~~	~~4~~
]Baer Creek and tributaries, from Farmington Bay to Interstate 15		2B	3B	4
[~~Baer Creek and tributaries, from Interstate Highway 15 to Highway US-89~~		~~2B~~	~~3B~~	~~4~~
]Baer Creek and tributaries, from Interstate 15 to U.S. Highway 89		2B	3B	4
Baer Creek and tributaries, from U.S. Highway [~~US-~~]89 to headwaters [—]	1C	2B	3A	4
[~~Shepard Creek and tributaries, from U.S. National Forest boundary to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
]Shepard Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A	4
Farmington Creek and tributaries, from Farmington Bay Waterfowl Management Area to U.S. National Forest boundary		2B	3B	4
Farmington Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A	4
[~~Rudd Creek and tributaries, from Davis aqueduct to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Rudd Creek and tributaries, from Davis aqueduct to headwaters		2B	3A	4
[~~Steed Creek and tributaries, from U.S. National Forest boundary to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
]Steed Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A	4
[~~Davis Creek and tributaries, from Highway US-89 to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Davis Creek and tributaries, from U.S. Highway 89 to headwaters		2B	3A	4
Lone Pine Creek and tributaries, from U.S. Highway [~~US-~~]89 to headwaters		2B	3A	4
Ricks Creek and tributaries, from [Highway I-]Interstate 15 to headwaters	1C	2B	3A	4
[~~Barnard Creek and tributaries, from Highway US-89 to headwaters~~		~~2B~~	~~3A~~	~~4~~
] Barnard Creek and tributaries, from U.S. Highway 89 to headwaters		2B	3A	4
[~~Parrish Creek and tributaries, from Davis Aqueduct to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Parrish Creek and tributaries, from Davis Aqueduct to headwaters		2B	3A	4
[~~Deuel Creek and tributaries, (Centerville Canyon) from Davis Aqueduct to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Deuel Creek and tributaries, (Centerville Canyon) from Davis Aqueduct to headwaters		2B	3A	4
[~~Stone Creek and tributaries, from Farmington Bay Waterfowl Management Area to U.S. National Forest boundary~~		~~2B~~	~~3A~~	~~4~~
]Stone Creek and tributaries, from Farmington Bay Waterfowl Management Area to U.S. National Forest Boundary		2B	3A	4
[~~Stone Creek and tributaries, from U.S. National Forest boundary to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
]Stone Creek and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A	4
[~~Barton Creek and tributaries, from U.S. National Forest boundary to headwaters~~		~~2B~~	~~3A~~	~~4~~
]Barton Creek and tributaries, from U.S. National Forest boundary to headwaters		2B	3A	4
[~~Mill Creek (Davis County) and tributaries, from confluence with State Canal to U.S. National Forest boundary~~		~~2B~~	~~3B~~	~~4~~
]Mill Creek (Davis County) and tributaries, from confluence with State Canal to U.S. National Forest boundary		2B	3B	4
[~~Mill Creek (Davis County) and tributaries, from U.S. National Forest boundary to headwaters~~	~~1C~~	~~2B~~	~~3A~~	~~4~~
]Mill Creek (Davis County) and tributaries, from U.S. National Forest boundary to headwaters	1C	2B	3A	4
[~~North Canyon Creek and tributaries, from U.S. National Forest boundary to headwaters~~		~~2B~~	~~3A~~	~~4~~
]North Canyon Creek and tributaries from U.S. National Forest boundary to headwaters		2B	3A	4
Howard Slough		2B	3C	4
Hooper Slough		2B	3C	4
Willard Slough		2B	3C	4
Willard Creek to Headwaters	1C	2B	3A	4
Chicken Creek to Headwaters	1C	2B	3A	4
Cold Water Creek to Headwaters	1C	2B	3A	4
One House Creek to Headwaters	1C	2B	3A	4
Garner Creek to Headwaters	1C	2B	3A	4

13.8 Snake River Basin
a. Raft River Drainage (Box Elder County)

TABLE

Raft River and tributaries	2B 3A	4
[~~Clear Creek and tributaries, from Utah-Idaho state line to headwaters~~	~~2B 3A~~	~~4~~
]Clear Creek and tributaries, from Utah-Idaho state line to headwaters	2B 3A	4
[~~Onemile Creek and tributaries, from Utah-Idaho state line to headwaters~~	~~2B 3A~~	~~4~~
]Onemile Creek and tributaries, from Utah-Idaho state line to headwaters	2B 3A	4
[~~George Creek and tributaries, from Utah-Idaho state line to headwaters~~	~~2B 3A~~	~~4~~
]George Creek and tributaries, from Utah-Idaho state line to headwaters	2B 3A	4
[~~Johnson Creek and tributaries, from Utah-Idaho state line to headwaters~~	~~2B 3A~~	~~4~~
]Johnson Creek and tributaries, from Utah-Idaho state line to headwaters	2B 3A	4
[~~Birch Creek and tributaries, from state line to headwaters~~	~~2B 3A~~	~~4~~
]Birch Creek and tributaries, from state line to headwaters	2B 3A	4
[~~Pole Creek and tributaries, from state line to headwaters~~	~~2B 3A~~	~~4~~
]Pole Creek and tributaries, from state line to headwaters	2B 3A	4
Goose Creek and tributaries	2B 3A	4
[~~Hardesty Creek and tributaries, from state line to headwaters~~	~~2B 3A~~	~~4~~
]Hardesty Creek and tributaries, from state line to headwaters	2B 3A	4
Meadow Creek and tributaries, from state line to headwaters	2B 3A	4

13.9 All irrigation canals and ditches statewide, except as otherwise designated: 2B, 3E, 4

13.10 All drainage canals and ditches statewide, except as otherwise designated: 2B, 3E

13.11 National Wildlife Refuges and State

Waterfowl Management Areas, and other Areas Associated with the Great Salt Lake

TABLE

Bear River National Wildlife Refuge, Box Elder County	2B	3B	3D	
Bear River Bay				
Open Water below approximately 4,208 ft.				5C
Transitional Waters approximately 4,208 ft. to Open Water				5E
Open Water above approximately 4,208 ft.	2B	3B	3D	
Brown[']s Park Waterfowl Management Area, Daggett County	2B	3A	3D	
Clear Lake Waterfowl Management Area, Millard County	2B	3C	3D	
Desert Lake Waterfowl Management Area, Emery County	2B	3C	3D	
Farmington Bay Waterfowl Management Area, Davis and Salt Lake Counties	2B	3C	3D	
Farmington Bay				
Open Water below approximately 4,208 ft.				5D
Transitional Waters approximately 4,208 ft. to Open Water				5E
Open Water above approximately 4,208 ft.	2B	3B	3D	
Fish Springs National Wildlife Refuge, Juab County	2B	3C	3D	
Harold Crane Waterfowl Management Area, Box Elder County	2B	3C	3D	
Gilbert Bay				
Open Water below approximately 4,208 ft.				5A
Transitional Waters approximately 4,208 ft. to Open Water				5E
Open Water above approximately 4,208 ft.	2B	3B	3D	
Gunnison Bay				
Open Water below approximately 4,208 ft.				5B
Transitional Waters approximately 4,208 ft. to Open Water				5E
Open Water above approximately 4,208 ft.	2B	3B	3D	
Howard Slough Waterfowl Management Area, Weber County	2B	3C	3D	
Locomotive Springs Waterfowl Management Area, Box Elder County	2B	3B	3D	
Ogden Bay Waterfowl Management Area, Weber County	2B	3C	3D	
Ouray National Wildlife Refuge, Uintah County	2B	3B	3D	
Powell Slough Waterfowl Management Area, Utah County	2B	3C	3D	
Public Shooting Grounds Waterfowl Management Area, Box Elder County	2B	3C	3D	
Salt Creek Waterfowl Management Area, Box Elder County	2B	3C	3D	
Stewart Lake Waterfowl Management Area, Uintah County	2B	3B	3D	
Timpie Springs Waterfowl Management Area, Tooele County	2B	3B	3D	

13.12 Lakes and Reservoirs. All lakes and any reservoirs greater than 10 acres not listed in 13.12 are assigned by default to the classification of the stream with which they are associated.

a. Beaver County

TABLE

Anderson Meadow Reservoir			2B	3A			4
Manderfield Reservoir			2B	3A			4
LaBaron Reservoir			2B	3A			4
Kent[±]s Lake			2B	3A			4
Minersville Reservoir			2B	3A		3D	4
Puffer Lake			2B	3A			
Three Creeks Reservoir			2B	3A			4

b. Box Elder County

TABLE

Cutler Reservoir (including portion in Cache County)			2B		3B	3D	4
Etna Reservoir			2B	3A			4
Lynn Reservoir			2B	3A			4
Mantua Reservoir			2B	3A			4
Willard Bay Reservoir	1C	2A			3B	3D	4

c. Cache County

TABLE

Hyrum Reservoir		2A		3A			4
Newton Reservoir			2B	3A			4
Porcupine Reservoir			2B	3A			4
Pelican Pond			2B		3B		4
Tony Grove Lake			2B	3A			4

d. Carbon County

TABLE

Grassy Trail Creek Reservoir	1C		2B	3A			4
Olsen Pond			2B		3B		4
Scofield Reservoir	1C		2B	3A			4

e. Daggett County

TABLE

Browne Reservoir			2B	3A			4
Daggett Lake			2B	3A			4
Flaming Gorge Reservoir (Utah portion)	1C	2A		3A			4
Long Park Reservoir	1C		2B	3A			4
Sheep Creek Reservoir			2B	3A			4
Spirit Lake			2B	3A			4
Upper Potter Lake			2B	3A			4

f. Davis County

TABLE

Farmington Ponds			2B	3A			4
Kaysville Highway Ponds			2B	3A			4
Holmes Creek Reservoir			2B		3B		4

g. Duchesne County

TABLE

Allred Lake			2B	3A			4
Atwine Lake			2B	3A			4
Atwood Lake			2B	3A			4
Betsy Lake			2B	3A			4
Big Sandwash Reservoir	1C		2B	3A			4
Bluebell Lake			2B	3A			4
Brown Duck Reservoir			2B	3A			4
Butterfly Lake			2B	3A			4
Cedarview Reservoir			2B	3A			4
Chain Lake #1			2B	3A			4
Chepeta Lake			2B	3A			4
Clements Reservoir			2B	3A			4
Cleveland Lake			2B	3A			4
Cliff Lake			2B	3A			4
Continent Lake			2B	3A			4
Crater Lake			2B	3A			4
Crescent Lake			2B	3A			4
Daynes Lake			2B	3A			4
Dean Lake			2B	3A			4
Doll Lake			2B	3A			4
Drift Lake			2B	3A			4
Elbow Lake			2B	3A			4
Farmer[±]s Lake			2B	3A			4
Fern Lake			2B	3A			4
Fish Hatchery Lake			2B	3A			4

Five Point Reservoir		2B	3A	4
Fox Lake Reservoir		2B	3A	4
Governor[±]s Lake		2B	3A	4
Granddaddy Lake		2B	3A	4
Hoover Lake		2B	3A	4
Island Lake		2B	3A	4
Jean Lake		2B	3A	4
Jordan Lake		2B	3A	4
Kidney Lake		2B	3A	4
Kidney Lake West		2B	3A	4
Lily Lake		2B	3A	4
Midview Reservoir (Lake Boreham)		2B	3B	4
Milk Reservoir		2B	3A	4
Mirror Lake		2B	3A	4
Mohawk Lake		2B	3A	4
Moon Lake	1C	2A	3A	4
North Star Lake		2B	3A	4
Palisade Lake		2B	3A	4
Pine Island Lake		2B	3A	4
Pinto Lake		2B	3A	4
Pole Creek Lake		2B	3A	4
Potter[±]s Lake		2B	3A	4
Powell Lake		2B	3A	4
Pyramid Lake		2A	3A	4
Queant Lake		2B	3A	4
Rainbow Lake		2B	3A	4
Red Creek Reservoir		2B	3A	4
Rudolph Lake		2B	3A	4
Scout Lake		2A	3A	4
Spider Lake		2B	3A	4
Spirit Lake		2B	3A	4
Starvation Reservoir	1C	2A	3A	4
Superior Lake		2B	3A	4
Swasey Hole Reservoir		2B	3A	4
Taylor Lake		2B	3A	4
Thompson Lake		2B	3A	4
Timothy Reservoir #1		2B	3A	4
Timothy Reservoir #6		2B	3A	4
Timothy Reservoir #7		2B	3A	4
Twin Pots Reservoir	1C	2B	3A	4
Upper Stillwater Reservoir	1C	2B	3A	4
X - 24 Lake		2B	3A	4

h. Emery County

TABLE

Cleveland Reservoir		2B	3A	4
Electric Lake		2B	3A	4
Huntington Reservoir		2B	3A	4
Huntington North Reservoir		2A	3B	4
Joe[±]s Valley Reservoir _		2A	3A	4
Millsite Reservoir	1C	2A	3A	4

i. Garfield County

TABLE

Barney Lake		2B	3A	4
Cyclone Lake		2B	3A	4
Deer Lake		2B	3A	4
Jacob[±]s Valley Reservoir		2B	3C 3D	4
Lower Bowns Reservoir		2B	3A	4
North Creek Reservoir		2B	3A	4
Panguitch Lake		2B	3A	4
Pine Lake		2B	3A	4
Oak Creek Reservoir (Upper Bowns)		2B	3A	4
Pleasant Lake		2B	3A	4
Posey Lake		2B	3A	4
Purple Lake		2B	3A	4
Raft Lake		2B	3A	4
Row Lake #3		2B	3A	4
Row Lake #7		2B	3A	4
Spectacle Reservoir		2B	3A	4
Tropic Reservoir		2B	3A	4
West Deer Lake		2B	3A	4
Wide Hollow Reservoir		2B	3A	4

j. Iron County

TABLE

Newcastle Reservoir			2B	3A				4
Red Creek Reservoir			2B	3A				4
Yankee Meadow Reservoir			2B	3A				4

k. Juab County

TABLE

Chicken Creek Reservoir			2B			3C	3D	4
Mona Reservoir			2B		3B			4
Sevier Bridge (Yuba) Reservoir		2A			3B			4

l. Kane County

TABLE

Navajo Lake			2B	3A				4

m. Millard County

TABLE

DMAD Reservoir			2B		3B			4
Fools Creek Reservoir			2B			3C	3D	4
Garrison Reservoir (Pruess Lake)			2B		3B			4
Gunnison Bend Reservoir			2B		3B			4

n. Morgan County

TABLE

East Canyon Reservoir	1C	2A		3A				4
Lost Creek Reservoir	1C		2B	3A				4

o. Piute County

TABLE

Barney Reservoir			2B	3A				4
Lower Boxcreek Reservoir			2B	3A				4
Manning Meadow Reservoir			2B	3A				4
Otter Creek Reservoir			2B	3A				4
Piute Reservoir			2B	3A				4
Upper Boxcreek Reservoir			2B	3A				4

p. Rich County

TABLE

Bear Lake (Utah portion)		2A		3A				4
Birch Creek Reservoir			2B	3A				4
Little Creek Reservoir			2B	3A				4
Woodruff Creek Reservoir			2B	3A				4

q. Salt Lake County

TABLE

Decker Lake			2B		3B		3D	4
Lake Mary	1C		2B	3A				
Little Dell Reservoir	1C		2B	3A				
Mountain Dell Reservoir	1C		2B	3A				

r. San Juan County

TABLE

Blanding Reservoir #4	1C		2B	3A				4
Dark Canyon Lake	1C		2B	3A				4
Ken[']s Lake_			2B	3A*[*]				4
Lake Powell (Utah portion)	1C	2A			3B			4
Lloyd[']s Lake_	1C		2B	3A				4
Monticello Lake			2B	3A				4
Recapture Reservoir			2B	3A				4

(*) Site-specific criteria are associated with this use.

s. Sanpete County

TABLE

Duck Fork Reservoir			2B	3A				4
Fairview Lakes	1C		2B	3A				4
Ferron Reservoir			2B	3A				4
Lower Gooseberry Reservoir	1C		2B	3A				4
Gunnison Reservoir			2B			3C		4
Island Lake			2B	3A				4
Miller Flat Reservoir			2B	3A				4
Ninemile Reservoir			2B	3A				4
Palisade Reservoir		2A		3A				4
Rolfson Reservoir			2B			3C		4
Twin Lakes			2B	3A				4
Willow Lake			2B	3A				4

t. Sevier County

TABLE

Annabella Reservoir			2B	3A				4
Big Lake			2B	3A				4

Farnsworth Lake	2B 3A	4
Fish Lake	2B 3A	4
Forsythe Reservoir	2B 3A	4
Johnson Valley Reservoir	2B 3A	4
Koosharem Reservoir	2B 3A	4
Lost Creek Reservoir	2B 3A	4
Redmond Lake	2B 3B	4
Rex Reservoir	2B 3A	4
Salina Reservoir	2B 3A	4
Sheep Valley Reservoir	2B 3A	4

u. Summit County

TABLE

Abes Lake	2B 3A	4
Alexander Lake	2B 3A	4
Amethyst Lake	2B 3A	4
Beaver Lake	2B 3A	4
Beaver Meadow Reservoir	2B 3A	4
Big Elk Reservoir	2B 3A	4
Blanchard Lake	2B 3A	4
Bridger Lake	2B 3A	4
China Lake	2B 3A	4
Cliff Lake	2B 3A	4
Clyde Lake	2B 3A	4
Coffin Lake	2B 3A	4
Cuberant Lake	2B 3A	4
East Red Castle Lake	2B 3A	4
Echo Reservoir	1C 2A 3A	4
Fish Lake	2B 3A	4
Fish Reservoir	2B 3A	4
Haystack Reservoir #1	2B 3A	4
Henry[']s Fork Reservoir	2B 3A	4
Hoop Lake	2B 3A	4
Island Lake	2B 3A	4
Island Reservoir	2B 3A	4
Jesson Lake	2B 3A	4
Kamas Lake	2B 3A	4
Lily Lake	2B 3A	4
Lost Reservoir	2B 3A	4
Lower Red Castle Lake	2B 3A	4
Lyman Lake	2A 3A	4
Marsh Lake	2B 3A	4
Marshall Lake	2B 3A	4
McPheters Lake	2B 3A	4
Meadow Reservoir	2B 3A	4
Meeks Cabin Reservoir	2B 3A	4
Notch Mountain Reservoir	2B 3A	4
Red Castle Lake	2B 3A	4
Rockport Reservoir	1C 2A 3A	4
Ryder Lake	2B 3A	4
Sand Reservoir	2B 3A	4
Scow Lake	2B 3A	4
Smith Moorehouse Reservoir	1C 2B 3A	4
Star Lake	2B 3A	4
Stateline Reservoir	2B 3A	4
Tamarack Lake	2B 3A	4
Trial Lake	1C 2B 3A	4
Upper Lyman Lake	2B 3A	4
Upper Red Castle	2B 3A	4
Wall Lake Reservoir	2B 3A	4
Washington Reservoir	2B 3A	4
Whitney Reservoir	2B 3A	4

v. Tooele County

TABLE

Blue Lake	2B 3B	4
Clear Lake	2B 3B	4
Grantsville Reservoir	2B 3A	4
Horseshoe Lake	2B 3B	4
Kanaka Lake	2B 3B	4
Rush Lake	2B 3B	
Settlement Canyon Reservoir	2B 3A	4
Stansbury Lake	2B 3B	4
Vernon Reservoir	2B 3A	4

w. Uintah County

TABLE

	1C	2A	2B	3A	3B	3D	4
Ashley Twin Lakes (Ashley Creek)	1C		2B	3A			4
Bottle Hollow Reservoir			2B	3A			4
Brough Reservoir			2B	3A			4
Calder Reservoir			2B	3A			4
Crouse Reservoir			2B	3A			4
East Park Reservoir			2B	3A			4
Fish Lake			2B	3A			4
Goose Lake #2			2B	3A			4
Matt Warner Reservoir			2B	3A			4
Oaks Park Reservoir			2B	3A			4
Paradise Park Reservoir			2B	3A			4
Pelican Lake			2B		3B		4
Red Fleet Reservoir	1C	2A		3A			4
Steinaker Reservoir	1C	2A		3A			4
Towave Reservoir			2B	3A			4
Weaver Reservoir			2B	3A			4
Whiterocks Lake			2B	3A			4
Workman Lake			2B	3A			4

x. Utah County

TABLE

	1C	2A	2B	3A	3B	3D	4
Big East Lake			2B	3A			4
Salem Pond		2A		3A			4
Silver Flat Lake Reservoir			2B	3A			4
Tibble Fork Resevoir			2B	3A			4
Utah Lake		[~~2B~~]2A			3B	3D	4

y. Wasatch County

TABLE

	1C	2A	2B	3A	3B	3D	4
Currant Creek Reservoir	1C		2B	3A			4
Deer Creek Reservoir	1C	2A		3A			4
Jordanelle Reservoir	1C	2A		3A			4
Mill Hollow Reservoir			2B	3A			4
Strawberry Reservoir	1C		2B	3A			4

z. Washington County

TABLE

	1C	2A	2B	3A	3B	3D	4
Baker Dam Reservoir			2B	3A			4
Gunlock Reservoir	1C	2A			3B		4
Ivins Reservoir			2B		3B		4
Kolob Reservoir			2B	3A			4
Lower Enterprise Reservoir			2B	3A			4
Quail Creek Reservoir	1C	2A			3B		4
Sand Hollow Reservoir	1C	2A			3B		4
Upper Enterprise Reservoir			2B	3A			4

aa. Wayne County

TABLE

	1C	2A	2B	3A	3B	3D	4
Blind Lake			2B	3A			4
Cook Lake			2B	3A			4
Donkey Reservoir			2B	3A			4
Fish Creek Reservoir			2B	3A			4
Mill Meadow Reservoir			2B	3A			4
Raft Lake			2B	3A			4

bb. Weber County

TABLE

	1C	2A	2B	3A	3B	3D	4
Causey Reservoir			2B	3A			4
Pineview Reservoir	1C	2A		3A			4

[~~** Denotes site specific temperature, see Table 2.14.2 Notes~~]

13.13 Unclassified Waters

All waters not specifically classified are presumptively classified: 2B, 3D

R317-2-14. Numeric Criteria.

TABLE 2.14.1
NUMERIC CRITERIA FOR DOMESTIC,
RECREATION, AND AGRICULTURAL USES

Parameter	____Domestic[——] ____Source[——] 1C(1)[——]	Recreation and Aesthetics 2A	2B	Agri-culture 4
BACTERIOLOGICAL (30-DAY GEOMETRIC MEAN) (NO.)/100 ML) (7)				
E. coli	206	126	206	
MAXIMUM (NO.)/100 ML) (7)				
E. coli	668	409	668	
PHYSICAL				
pH (RANGE)	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0
Turbidity Increase (NTU)		10	10	
METALS (DISSOLVED, MAXIMUM MG/L) (2)				

Arsenic	0.01			0.1
Barium	1.0			
Beryllium	<0.004			
Cadmium	0.01			0.01
Chromium	0.05			0.10
Copper				0.2
Lead	0.015			0.1
Mercury	0.002			
Selenium	0.05			0.05
Silver	0.05			
INORGANICS (MAXIMUM MG/L)				
Bromate	0.01			
Boron				0.75
Chlorite	<1.0			
Fluoride ___[~~(3)~~]	4.0[~~1.4-2.4~~]			
Nitrates as N	10			
Total Dissolved Solids (4)				1200
	RADIOLOGICAL			
(MAXIMUM pCi/L)				
Gross Alpha	15			15
Gross Beta	4 mrem/yr	Radium 226, 228		
(Combined)	5			
Strontium 90	8			
Tritium	20000			
Uranium	30			
ORGANICS (MAXIMUM UG/L)				
[~~Chlorophenoxy Herbicides~~]				
2,4-D 94-75-7[——]		70		
2,4,5-TP 93-72-1[——]		10[~~Methoxychlor~~ 40]		
Alachlor 15972-60-8	2			
Atrazine 1912-24-9	3			
Carbofuran 1563-66-2	40			
Dalapon 75-99-0	200			
Di(2ethylhexl)adipate 103-23-1	400			
Dibromochloropropane 96-12-8	0.2			
Dinoseb 88-85-7	7			
Diquat 85-00-7	20			
Endothall 145-73-3	100			
Ethylene Dibromide 106-93-4	0.05			
POLLUTION INDICATORS (5)				
BOD (MG/L)		5	5	5
Nitrate as N (MG/L)		4	4	
Total Phosphorus as P (MG/L)(6)		0.05	0.05	

FOOTNOTES:

(1) [Reserved]See also numeric criteria for water and organism in Table 2.14.6.

(2) The dissolved metals method involves filtration of the sample in the field, acidification of the sample in the field, no digestion process in the laboratory, and analysis by approved laboratory methods for the required detection levels.

(3) Reserved[~~Maximum concentration varies according to the daily maximum mean air temperature.~~

~~TEMP (C)~~	~~MG/L~~
~~12.0~~	~~2.4~~
~~12.1-14.6~~	~~2.2~~
~~14.7-17.6~~	~~2.0~~
~~17.7-21.4~~	~~1.8~~
~~21.5-26.2~~	~~1.6~~
~~26.3-32.5~~	~~1.4~~]

(4) SITE SPECIFIC STANDARDS FOR TOTAL DISSOLVED SOLIDS (TDS)

Blue Creek and tributaries, Box Elder County, from Bear River Bay, Great Salt Lake to Blue Creek Reservoir:
March through October daily maximum 4,900 mg/l and an average of 3,800 mg/l; November through February daily maximum 6,300 mg/l and an average of 4,700 mg/l. Assessments will be based on TDS concentrations measured at the location of STORET 4960740.

Blue Creek Reservoir and tributaries, Box Elder County, daily maximum 2,100 mg/l;

Castle Creek from confluence with the Colorado River to Seventh Day Adventist Diversion: 1,800 mg/l;

Cottonwood Creek from the confluence with Huntington Creek to Highway [~~I-57;~~]U-57; 3,500 mg/l;

Ferron Creek from the confluence with San Rafael River to Highway U-10: 3,500 mg/l;

Huntington Creek and tributaries from the confluence with Cottonwood Creek to Highway U-10: 4,800 mg/l;

Ivie Creek and its tributaries from the confluence with Muddy Creek to the confluence with Quitchupah Creek: 3,800 mg/l provided that total sulfate not exceed 2,000 mg/l to protect the livestock watering agricultural existing use;

Ivie Creek and its tributaries from the confluence with Quitchupah Creek to Highway U-10: 2,600 mg/l;

Lost Creek from the confluence with Sevier River to U.S.[~~Forest~~] National Forest[~~Service B~~] boundary: 4,600 mg/l;

Muddy Creek and tributaries from the confluence with Ivie Creek to Highway U-10: 2,600 mg/l;

Muddy Creek from confluence with Fremont River to confluence with Ivie Creek: 5,800 mg/l;

North Creek from the confluence with Virgin River to headwaters: 2,035 mg/l;

Onion Creek from the confluence with Colorado River to road crossing above Stinking Springs: 3000 mg/l;

Brine Creek-Petersen Creek, from the confluence with the Sevier River to Highway U-119 Crossing: 9,700 mg/l;

Price River and tributaries from confluence with Green River to confluence with Soldier Creek: 3,000 mg/l;

Price River and tributaries from the confluence with Soldier Creek to Carbon Canal Diversion: 1,700 mg/l;

Quitchupah Creek and tributaries from the confluence with Ivie Creek to Highway U-10:[
]_3,800 mg/l provided that total sulfate not exceed 2,000 mg/l to protect the livestock watering agricultural existing use;

Rock Canyon Creek from the confluence with Cottonwood Creek to headwaters: 3,500 mg/l;

San Pitch River from below Gunnison Reservoir to the Sevier River: 2,400 mg/l;

San Rafael River from the confluence with the Green River to Buckhorn Crossing: 4,100 mg/l;

San Rafael River from the Buckhorn Crossing to the confluence with Huntington Creek and Cottonwood Creek: 3,500 mg/l;

Sevier River between Gunnison Bend Reservoir and DMAD Reservoir: 1,725 mg/l;

Sevier River from Gunnison Bend Reservoir to [Clear]Crafts Lake:_ 3,370_[
]mg/l;

South Fork Spring Creek from confluence with Pelican Pond Slough Stream to U.S. Highway 89[――――――] 1,450 mg/l (Apr.-Sept.)

1,950 mg/l (Oct.-March)

Virgin River from the Utah/Arizona border to Pah Tempe Springs: 2,360 mg/l

(5) Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

(6) Total Phosphorus as P (mg/l) indicator for lakes and reservoirs shall be 0.025.

(7) Where the criteria are exceeded and there is a reasonable basis for concluding that the indicator bacteria E. coli are primarily from natural sources (wildlife), e.g., in National Wildlife Refuges and State Waterfowl Management Areas, the criteria may be considered attained provided the density attributable to non-wildlife sources is less than the criteria. Exceedences of E. coli from nonhuman nonpoint sources will generally be addressed through appropriate Federal, State, and local nonpoint source programs.

Measurement of E. coli using the "Quanti-Tray 2000" procedure is approved as a field analysis. Other EPA approved methods may also be used.

For water quality assessment purposes, up to 10% of representative samples may exceed the 668 per 100 ml criterion (for 1C and 2B waters) and 409 per 100 ml (for 2A waters). For small datasets, where exceedences of these criteria are observed, follow-up ambient monitoring should be conducted to better characterize water quality.

TABLE 2.14.2
NUMERIC CRITERIA FOR AQUATIC WILDLIFE(8)

Parameter	Aquatic Wildlife				
	3A	3B	3C	3D	5
PHYSICAL					
Total Dissolved Gases	(1)	(1)			
Minimum Dissolved Oxygen (MG/L) (2)(2a)					
30 Day Average	6.5	5.5	5.0	5.0	
7 Day Average	9.5/5.0	6.0/4.0			
Minimum	8.0/4.0	5.0/3.0	3.0	3.0	
Max. Temperature(C)(3)	20	27	27		
Max. Temperature Change (C)(3)	2	4	4		
pH (Range)(2a)	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	
Turbidity Increase (NTU)	10	10	15	15	
METALS (4) (DISSOLVED, UG/L)(5)					
Aluminum					
4 Day Average (6)	87	87	87	87	
1 Hour Average	750	750	750	750	
Arsenic (Trivalent)					
4 Day Average	150	150	150	150	
1 Hour Average	340	340	340	340	
Cadmium (7)					
4 Day Average	[0.25]0.72	[0.25]0.72	[0.25]0.72	[0.25]0.72	
1 Hour Average	[2.0]1.8	[2.0]1.8	[2.0]1.8	1.8[2.0]	
Chromium (Hexavalent)					
4 Day Average	11	11	11	11	
1 Hour Average	16	16	16	16	
Chromium (Trivalent) (7)					
4 Day Average	74	74	74	74	
1 Hour Average	570	570	570	570	
Copper (7)					
4 Day Average	9	9	9	9	
1 Hour Average	13	13	13	13	
Cyanide (Free)					
4 Day Average	5.2	5.2	5.2		
1 Hour Average	22	22	22	22	
Iron (Maximum)	1000	1000	1000	1000	
Lead (7)					
4 Day Average	2.5	2.5	2.5	2.5	
1 Hour Average	65	65	65	65	
Mercury					
4 Day Average	0.012	0.012	0.012	0.012	
Nickel (7)					
4 Day Average	52	52	52	52	
1 Hour Average	468	468	468	468	
Selenium					
4 Day Average	4.6	4.6	4.6	4.6	
1 Hour Average	18.4	18.4	18.4	18.4	
Selenium (14) Gilbert Bay (Class 5A) Great Salt Lake Geometric Mean over Nesting Season (mg/kg dry wt)				12.5	
Silver					
1 Hour Average (7)	[1.6]3.2	[1.6]3.2	[1.6]3.2	[1.6]3.2	
Tributyltin					
4 Day Average	0.072	0.072	0.072	0.072	
1 Hour Average	0.46	0.46	0.46	0.46	
Zinc (7)					
4 Day Average	120	120	120	120	
1 Hour Average	120	120	120	120	
INORGANICS (MG/L) (4)					
Total Ammonia as N (9)					
30 Day Average	(9a)	(9a)	(9a)	(9a)	
1 Hour Average	(9b)	(9b)	(9b)	(9b)	
Chlorine (Total Residual)					
4 Day Average	0.011	0.011	0.011	0.011	
1 Hour Average	0.019	0.019	0.019	0.019	
Hydrogen Sulfide (Undissociated, Max. UG/L)	2.0	2.0	2.0	2.0	
Phenol(Maximum)	0.01	0.01	0.01	0.01	
RADIOLOGICAL (MAXIMUM pCi/L)					
ORGANICS (UG/L) (4)					
Acrolein					
4 Day Average	3.0	3.0	3.0	3.0	

1 Hour Average	3.0	3.0	3.0	3.0
Aldrin				
1 Hour Average	1.5	1.5	1.5	1.5
Carbaryl				
4 Day Average	2.1	2.1	2.1	2.1
1 Hour Average	2.1	2.1	2.1	2.1
Chlordane				
4 Day Average	0.0043	0.0043	0.0043	0.0043
1 Hour Average	1.2	1.2	1.2	1.2
Chlorpyrifos				
4 Day Average	0.041	0.041	0.041	0.041
1 Hour Average	0.083	0.083	0.083	0.083
4,4' -DDT				
4 Day Average	0.0010	0.0010	0.0010	0.0010
1 Hour Average	0.55	0.55	0.55	0.55
Diazinon				
4 Day Average	0.17	0.17	0.17	0.17
1 Hour Average	0.17	0.17	0.17	0.17
Dieldrin				
4 Day Average	0.056	0.056	0.056	0.056
1 Hour Average	0.24	0.24	0.24	0.24
Alpha-Endosulfan				
4 Day Average	0.056	0.056	0.056	0.056
1 Hour Average	0.11	0.11	0.11	0.11
beta-Endosulfan				
4 Day Average	0.056	0.056	0.056	0.056
1 Day Average	0.11	0.11	0.11	0.11
Endrin				
4 Day Average	0.036	0.036	0.036	0.036
1 Hour Average	0.086	0.086	0.086	0.086
Heptachlor				
4 Day Average	0.0038	0.0038	0.0038	0.0038
1 Hour Average	0.26	0.26	0.26	0.26
Heptachlor epoxide				
4 Day Average	0.0038	0.0038	0.0038	0.0038
1 Hour Average	0.26	0.26	0.26	0.26
Hexachlorocyclohexane (Lindane)				
4 Day Average	0.08	0.08	0.08	0.08
1 Hour Average	1.0	1.0	1.0	1.0
Methoxychlor (Maximum)	0.03	0.03	0.03	0.03
Mirex (Maximum)	0.001	0.001	0.001	0.001
Nonylphenol				
4 Day Average	6.6	6.6	6.6	6.6
1 Hour Average	28.0	28.0	28.0	28.0
Parathion				
4 Day Average	0.013	0.013	0.013	0.013
1 Hour Average	0.066	0.066	0.066	0.066
PCB[']s				
4 Day Average	0.014	0.014	0.014	0.014
Pentachlorophenol (11)				
4 Day Average	15	15	15	15
1 Hour Average	19	19	19	19
Toxaphene				
4 Day Average	0.0002	0.0002	0.0002	0.0002
1 Hour Average	0.73	0.73	0.73	0.73
POLLUTION INDICATORS (10)				
Gross Alpha (pCi/L)	15	15	15	15
Gross Beta (pCi/L)	50	50	50	50
BOD (MG/L)	5	5	5	5
Nitrate as N (MG/L)	4	4	4	
Total Phosphorus as P(MG/L) (12)	0.05	0.05		

FOOTNOTES:

(1) Not to exceed 110% of saturation.

(2) These limits are not applicable to lower water levels in deep impoundments. First number in column is for when early life stages are present, second number is for when all other life stages present.

(2a) These criteria are not applicable to Great Salt Lake impounded wetlands. Surface water in these wetlands shall be protected from changes in pH and dissolved oxygen that create significant adverse impacts to the existing beneficial uses. To ensure protection of uses, the Director shall develop reasonable protocols and guidelines that quantify the physical, chemical, and biological integrity of these waters. These protocols and guidelines will include input from local governments, the regulated community, and the general public. The Director will inform the Water Quality Board of any protocols or guidelines that are developed.

(3) Site Specific Standards for Temperature
Ken[']s Lake: From June 1st - September 20th, 27 degrees C.

(4) Where criteria are listed as 4-day average and 1-hour average concentrations, these concentrations should not be exceeded more often than once every three years on the average.

(5) The dissolved metals method involves filtration of the sample in the field, acidification of the sample in the field, no digestion process in the laboratory, and analysis by EPA approved laboratory methods for the required detection levels.

(6) The criterion for aluminum will be implemented as follows:

Where the pH is equal to or greater than 7.0 and the hardness is equal to or greater than 50 ppm as CaCO3 in the receiving water after mixing, the 87 ug/l chronic criterion (expressed as total recoverable) will not apply, and aluminum will be regulated based on compliance with the 750 ug/l acute aluminum criterion (expressed as total recoverable).

(7) Hardness dependent criteria. 100 mg/l used. Conversion factors for ratio of total recoverable metals to dissolved metals must also be applied. In waters with a hardness greater than 400 mg/l as CaCO3, calculations will assume a hardness of 400 mg/l as CaCO3. See Table 2.14.3 for complete equations for hardness and conversion factors.

(8) [Reserved]See also numeric criteria for organism only in Table 2.14.6.

(9) The following equations are used to calculate Ammonia criteria concentrations:

(9a) The thirty-day average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average, the chronic criterion calculated using the following equations.

Fish Early Life Stages are Present:

mg/l as N (Chronic) = $((0.0577/(1+10^{7.688-pH})) + (2.487/(1+10^{pH-7.688}))) * MIN (2.85, 1.45*10^{0.028*(25-T)})$

Fish Early Life Stages are Absent:

mg/l as N (Chronic) = $((0.0577/(1+10^{7.688-pH})) + (2.487/(1+10^{pH-7.688}))) * 1.45*10^{0.028*(25-MAX(T,7))})$

(9b) The one-hour average concentration of total ammonia nitrogen (in mg/l as N) does not exceed, more than once every three years on the average the acute criterion calculated using the following equations.

Class 3A:

mg/l as N (Acute) = $(0.275/(1+10^{7.204-pH})) + (39.0/1+10^{pH-7.204}))$

Class 3B, 3C, 3D:

mg/l as N (Acute) = $0.411/(1+10^{7.204-pH})) + (58.4/(1+10^{pH-7.204}))$

In addition, the highest four-day average within the 30-day period should not exceed 2.5 times the chronic criterion. The "Fish Early Life Stages are Present" 30-day average total ammonia criterion will be applied by default unless it is determined by the Director, on a site-specific basis, that it is appropriate to apply the "Fish Early Life Stages are Absent" 30-day average criterion for all or some portion of the year. At a minimum, the "Fish Early Life Stages are Present" criterion will apply from the beginning of spawning through the end of the early life stages. Early life stages include the pre-hatch embryonic stage, the post-hatch free embryo or yolk-sac fry stage, and the larval stage for the species of fish expected to occur at the site. The Director will consult with the Division of Wildlife Resources in making such determinations. The Division will maintain information regarding the waterbodies and time periods where application of the "Early Life Stages are Absent" criterion is determined to be appropriate.

(10) Investigation should be conducted to develop more information where these levels are exceeded.

(11) pH dependent criteria. pH 7.8 used in table. See Table 2.14.4 for equation.

(12) Total Phosphorus as P (mg/l) as a pollution indicator for lakes and reservoirs shall be 0.025.

(13) Reserved

(14) The selenium water quality standard of 12.5 (mg/kg dry weight) for Gilbert Bay is a tissue based standard using the complete egg/embryo of aquatic dependent birds using Gilbert Bay based upon a minimum of five samples over the nesting season. Assessment procedures are incorporated as a part of this standard as follows:

Egg Concentration Triggers: DWQ Responses

Below 5.0 mg/kg: Routine monitoring with sufficient intensity to determine if selenium concentrations within the Great Salt Lake ecosystem are increasing.

5.0 mg/kg: Increased monitoring to address data gaps, loadings, and areas of uncertainty identified from initial Great Salt Lake selenium studies.

6.4 mg/kg: Initiation of a Level II Antidegradation review by the State for all discharge permit renewals or new discharge permits to Great Salt Lake. The Level II Antidegradation review may include an analysis of loading reductions.

9.8 mg/kg: Initiation of preliminary TMDL studies to evaluate selenium loading sources.

12.5 mg/kg and above: Declare impairment. Formalize and implement TMDL.

Antidegradation
Level II Review procedures associated with this standard are referenced at R317-2-3.5.C.

TABLE
1-HOUR AVERAGE (ACUTE) CONCENTRATION OF
TOTAL AMMONIA AS N (MG/L)

pH	Class 3A	Class 3B, 3C, 3D
6.5	32.6	48.8
6.6	31.3	46.8
6.7	29.8	44.6
6.8	28.1	42.0
6.9	26.2	39.1
7.0	24.1	36.1
7.1	22.0	32.8
7.2	19.7	29.5
7.3	17.5	26.2
7.4	15.4	23.0
7.5	13.3	19.9
7.6	11.4	17.0
7.7	9.65	14.4
7.8	8.11	12.1
7.9	6.77	10.1
8.0	5.62	8.40
8.1	4.64	6.95
8.2	3.83	5.72
8.3	3.15	4.71
8.4	2.59	3.88
8.5	2.14	3.20
8.6	1.77	2.65
8.7	1.47	2.20
8.8	1.23	1.84
8.9	1.04	1.56
9.0	0.89	1.32

TABLE
30-DAY AVERAGE (CHRONIC) CONCENTRATION OF
TOTAL AMMONIA AS N (MG/l)

Fish Early Life Stages Present
Temperature, C

pH	0	14	16	18	20	22	24	26	28	30
6.5	6.67	6.67	6.06	5.33	4.68	4.12	3.62	3.18	2.80	2.46
6.6	6.57	6.57	5.97	5.25	4.61	4.05	3.56	3.13	2.75	2.42
6.7	6.44	6.44	5.86	5.15	4.52	3.98	3.50	3.07	2.70	2.37
6.8	6.29	6.29	5.72	5.03	4.42	3.89	3.42	3.00	2.64	2.32
6.9	6.12	6.12	5.56	4.89	4.30	3.78	3.32	2.92	2.57	2.25
7.0	5.91	5.91	5.37	4.72	4.15	3.65	3.21	2.82	2.48	2.18
7.1	5.67	5.67	5.15	4.53	3.98	3.50	3.08	2.70	2.38	2.09
7.2	5.39	5.39	4.90	4.31	3.78	3.33	2.92	2.57	2.26	1.99
7.3	5.08	5.08	4.61	4.06	3.57	3.13	2.76	2.42	2.13	1.87
7.4	4.73	4.73	4.30	3.78	3.32	2.92	2.57	2.26	1.98	1.74
7.5	4.36	4.36	3.97	3.49	3.06	2.69	2.37	2.08	1.83	1.61
7.6	3.98	3.98	3.61	3.18	2.79	2.45	2.16	1.90	1.67	1.47
7.7	3.58	3.58	3.25	2.86	2.51	2.21	1.94	1.71	1.50	1.32
7.8	3.18	3.18	2.89	2.54	2.23	1.96	1.73	1.52	1.33	1.17
7.9	2.80	2.80	2.54	2.24	1.96	1.73	1.52	1.33	1.17	1.03
8.0	2.43	2.43	2.21	1.94	1.71	1.50	1.32	1.16	1.02	0.90
8.1	2.10	2.10	1.91	1.68	1.47	1.29	1.14	1.00	0.88	0.77
8.2	1.79	1.79	1.63	1.43	1.26	1.11	0.97	0.86	0.75	0.66
8.3	1.52	1.52	1.39	1.22	1.07	0.94	0.83	0.73	0.64	0.56
8.4	1.29	1.29	1.17	1.03	0.91	0.80	0.70	0.62	0.54	0.48
8.5	1.09	1.09	0.99	0.87	0.76	0.67	0.59	0.52	0.46	0.40
8.6	0.92	0.92	0.84	0.73	0.65	0.57	0.50	0.44	0.39	0.34
8.7	0.78	0.78	0.71	0.62	0.55	0.48	0.42	0.37	0.33	0.29
8.8	0.66	0.66	0.60	0.53	0.46	0.41	0.36	0.32	0.28	0.24
8.9	0.56	0.56	0.51	0.45	0.40	0.35	0.31	0.27	0.24	0.21
9.0	0.49	0.49	0.44	0.39	0.34	0.30	0.26	0.23	0.20	0.18

TABLE
30-DAY AVERAGE (CHRONIC) CONCENTRATION OF
TOTAL AMMONIA AS N (MG/l)

Fish Early Life Stages Absent
Temperature, C

pH	0-7	8	9	10	11	12	13	14	16
6.5	10.8	10.1	9.51	8.92	8.36	7.84	7.36	6.89	6.06
6.6	10.7	[~~10.1~~]<u>9.99</u>	9.37	[~~9.37~~]<u>8.79</u>	[~~8.79~~]<u>8.24</u>	[~~8.24~~]<u>7.72</u>	[~~7.72~~]<u>7.24</u>	[~~7.24~~]<u>6.79</u>	[~~6.36~~]<u>5.97</u>
6.7	10.5	[~~9.99~~]<u>9.81</u>	9.20	8.62	8.08	7.58	7.11	6.66	5.86
6.8	10.2	[~~9.81~~]<u>9.58</u>	8.98	8.42	7.90	7.40	6.94	6.51	5.72
6.9	9.93	9.31	8.73	8.19	7.68	7.20	6.75	6.33	5.56
7.0	9.60	9.00	8.43	7.91	7.41	6.95	6.52	6.11	5.37
7.1	9.20	8.63	8.09	7.58	7.11	6.67	6.25	5.86	5.15
7.2	8.75	8.20	7.69	7.21	6.76	6.34	5.94	5.57	4.90
7.3	8.24	7.73	7.25	6.79	6.37	5.97	5.60	5.25	4.61
7.4	7.69	7.21	6.76	6.33	5.94	5.57	5.22	4.89	4.30
7.5	7.09	6.64	6.23	5.84	5.48	5.13	4.81	4.51	3.97
7.6	6.46	6.05	5.67	5.32	4.99	4.68	4.38	4.11	3.61
7.7	5.81	5.45	5.11	4.79	4.49	4.21	3.95	3.70	3.25
7.8	5.17	4.84	4.54	4.26	3.99	3.74	3.51	3.29	2.89

7.9	4.54	4.26	3.99	3.74	3.51	3.29	3.09	2.89	2.54
8.0	3.95	3.70	3.47	3.26	3.05	2.86	2.68	2.52	2.21
8.1	3.41	3.19	2.99	2.81	2.63	2.47	2.31	2.17	1.91
8.2	2.91	2.73	2.56	2.40	2.25	2.11	1.98	1.85	1.63
8.3	2.47	2.32	2.18	2.04	1.91	1.79	1.68	1.58	1.39
8.4	2.09	1.96	1.84	1.73	1.62	1.52	1.42	1.33	1.17
8.5	1.77	1.66	1.55	1.46	1.37	1.28	1.20	1.13	0.990
8.6	1.49	1.40	1.31	1.23	1.15	1.08	1.01	0.951	0.836
8.7	1.26	1.18	1.11	1.04	0.976	0.915	0.858	0.805	0.707
8.8	1.07	1.01	0.944	0.885	0.829	0.778	0.729	0.684	0.601
8.9	0.917	0.860	0.806	0.758	0.709	0.664	0.623	0.584	0.513
9.0	0.790	0.740	0.694	0.651	0.610	0.572	0.536	0.503	0.442

pH	18	20	22	24	26	28	30
6.5	5.33	4.68	4.12	3.62	3.18	2.80	2.46
6.6	5.25	4.61	4.05	3.56	3.13	2.75	2.42
6.7	5.15	4.52	3.98	3.50	3.07	2.70	2.37
6.8	5.03	4.42	3.89	3.42	3.00	2.64	2.32
6.9	4.89	4.30	3.78	3.32	2.92	2.57	2.25
7.0	4.72	4.15	3.65	3.21	2.82	2.48	2.18
7.1	4.53	3.98	3.50	3.08	2.70	2.38	2.09
7.2	4.41	3.78	3.33	2.92	2.57	2.26	1.99
7.3	4.06	3.57	3.13	2.76	2.42	2.13	1.87
7.4	3.78	3.32	2.92	2.57	2.26	1.98	1.74
7.5	3.49	3.06	2.69	2.37	2.08	1.83	1.61
7.6	3.18	2.79	2.45	2.16	1.90	1.67	1.47
7.7	2.86	2.51	2.21	1.94	1.71	1.50	1.32
7.8	2.54	2.23	1.96	1.73	1.52	1.33	1.17
7.9	2.24	1.96	1.73	1.52	1.33	1.17	1.03
8.0	[0.94]1.94	1.71	1.50	1.32	1.16	1.02	0.897
8.1	[0.68]1.68	1.47	1.29	1.14	1.00	0.879	0.733
8.2	[0.43]1.43	1.26	1.11	[0.073]1.073	0.855	0.752	0.661
8.3	[0.22]1.22	1.07	0.941	0.827	0.727	0.639	0.562
8.4	[0.03]1.03	0.906	0.796	0.700	0.615	0.541	0.475
8.5	0.870	0.765	0.672	0.591	0.520	0.457	0.401
8.6	0.735	0.646	0.568	0.499	0.439	0.396	0.339
8.7	0.622	0.547	0.480	0.422	0.371	0.326	0.287
8.8	0.528	0.464	0.408	0.359	0.315	0.277	0.244
8.9	0.451	0.397	0.349	0.306	0.269	0.237	0.208
9.0	0.389	0.342	0.300	0.264	0.232	0.204	0.179

TABLE 2.14.3a
EQUATIONS TO CONVERT TOTAL RECOVERABLE METALS STANDARD
WITH HARDNESS (1) DEPENDENCE TO DISSOLVED METALS STANDARD
BY APPLICATION OF A CONVERSION FACTOR (CF).

Parameter	4-Day Average (Chronic) Concentration (UG/L)
CADMIUM	CF * [$e^{(0.7409 (\ln(hardness)) - 4.719)}$]$e^{(0.7977*\ln(hardness)-.3.909)}$ CF = 1.101672 - ln(hardness) (0.041838)
CHROMIUM III	CF * $e^{(0.8190(\ln(hardness)) + 0.6848)}$ CF = 0.860
COPPER	CF * $e^{(0.8545(\ln(hardness)) -1.702)}$ CF = 0.960
LEAD	CF * $e^{(1.273(\ln(hardness))-4.705)}$ CF = 1.46203 - ln(hardness)(0.145712)
NICKEL	CF * $e^{(0.8460(\ln(hardness))+0.0584)}$ CF = 0.997
SILVER	N/A
ZINC	Cf * $e^{(0.8473(\ln(hardness))+0.884)}$ CF = 0.986

TABLE 2.14.3b
EQUATIONS TO CONVERT TOTAL RECOVERABLE METALS STANDARD
WITH HARDNESS (1) DEPENDENCE TO DISSOLVED METALS STANDARD
BY APPLICATION OF A CONVERSION FACTOR (CF).

Parameter	1-Hour Average (Acute) Concentration (UG/L)
CADMIUM	CF * [$e^{(1.0166(\ln(hardness)) - 3.924)}$]$e^{(0.9789*\ln(hardness)-3.866)}$ CF = 1.136672 - ln(hardness)(0.041838)
CHROMIUM (III)	CF * $e^{(0.8190(\ln(hardness)) +3.7256)}$ CF = 0.316
COPPER	CF * $e^{(0.9422(\ln(hardness))- 1.700)}$ CF = 0.960
LEAD	CF * $e^{(1.273(\ln(hardness))-1.460)}$ CF = 1.46203 - ln(hardness)(0.145712)
NICKEL	CF * $e^{(0.8460(\ln(hardness)) +2.255)}$ CF= 0.998
SILVER	CF * $e^{(1.72(\ln(hardness))- 6.59)}$ CF = 0.85
ZINC	CF * $e^{(0.8473(\ln(hardness)) +0.884)}$ CF = 0.978

FOOTNOTE:
(1) Hardness as mg/l $CaCO_3$.

TABLE 2.14.4
EQUATIONS FOR PENTACHLOROPHENOL
(pH DEPENDENT)

4-Day Average (Chronic) Concentration (UG/L)	1-Hour Average (Acute) Concentration (UG/L)
$e^{(1.005(pH))-5.134}$	$e^{(1.005(pH))-4.869}$

TABLE 2.14.5
SITE SPECIFIC CRITERIA FOR
DISSOLVED OXYGEN FOR JORDAN RIVER, SURPLUS CANAL, AND STATE CANAL
(SEE SECTION 2.13)

DISSOLVED OXYGEN:	
May-July	
7-day average	5.5 mg/l
30-day average	5.5 mg/l
Instantaneous minimum	4.5 mg/l
August-April	
30-day average	5.5 mg/l
Instantaneous minimum	4.0 mg/l

TABLE 2.14.6
LIST OF HUMAN HEALTH CRITERIA (CONSUMPTION)

Chemical Parameter [ ]and CAS #	Water and Organism (ug/L)	Organism Only (ug/L)
	Class 1C	Class 3A,3B,3C,3D
Antimony 7440-36-0[———]	5.6	640
Arsenic 7440-38-2[———]	A	A
Beryllium 7440-41-7[———]	C	C
[Cadmium	C	C
]Chromium III 16065-83-1 [———]	C	C
Chromium VI 18540-29-9 [———]	C	C
Copper 7440-50-8 [———]	1,300	
[Lead	C	C
]Mercury 7439-97-6 [———]	A	A
Nickel 7440-02-0 [———]	[100 MCL]610	4,600

Selenium 7782-49-2 [———] [A—]170 4,200
Thallium 7440-28-0 [———] 0.24 0.47
Zinc 7440-66-6 [———] 7,400 26,000
Free Cyanide 57-12-5 [———] 140 140
Asbestos 1332-21-4 [———] 7 million
Fibers/L
2,3,7,8-TCDD Dioxin 1746-01-6 [———]5.0 E -9 B 5.1 E-9 B
Acrolein 107-02-8 [———] [6.0]3.0
[9.0]400
Acrylonitrile 107-13-1 [———] [0.051 B]0.061 [0.25
B]7.0
[Alachlor 2.0
]Atrazine 1912-24-9 [———] 3.0
Benzene 71-43-2 [———] [2.2]2.1 B 51 B
Bromoform 75-25-2 [———] [4.3]7.0 B
[140]120 B
[Carbofuran 40
]Carbon Tetrachloride 56-23-5 [———] [0.23]0.4 B [1.6]_
5 B
Chlorobenzene 57-12-5 [———] 100 MCL 1,600
Chlorodibromomethane 124-48-1 [———]0.40 B 13 B
[Chloroethane
2-Chloroethylvinyl Ether
]Chloroform 67-66-3 [———] 5.7 B 470 B
Dalapon 75-99-0 [———] 200
[Di(2ethylhexl)adipate 400
Dibromochloropropane 0.2
]Dichlorobromomethane 75-27-4 [———] 0.55 B 17 B
[1,1 Dichloroethane
]1,2-Dichloroethane 107-06-2 [———] [0.38]9.9 B [37]_
650 B
1,1-Dichloroethylene 75-35-4 [———] [7]300 MCL[—]
[7,100]20,000
Dichloroethylene (cis-1,2)
156-59-2 70
[Dinoseb 7.0
]Diquat 231-36-7 [———] 20
1,2-Dichloropropane 78-87-5 [———] [0.50]0.90 B [15]31
B
1,3-Dichloropropene 542-75-6 [———] [0.34]0.27
[21]12
[Endothall 100
]Ethylbenzene 100-41-4[———] [530]68_
[2,100]130
[Ethylene Dibromide 0.05
]Glyphosate 1071-83-6[———] 700
[Haloacetic acids 60 E
]Methyl Bromide 74-83-9 [———] [47]100[-]
[1,500]10,000
[Methyl Chloride F F
]Methylene Chloride 75-09-2 [———] [4.6]20 B [590]_
1,000 B
[Ocamyl (vidate) 200
Picloram 500
Simazine 4
Styrene 100
]1,1,2,2-Tetrachloroethane
79-34-5 [0.17]0.2 B [4.0]_3 B
Tetrachloroethylene 127-18-4 [———] [0.69]10 B__
[3.3]29 B
Toluene 108-88-3[———] [1,000]57
[15,000]__520
1,2 -Trans-Dichloroethylene
156-60-5 100 MCL [10,000]4,000
1,1,1-Trichloroethane 71-55-6 [———200]10,000 MCL
[F]200,000
1,1,2-Trichloroethane 79-00-5 [———0.59]0.55 B [16]8.9
B
Trichloroethylene 79-01-6 [———] [2.5]0.6 B [30]7 B
Vinyl Chloride 75-01-4 [———] [0.025]0.022
[2.4]1.6
Xylenes 1330-20-7 [———] 10,000
2-Chlorophenol 95-57-8 [———] [81]30 [150]800
2,4-Dichlorophenol 120-83-2 [———] [77]10 [290]60
2,4-Dimethylphenol 105-67-9 [———] [380]100
[850]3,000
2-Methyl-4,6-Dinitrophenol
534-52-1 [13.0]2___ [280]30
2,4-Dinitrophenol 51-28-5 [———] [69]10
[5,300]300
[2-Nitrophenol
4-Nitrophenol
]3-Methyl-4-Chlorophenol
59-50-7 500 2,000
Pen[e]tachlorophenol 87-86-5_ [———] [0.27]0.03 B
[3.0]0.04 B
Phenol 108-95-2 [———10,000]4,000_
[860,000]300,000
2,4,5-Trichlorophenol 95-95-4 300 600
2,4,6-Trichlorophenol 88-06-2 [———1.4]1.5 B [2.4]2.8
B
Acenaphthene 83-32-9 [———] [670]70 [990]_90
[Acenaphthylene
]Anthracene 120-12-7 [———] [8,300]300
[40,000]__400
Benzidine 92-87-5 [———] [0.000086]0.00014 B_
[0.00020]0.011 B
BenzoaAnthracene 56-55-3 [———] [0.0038]0.0012 B
[0.018]0.0013 B
BenzoaPyrene 50-32-8 [———] [0.0038]0.00012 B [-
0.018]0.00013 B
BenzobFluoranthene 205-99-2 [———] [0.0038]0.0012 B
0.018 B
[BenzoghiPerylene
]BenzokFluoranthene 207-08-9 [———] [0.0038]0.012 B
[0.018]_0.013 B
[Bis2-ChloroethoxyMethane
]Bis2-Chlorolmethylether
542-88-1 0.00015 0.017
Bis2-Chlorolmethylethylether
108-60-1 200 B 4000
Bis2-ChloroethylEther
111-44-40 0.030 B [0.53]2.2 B
Bis2-Chlorolmethylether
542-88-1 0.00015 0.017
Bis2-Chlorolmethylethylether
108-60-1 200 B 4000
Bis2-ChloroisopropylEther
39638-32-9 1,400 65,000
Bis2-EthylhexylPhthalate
117-81-7 [1.2]0.32 B[-] [2.2]0.037 B
[4-Bromophenyl Phenyl Ether
]Butylbenzyl Phthalate
85-68-7 [1,500]0.1 [1,900]__0.1
2-Chloronaphthalene 91-58-7 [———] [1,000]800_
[1,600]1,000
[4 Chlorophenyl Phenyl Ether
]Chrysene 218-01-9 [———] 0.0038 B 0.018 B
Dibenzoa,hAnthracene 53-70-3 [———] 0.0038 B 0.018 B
1,2-Dichlorobenzene 95-50-1 [———] [420]1,000[—]
[1,300]3,000
1,3-Dichlorobenzene 541-73-1 [———] [320]7__
[960]10
1,4-Dichlorobenzene 106-46-7 [———] [63]300 [-
190]900
3,3-Dichlorobenzidine
91-94-1 [0.021]0.04 B [0.028]_0.15 B
Diethyl Phthalate 64-66-2 [———] [17,000]600___
[44,000]600
Dimethyl Phthalate 131-11-3 [———] [270,000]2,000_
[1,100,000]2,000
Di-n-Butyl Phthalate 84-74-2 [———] [2,000]20__
[4,500]30
2,4-Dinitrotoluene 121-14-2 [———] [0.11]0.49 B
[3.4]1.7 B
Dinitrophenols 25550-58-7 10 1,000
[2,6 Dinitrotoluene
Di-n-Octyl Phthalate
]1,2-Diphenylhydrazine
122-66-7 0.036 B 0.20 B

Fluoranthene 206-44-0 [———] [130]20
[140]20
Fluorene 86-73-7 [———] [1,100]50
[5,300]70
Hexachlorobenzene 118-74-1 [———] [0.00028]0.000079 B [–
0.00029]0.000079 B
[Hexachlorobutedine]Hexachlorobutadiene 87-68-3 [———] [0.44]0.01
B [18]0.01 B
Hexachloroethane 67-72-1 [———] 1.4 B 3.3 B
Hexachlorocyclopentadiene
77-47-4 4[0] [1,100]4
Ideno 1,2,3-cdPyrene
193-39-5 [0.0038]0.0012 B [0.018]0.0013
B
Isophorone 78-59-1 [———] [35]34 B
[960]1,800 B
[Naphthalene
]Nitrobenzene 98-95-3 [———] [17]10
[690]600
N-Nitrosodiethylamine 55-18-5 0.0008 B 1.24 B
N-Nitrosodimethylamine
62-75-9 0.00069 B 3.0 B
N-Nitrosodi-n-Propylamine
621-64-7 0.005 B 0.51 B
N-Nitrosodiphenylamine
86-30-6 3.3 B 6.0 B
N-Nitrosoyrrolidine 930-55-2 0.016 B 34 B
Pentachlorobenzene 608-93-5 0.1 0.1
[Phenanthrene]Pyrene 129-00-0 [830] 20
[4,000]30
1,2,4-Trichlorobenzene
120-82-1 [35]0.07 MCL[———] [70]0.076
Aldrin 309-00-2 [———] [0.000049]0.00000077 B [—]
[0.000050]0.00000077 B
alpha-BHC 319-84-6 [———] [0.0026]0.00036 B [–]
[0.0049]0.000050 B
beta-BHC 319-85-7 [———] [0.0091]0.008 B
[0.017]0.014 B
gamma-BHC (Lindane) 58-89-9 [———] [0.2]4.2 MCL
[1.8]4.4
[delta-BHC
]Hexachlorocyclohexane (HCH)
Technical 608-73-1 0.0066 0.010
Chlordane 57-74-9 [———] [0.00080]0.00030 B
[0.00081]0.00032 B
4,4-DDT 50-29-3 [———] [0.00022]0.000032 B [–]
[0.00022]0.000030 B
4,4-DDE 72-55-9 [———] [0.00022]0.000018 B [–]
[0.00022]0.000018 B
4,4-DDD 72-54-8 [———] [0.00031]0.00012 B
[0.00031]0.00012 B
Dieldrin 60-57-1 [———] [0.000052]0.0000012 B [–]
[0.000054]0.0000012 B
alpha-Endosulfan 959-98-8 [———] [62]20 [89]30
beta-Endosulfan 33213-65-9 [———] [62]20
[89]40
Endosulfan Sulfate 1031-07-8 [———] [62]20 [89]40
Endrin 72-20-8 [———] [0.059]0.03
[0.060]0.03
Endrin Aldehyde 7421-93-4 [———] [0.29]1
[0.30]1
Heptachlor 76-44-8 [———] [0.000079]0.0000059 B [–]
[0.000079]0.0000059 B
Heptachlor Epoxide 1024-57-3 [———] [0.000039]0.000032 B
[0.000039]0.000032 B
Methoxychlor 72-43-5 0.02 MCL 0.02
Polychlorinated Biphenyls
(PCBs) 1336-36-3 0.000064 B,D 0.000064 B,D
[PCB's
]Toxaphene 8001-35-2 [———] [0.00028]0.0007 B
[0.00028]0.00071 B
Footnotes:
A. See Table 2.14.2
B. Based on carcinogenicity of 10-6 risk.
C. EPA has not calculated a human criterion for this contaminant. However, permit authorities should address this contaminant in NPDES permit actions using the State's existing narrative criteria for toxics
D. This standard applies to total PCBs.

KEY: water pollution, water quality standards
Date of Enactment or Last Substantive Amendment: [November 30, 2015]2018
Notice of Continuation: September 26, 2017[-1317, 1329]
Authorizing, and Implemented or Interpreted Law: 19-5; FWPCA 33 USC 1251, 1311-1317, 1329

Health, Disease Control and Prevention, Environmental Services
R392-100
Food Service Sanitation

NOTICE OF PROPOSED RULE
(Amendment)
DAR FILE NO.: 42684
FILED: 03/14/2018

RULE ANALYSIS

PURPOSE OF THE RULE OR REASON FOR THE CHANGE: This rule requires an amendment in order to define food trucks and to exempt them from this rule. Food truck sanitation requirements will be specified in the proposed new Rule R392-102, Food Truck Sanitation. This filing for Rule R392-100 is the same amendment that was under Filing No. 42320 published in the December 1, 2017, Bulletin which was allowed to lapse so that this amendment to Rule R392-100 and the proposed Rule R392-102 can be made effective at the same time. (EDITOR'S NOTE: The proposed new Rule R392-102 is under Filing No. 42685 in this issue, April 1, 2018, of the Bulletin.)

SUMMARY OF THE RULE OR CHANGE: In Section R392-100-2, added definitions for "Food Cart", "Food Truck", and "Ice Cream Truck". In Section R392-100-3, included a statement that food trucks are exempt from the requirements of this rule.

STATUTORY OR CONSTITUTIONAL AUTHORIZATION FOR THIS RULE: Section 26-1-5 and Section 26-15-2 and Subsection 26-1-30(23)

ANTICIPATED COST OR SAVINGS TO:
♦ THE STATE BUDGET: Amending Rule R392-100 will likely not result in a cost or benefit to the state budget due to the state not directly permitting or regulating food trucks, nor will this change the current work load for state employees.
♦ LOCAL GOVERNMENTS: Amending Rule R392-100 will likely not result in a cost or benefit to local governments. The 13 local health departments will not change how food trucks are regulated due to these changes. Food trucks will just be