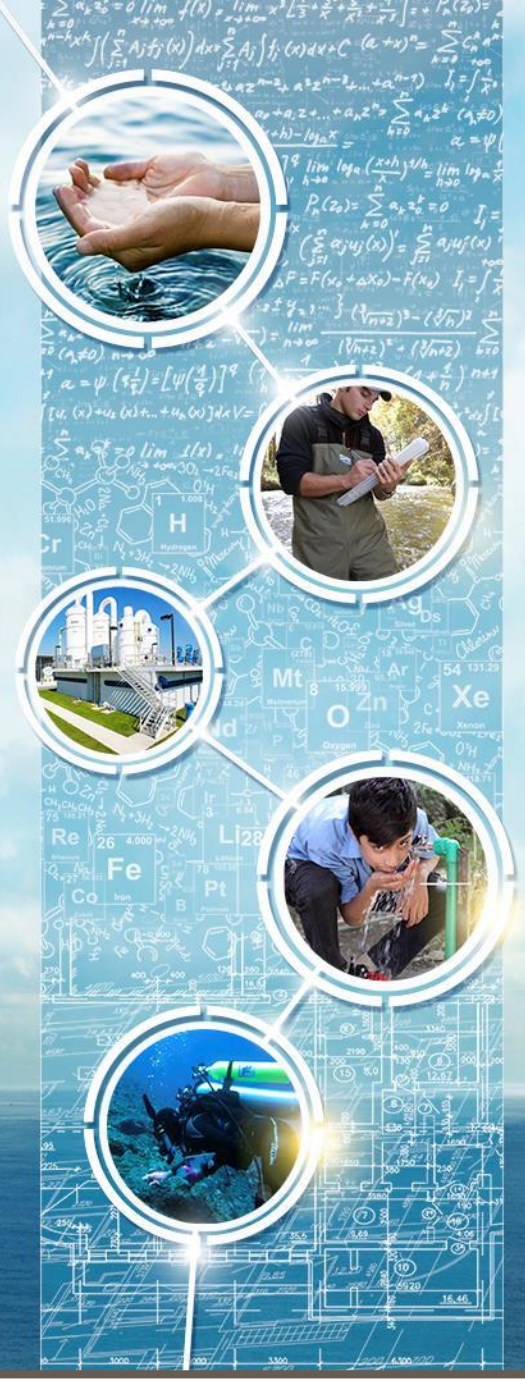


TETRA TECH

Utah Lake Watershed Model Update

November 29, 2022

Michelle Schmidt, Maddie Keefer, Afshin Shabani, Cole Blasko, Jon Butcher, Kevin Kratt (Tetra Tech)

Watershed Model Selection

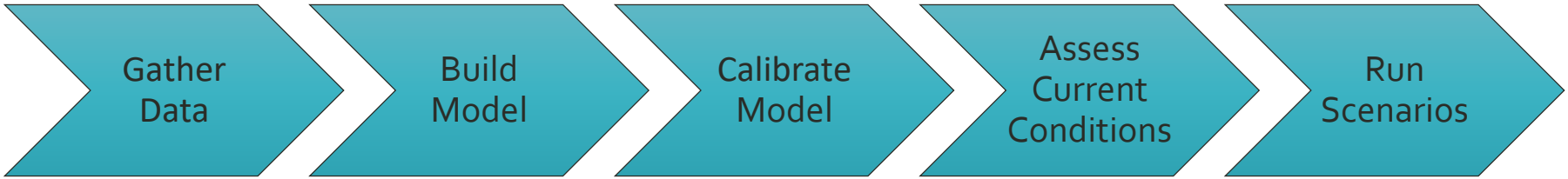
- Specific criteria defined related to watershed characteristics and simulation capabilities, source representation, usability, and general platform criteria
- Quantitatively ranked 11 modeling platforms
- Top rated: Hydrologic Simulation Program - FORTRAN

Table 2. Summary of model evaluation for the Utah Lake watershed

Key: green check (✓) = model meets criterion, yellow check (✓) = model partially meets criterion, red cross (×) = model does not meet criterion

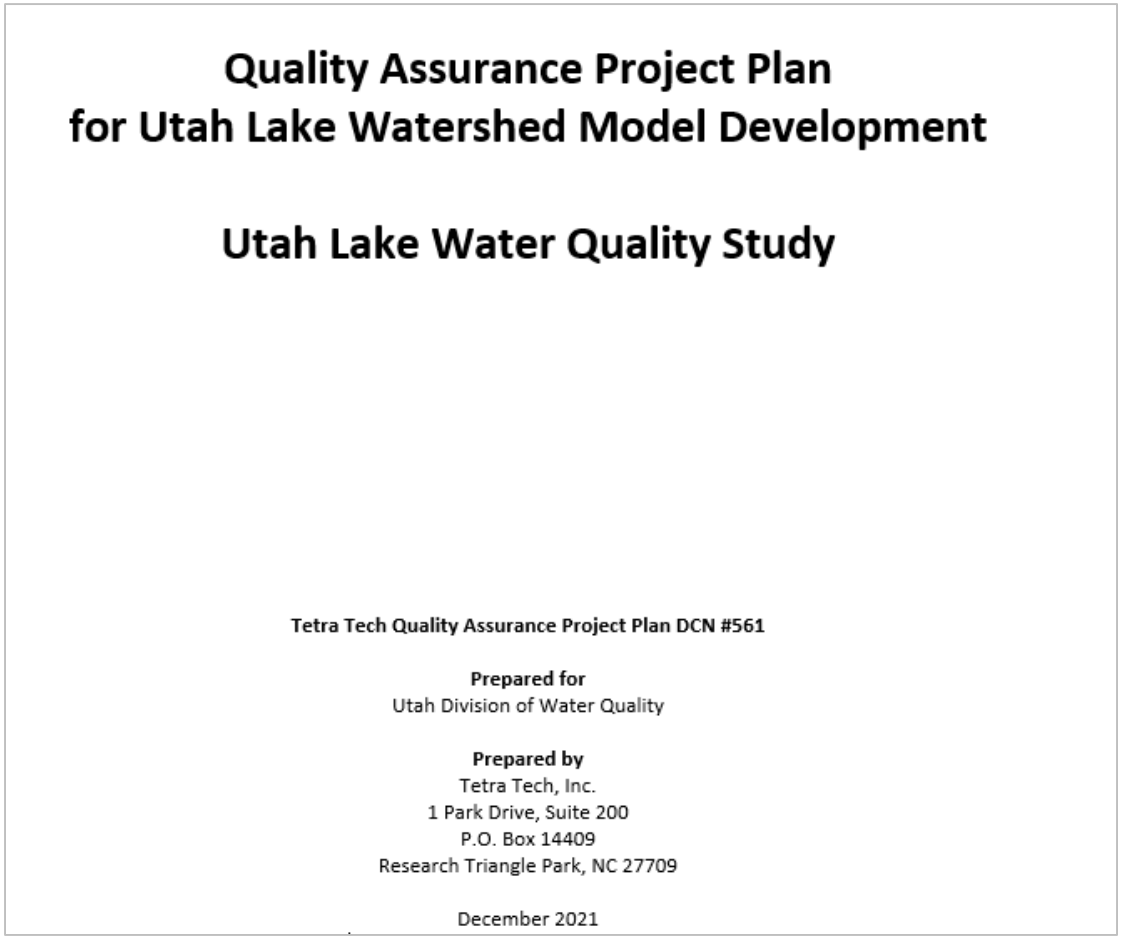
Criterion	Relative Importance	APEX	DHSVM/ RHESSys	GSSHA	GWLF	HEC-RAS/HMS	HSPF	LSPC	SWAT	SWMM	Univ of Utah	WARMF
Key watershed characteristics and simulation capabilities												
Includes dynamic, processed-based hydrology and water quality simulation	High	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓
Simulates flows and loads from direct runoff and shallow groundwater	High	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓
Simulates state variables, processes, and loads for the water quality constituents of concern including but not limited to:												
Sediment: including both upland and channel erosion and sediment transport	High	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
Nutrients: build-up and wash-off of nutrients on the landscape, represents species for nitrogen and phosphorus as well as particulate, dissolved, and total forms, simulates stream transport and cycling	High	✓	×	✓	✓	✓	✓	✓	✓	×	✓	✓

Modeling Process



Watershed Modeling QAPP

- Quality objectives for measured and modeled data
- Model framework to support the project goals and objectives
- Data collection and acquisition to support model build and calibration
- Specification of quality assurance/quality control (QA/QC) activities to assess model performance
- Model usability assessment



Quality Assurance Project Plan
for Utah Lake Watershed Model Development

Utah Lake Water Quality Study

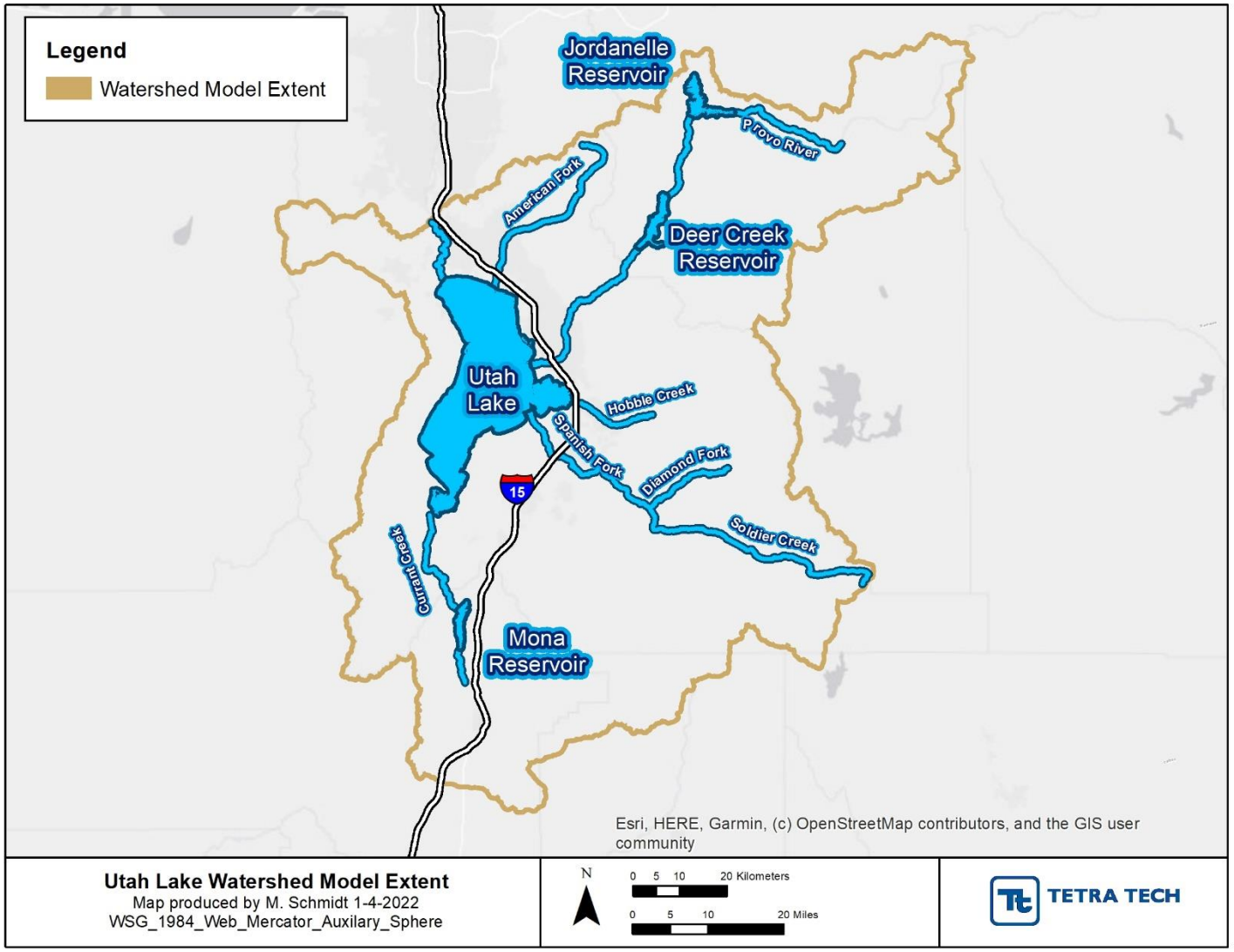
Tetra Tech Quality Assurance Project Plan DCN #561

Prepared for
Utah Division of Water Quality

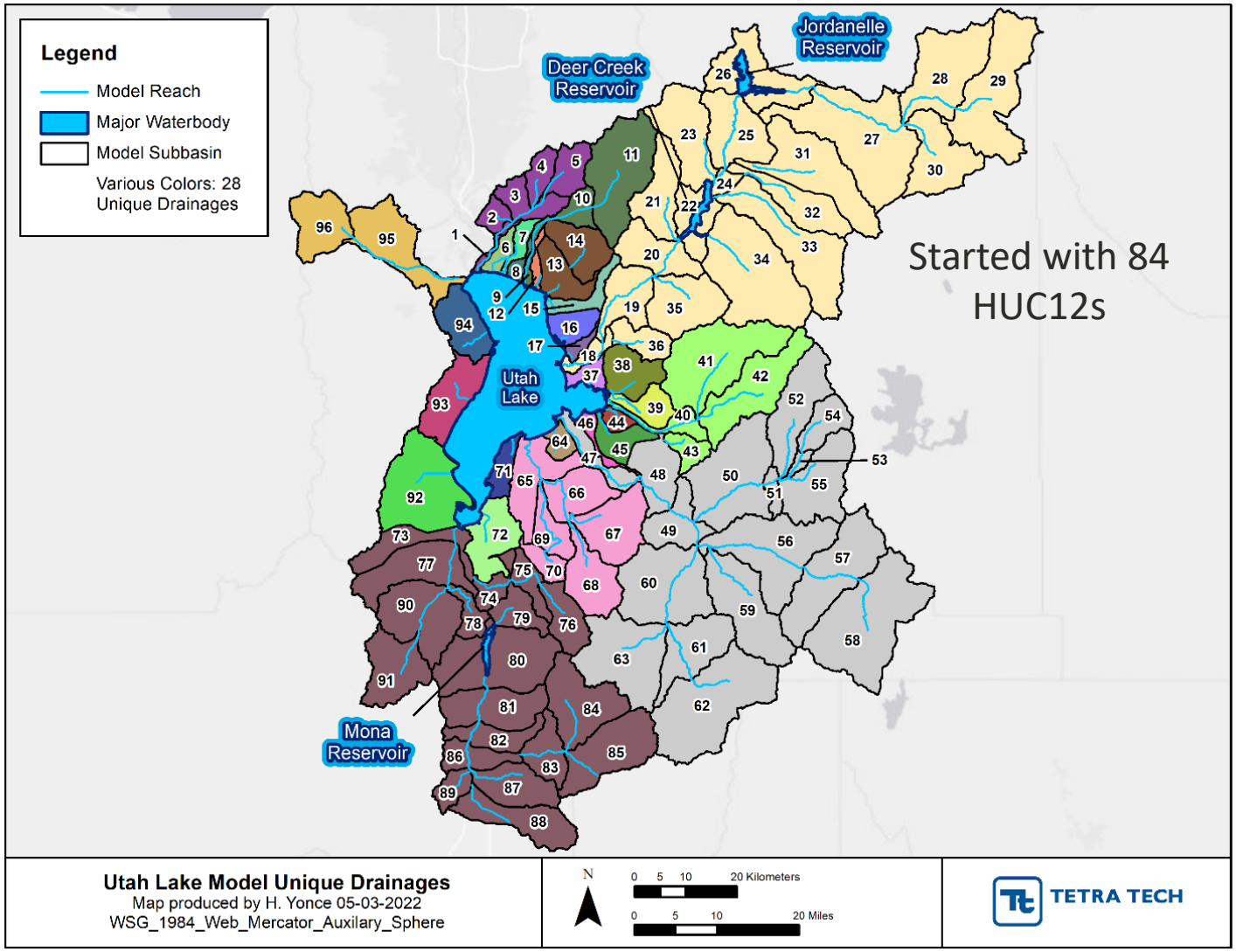
Prepared by
Tetra Tech, Inc.
1 Park Drive, Suite 200
P.O. Box 14409
Research Triangle Park, NC 27709

December 2021

Model Extent

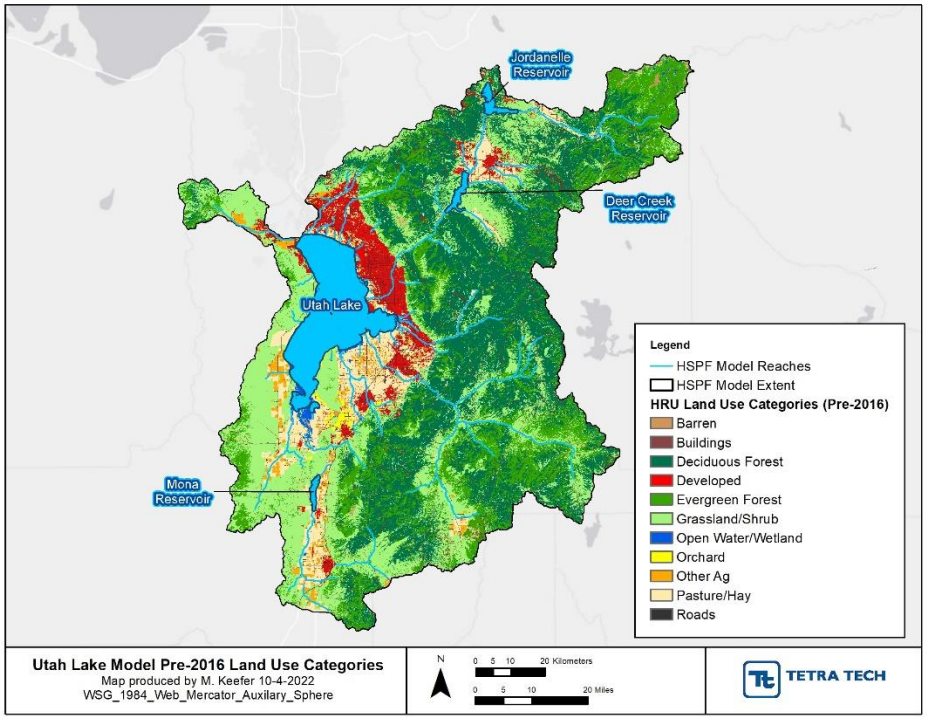


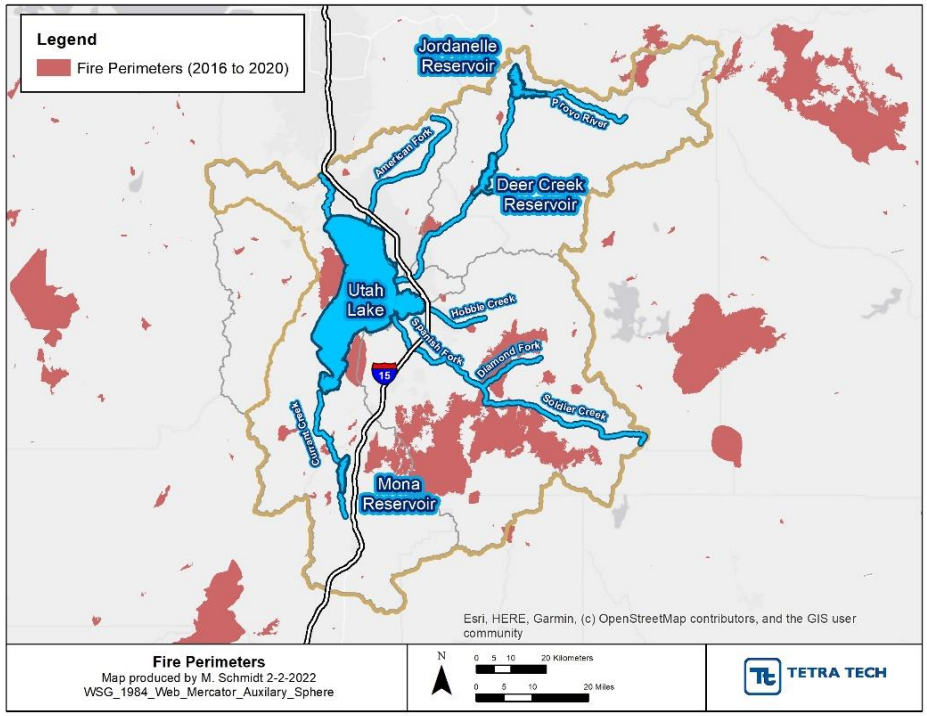
Model Delineations



Hydrologic Response Units

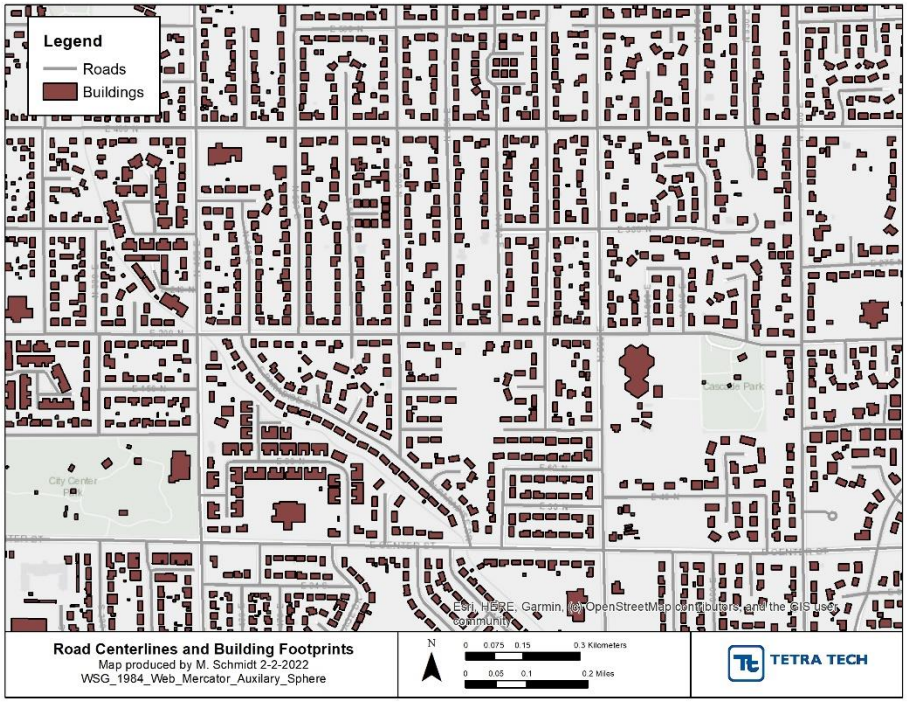
- Climate, geology, topography, and land use/cover influence runoff and stream water quality; combined features to form model HRUs
- Land use: combined NLCD 2016, Utah's water related land use coverage, post-2016 fire perimeters

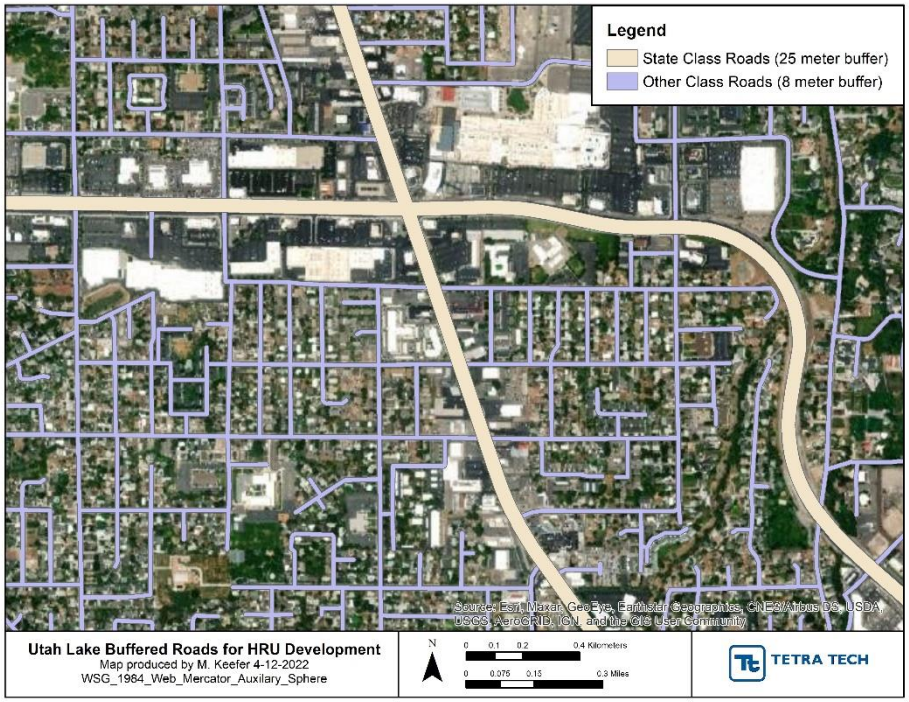




Hydrologic Response Units

- Impervious HRUs applied coverages for buildings and roads

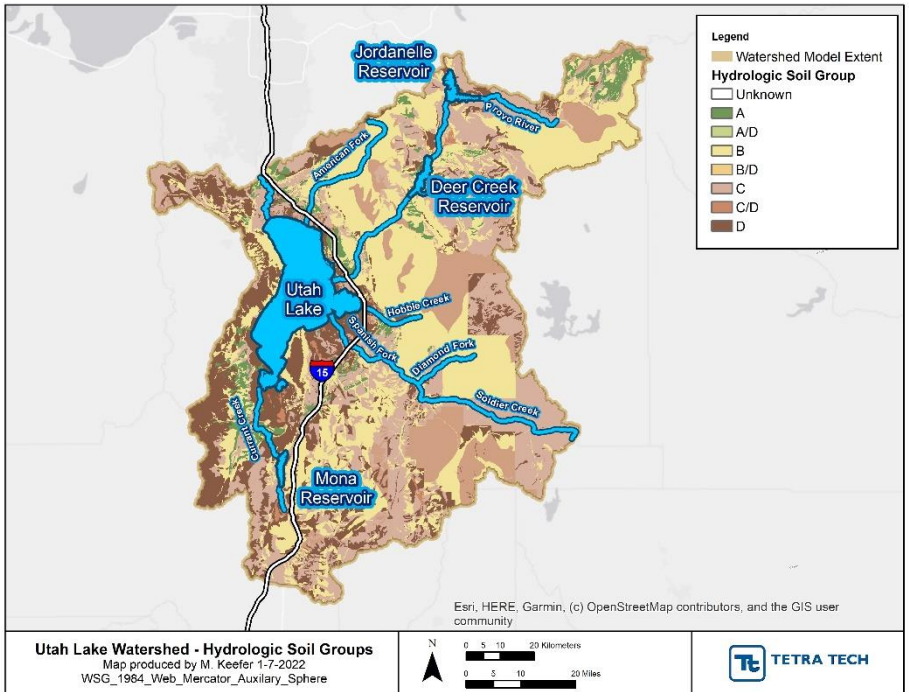


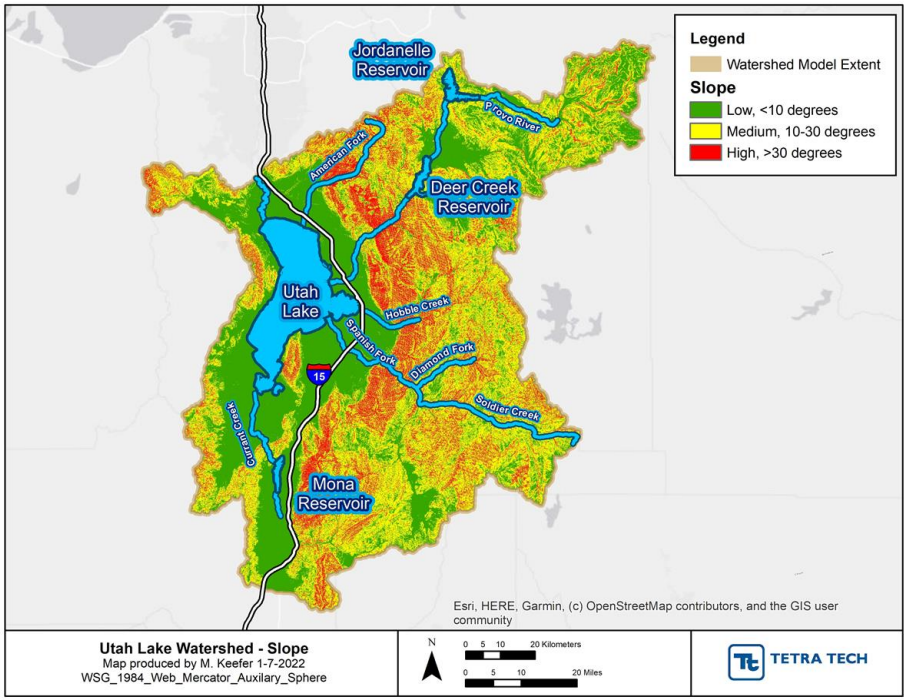


Hydrologic Response Units

- USDA Soil Survey Geographic Database (SSURGO)
  - Hydrologic Soil Group
    - A/B: higher infiltration
    - C/D: lower infiltration
- USGS 10-meter digital elevation model (DEM)

Model Slope	Percent of Total Area
Low (<10 degrees)	41.22%
Medium (10-30 degrees)	43.58%
High (>30 degrees)	15.20%

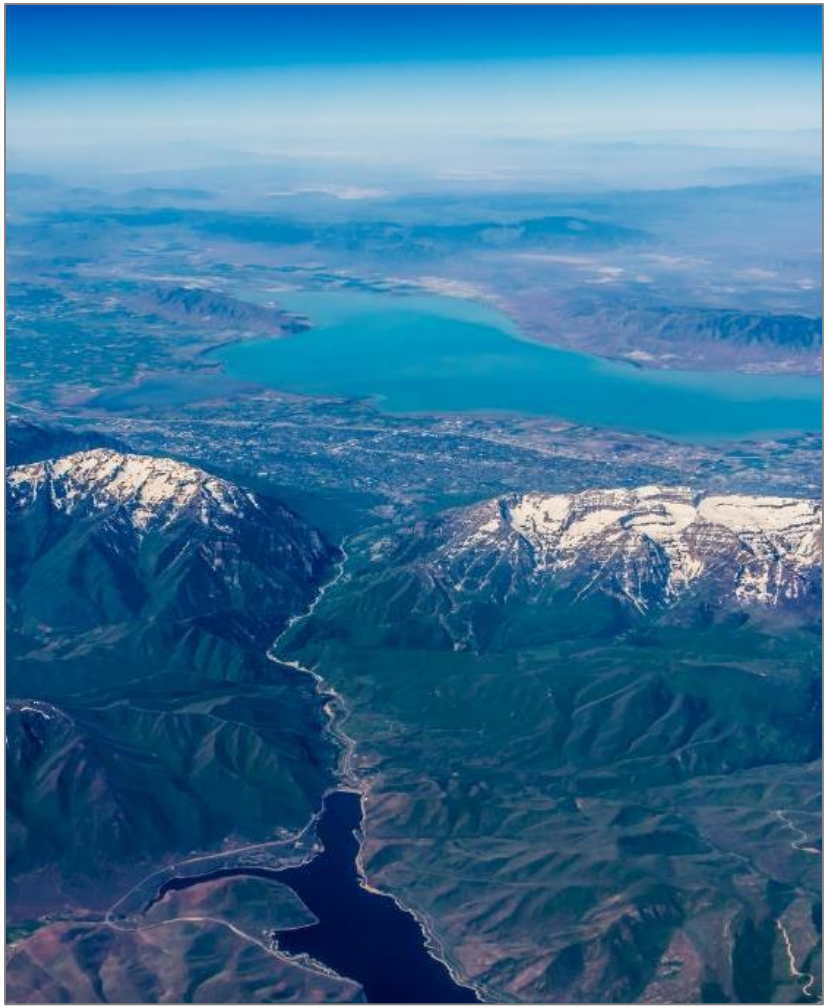




Irrigation

- Irrigation of agricultural lands and lawns/landscapes represented
  - Reference evapotranspiration (ET_o) from Utah Climate Center (e.g., AgWeather sites)
  - Crop coefficients to estimate water demand for crop type
  - Irrigation demand = crop water demand - precipitation

Diversions and releases

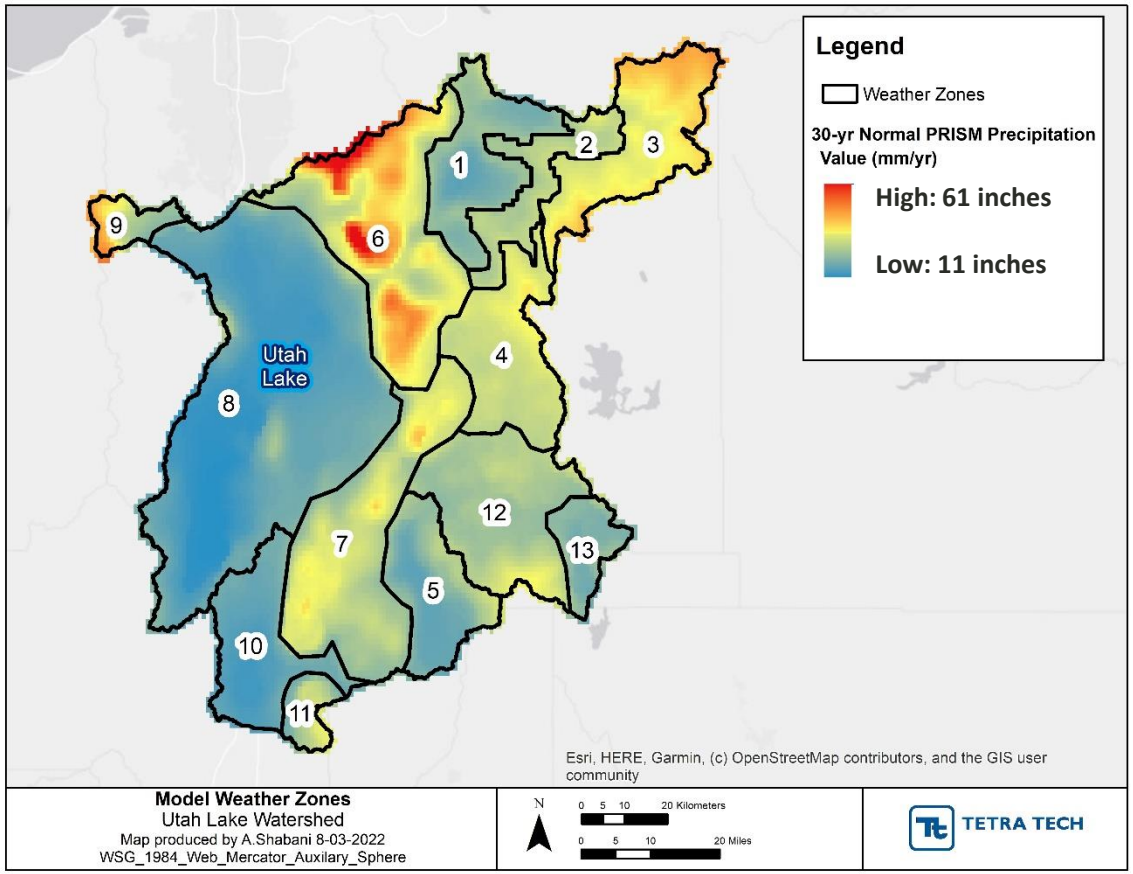


- Data obtained from
  - Central Utah Water Conservancy District
  - Provo River Water Users Association
  - Utah Division of Water Rights
  - Annual distribution system reports
- Diversion time series represented as withdrawals
- Releases represented as external water imports

Weather

- Hourly time series
- 13 weather zones
- Derived from gridded weather datasets

Variable	Source
Precipitation	PRISM
Potential evapotranspiration	NLDAS
Air temperature	NLDAS
Wind speed	NLDAS
Solar radiation	NLDAS
Dew point temperature	NLDAS
Cloud cover	NARR



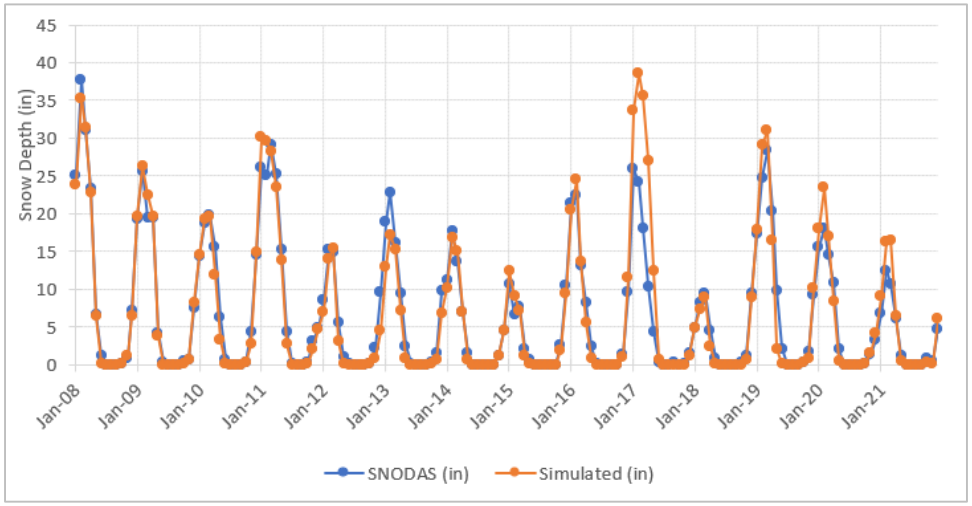
Permitted Point Source Discharges

- Time series based on facility data from:
  - Discharge monitoring report (DMR) data
  - Monthly operating reports (MOR)

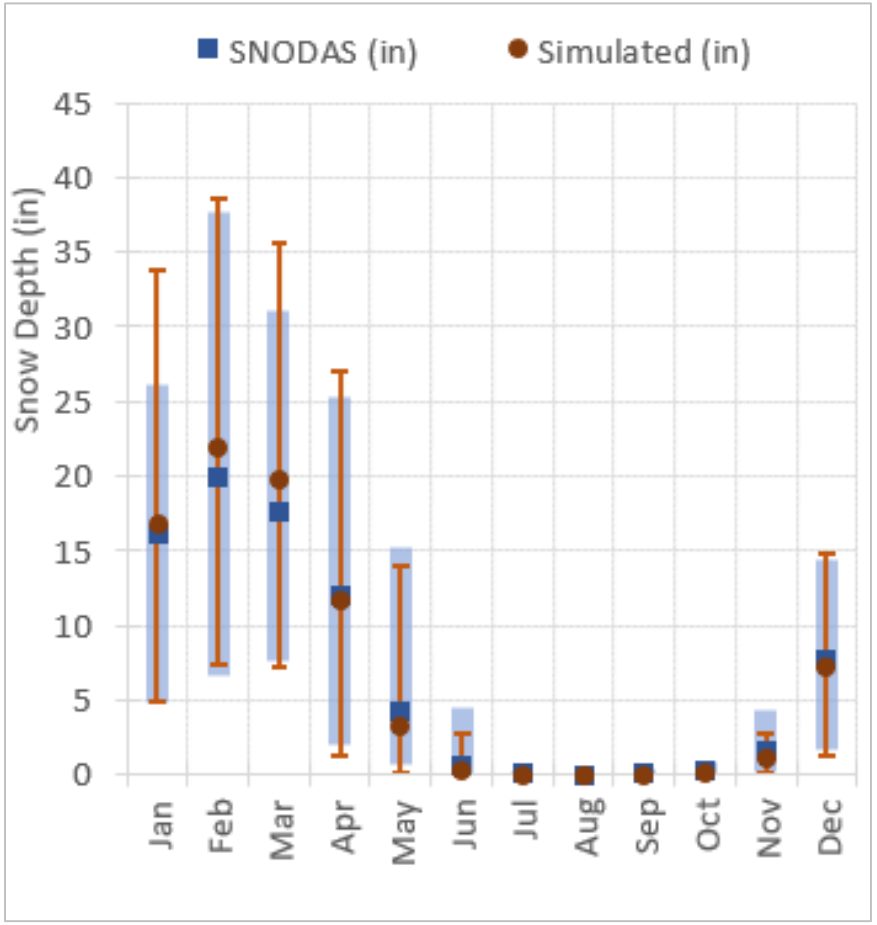
Facility	Type
Payson City WWTP	Municipal
Salem City WRF	Municipal
Salem City Corporation	Municipal
Provo City Corporation	Municipal
Mona City WWTP	Municipal
Springville WWTP	Municipal
Spanish Fork WWTP	Municipal
Jordanelle WRF	Municipal
Nephi Rubber Products	Industrial
Ensign Bickford Company	Industrial
Payson Power Plant	Industrial
McWane Ductile – Utah	Industrial
PacifiCorp Lake Side Power Plant	Industrial
Midway Fish Hatchery	Aquatic Animal Production Facility
Springville Fish Hatchery	Aquatic Animal Production Facility

Hydrology Calibration - Snow

Predicted snow depth and snow melt timing closely matches SNODAS data

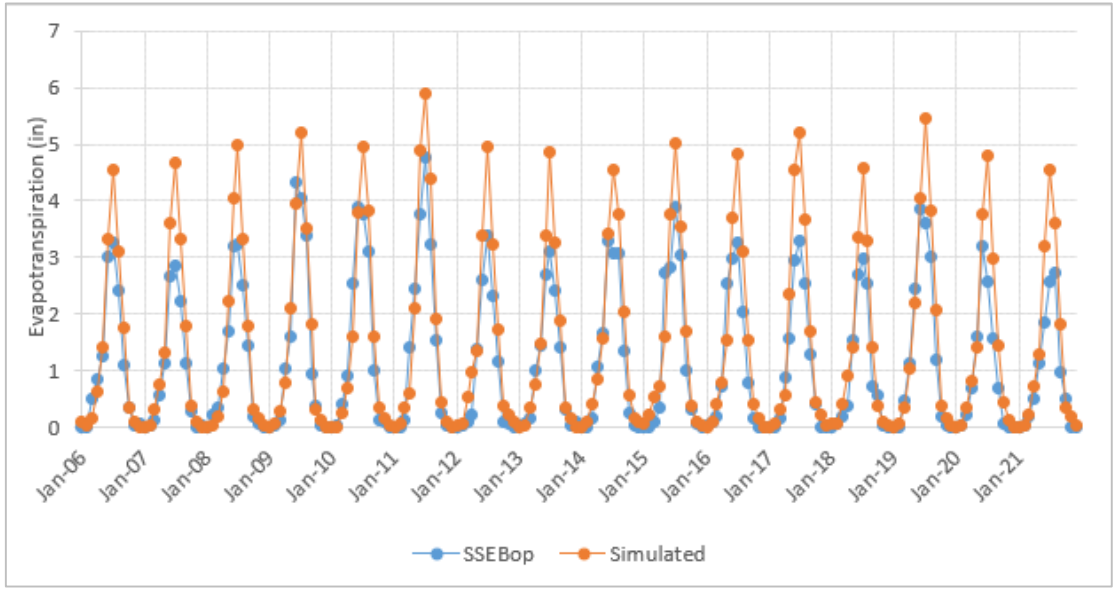


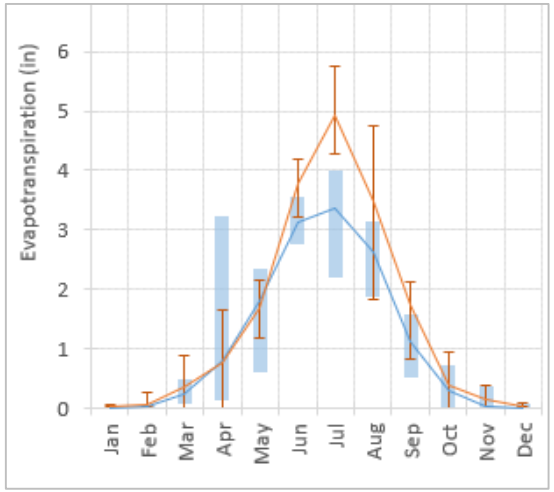
Metric	Snow Depth	Snow Water Equivalent
Relative Error	3%	-4%
Monthly NSE	0.89	0.88
Monthly R^2	0.91	0.89

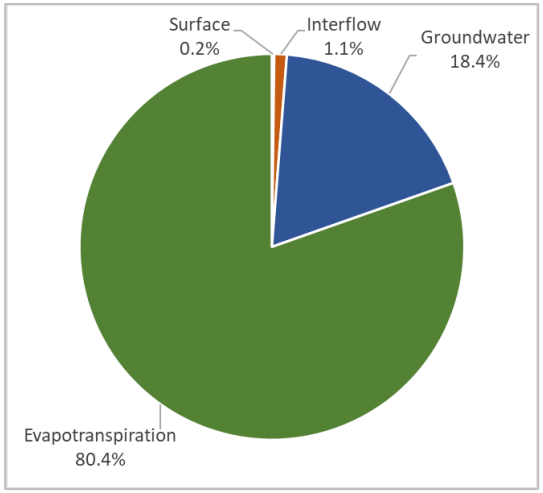


Evapotranspiration

- Simulated seasonal ET patterns align with SSEBop
- Model predicts higher ET in the summer
- SSEBop is based on remotely sensed data, and is also an estimate
- Irrigation in the summer supplies additional water for ET, which may not be fully captured by SSEBop
- For this area, Sanford and Selnick estimate ET is 0.8-0.89 of the water balance (calibrated ET = 0.8)





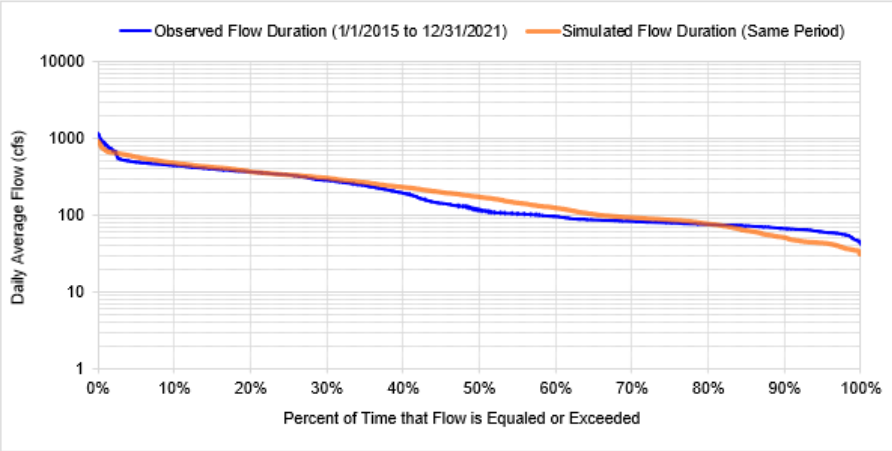


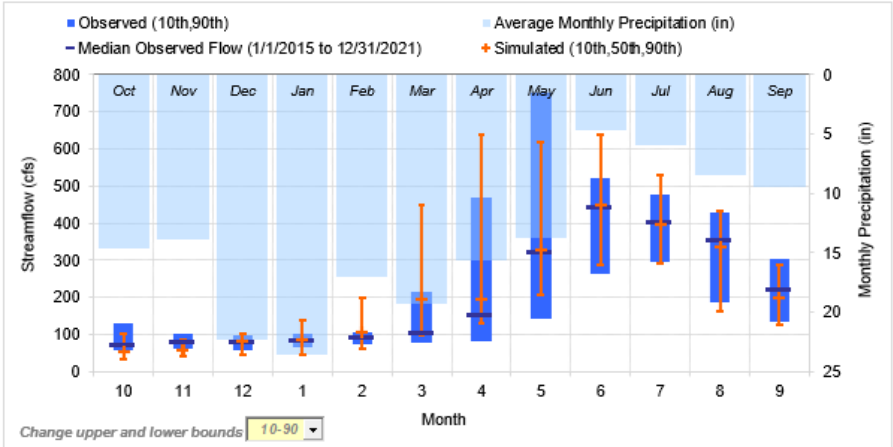
Hydrologic calibration

- Guided by multiple visuals and statistical metrics related to:
  - Total flow
  - Seasonal/monthly flows
  - High/low flow distribution
  - Nash Sutcliffe efficiency (NSE) coefficients
- Daily streamflow records obtained from USGS monitoring sites
- Calibration seeks to obtain the best overall fit at multiple locations, with priority on larger tributaries to Utah Lake (Spanish Fork, Provo River)

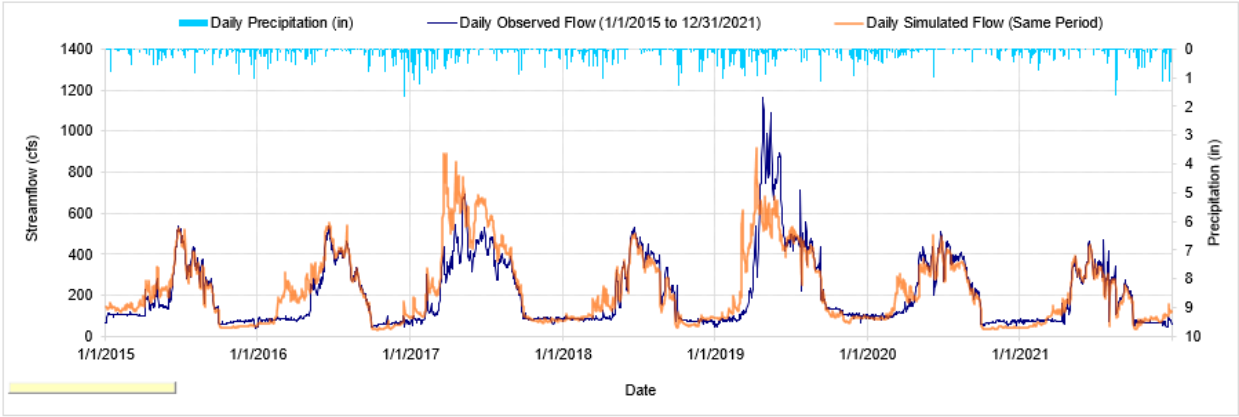
Spanish Fork

Serves as key hydrologic calibration site given relatively robust diversion data are available.



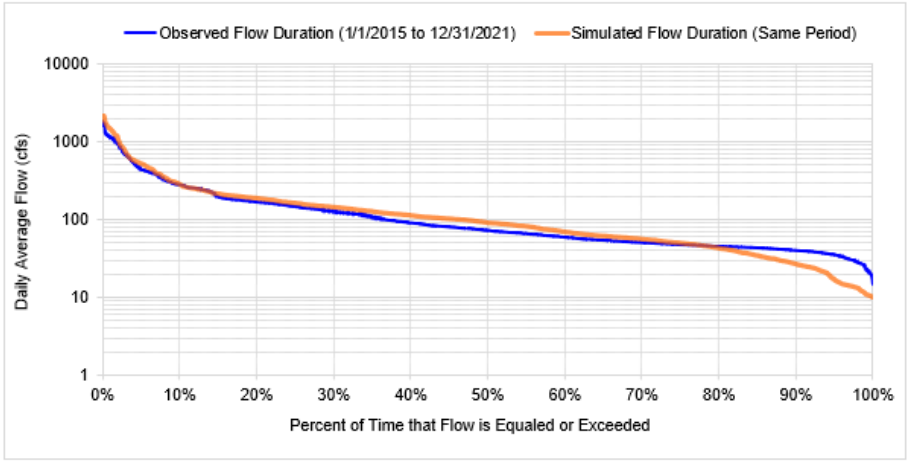


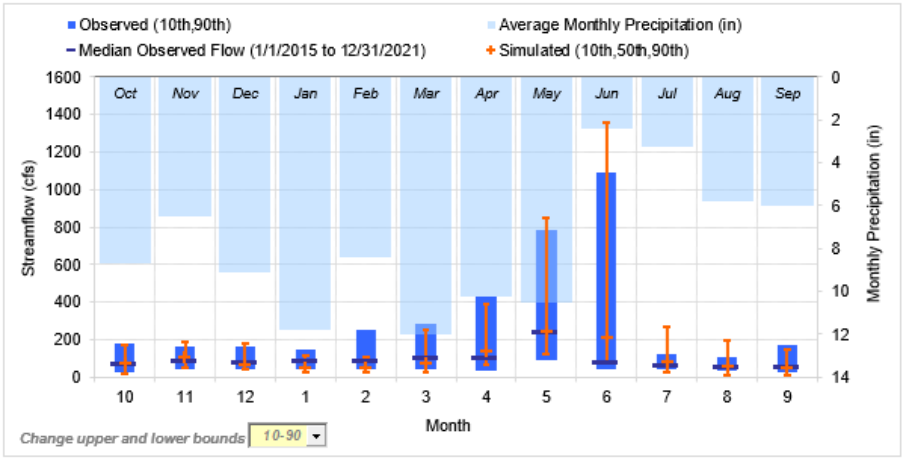
Metric	Value
Total Flow RE	7.7%
Lowest 50% Flows RE	8.2%
Highest 10% Flows RE	4.1%
Monthly NSE	0.815



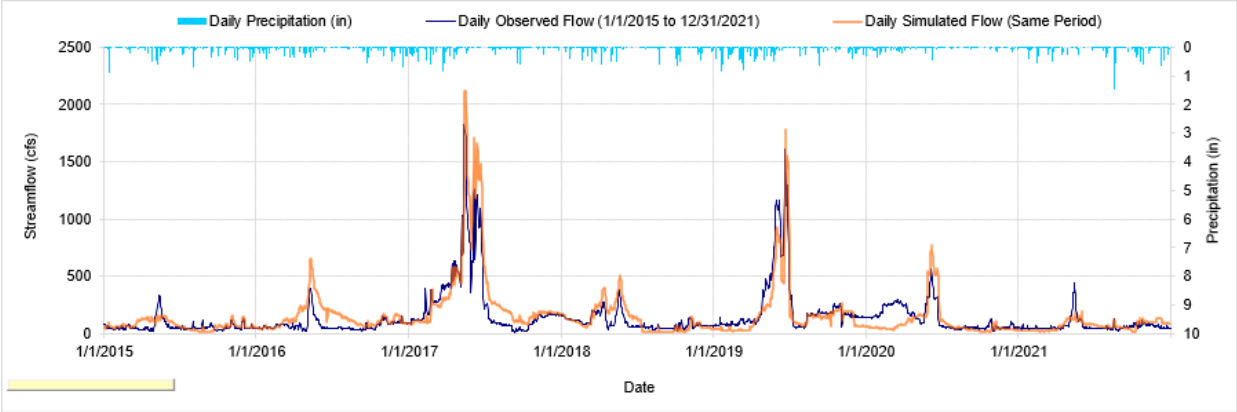
Provo River

Serves as key hydrologic calibration site. Influenced by releases from Deer Creek Reservoir, several major diversions, and local hydrology.





Metric	Value
Total Flow RE	10.9%
Lowest 50% Flows RE	1.0%
Highest 10% Flows RE	13.6%
Monthly NSE	0.752

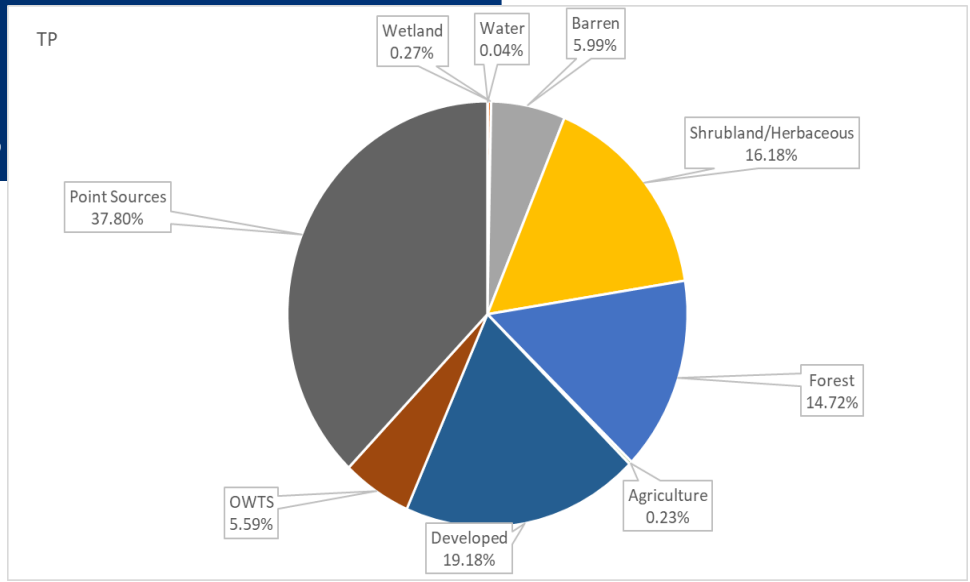


Hydrologic Calibration Sites

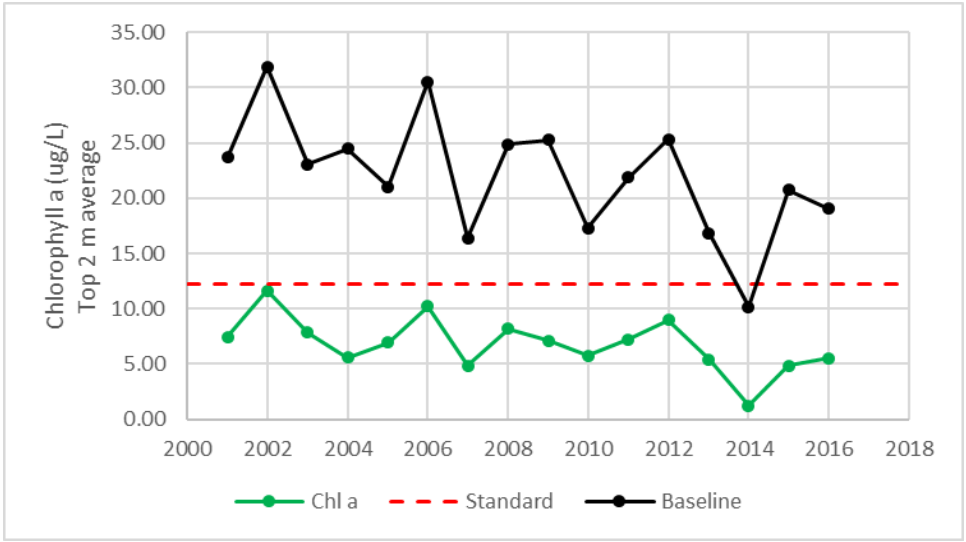
Site	Total Flow Relative Error	Lowest 50% Flows Relative Error	Highest 10% Flows Relative Error	Monthly NSE
Provo River	11%	1%	14%	0.752
Spanish Fork	8%	8%	4%	0.815
American Fork	32%	88%	-12%	0.738
Sixth Water Creek	-2%	-5%	-11%	0.597
Salt Creek at Nephi	-4%	-3%	-3%	0.994
Diamond Fork	-4%	-14%	-3%	0.585
Currant Creek	-37%	17%	30%	0.700
Hobble Creek	-32%	24%	3%	-0.067
Dry Creek	-15%	395%	-58%	0.581
Summit Creek	-57%	-43%	-59%	-0.020

Watershed Model Applications

- As the watershed model is scoped and built it can help with
  - Representing flow of water and fate and transport of nutrients by surface and subsurface pathways as a function of land use, soils, slope, and weather at an hourly time step
  - Quantifying nutrient load contributions by sector/source
  - Simulating reductions in point and nonpoint source loads
  - Evaluating alternative future conditions (e.g., climate, land use)
  - Linking watershed activities to loading to Utah Lake



Example TP relative source contribution chart (Bear Creek watershed, Colorado)



Example reservoir chlorophyll-a response to nutrient load reductions (Bear Creek watershed, Colorado)

Watershed Model Applications

- Not currently set up to help with
  - Evaluating other pollutants (e.g., bacteria, metals)
  - Simulating mechanisms of specific urban BMPs
  - Simulating mechanisms of specific agricultural BMPs
  - Identifying certain pollution issues (e.g., locations of failing septic systems)

Next steps

- Watershed model
  - Continue model calibration
    - Sediment
    - Water quality (e.g., water temperature, nutrients)
  - Watershed modeling report
  - Nutrient source assessment
  - Management scenarios
- Lake model
  - Calibration has progressed well
  - Waiting on atmospheric deposition decisions, then finalize calibration
  - Conduct stressor-response scenarios and support NNC development

Utah Lake Preliminary Point Source Estimates

Photo: Utah Lake Commission

WATER QUALITY

John Mackey, P.E., Director

Division of Water Quality
jkmackey@utah.gov

utahlake.deq.utah.gov

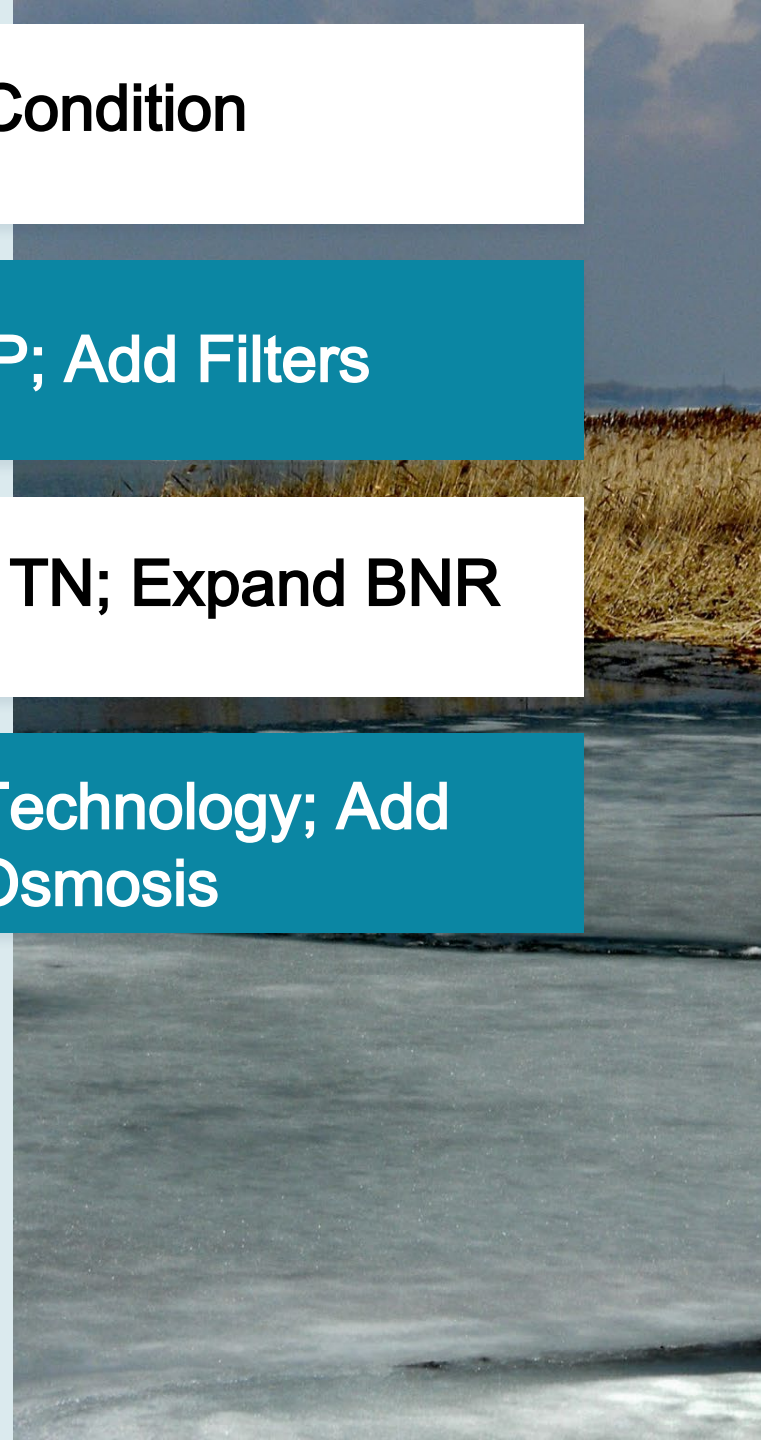
Utah Lake Water Quality Study POTW Group:

- Salem City
- Timpanogos SSD
- Springville City
- Provo City
- Spanish Fork City
- Payson City

Utah Lake Water Reclamation Facility Upgrades

Nutrient Control/ Process Scenarios

- ❑ Baseline Condition
- ❑ <1 ppm TP; Add Filters
- ❑ 6 – 8 ppm TN; Expand BNR
- ❑ Limits of Technology; Add Reverse Osmosis



Scenarios Construction Cost Summary

Baseline

$774.4 Million Invested / Planned

Add Filters

$431.7 Million

And Expand BNR

$566.2 Million

And Reverse Osmosis

$698 Million

Scenarios Construction Cost Summary

Utility Name	Baseline Cost	Add Filters	Add BNR	Add RO
Salem City	$22.2	$4.7	$8.7	$15.6
Timpanogos SSD	$223	$241	$305	$348
Orem City	$152	$26	$46	$61
Springville City	$67	$95	$97	$112
Provo City	$120	$65	$83	$113
Spanish Fork City	$110	--	$17	$32
Payson City	$80.4	--	$9.5	$16.4
TOTAL	$774	$432	$566	$698

Scenarios Present Value (20 -years) Cost Summary

Baseline

$1,262 Million

Add Filters

$678 Million

And Expand BNR

$870 Million

And Reverse Osmosis

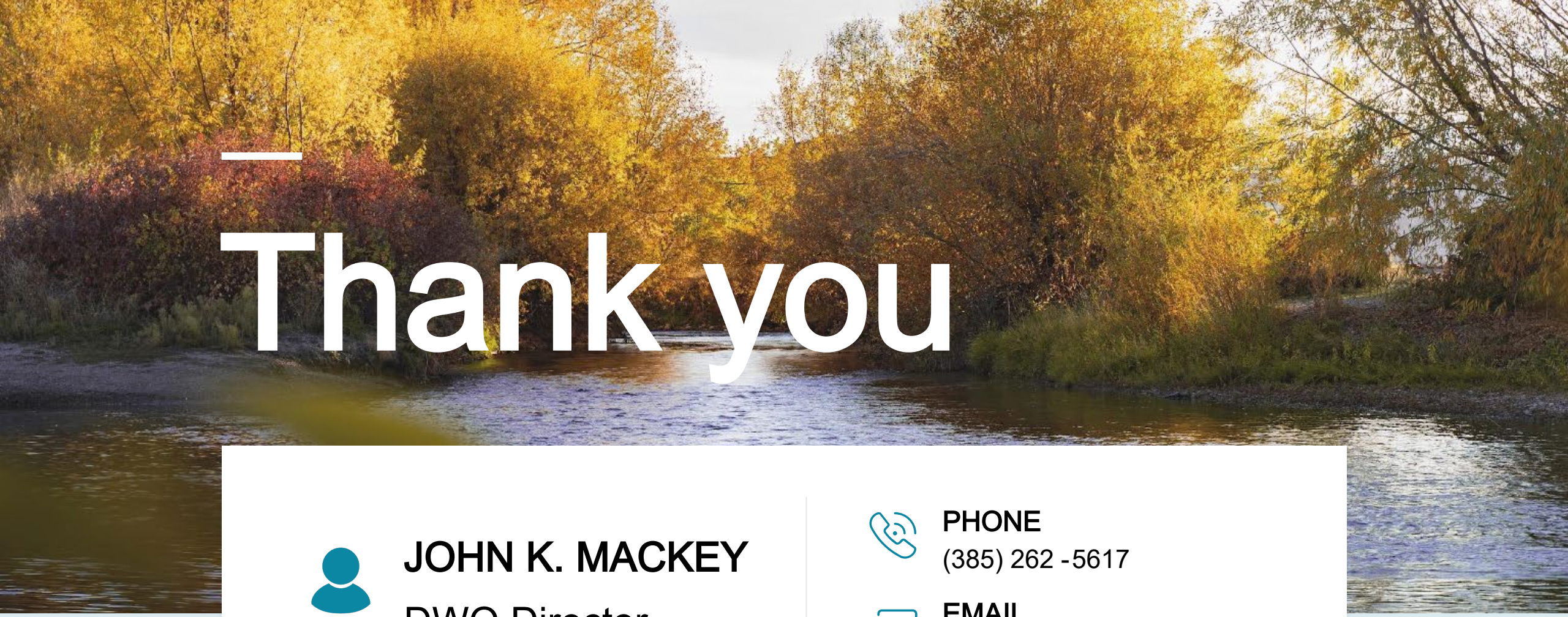
$1,071 Million

Scenarios Present Value Cost Summary

Utility Name	Baseline Cost	Add Filters	Add BNR	Add RO
Salem City	$34.5	$9.9	$17.9	$28.1
Timpanogos SSD	$384	$308	$398	$483
Orem City	$212	$76	$103	$131
Springville City	$112	$156	$159	$187
Provo City	$206	$121	$141	$169
Spanish Fork City	$193	4	$36	$48
Payson City	$121	3	$15	$25.2
TOTAL	$1.262	$678	$870	$1,071

Questions?

utahlake.deq.utah.gov



Thank you

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DWQ Director

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Questions? Contact us

ULWQS Steering Committee

Science Panel Nomination Process

November 29, 2022

Science Panel Purpose

1. Guide development of a scientifically defensible approach for developing site-specific nutrient criteria
2. Recommend scientific studies, based on the scope outlined by the Steering Committee
3. Guide study efforts during implementation by providing advice to principal investigators and study contractors
4. Review, interpret, and provide comments on study results
5. Provide an independent, scientific peer review process on relevant Utah Lake studies and research reports
6. Recommend science-based site-specific nutrient criteria to ensure long-term protection of Utah Lake's designated uses to the Steering Committee

Science Panel Composition

- Science Panel has 5 independent and 5 ex officio members.
  - Independent members provide independent and objective recommendations to the Steering Committee.
  - Ex officio members provide local context, share professional experience and expertise, and advise on relevant experience with Utah and Utah Lake.
- Science Panel members are expected to be independent and objective.
  - "Independent" means that these individuals are not financially connected to any of the individuals or organizations represented on the Steering Committee and will not bid on ULWQS work.
  - "Objective" means members will approach all data and findings with an open mind and eliminate personal biases.

Science Panel Membership Updates

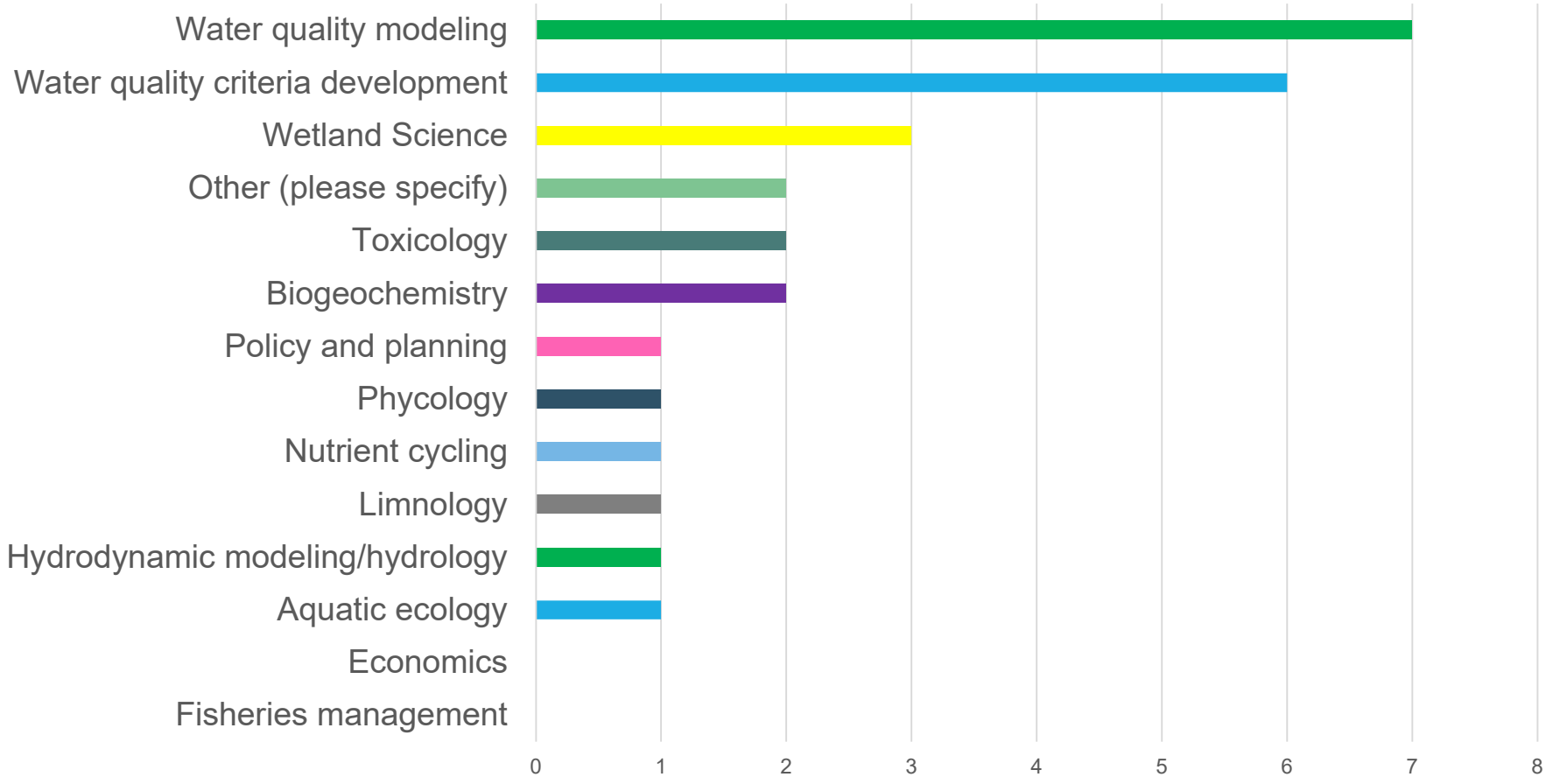
- James Martin, Ryan King, and Soren Brothers resigned from the Science Panel
  - This created a gap in expertise on aquatic ecology/criteria development, water quality modeling, and shallow lake limnology

- The primary expertise of the remaining Science Panel members is:
  - Two members with expertise in limnology
  - Four members with expertise in biogeochemistry
  - One member with expertise in fisheries management

Science Panel Process and Decision-Making

- Science Panel members provide input on how to fill openings.
- Steering Committee members nominate new members using Science Panel input.
- Steering Committee co-chairs (Eric Ellis and John Mackey) retain authority for replacing members based on the Steering Committee's nominations/recommendations.

Science Panel Input – Missing Areas of Expertise



Science Panel Input – Missing Areas of Expertise

- Science Panel comments:
  - The departure of James Martin and Ryan King from the Science Panel has resulted in a loss of expertise on modeling and water quality criteria development. New Science Panel members should fill these gaps in expertise.
  - A modeling expert can help provide guidance, clarification, and interpretation of results. They will also be able to help implement the calcite scavenging model add-on.
  - The results of the model are going to inform the decision on nutrient criteria, so it is important to have a modeling expert weigh in.
  - An expert in criteria development and standards implementation will be critical as these are the next steps in the ULWQS process.
  - Additional help with phycology and toxicology would be useful.

Science Panel Input – Recommendations

- Science Panel members in total recommended 13 people to join the Science Panel.
- The Steering Committee received a report on Science Panel input and a nomination form. Members nominated seven people to join the Science Panel:
  - Dr. Zach Aanderud, Brigham Young University
  - Dr. Ben Abbott, Brigham Young University
  - Dr. Walter Dodds, Kansas State University
  - Dr. Ramesh Goel, University of Utah
  - Dr. David Richards, OreoHelix Ecological
  - Dr. Thad Scott, Baylor University
  - Mr. Tim Wool, Unaffiliated (retired USEPA)

ULWQS Steering Committee

Science Panel Nominee – Open Session

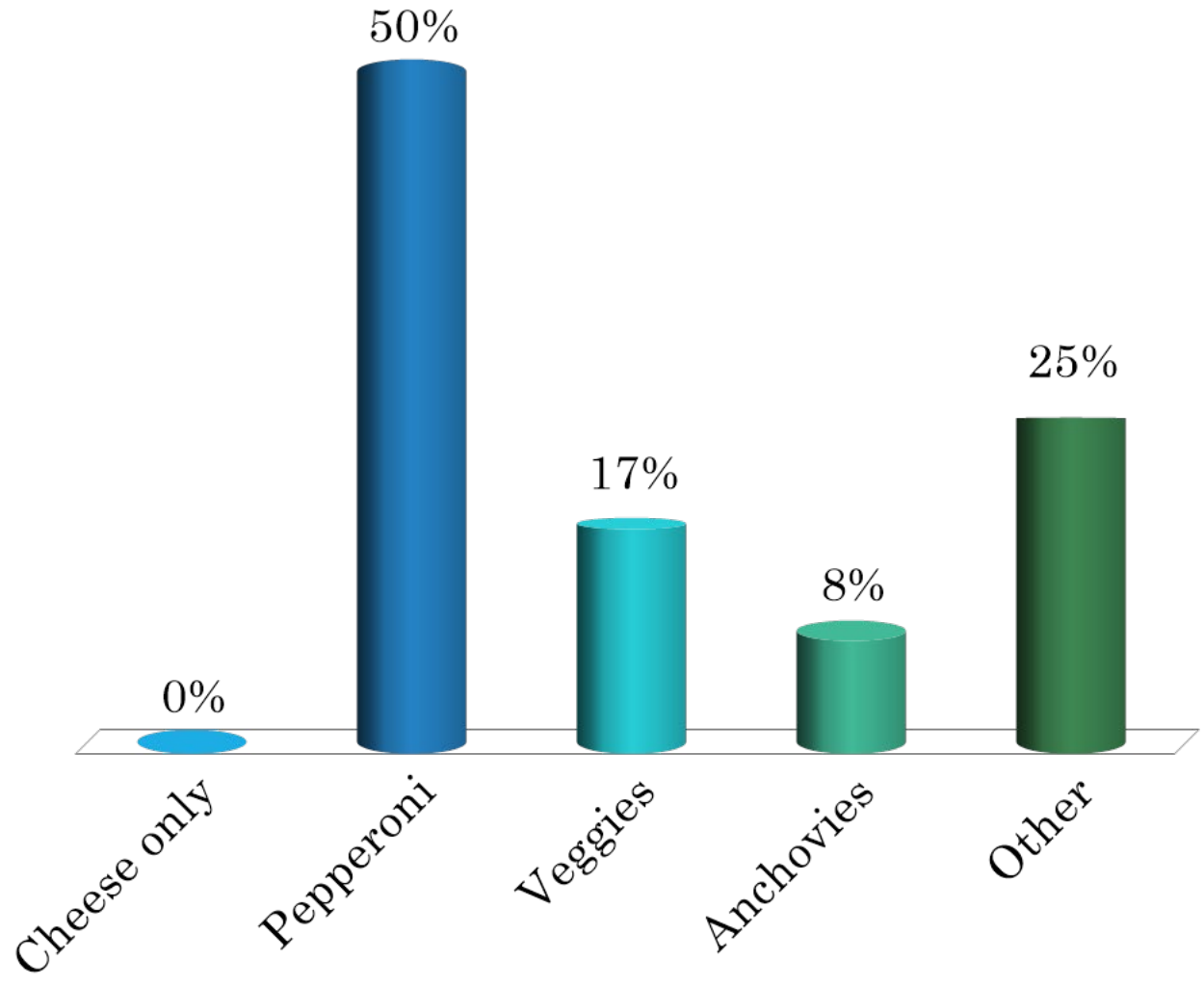
PointSolutions Instructions

Steps to participate in poll:

1. Go to www.ttpoll.com
2. Enter the Session ID: ULWQS
3. Enter your first name and last name

What is your favorite pizza topping?

A. Cheese only
B. Pepperoni
C. Veggies
D. Anchovies
E. Other

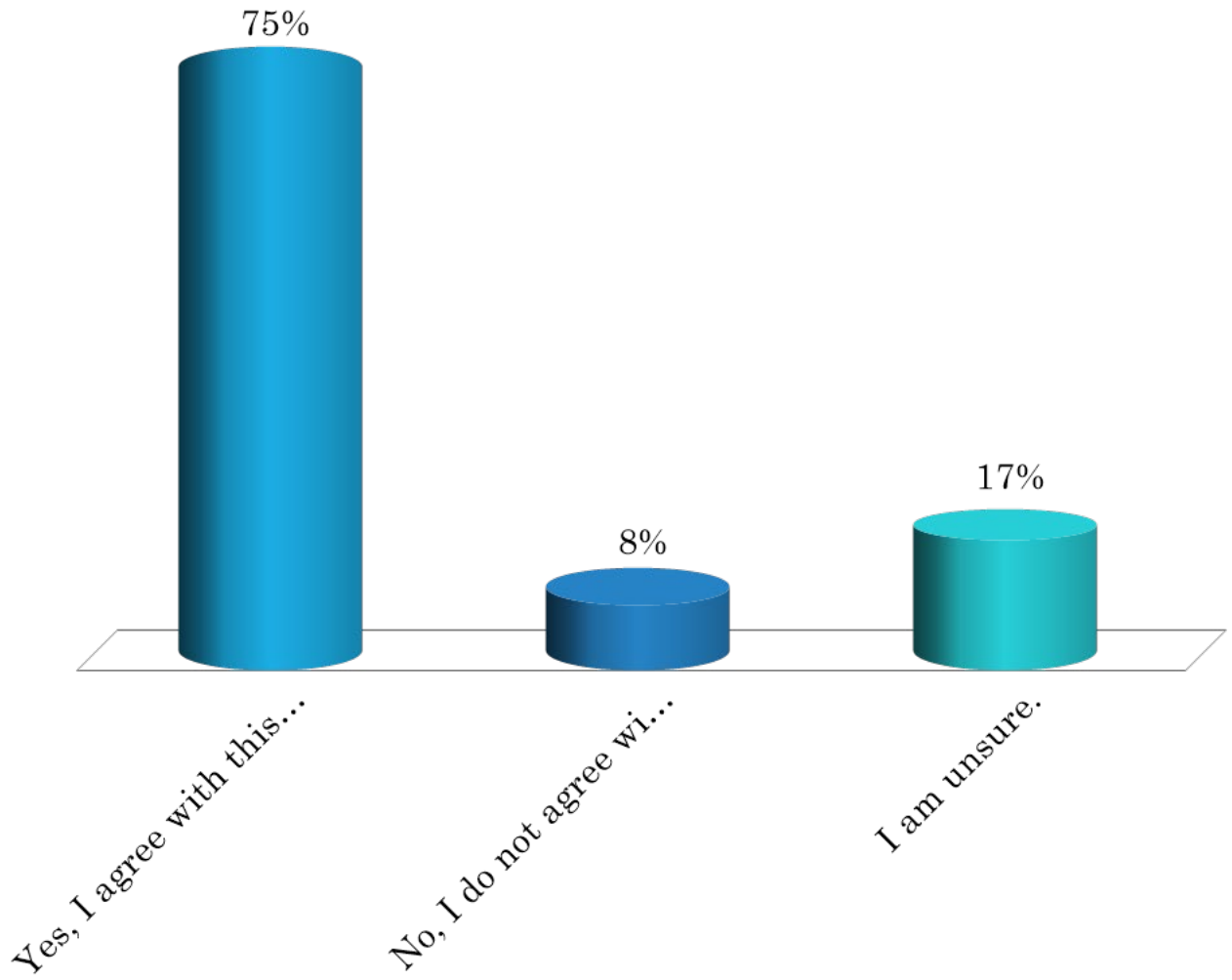


The Science Panel identified that the priority areas of expertise currently needed on the Science Panel are water quality modeling, water quality criteria development, and wetland science. Do you agree with this list?

A. Yes, I agree with this list.

B. No, I do not agree with this list.

C. I am unsure.



ULWQS Steering Committee

Science Panel Nominee – Open Session

Do you agree to advance Thad Scott and Tim Wool (independent) and Zach Aanderud (ex officio) as nominees to join the ULWQS Science Panel?

A. Yes, I agree with this slate of candidates.

B. No, I do not agree with this slate of candidates.