




PEAK Water Sustainability Engine

PEAK WATER
SUSTAINABILITY ENGINE

SWSIE
NSF Engines Southwest Sustainability Innovation Engine
swsie.asu.edu

CSC

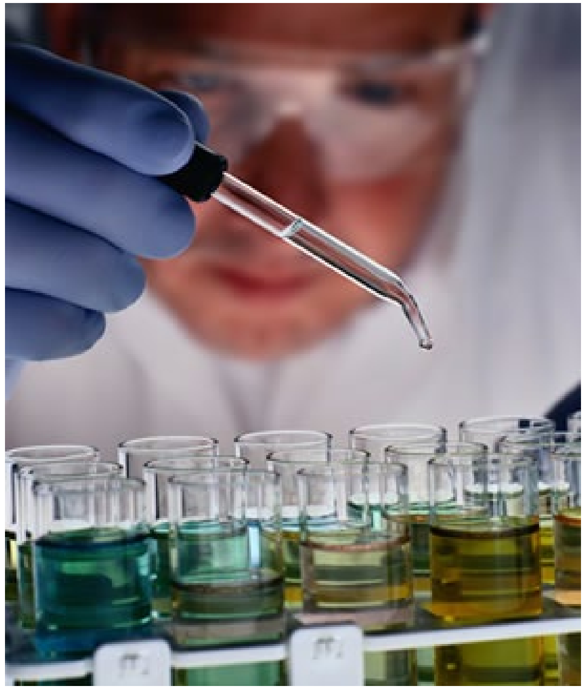
U RESEARCH

PEAK Water Introduction

Holistically and collaboratively examining water to enable sustainable local and global solutions.

PEAK Water: Pillars

Forum connecting interdisciplinary research community



PEAK WATER
SUSTAINABILITY ENGINE

PEAK Water: Pillars

Fostering collaboration with partners

PEAK WATER
SUSTAINABILITY ENGINE

PEAK Water: Pillars

Serve as scaffolding to support research efforts

PEAK WATER
SUSTAINABILITY ENGINE

PEAK Water Executive Council

Paul Brooks

Jennifer Follstad Shah

Joshua Graham

PEAK WATER SUSTAINABILITY ENGINE

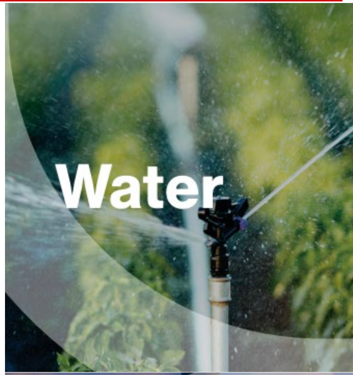
NSF Southwest Sustainability Innovation Engine (SWSIE)

SWSIE

NSF Engines: Southwest Sustainability Innovation Engine

swsie.asu.edu

Mission: Southwest Sustainability Innovation Engine aims to transform the pressing climate challenges facing the Desert Southwest into economic opportunities by unleashing the potential of STEM discovery and education.



For more information and to connect with SWSIE

Reach Out Directly: swsie@utah.edu

Thank You

PEAK Research Roster

Join PEAK Water Research Roster and receive digital communication

Large Infrastructure Funding Team

LIFT assists response teams large-scale, interdisciplinary grant opportunities

PEAK Water Kickoff Agenda

3:45-4:15 PM	**CHECK-IN**
4:15-4:30 PM	**WELCOME** Welcome – Jakob Jensen, Associate Vice President of Research Introduction to PEAK Water – Marian Rice, Associate Director
4:30-5:00 PM	**KEYNOTE** Soren Simonsen, Executive Director Jordan River Commission Laura Briefer, Director Salt Lake City Department of Public Utilities
5:00-5:15 PM	**BREAK**
5:15-6:00 PM	**LIGHTING TALKS**
6:00-6:30 PM	**SOCIAL AND NETWORKING**

PEAK WATER
SUSTAINABILITY ENGINE

Boundary Waters, Minnesota

Rainbow Bridge, Lake Powell, Utah

Colorado River / Lake Austin, Austin, Texas

Colorado River / Lake Travis, Austin, Texas

Antelope Island Visitor Center, Davis County (Dana Sohm, 2007)

“First Encampment Park” – Salt Lake City (1997)


Farmington Bay Waterfowl Management Area, Davis County (2006)

Farmington Bay Waterfowl Management Area, Davis County (2006)


Swaner EcoCenter, Park City, Utah (2008)


Juan Venado Island & Estuary Nature Preserve, León, Nicaragua (2017)

Juan Venado Island & Estuary Nature Preserve, León, Nicaragua (2017)

Great Salt Lake South Shorelands, Salt Lake & Davis County (2017)

Jordan River, North Salt Lake (2018)

“Spiral Jetty” – Great Salt Lake, Box Elder County (Halle Simonsen, 2020)


“3 Bison” – Antelope Island & Great Salt Lake, Davis County (Halle Simonsen, 2021)

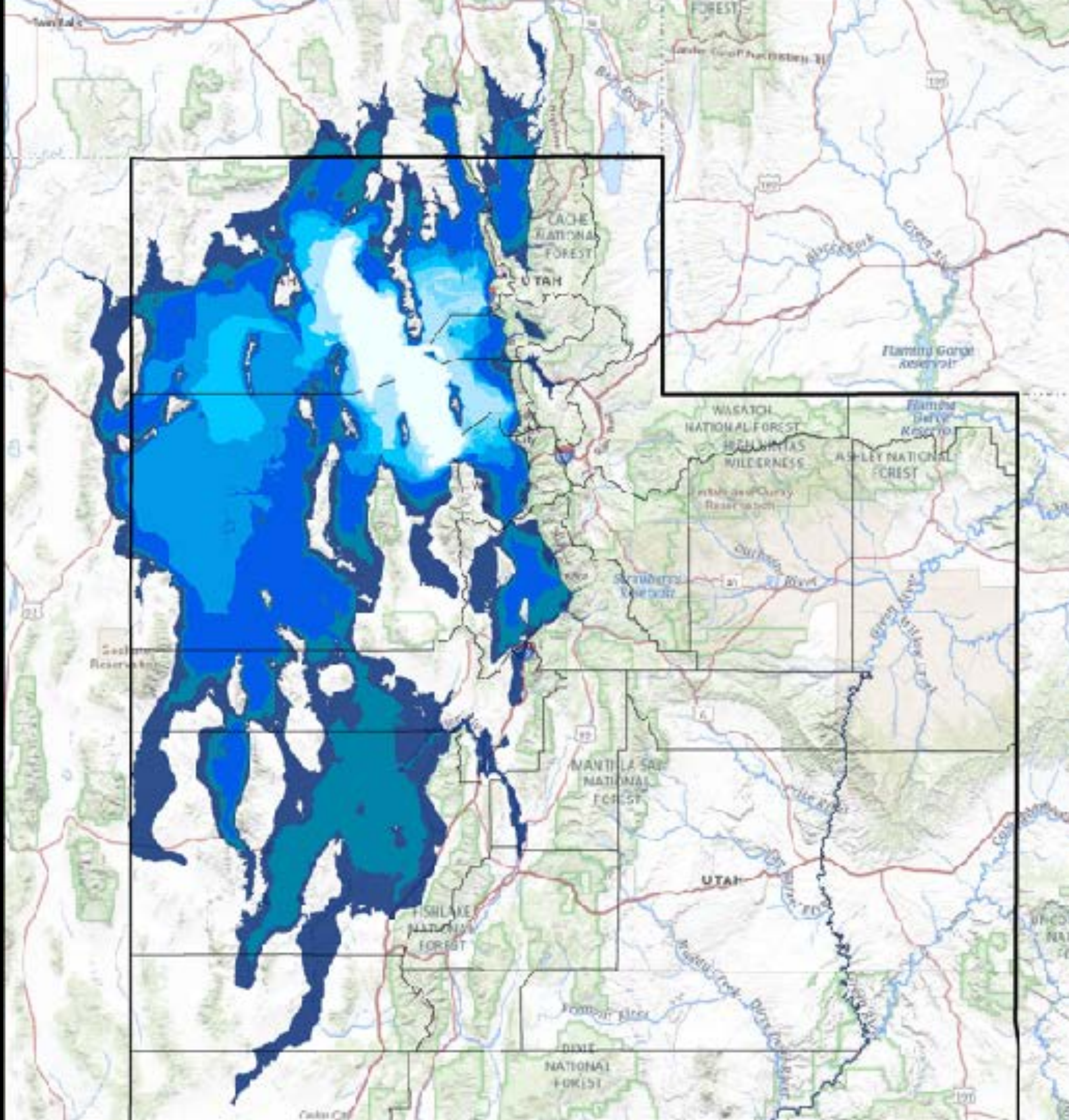
“Great Salt Lake”, Salt Lake County (Halle Simonsen, 2021)

Jordan River, North Salt Lake (2023)

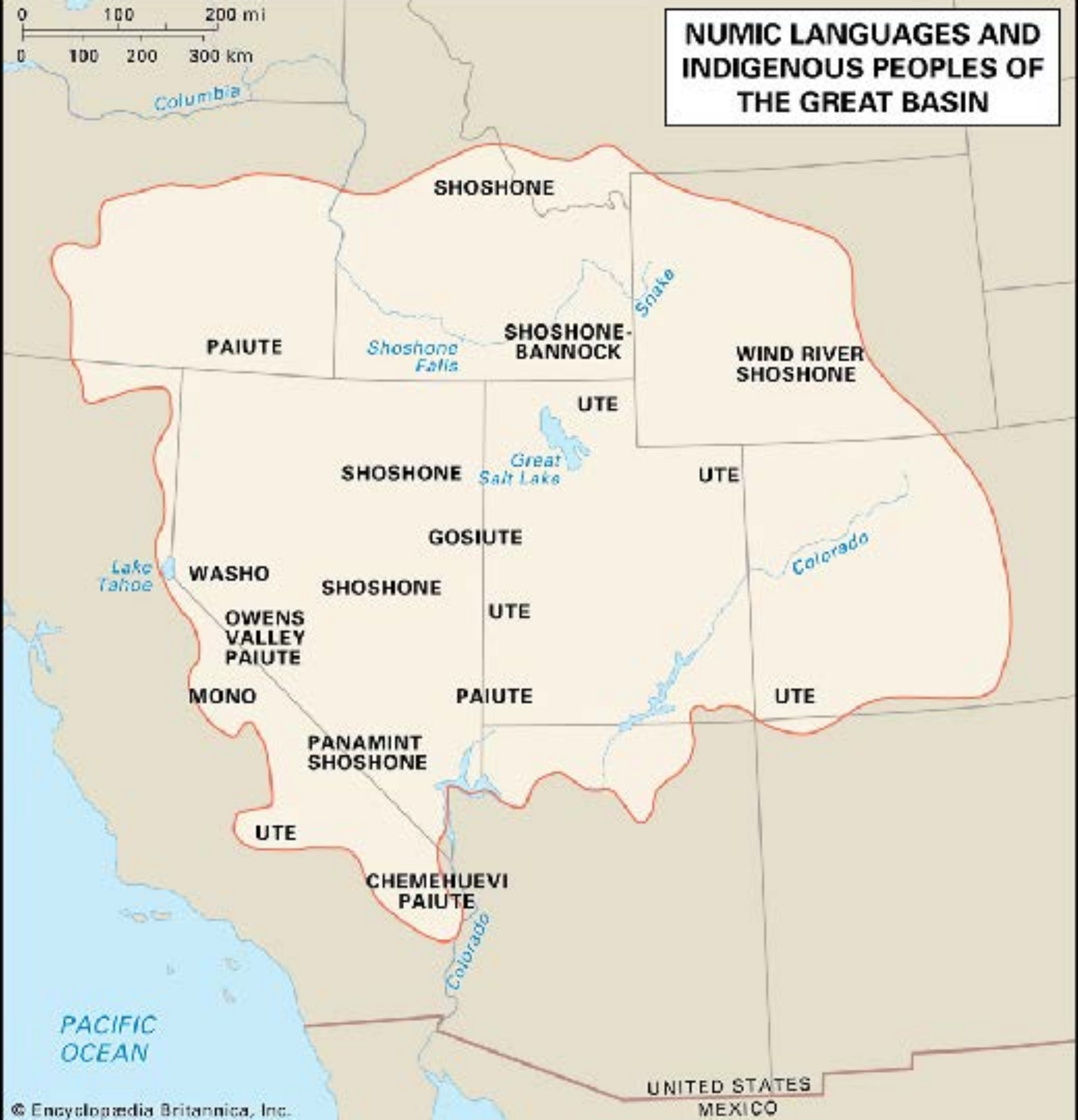

Jordan River (Neil Franti, 2015)


What Do You Know
about the
Jordan River?
Soren Simonsen
Executive Director, Jordan River Commission


“The Valley of the Kings” (M.C. Paulsen, 1996)



SLChistory.org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200
300 km
Columbia
SHOSHONE
Snake
PAIUTE
Shoshone Falls
SHOSHONE-BANNOCK
WIND RIVER SHOSHONE
UTE
Great Salt Lake
SHOSHONE
UTE
GOSIUTE
Lake Tahoe
WASHO
SHOSHONE
Colorado
OWENS VALLEY PAIUTE
UTE
MONO
PAIUTE
UTE
PANAMINT SHOSHONE
UTE
CHEMEHUEVI PAIUTE
Colorado
PACIFIC OCEAN
UNITED STATES
MEXICO
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Jordan River (Neil Franti, 2015)

Jordan River & Parkway Info

Jordan River & Watershed

- 51 mile river, through Utah's most urbanized region
- Flows north from Utah Lake to Great Salt Lake
- 3,805 square mile watershed including the entire Utah Lake watershed
- 13 natural creek and stream tributaries, 4 waste water treatment discharges, and numerous stormwater discharges

Wildlife

- 157 "common" bird species – migratory and year round varieties
- 52 large and small mammal species
- 27 fish species – 9 families (not including invertebrates)
- 17 amphibian and reptile species

Outdoor Recreation

- 46 mile multi-use trail, part of larger 170+ mile urban trail network
- Diverse recreation opportunities include: multi-use trails and connectors, water trail, bike parks, sports parks, nature centers, wildlife preserves, fishing areas, golf courses, active and passive parks, community gardens, open space and natural lands

Jordan River (Neil Franti, 2015)

Regulatory Jurisdictions

Cities

- 16 municipal jurisdictions
- land use and zoning, storm water, transportation and mobility systems, parks, trails and open space, fire and public safety

Counties

- 3 counties – Utah, Salt Lake, Davis
- parks, trails and open space, transportation and mobility, public health, watershed and flood control, fire and public safety

Special Districts

- water, waste water, storm water, transportation and mobility

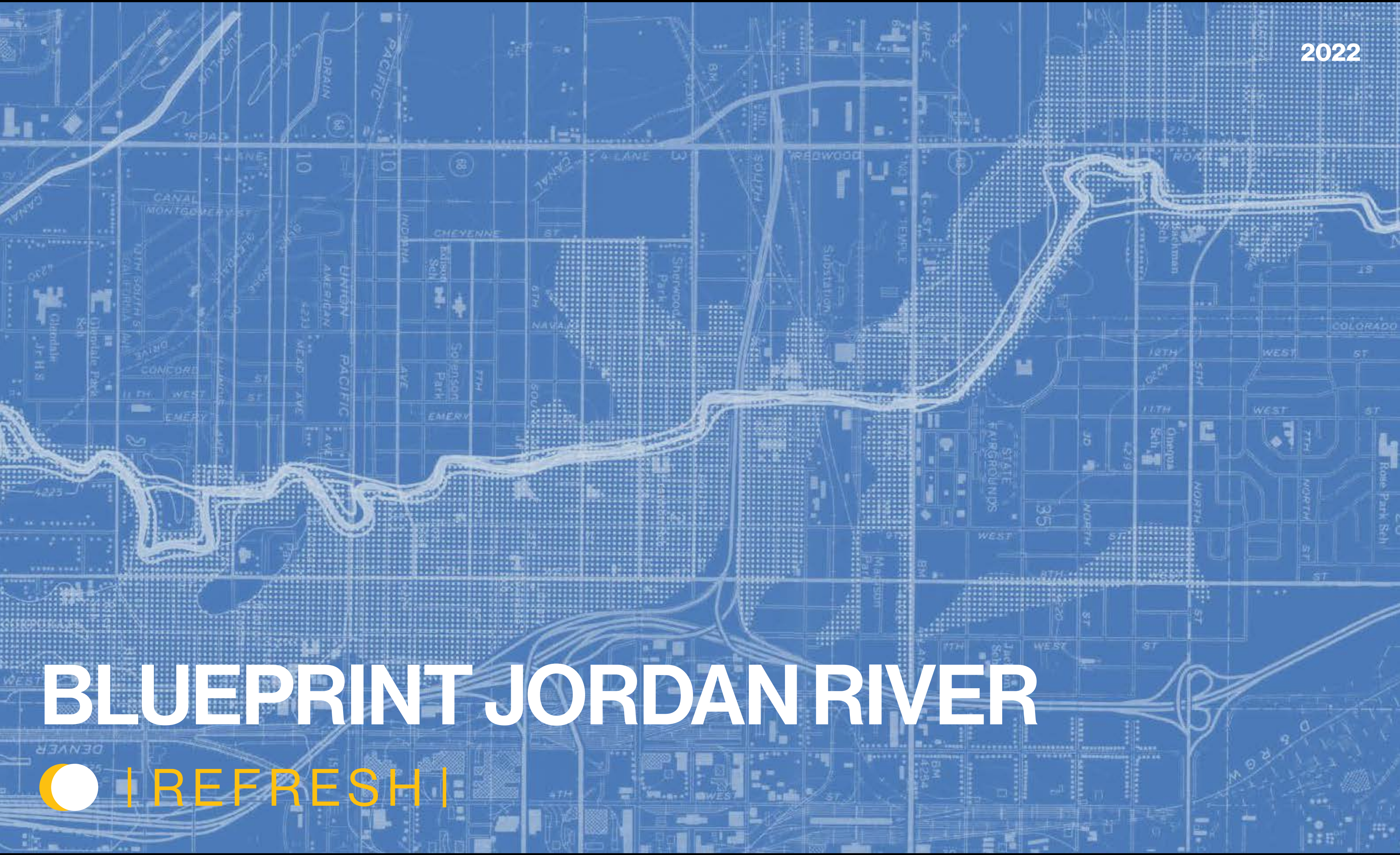
State & Federal

- land management, water quality, water rights, air quality, transportation and mobility, fish and wildlife protection, fire and public safety, emergency management

Mission & Purpose of the Jordan River Commission

Blueprint Jordan River

2022



BLUEPRINT JORDAN RIVER

| REFRESH |

BlueprintJordanRiver.org

HABITAT AND NATURAL SYSTEMS

- Protect and preserve natural open spaces
- Manage habitats and natural ecosystems

WATER AND THE RIVER

- Use a coordinated watershed approach to improve water quality
- Manage river flows for natural river function
- Enhance the hydrological function of the river

COMFORT AND INCLUSIVITY

- Make the Parkway a welcoming place for visitors of all abilities, backgrounds, and circumstances
- Comprehensive maintenance, trash removal, and cleaning
- Mitigate homelessness

RECREATION

- Support, expand, and enhance opportunities for recreational uses and active transportation throughout the Parkway

SAFETY AND WELLBEING

- Improve safety and security while fostering a comfortable environment for recreation and leisure
- Add balanced lighting solutions and surveillance to improve visibility while minimizing impacts to wildlife
- Manage wildfire risk and prepare for response and recovery

DEVELOPMENT AND TRANSPORTATION

- Improve access to the Parkway and enhance the Parkway's role as a regional transportation corridor
- Ensure that development highlights the Jordan River and enhances the Parkway
- Promote harmony between infrastructure and river functions

COMMUNICATIONS, EDUCATION, AND ART

- Improve visitor experience, wayfinding, point of interest identification, and education
- Provide experiential learning opportunities for visitors to the Parkway
- Support art, placemaking, and community engagement

Jordan River, West Jordan (2020)

Jordan River, West Jordan (2024)

Jordan River, South Salt Lake (2021)

Jordan River, Lehi (2021)

Jordan River, Various Locations

Jordan River, Lehi (2022)

Jordan River, Salt Lake City (2019)

Jordan River, Salt Lake City (2016)

Jordan River, Salt Lake City (2018)

Jordan River, Murray (2019)

Jordan River, Salt Lake City (2020)


Jordan River, Salt Lake City (2017)


Jordan River, South Jordan (2019)

Jordan River, West Jordan (2017)

Jordan River, Salt Lake City (2019)

Jordan River, Salt Lake City (2015)


Jordan River, Saratoga Springs (2018)

Jordan River, Salt Lake City (2018)

Jordan River, Salt Lake City (2021)

Jordan River, Salt Lake City (2021)

Jordan River, Salt Lake City (2021)

Jordan River, Lehi (2019)

Jordan River, Lehi (2022)


Jordan River, Bluffdale (2019)

Jordan River, Bluffdale (2024)

Jordan River, Bluffdale (2024)

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JordanRiverCommission.gov

BlueprintJordanRiver.org
MyJordanRiver.org
GetToTheRiver.org
JordanRiverFriends.org
LoveYourWatershed.org

#JordanRiverParkway #OurRiverOurFuture
#GetToTheRiver #MyJordanRiver #NatureInTheCity
#LoveYourWatershed #LitterAndLeaves

@JordanRiverComm @GetToTheRiver

Thank You!

Planning Salt Lake City's Water Future

PEAK Water Sustainability Engine Kickoff Event

Laura Briefer, Director

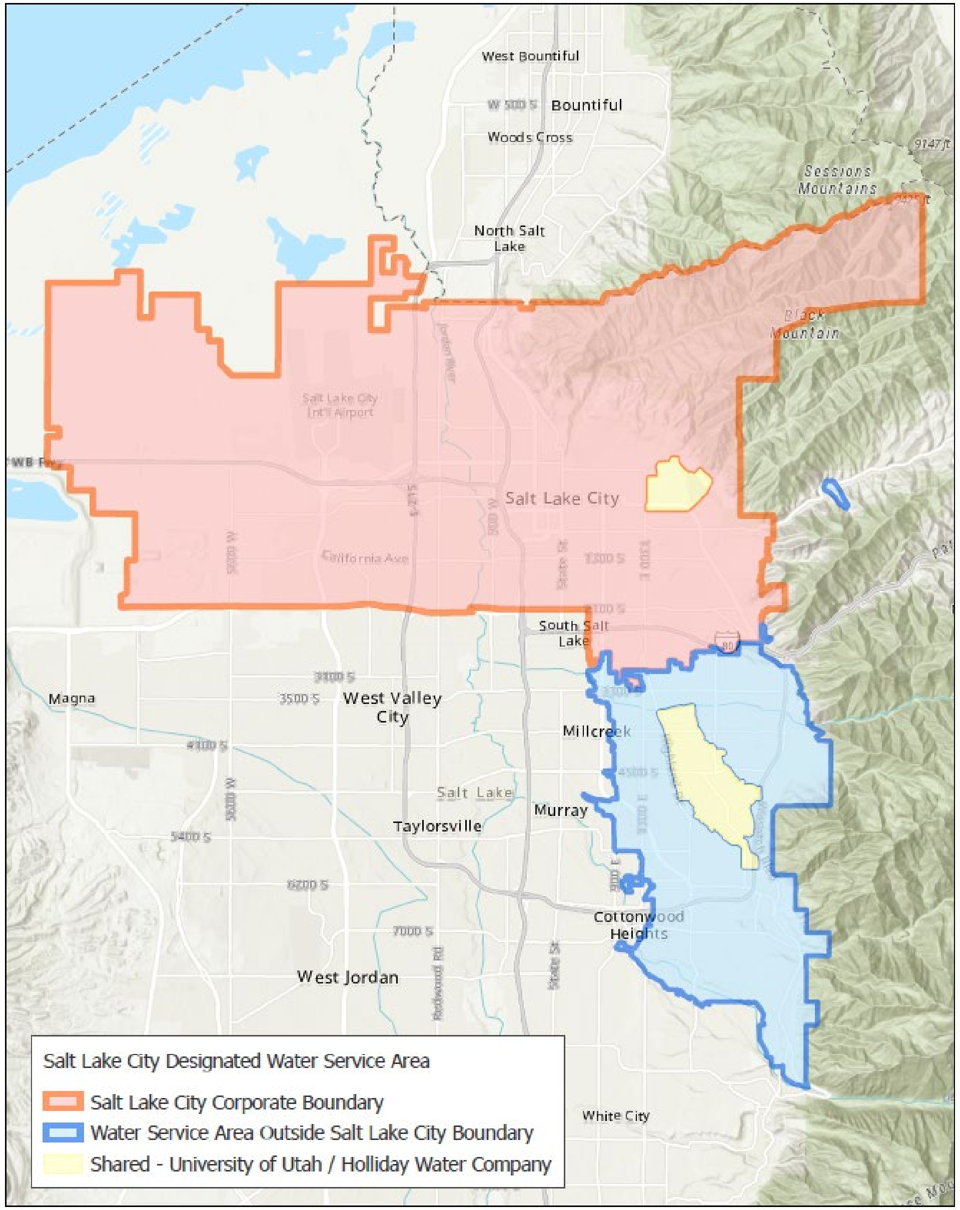
Salt Lake City Public Utilities

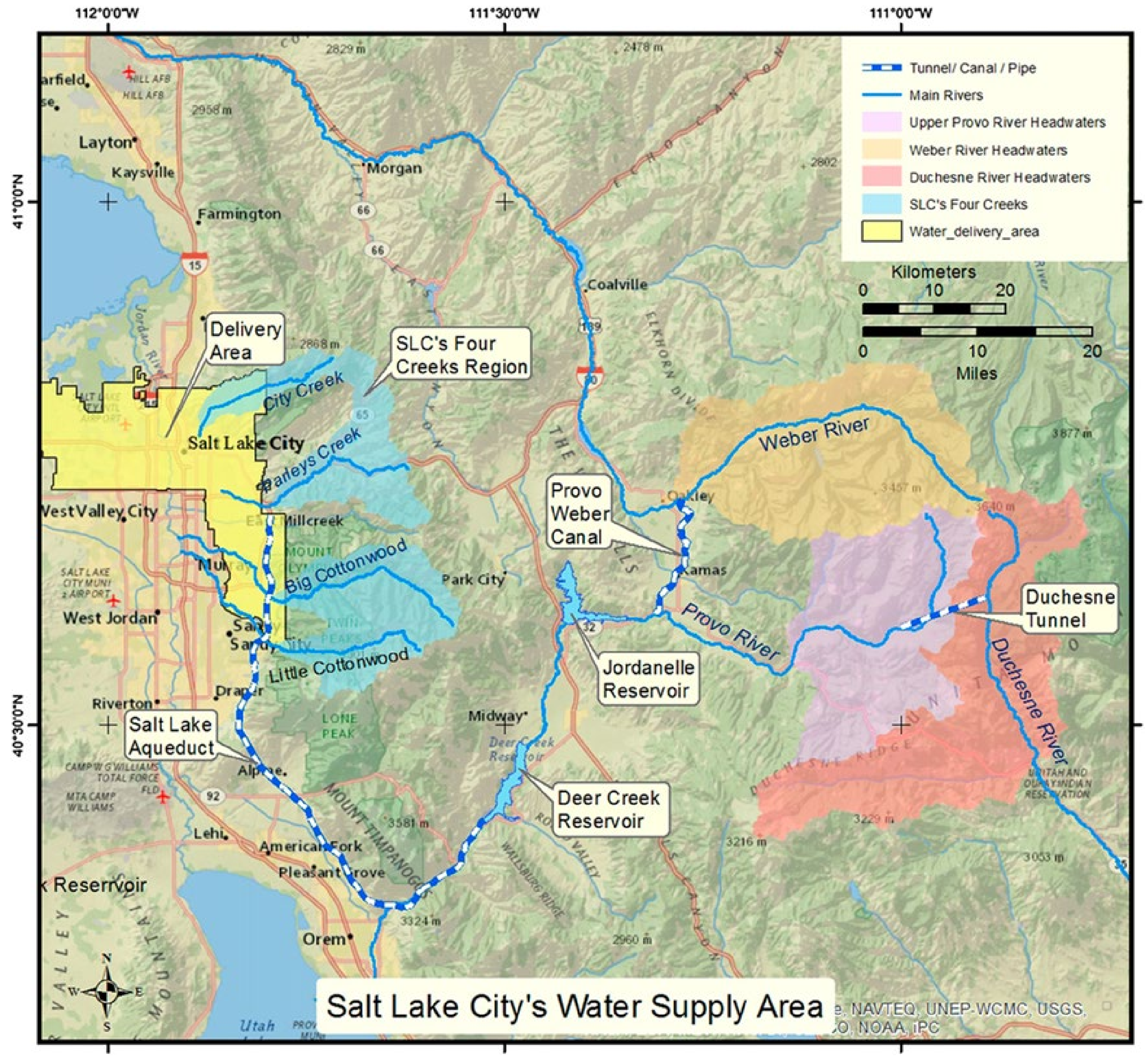
January 22, 2025

Salt Lake City Public Utilities Mission and Water Services

- Drinking Water – 365,000 people along the Wasatch Front in 141 square miles
- Watershed jurisdiction across 190 square miles of Wasatch Mountains
- Wastewater and stormwater – 200,000 people in Salt Lake City
- *"Serving our community, protecting our environment"*

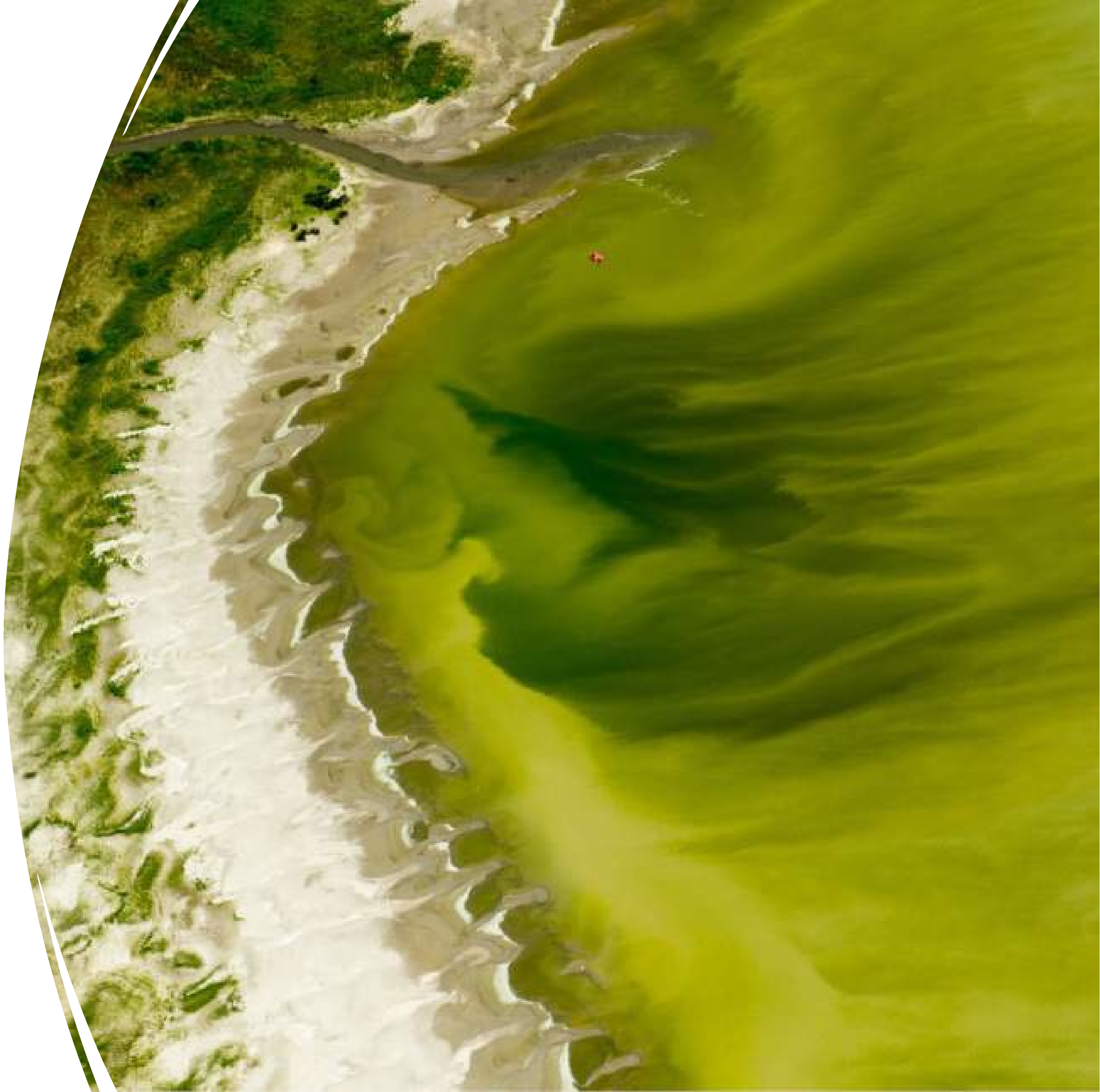
Salt Lake City Designated Water Service Area Map




Salt Lake City's Water Supply Area
Tunnel/ Canal / Pipe
Main Rivers
Upper Provo River Headwaters
Weber River Headwaters
Duchesne River Headwaters
SLC's Four Creeks
Water_delivery_area
Kilometers
0 10 20
0 10 20
Miles
Delivery Area
SLC's Four Creeks Region
City Creek
Parleys Creek
Big Cottonwood
Little Cottonwood
Salt Lake City
Provo Weber Canal
Jordanelle Reservoir
Deer Creek Reservoir
Salt Lake Aqueduct
Duchesne Tunnel
Weber River
Provo River
Duchesne River
Layton
Kaysville
Farmington
Morgan
Coalville
Park City
Oakley
Kamas
Midway
West Valley City
West Jordan
Millcreek
Riverton
Draper
Alpine
Lehi
American Fork
Pleasant Grove
Orem
112°0'0"W
111°30'0"W
111°0'0"W
41°0'0"N
40°30'0"N

Why do we plan?

- Conditions change
  - Physical and environmental
  - Legal/regulatory
  - Population Changes
  - Public values
  - Changes in risk factors affecting water
- Our understandings change
  - We've gained knowledge over time that may require new approaches
  - Examples – climate change; PFAS; nutrient and pharmaceutical impacts to water quality



What are we planning to address?

- Climate change
- Population growth and land use changes
- Great Salt Lake and ecological needs
- Water quality needs and regulations
- Aging infrastructure
- Public values toward water

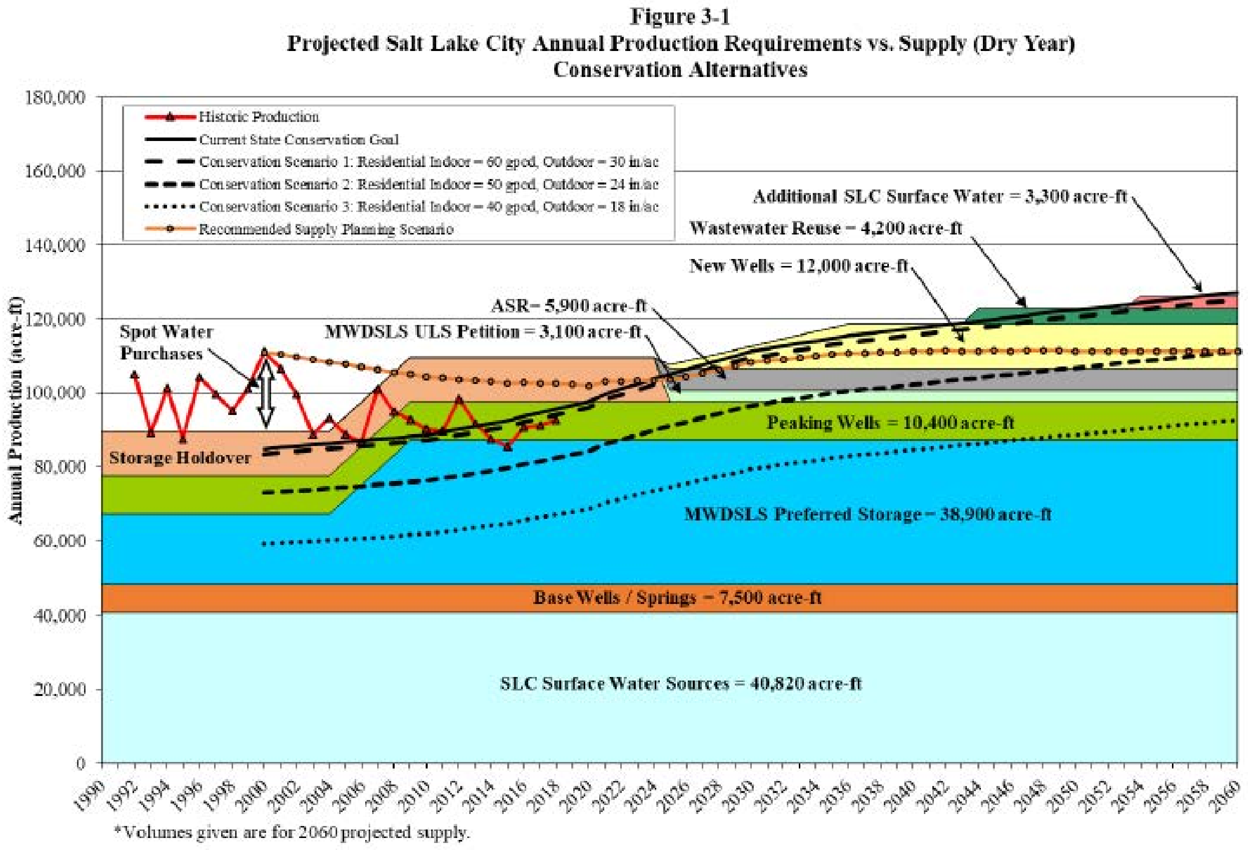
How are we planning?

- Water supply and demand through 2065
- Drought contingency and conservation
- Watershed/source water protection
- Stormwater and integrated water management
- Climate vulnerability and adaptation
- Great Salt Lake water needs
- Infrastructure needs
- Financial strategies and water affordability
- Public engagement
- Public policy strategies

Water supply and demand – 2065 and Beyond

- Drivers for 2065 Plan:
- Land use changes and growth
  - 20-25% residential population growth by 2060
  - State prison relocated to service area
  - Inland Port and growth in industrial uses
  - Increased densification
- Regulatory
- Updated climate change information
  - Updated National Climate Assessment
  - Local research

Projected *Annual* Water Supply and Demand Scenarios



Risk and Redundancy Planning

- Single Source Loss
  - Loss of a groundwater well or equivalent quantity
- Catastrophic Source Loss
  - For annual supply, loss of Big Cottonwood Creek or equivalent quantity
  - For peak day, loss of Parleys, or equivalent quantity
- Great Salt Lake
- Climate Change

Water supply and demand 2065 findings

- Water supplies will be adequate to meet 2065 demands if the following occur:
- 1) Additional conservation efforts are implemented
- 2) Additional water source development occurs
- 3) Assumes a climate factor of net 10-20% change due to any combination of increased demand or reduced supply
- 4) *Incorporates redundancy buffers in case of loss of a water source*

Academic partnerships

- **Climate vulnerability and adaptation planning – multi-year phased project**
- Dr. Paul Brooks – Geology and Geophysics
- Dr. Steve Burian – Engineering
- Dr. Court Strong – Atmospheric Sciences
- Engaging students and research opportunities
- Training the next generation of water stewards

Lightning Talks

Paul Brooks; Court Strong, Ryan Johnson; Steve Burian	**The SLCDPU-UU Partnership: Advancing Fundamental Understanding and Societal Application in Water Resources**
Joshua Graham	Shoring Up: Art Education on the Edge of the Great Salt Lake
Nathan Lunstad	Integrated Water Distribution Systems
Zinan Yu	Phosphate Recovery from Wastewater
Ling Zang	PFAS Separation Technology
Deisy Carvalho Fernandes	Pollution Prevention and PFAS Mitigation: Building a Sustainable Future
Ryan Johnson	Coupling Large-Scale Datasets and Machine Learning to Advance High-Resolution Snow Mapping
Rick Forster	Seasonal Snow and Glacier Measurements using Radar Remote Sensing
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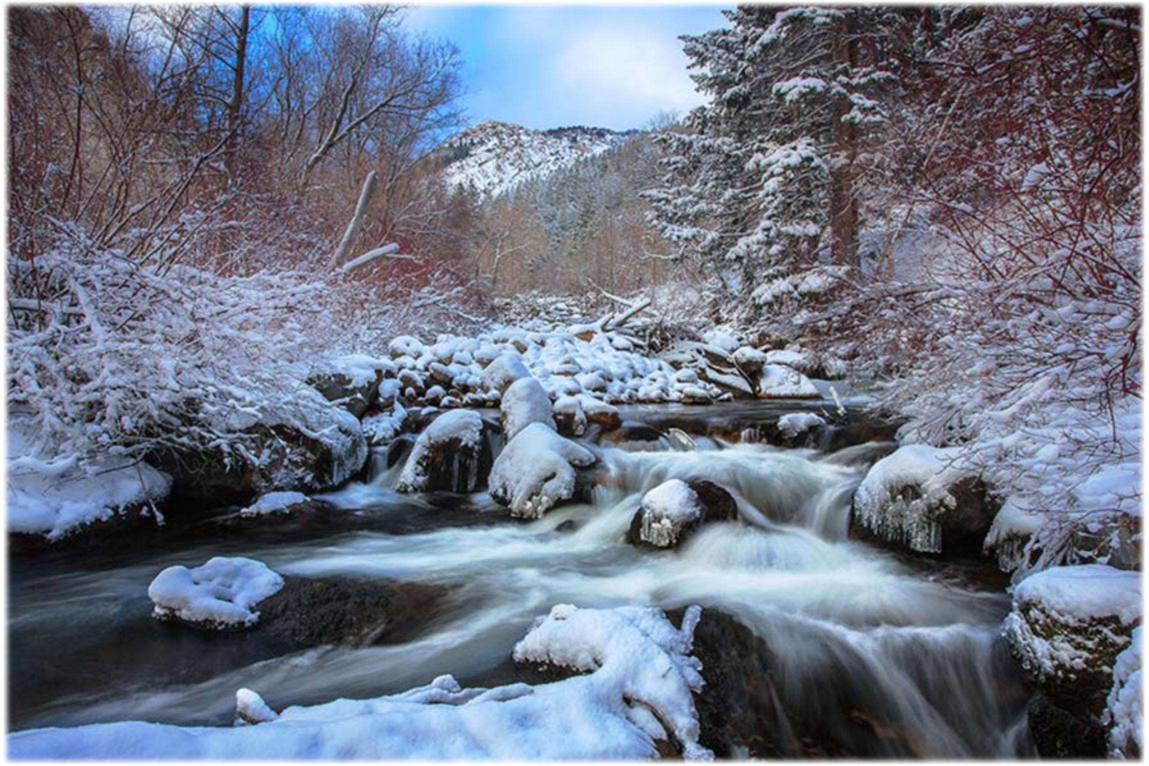
Ramesh Goel	Harmful Algal Blooms
Brig Daniels	Legal Reforms and the Effort to Save Great Salt Lake
Emily Lewis	Water Policy

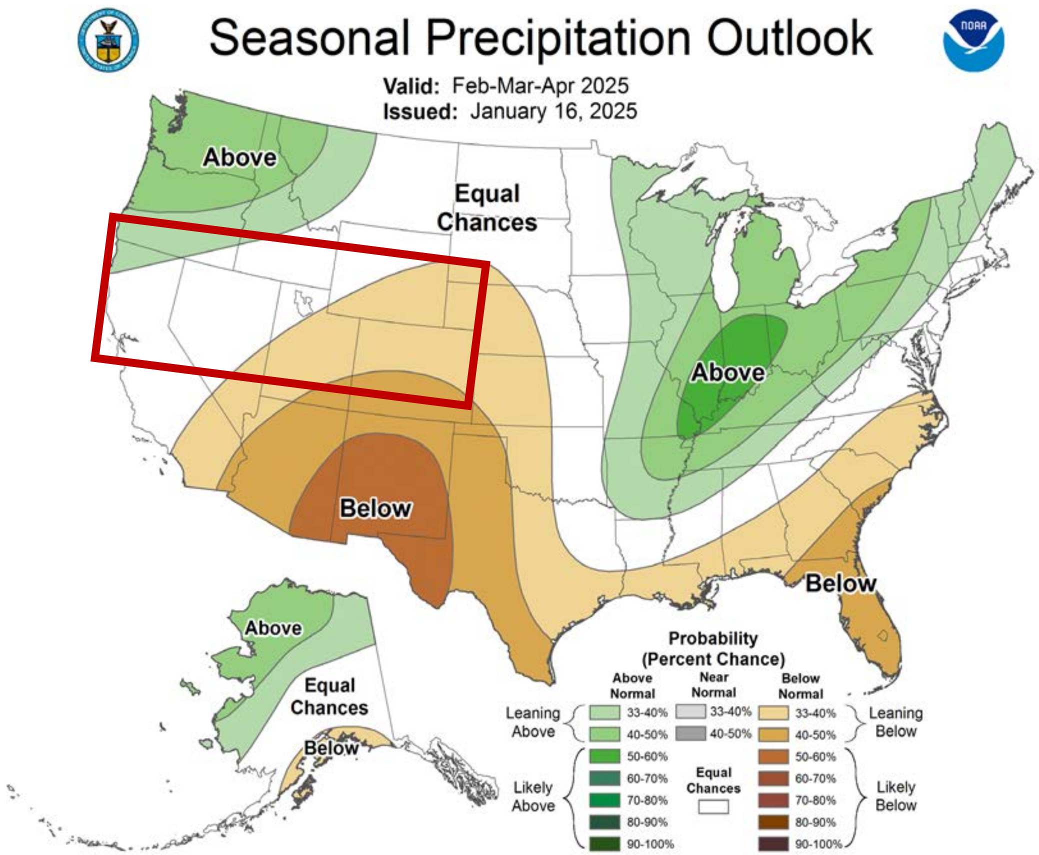
The SLCDPU-UU partnership: Advancing fundamental understanding and societal application in water resources

How much will it snow?



How efficiently will that snow be translated to streamflow?

Two critical questions in western water resources



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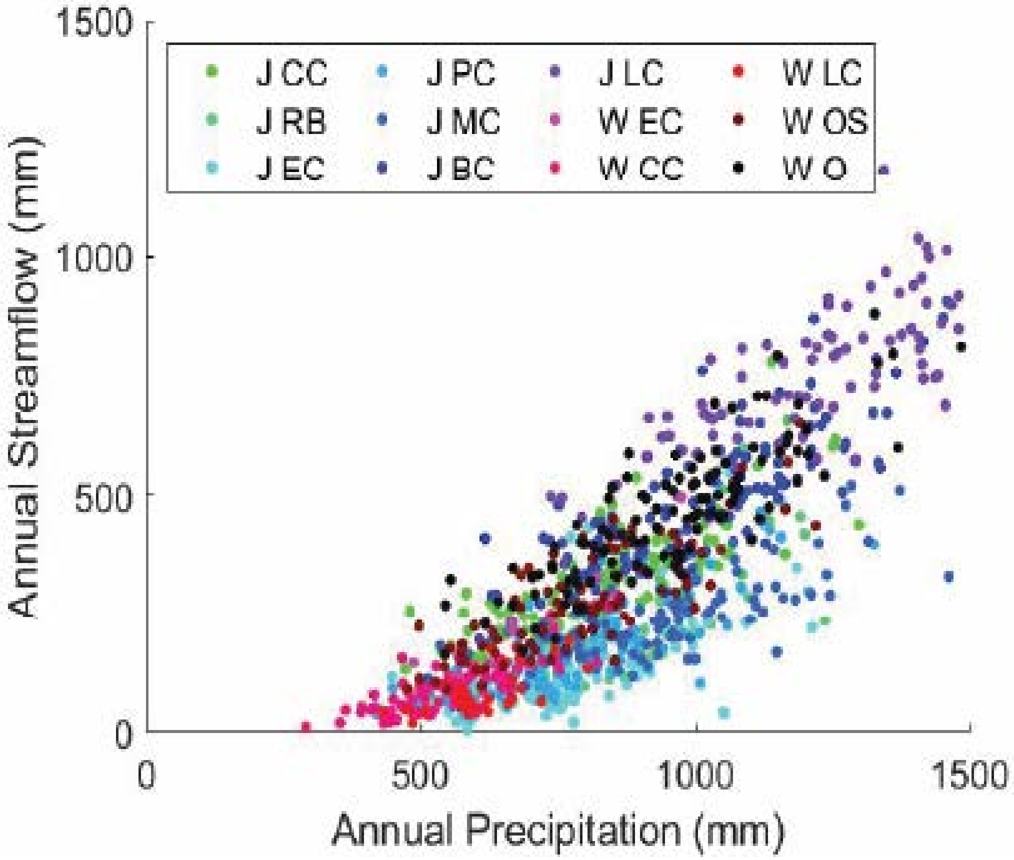

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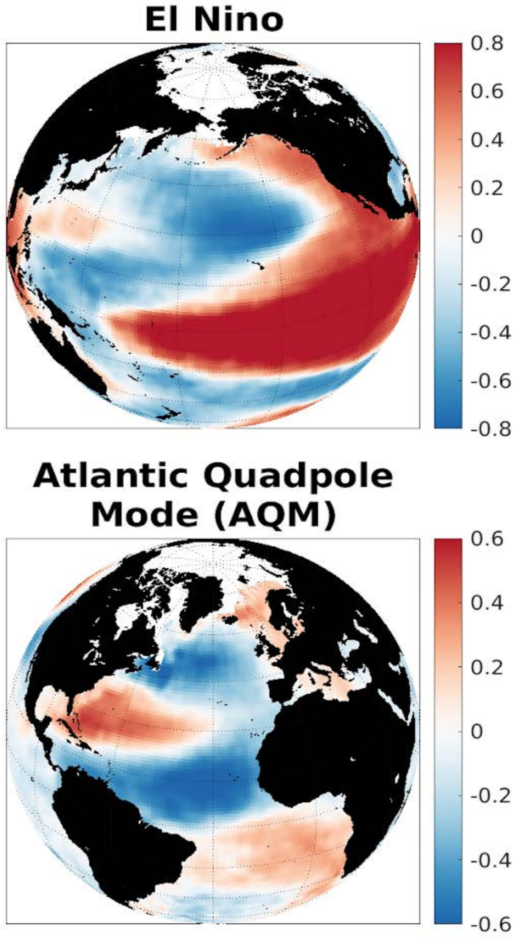

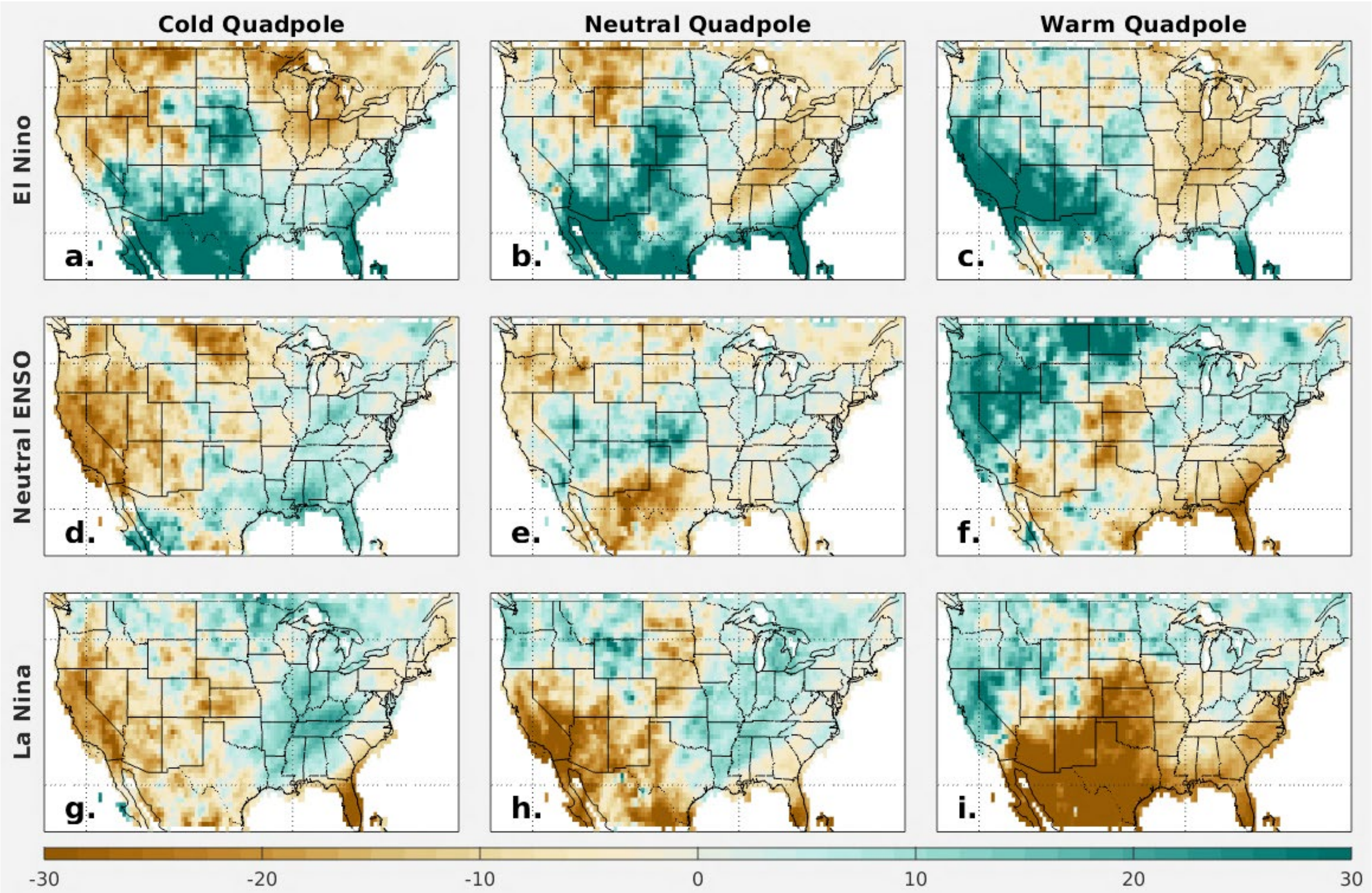

Atlantic Sea Surface Temperature interacts with ENSO to control western North American climate

Stone et al. 2023, *npj Climate and Atmospheric Science*

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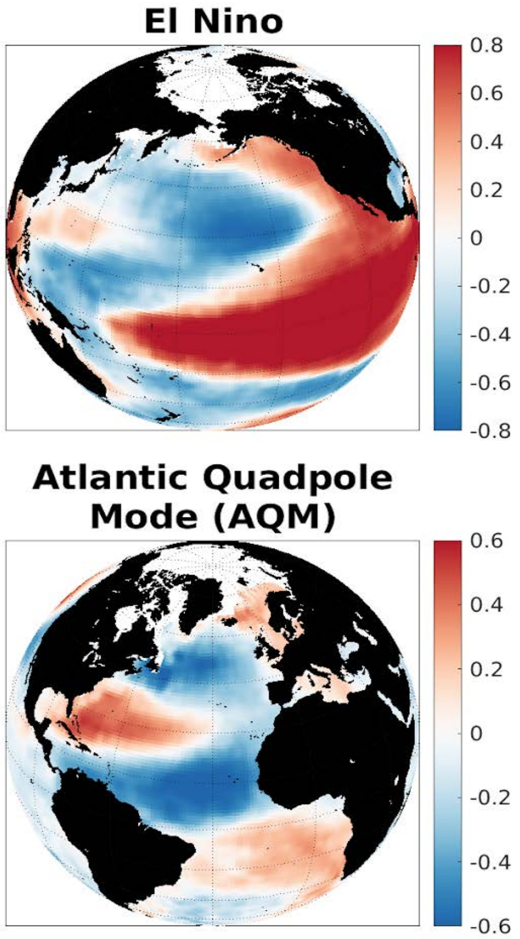

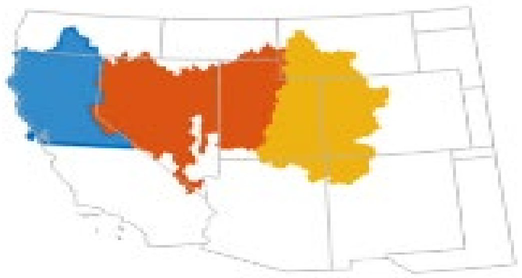

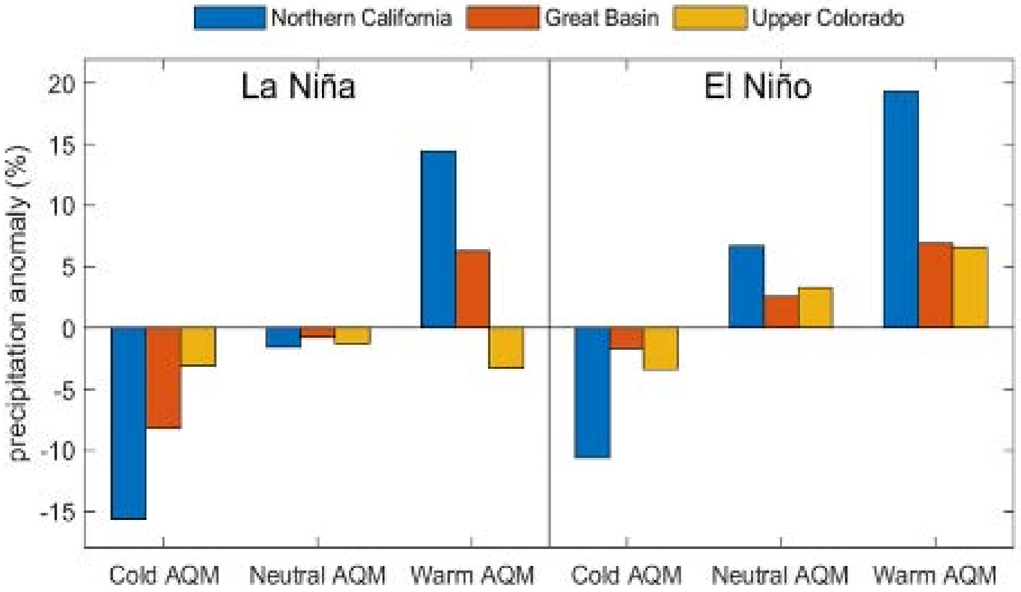

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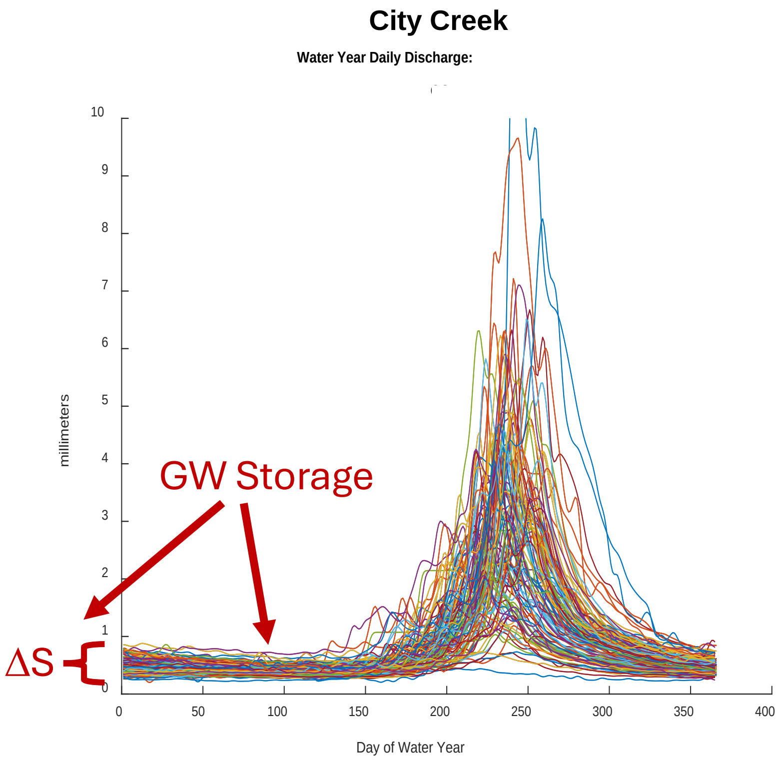
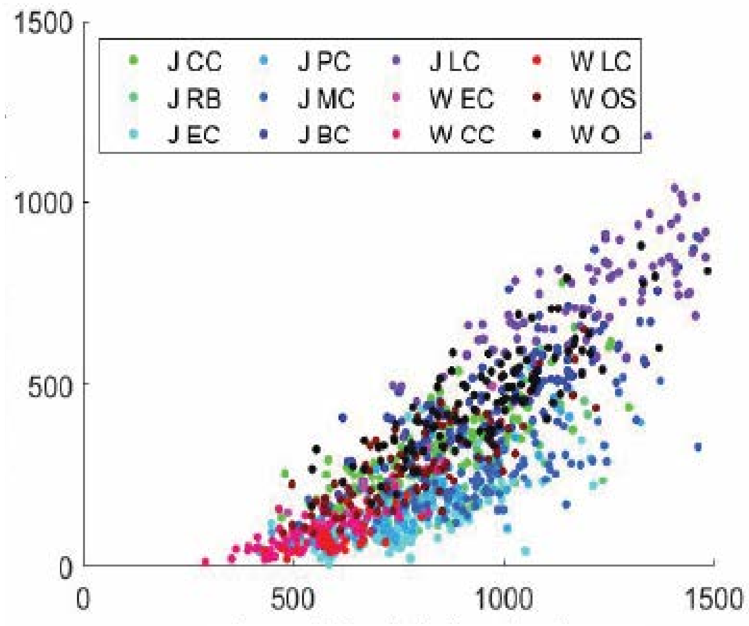
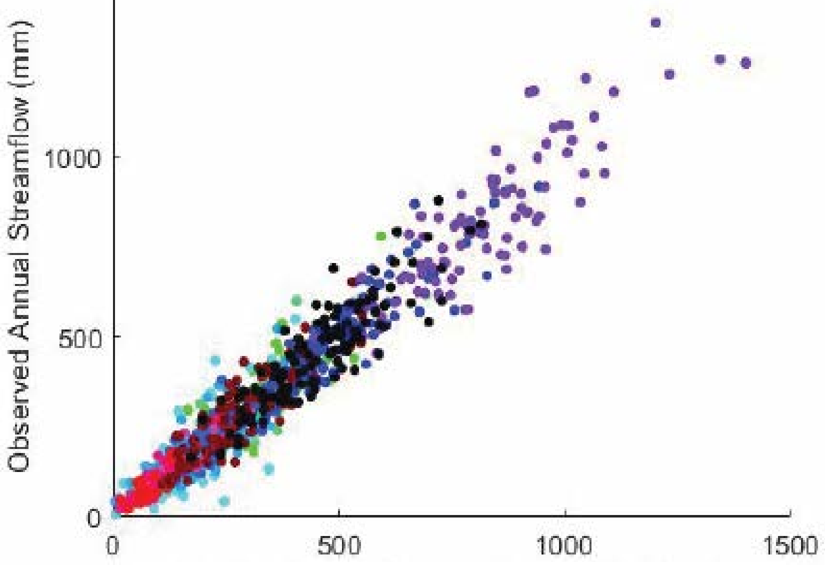




Precipitation



Precipitation + Storage

Runoff efficiency is strongly related to the *amount* of groundwater storage

Gelderloos 2019, Brooks et al. 2021, Wolf et al, 2023, Wolf et al. in press

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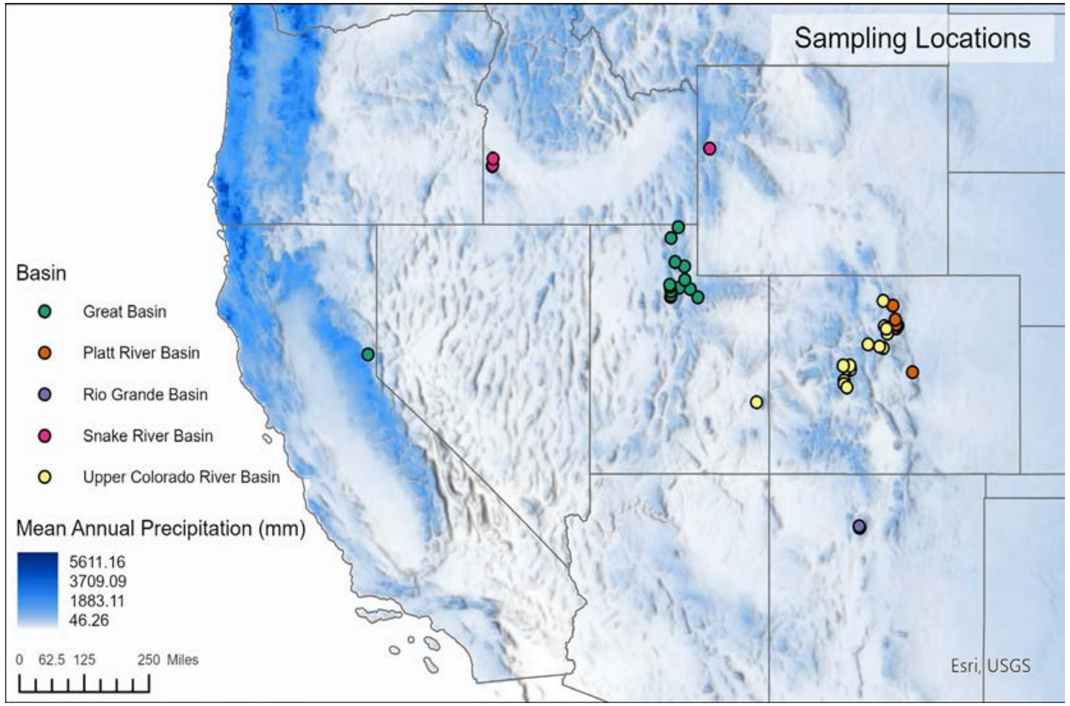


Tritium age dating

Clastic

Hard Rock

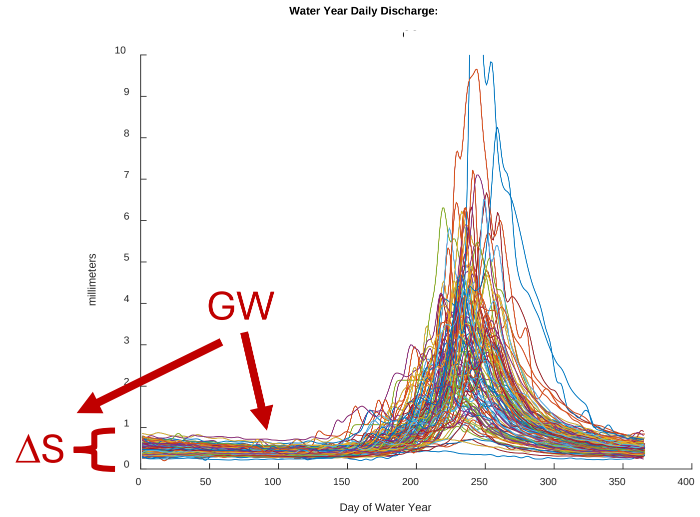
Runoff efficiency is related to the *age* of groundwater

The *age* of groundwater is related to bedrock geology

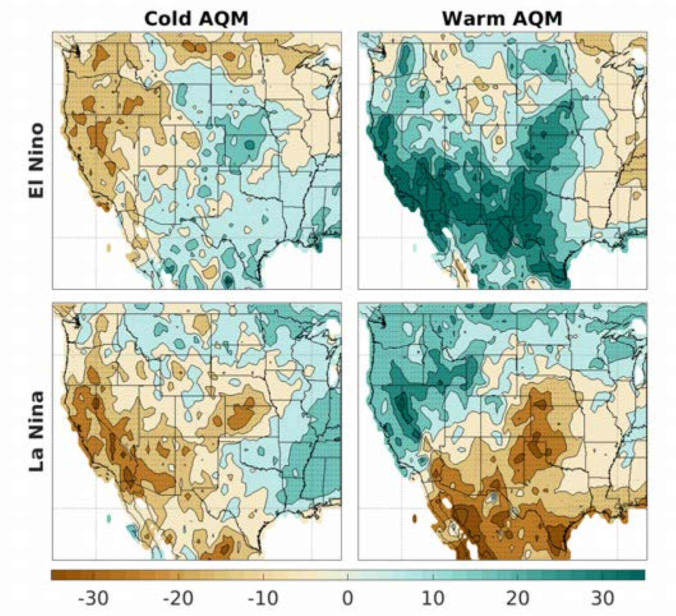
On average, it takes 5.5 years for snowmelt to reach the stream

Brooks et al. In Review *Science*

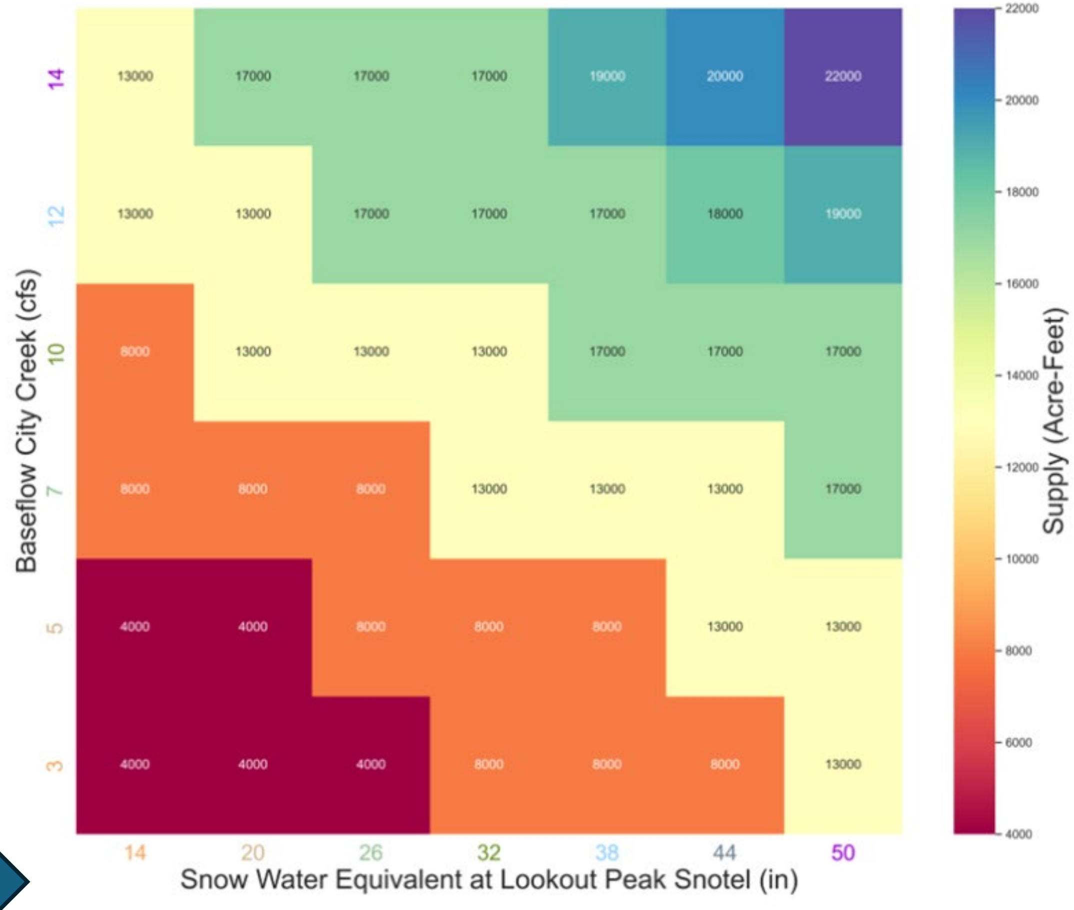
How do we put this to work for decision support?



How efficient is runoff?



How much snow?



Low dimensional models and “simple”, physically-relevant tools based on emerging process understanding

Lightning Talks

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Joshua Graham	**Shoring Up: Art Education on the Edge of the Great Salt Lake**
Nathan Lunstad	Integrated Water Distribution Systems
Zinan Yu	Phosphate Recovery from Wastewater
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Ramesh Goel	Harmful Algal Blooms
Brig Daniels	Legal Reforms and the Effort to Save Great Salt Lake
Emily Lewis	Water Policy


SHORING UP
Art education research on the edge of the Great Salt Lake


josh.graham@utah.edu

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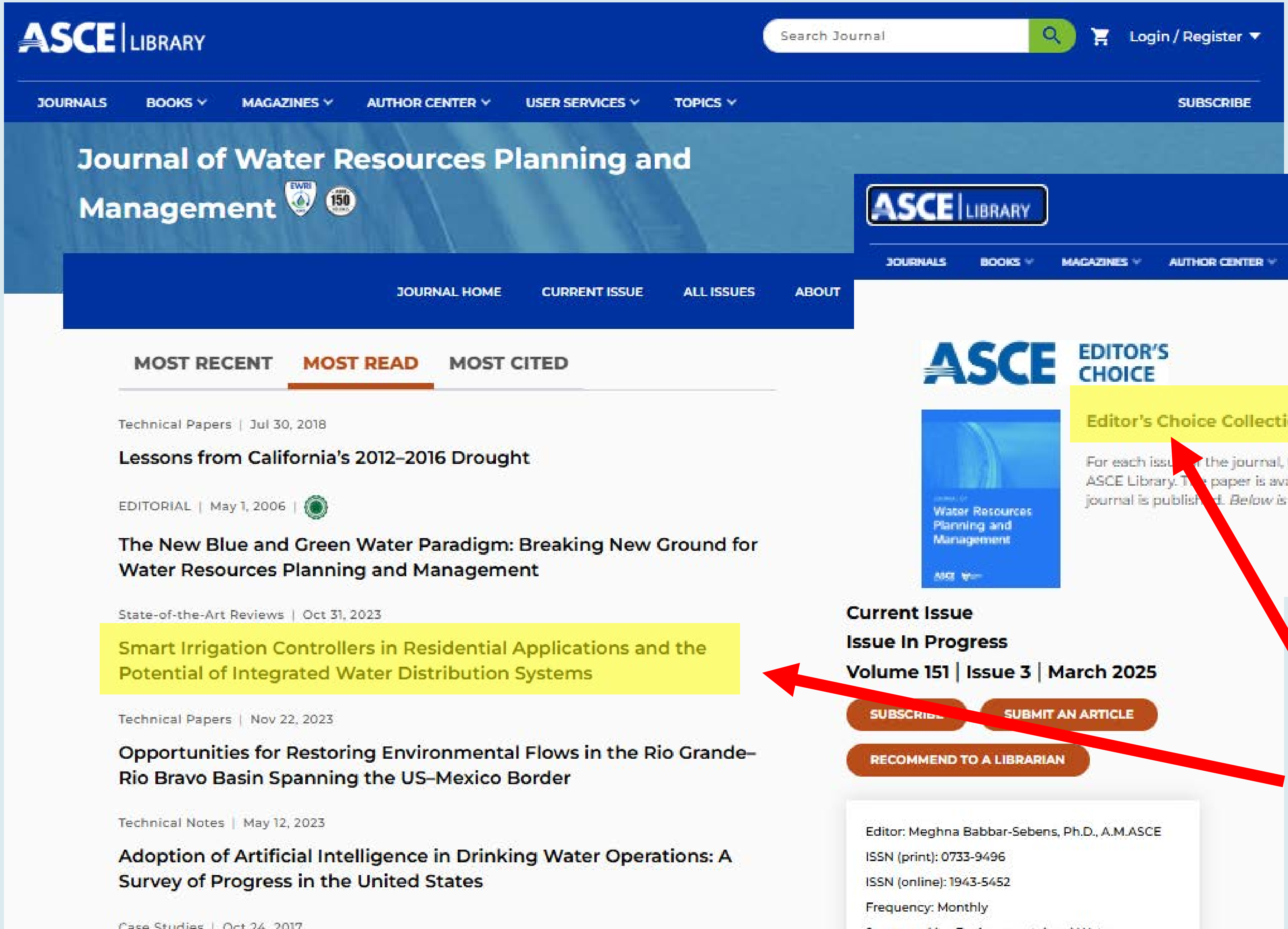
Integrated Water Distribution Systems

Nathan Lunstad, Ph.D., P.E., Director

UTAH DEPARTMENT *of* ENVIRONMENTAL QUALITY
DRINKING WATER

Relevant and of Interest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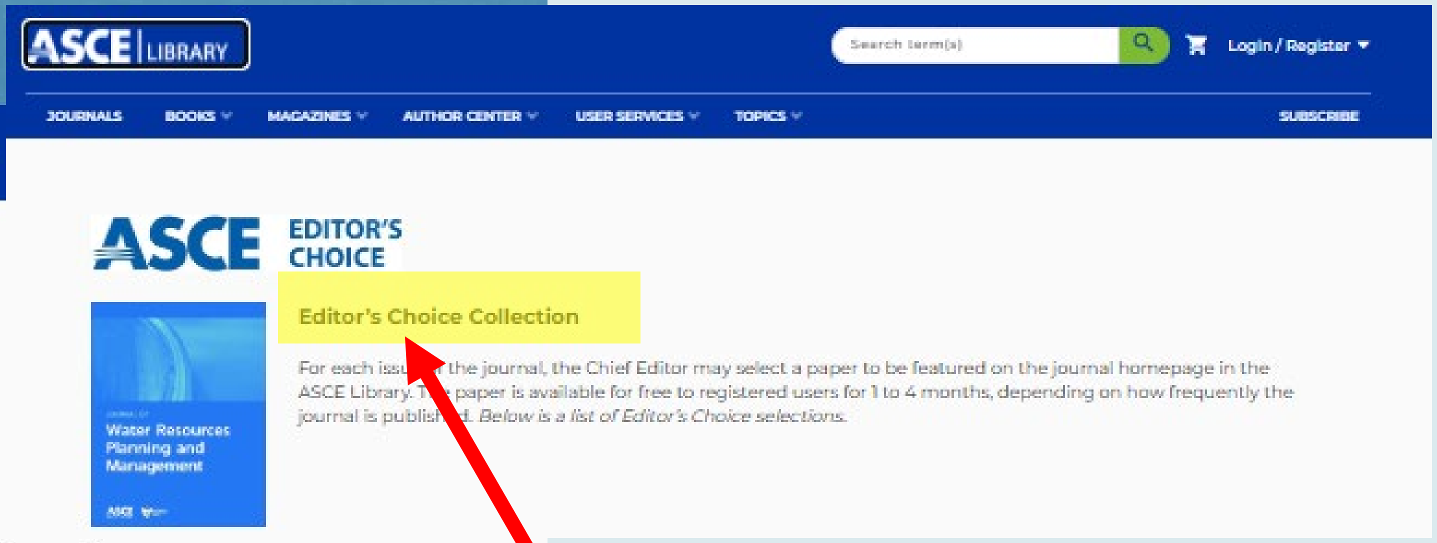
Editor: Meghna Babbar-Sebens, Ph.D., A.M.ASCE

ISSN (print): 0733-9496

ISSN (online): 1943-5452

Frequency: Monthly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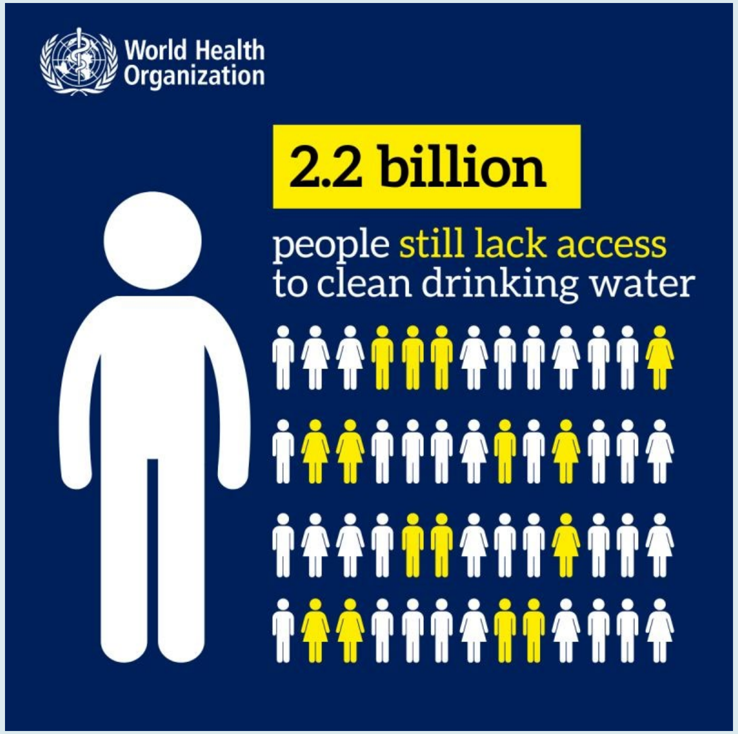
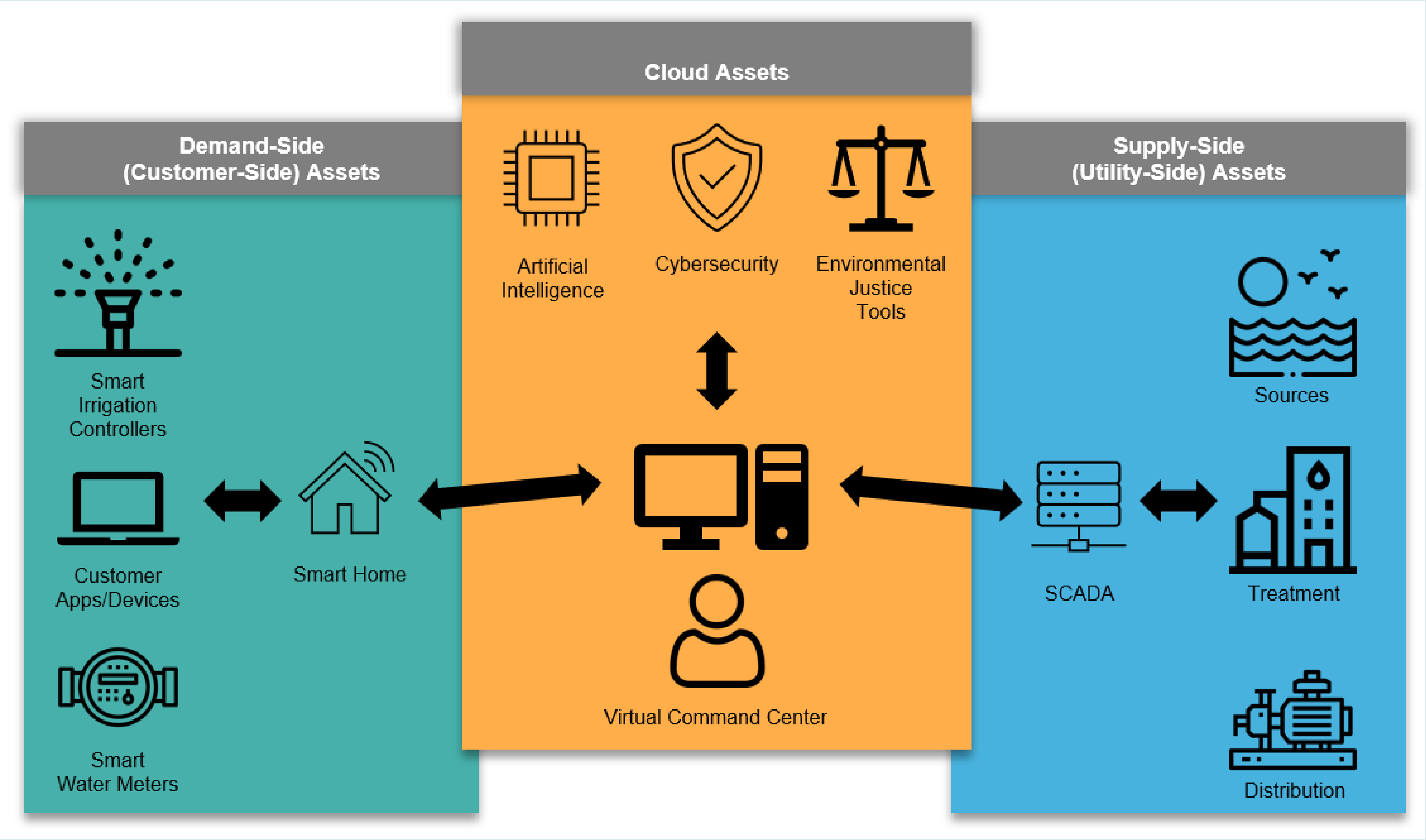
Smart Water Management is NOT Solving our Water Health Crises

≠

Safe, Reliable Drinking Water



Integrated Water Distribution Systems



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DrinkingWater.utah.gov

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Phosphate recovery from wastewater
Receptors for Direct Ocean Capture of CO_2

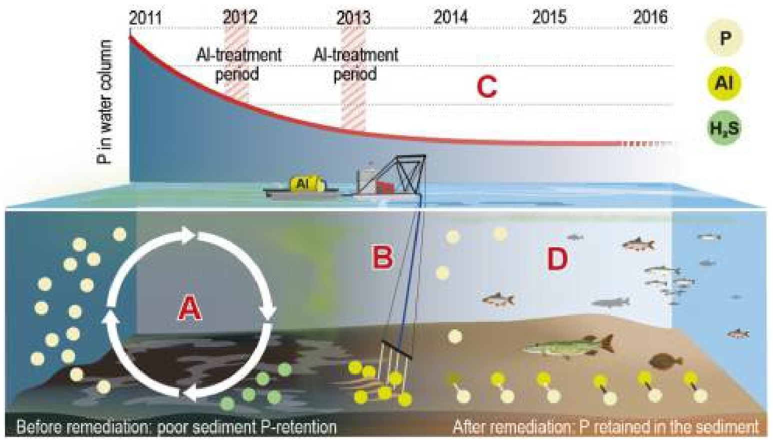
Valérie C. Pierre

Department of Chemistry

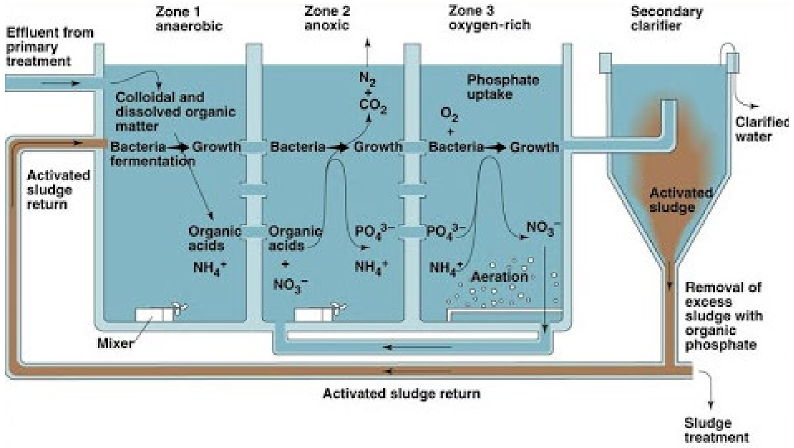
Phosphate removal and water purification

Chemical

- Precipitation with metal salts (Al^{III})



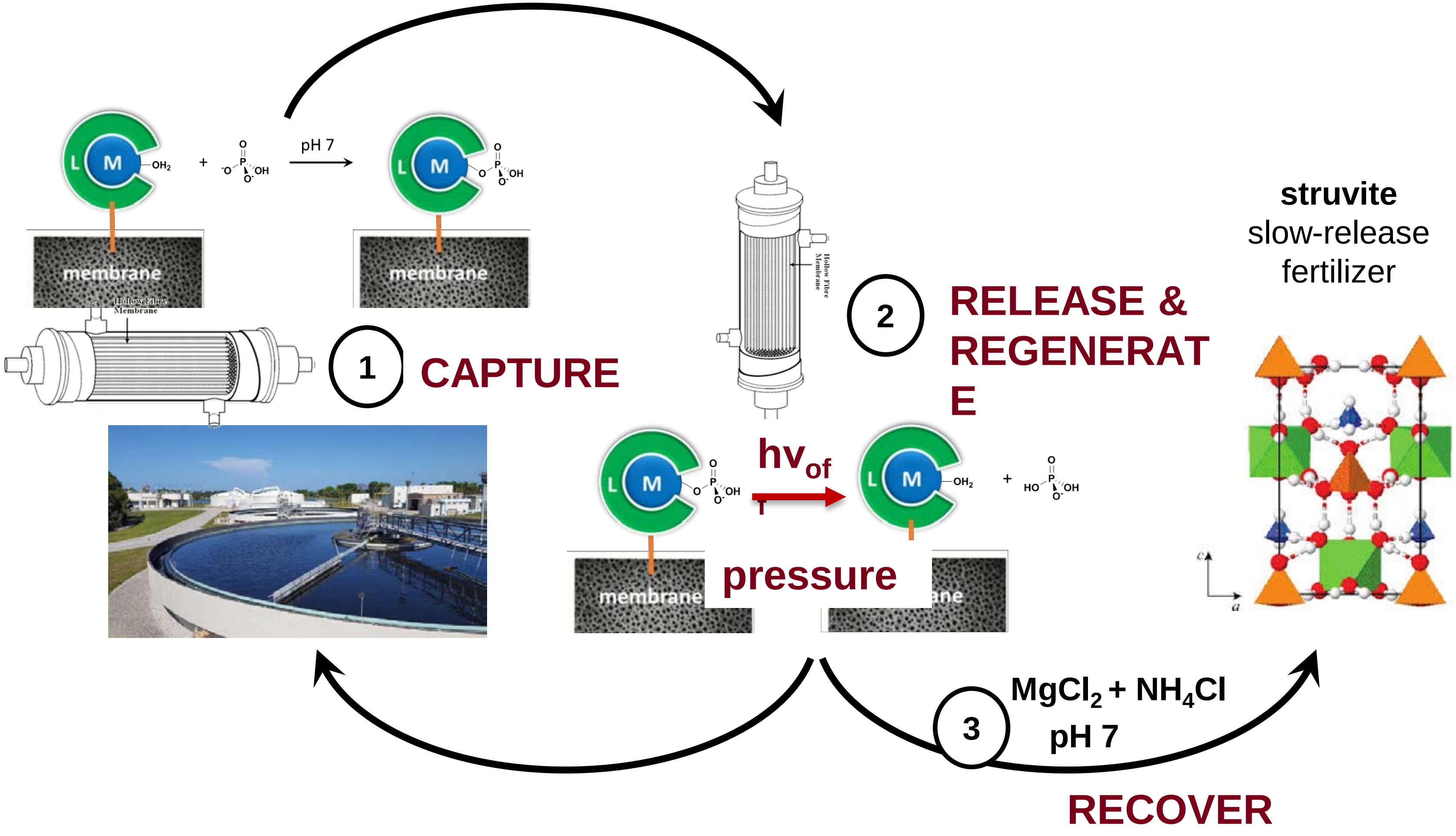
Biological nutrient removal



Drawbacks:

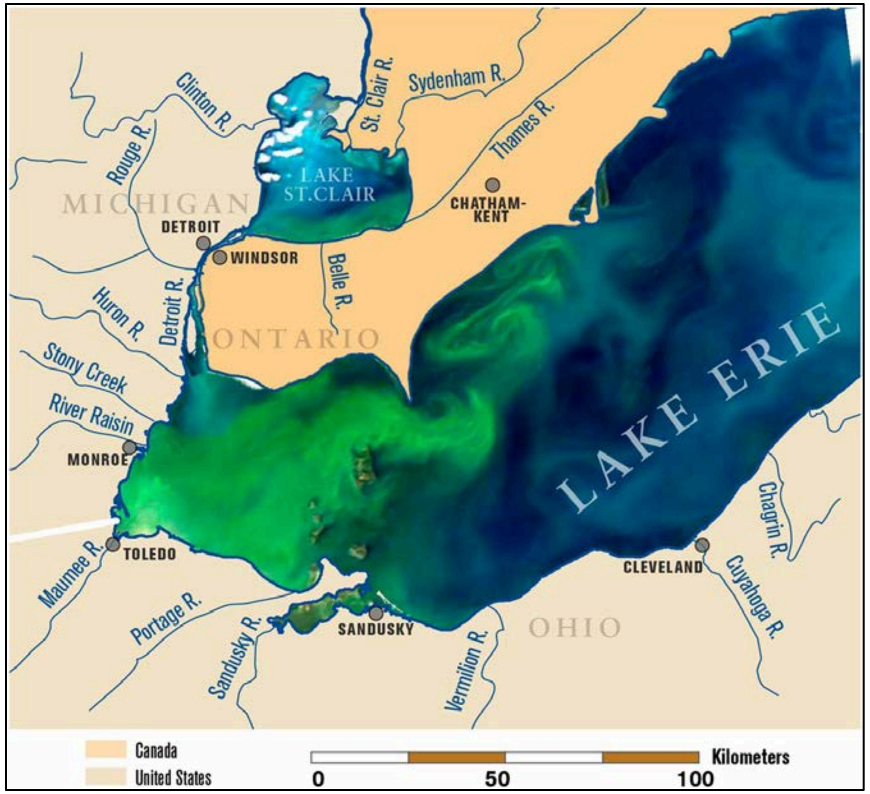
Costs, time, phosphate level remain high, no phosphate recovery

From phosphate removal to recovery

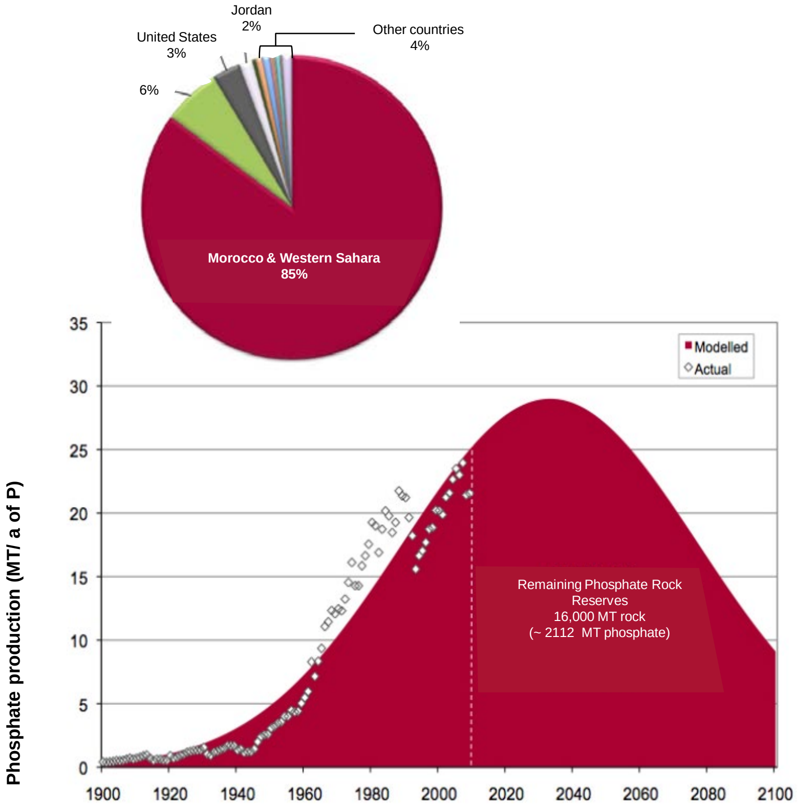


Consequences

Eutrophication



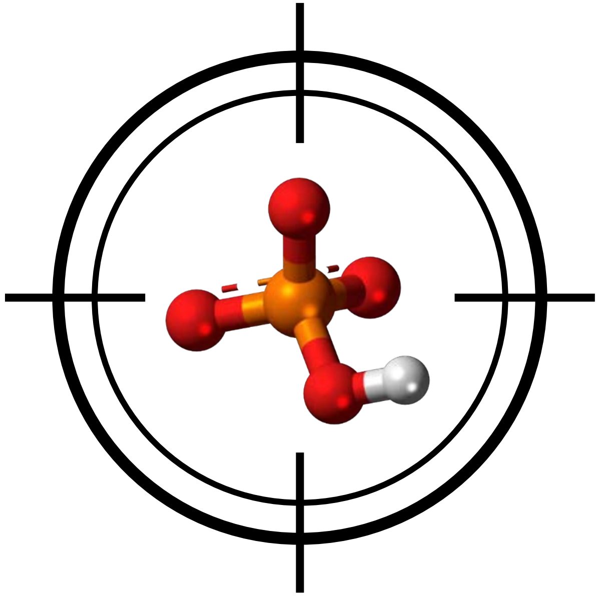
Depleting Resources



Requirements for phosphate receptors

Environmental applications

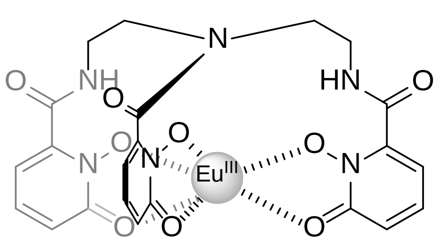
- Efficacy in complex aqueous media
- Affinity for [Pi] < 0.1 µM
  - High affinity receptors
- High selectivity over HCO_3^- and Cl^-
- Coastal water applications: complete selectivity over Cl^- required

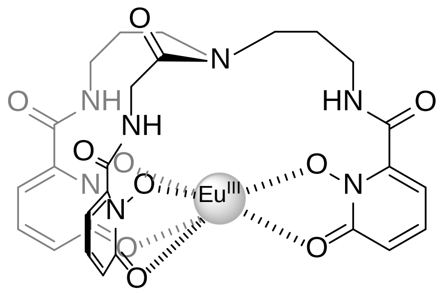


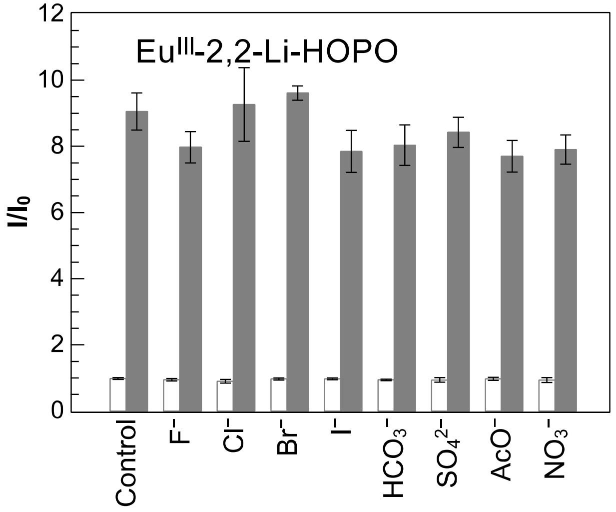
Medical applications

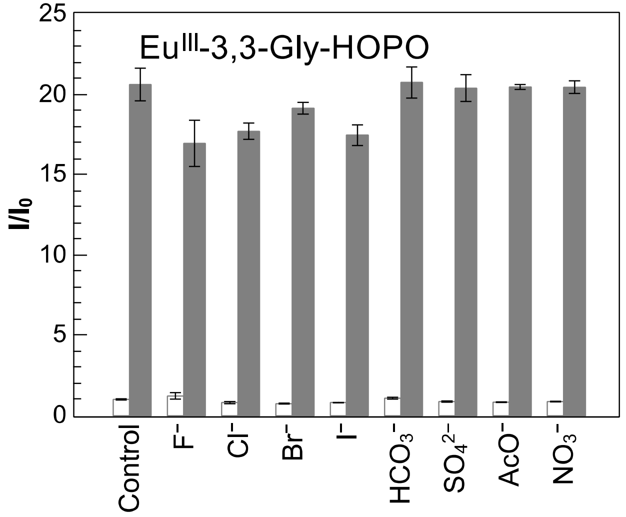
- Efficacy in complex aqueous media
- Affinity for [Pi] <1.4 mM
  - medium affinity receptors
- Complete selectivity over HCO_3^- and Cl^- required
- Selectivity over SO_4^{2-}, lactate, citrate favored

Achieving high selectivity for phosphate





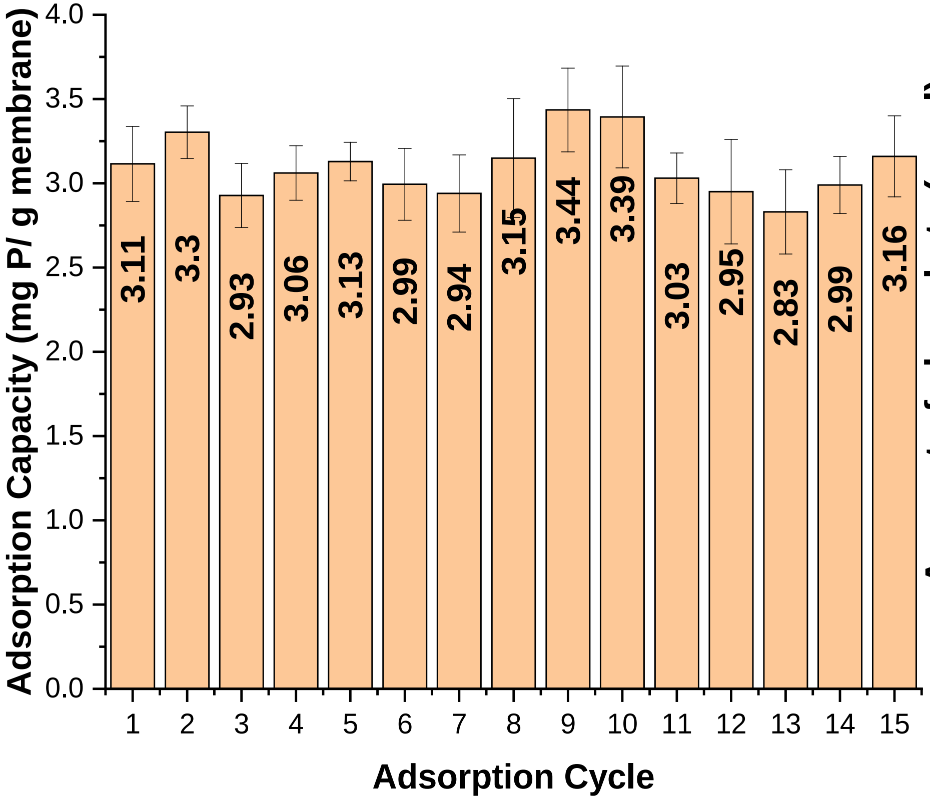


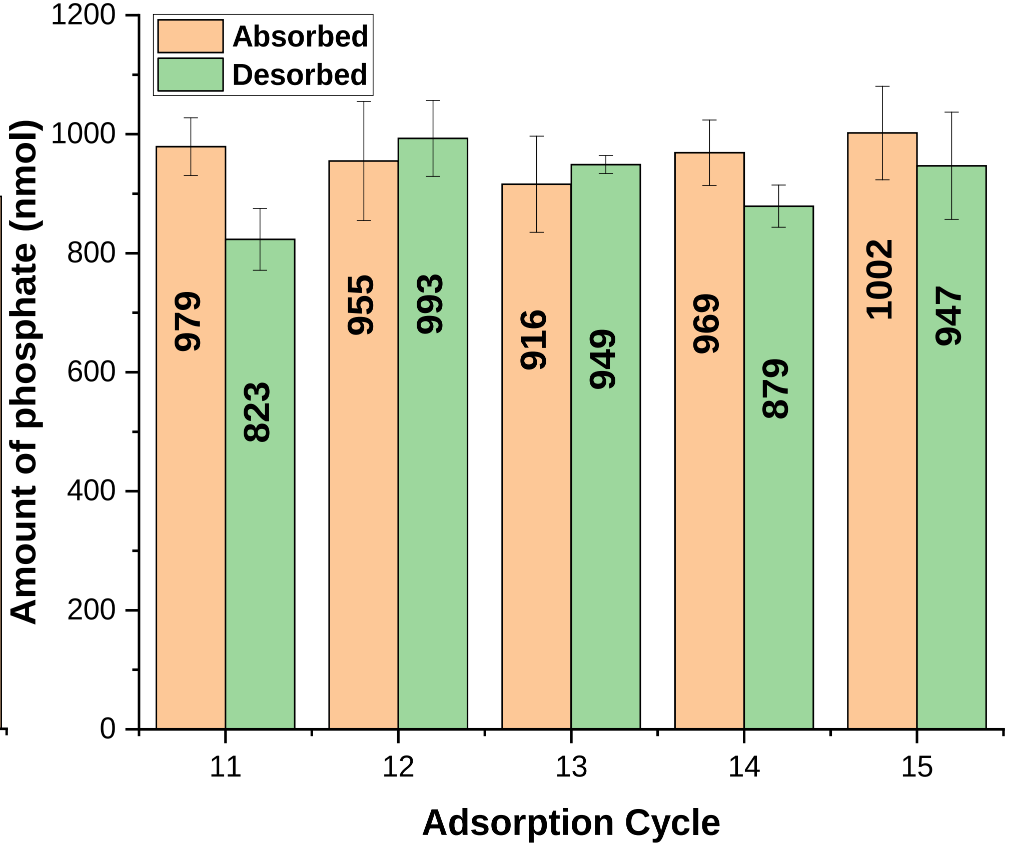


White bar: competing anion
Black bar: competing anion + 10 eq. $HPO_4^{2-}/H_2PO_4^{-}$

 Huang, S.-Y.; Qian, M.; Pierre, V. C. *Inorg. Chem.* **2020,** *59*, 4096-4108.

Material regeneration in 53ppm wastewater activated sludge elution

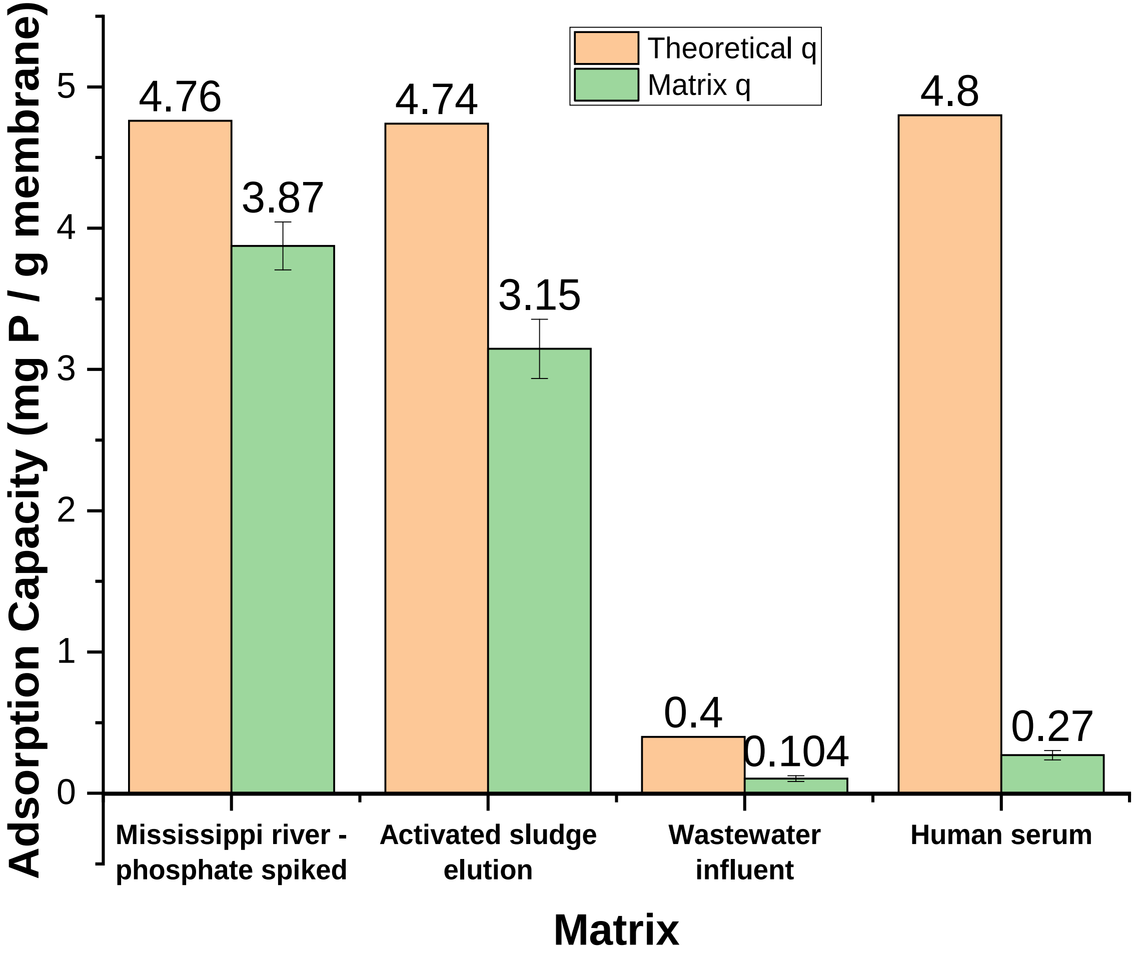




q_{avg}=3.1 mg P / g membrane

Average Recovery Rate: 95%
Average Purity: 90% +

Solid supported receptors: media affect affinity but not selectivity

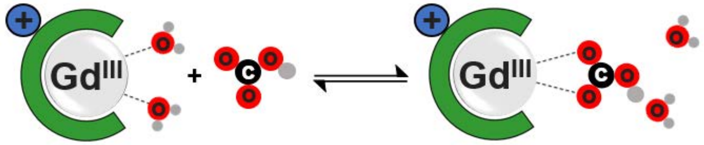


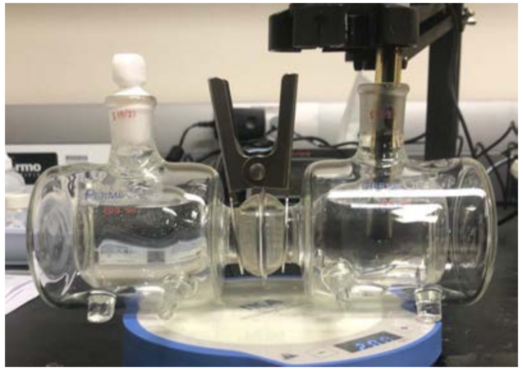
Matrix Name	q_{matrix}/q_{theory} x 100%
Mississippi River	81.3%
Activated Sludge Elution	66.4%
Wastewater Influent	26%
Human Serum	5.6%

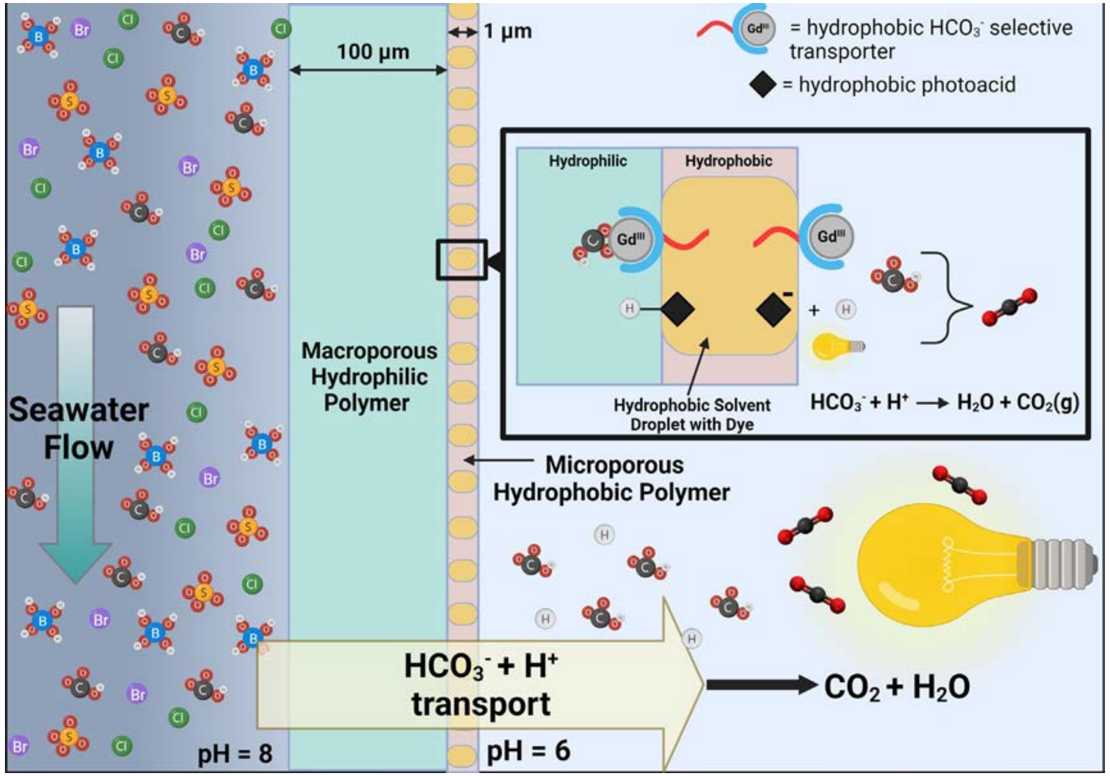
Higher complexity, larger loss of adsorption capacity

Experimental condition: 1cm^2 membrane (10mg) placed in 2ml matrix solution (1ml for serum). n=3. Different adsorption capacity across matrix is due to different phosphate concentration in each sample.

SLM Transport of Bicarbonate





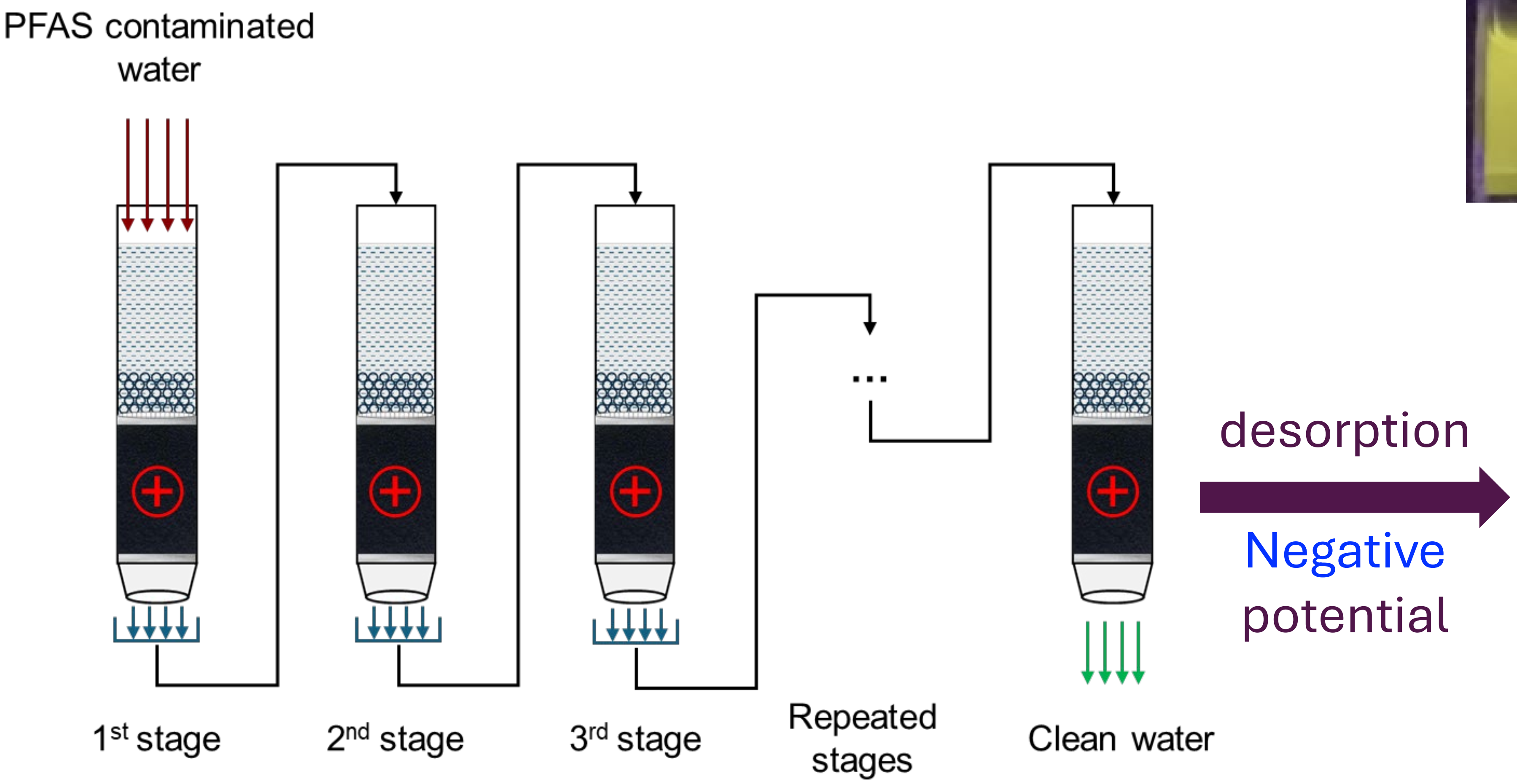


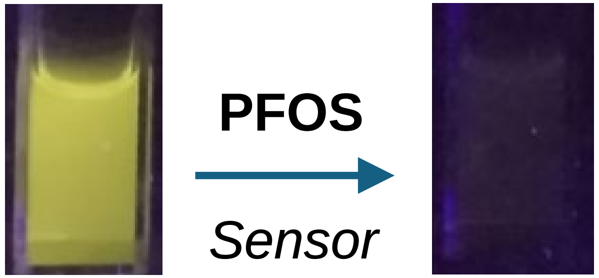
Lightning Talks

Paul Brooks; Court Strong, Ryan Johnson; Steve Burian	The SLCDPU-UU Partnership: Advancing Fundamental Understanding and Societal Application in Water Resources
Joshua Graham	Shoring Up: Art Education on the Edge of the Great Salt Lake
Nathan Lunstad	Integrated Water Distribution Systems
Zinan Yu	Phosphate Recovery from Wastewater
Ling Zang	**PFAS Separation Technology**
Deisy Carvalho Fernandes	Pollution Prevention and PFAS Mitigation: Building a Sustainable Future
Ryan Johnson	Coupling Large-Scale Datasets and Machine Learning to Advance High-Resolution Snow Mapping
Rick Forster	Seasonal Snow and Glacier Measurements using Radar Remote Sensing
Sameer Rao	Atmospheric Water Harvesting and Brine Management
Ramesh Goel	Harmful Algal Blooms
Brig Daniels	Legal Reforms and the Effort to Save Great Salt Lake
Emily Lewis	Water Policy

Full range treatment of PFAS: detection, filtration, destruction

Ling Zang, MSE department





Complete defluorination (mineralization) of PFAS → non-toxic species like F^- ion, small acids

Positive Potential Applied on Each Stage

Patents: U-7522, U-8030, U-8554, U-8556, U-8676, U-8712

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Pollution Prevention and PFAS Mitigation: Building a Sustainable Future

Dr. Deisy C. Carvalho Fernandes

Assistant Professor

PEAK Water Kick-Off Event

01/22/2025

Department of
CHEMICAL ENGINEERING
THE UNIVERSITY OF UTAH

Department of
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THE UNIVERSITY OF UTAH

The Urgent Need for Action

- Utah: A rapidly growing state facing severe environmental challenges.
- **Water Scarcity:**
  - 97% of the state in severe drought.
  - The Great Salt Lake at historic lows, risking ecological collapse.
- Air and water pollution threaten health and ecosystems.

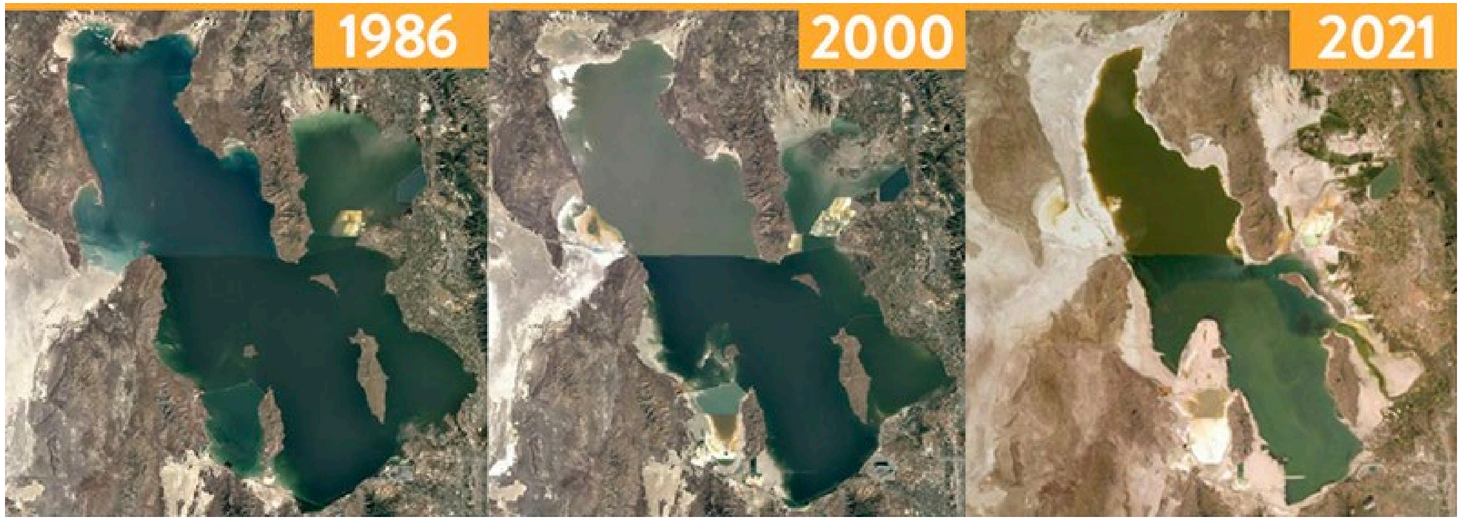

Figure 2: The Great Salt Lake aerial imagery showing the devastating impact from the prolonged drought in the west, coupled with a surging population in Utah.

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Pollution Prevention through Industrial Assessments

The U2P3 Program Overview

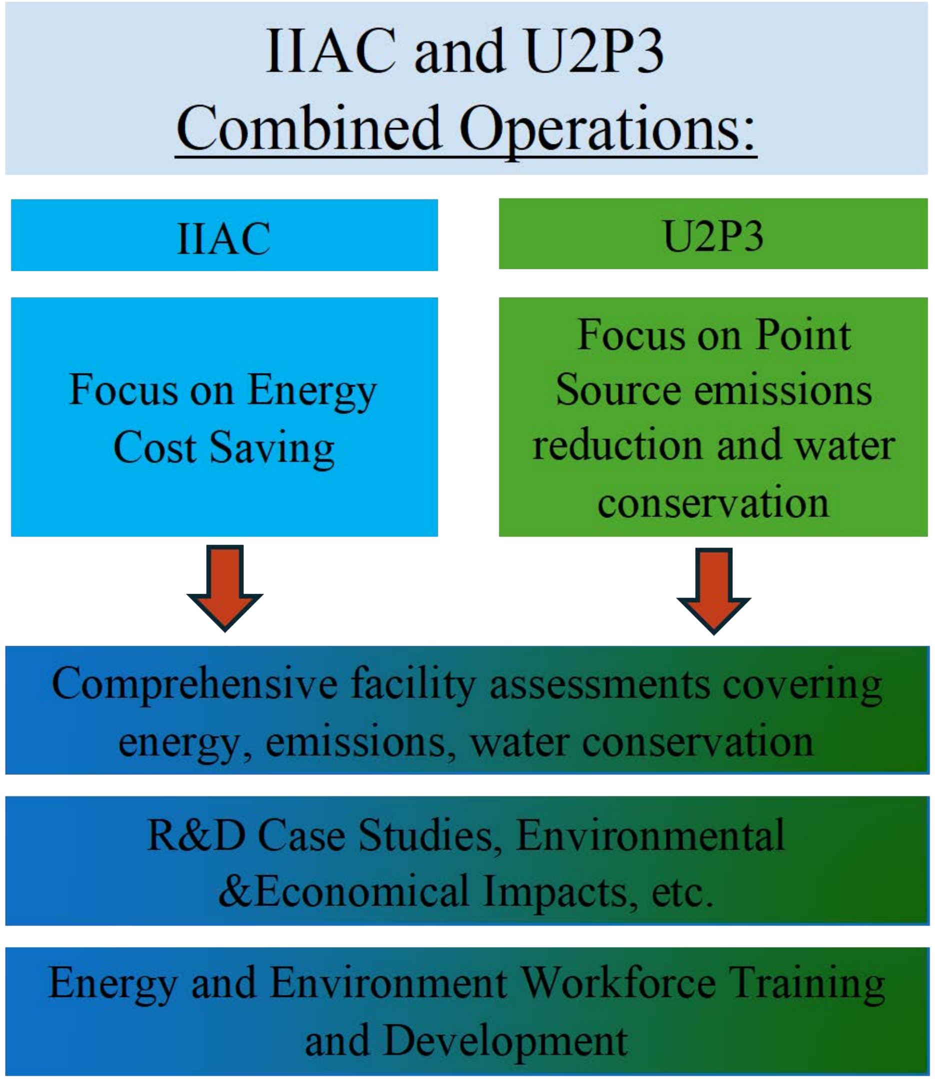
Mission: Reduce water pollution, hazardous chemical use, and industry emissions.

Key Sectors:

- Food and Beverage
- Chemical Manufacturing
- Automotive and Aerospace
- Metal Fabrication

Collaborators:

- Intermountain Industrial Assessment Center (IIAC)
- Utah Division of Environmental Quality



Measuring Impact

Metrics:

- Water saved per facility assessed.
- Reduction in hazardous chemicals and materials released to water.
- Dollar savings for businesses implementing recommendations.

Examples of Expected Results:

10 facilities assessed, leading to measurable reductions in water and emissions over two years.

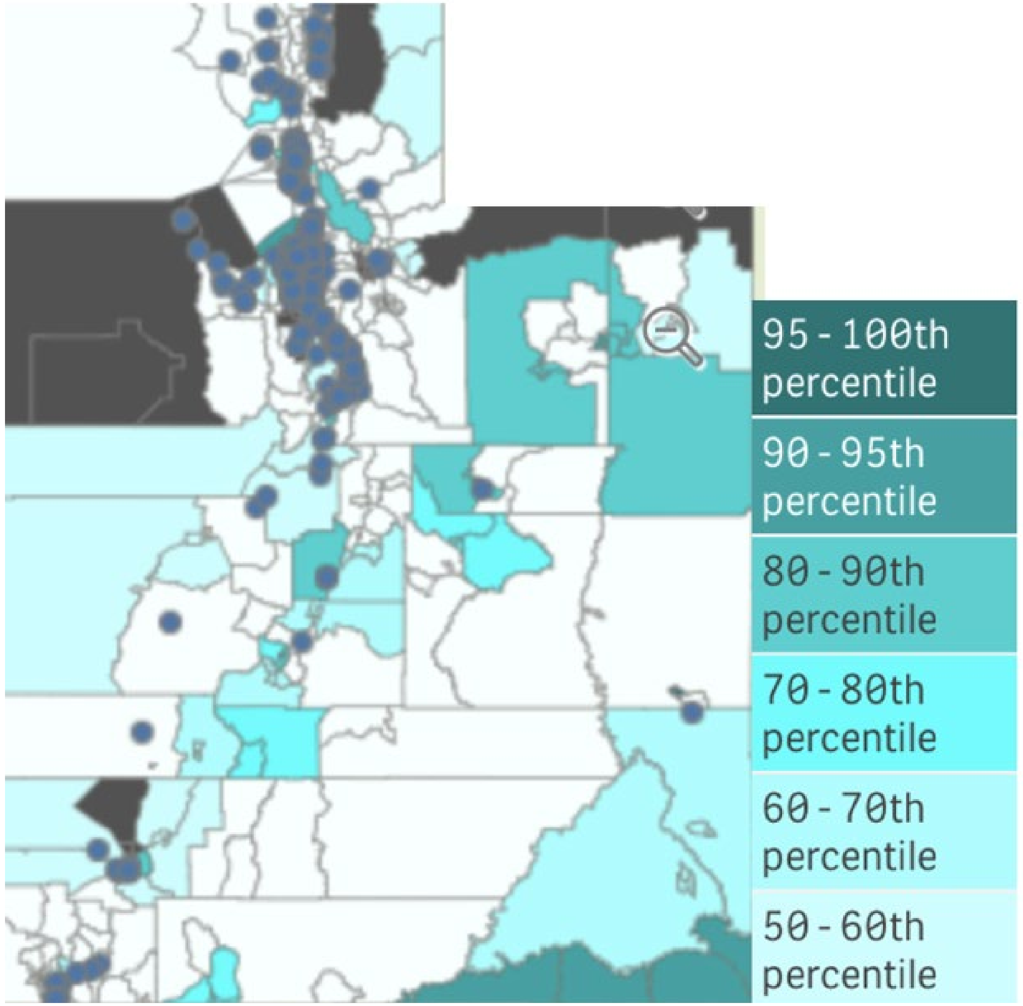


Figure 3. EPA's Pollution Prevention (P2) Environmental Justice (EJ) Facility Mapping Tool for Utah, highlighting regions with low life expectancy. Dots indicate facilities listed in EPA's P2 EJ tool. Each of these facilities have P2 contact

Experimental Research

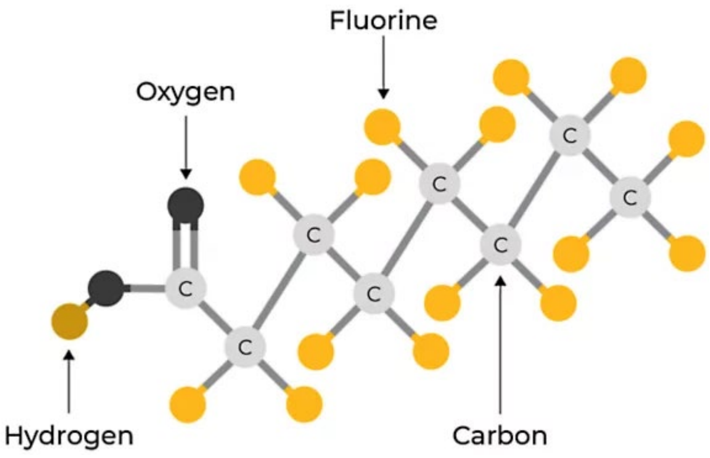
PFAS Mitigation Innovations by 3D printing integrated system combining adsorption and sensing.

PFAS and Graphene

- PFAS ("forever chemicals") persist in the environment and bioaccumulate.
- Linked to health issues: cancer, immune disruption, and developmental impacts.
- EPA monitoring shows over 27 million people exposed to PFAS above safe limits.

Regional Focus:

- Great Salt Lake: A terminal lake accumulating pollutants, including PFAS.
- Impact: 80% of Utah’s population potentially affected.



Graphene

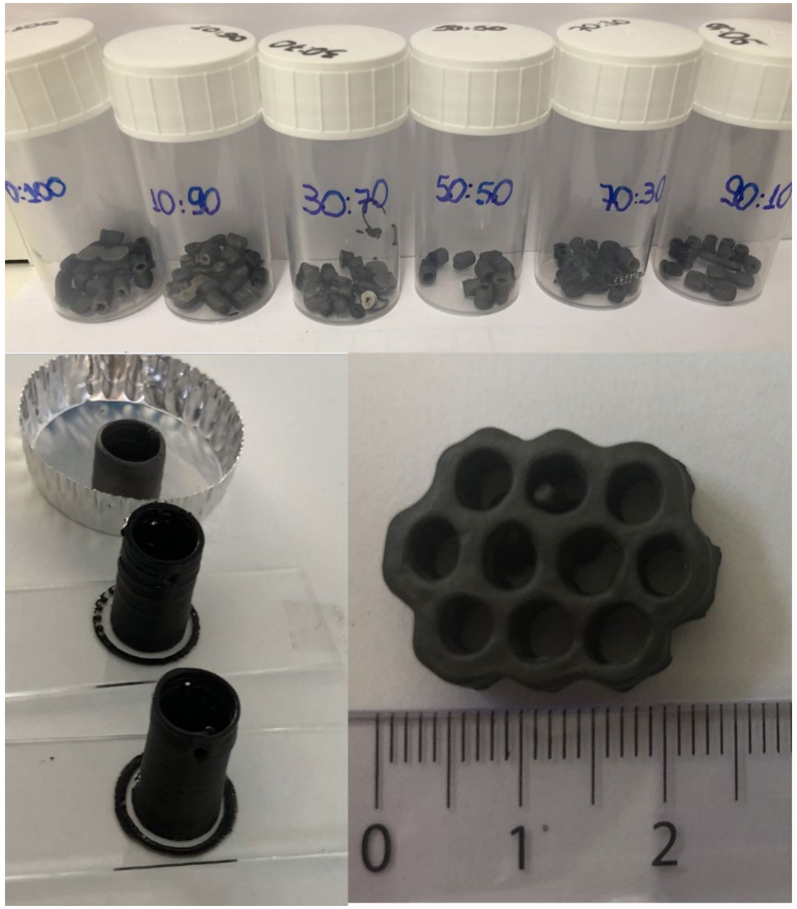
Ritter, K. A. & Lyding, J. W. *Nat Mater* **8**, 235-242, doi:http://www.nature.com/nmat/journal/v8/n3/suppinfo/nmat2378_S1.html (2009)

3D printing

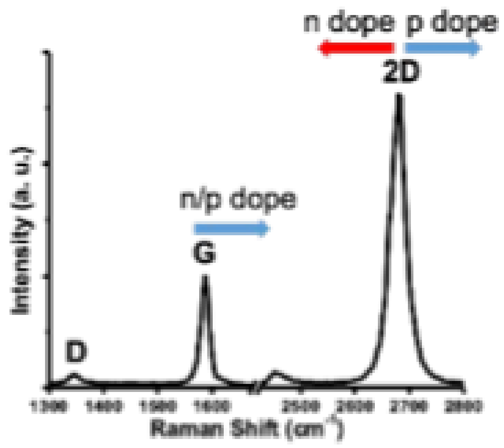
3D-Printed Graphene Oxide Gels:

- High adsorption capacity.
- Scalable and environmentally adaptive.

- **Highly porous 3D-printed structures**



Outcomes and Implications



3D-Printed Graphene Oxide Gels:

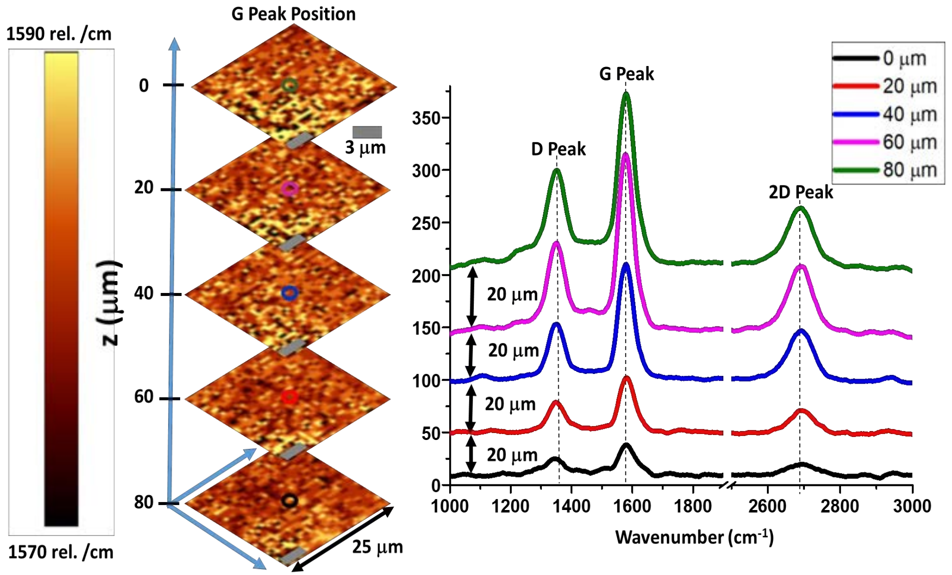
- High adsorption capacity.
- Scalable and environmentally adaptive.

Key Outcomes:

- Rapid, portable, and scalable PFAS detection.
- Dual-function materials for monitoring and remediation.
- Broad applicability for diverse water systems.

Future Directions:

Expanding applications with other 2D nanomaterials and other contaminants like heavy metals.



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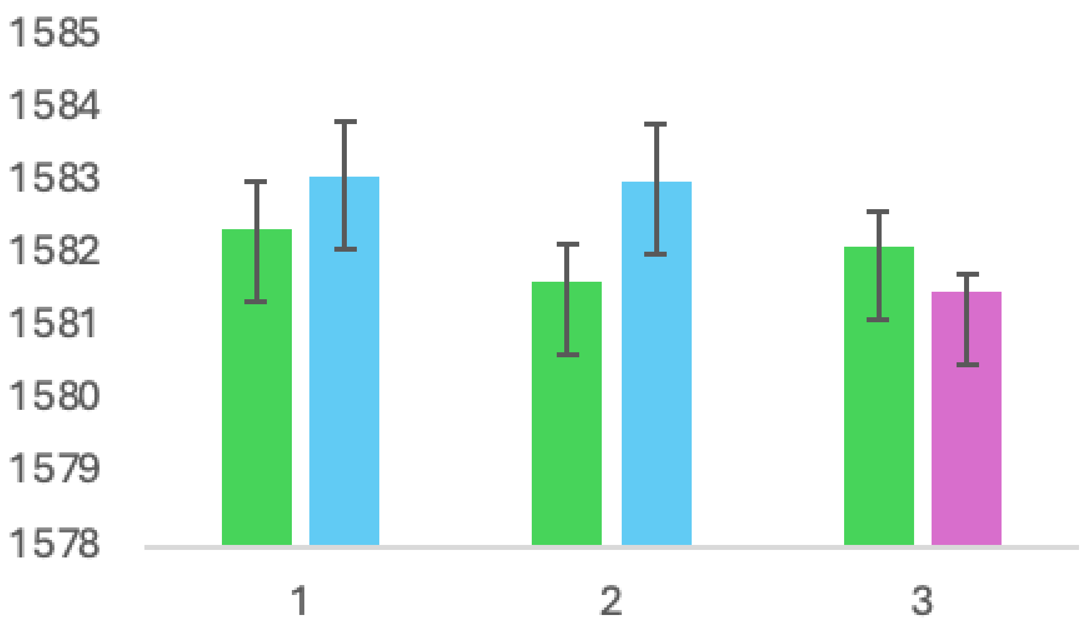
Challenges of PFAS Detection and Remediation

- **Key Challenges**:
  - Resistance to degradation due to strong carbon-fluorine bonds.
  - Limitations of current methods: Expensive, time-consuming, and low sensitivity.
  - Complexity of environmental matrices (e.g., sediment and wastewater).
- **Visual**: Diagram comparing traditional and innovative detection/remediation approaches.



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Conclusion

Synergies:

Combining advanced materials for PFAS mitigation with holistic pollution prevention strategies amplifies environmental benefits.

Commitment:

Leveraging research and partnerships to build sustainable water management systems.

Questions

Thank you for your attention!

Acknowledgment

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Combining Large-Domain meteorological datasets and remote sensing products in a Machine Learning framework to create high spatial resolution, SWE maps: SWEMLv2.0

Ryan Johnson PhD
Dane Liljestrand
Vishnu Gindi
Hudson Markin
Savalan Neisary
Md Shahabul Alam PhD

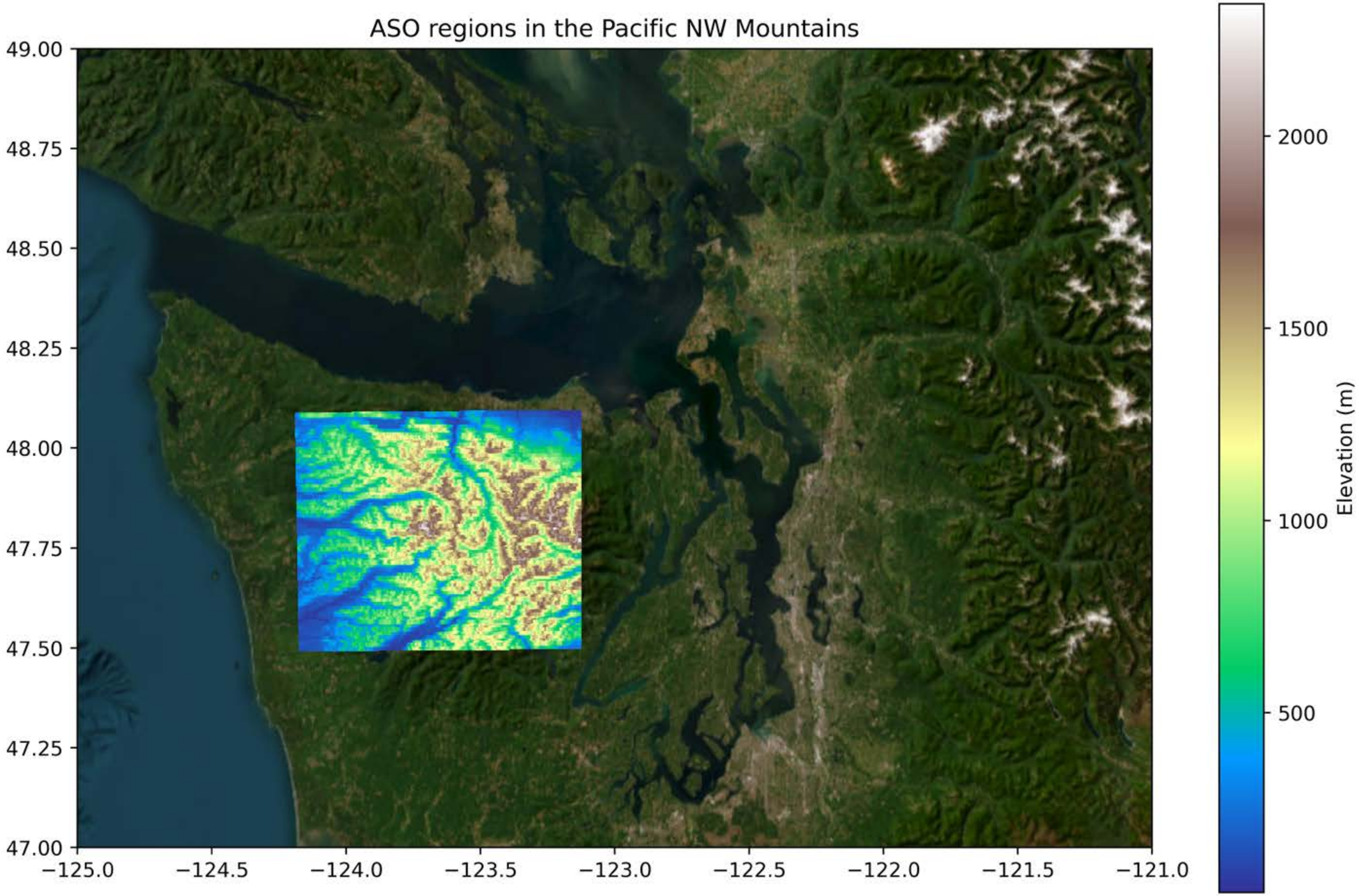
Modeling Domain: Sierra Nevada, Colorado Rockies, Pacific Northwest

ASO SWE product used as ML model target

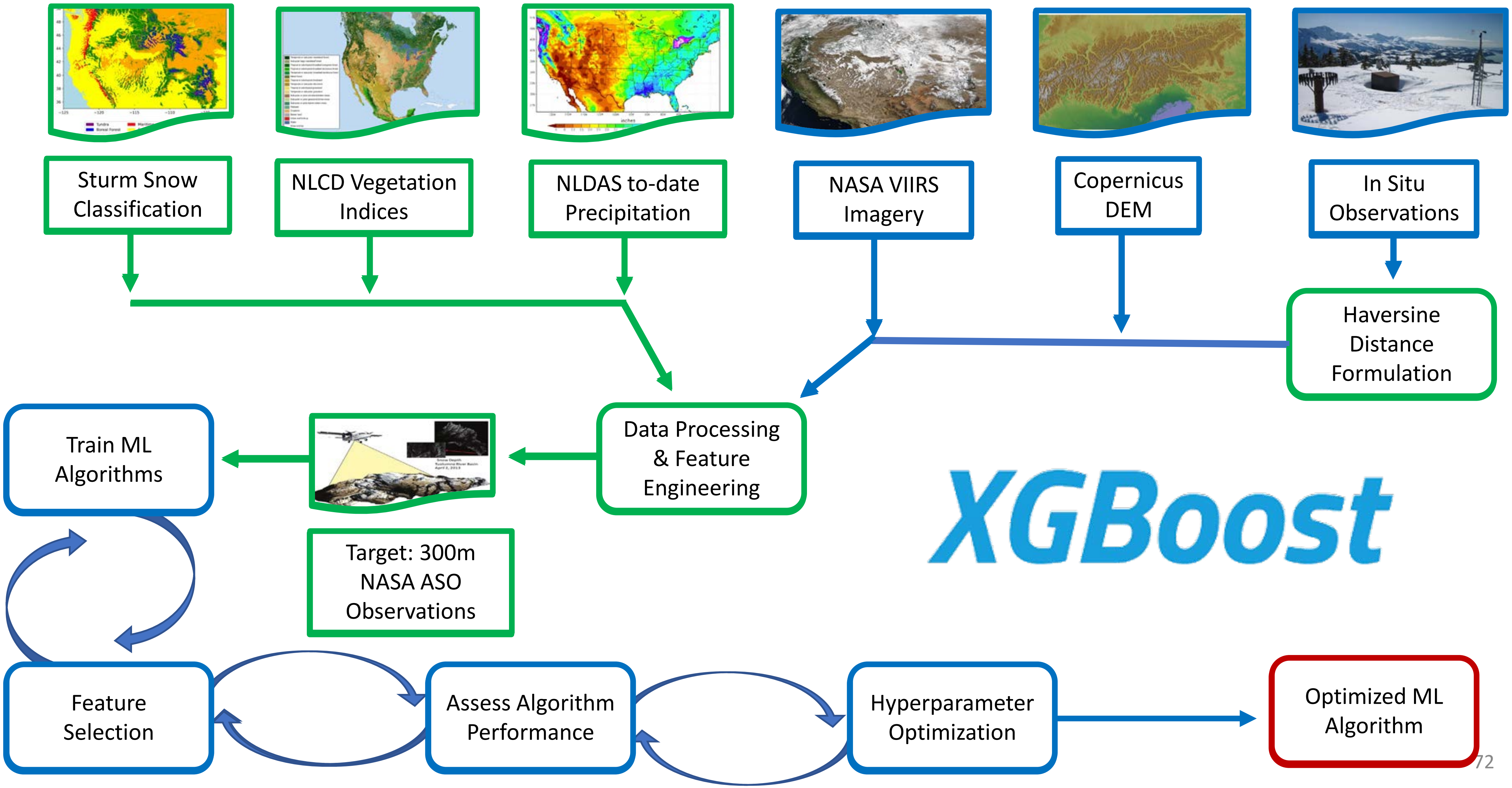
Sierra Nevada:
- Tuolumne
- Merced
- San Joaquin
- Kings

Colorado Rockies
- East
- Taylor
- Upper Rio Grande
- Conejos
- Blue

Pacific Northwest
- Olympic Peninsula



ML Snow Modeling Approach

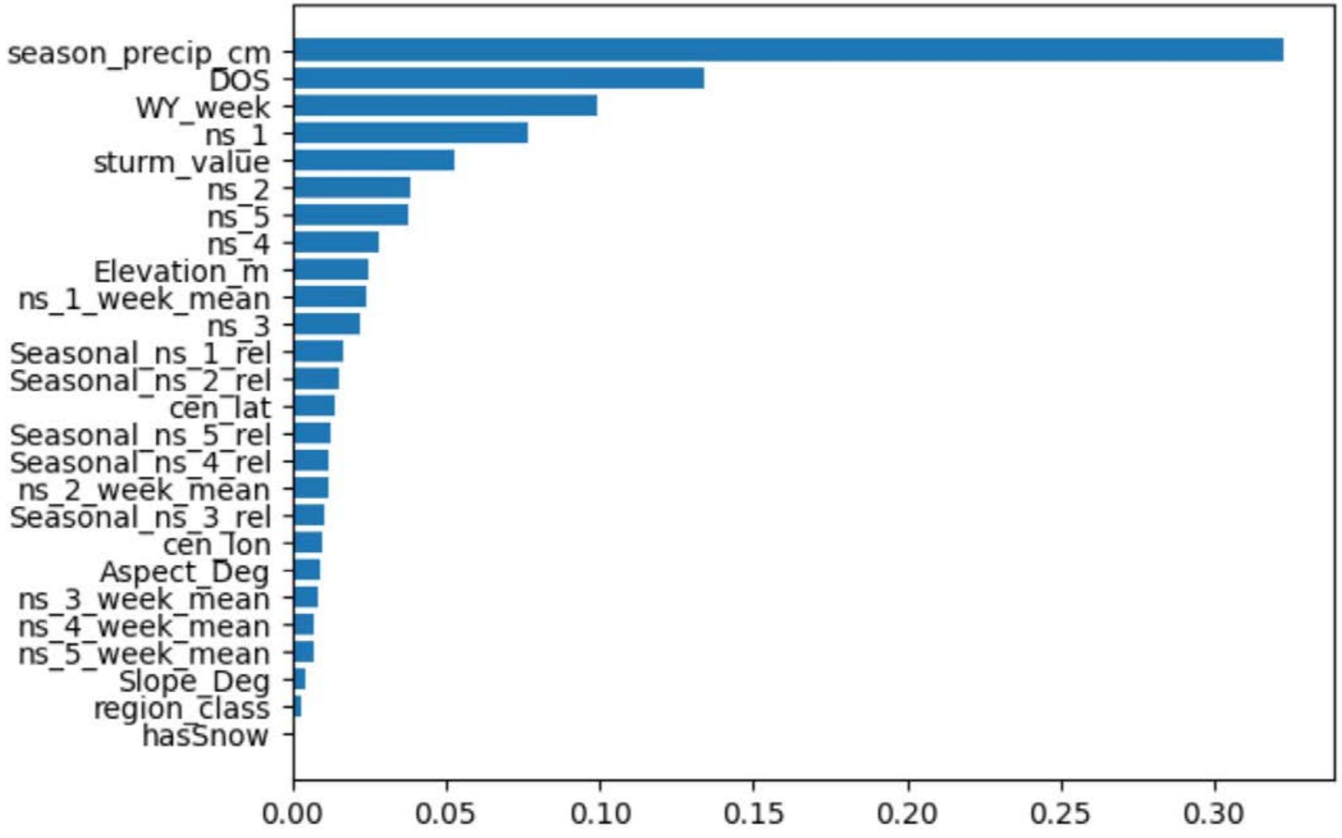


SWEMLv2.0 Training Protocol

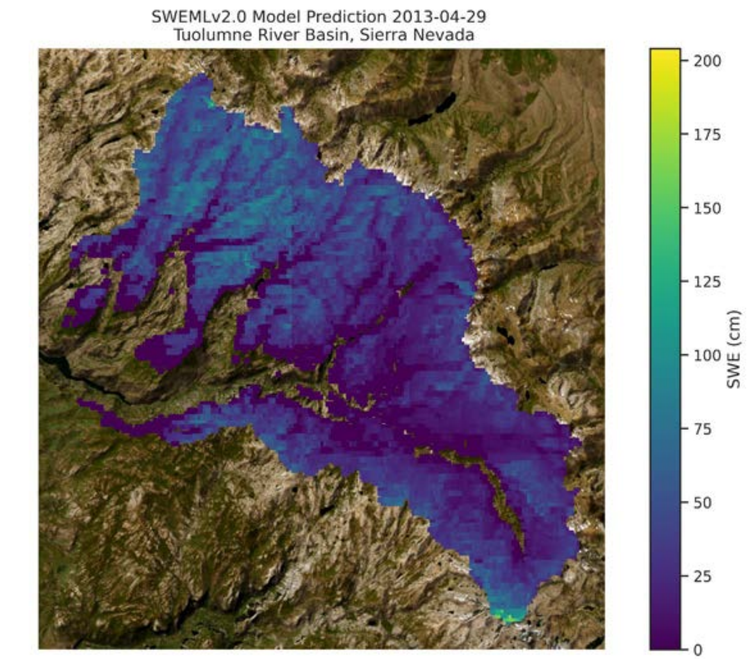
- Target: ASO SWE product 2013-2019
- Removed bad ASO scenes
- 97 scenes from the Sierra Nevada
- 11 scenes from the Colorado Rockies
- 2 scenes from the Olympic region
- Removed SWE values < 1 cm
- 300 m spatial resolution

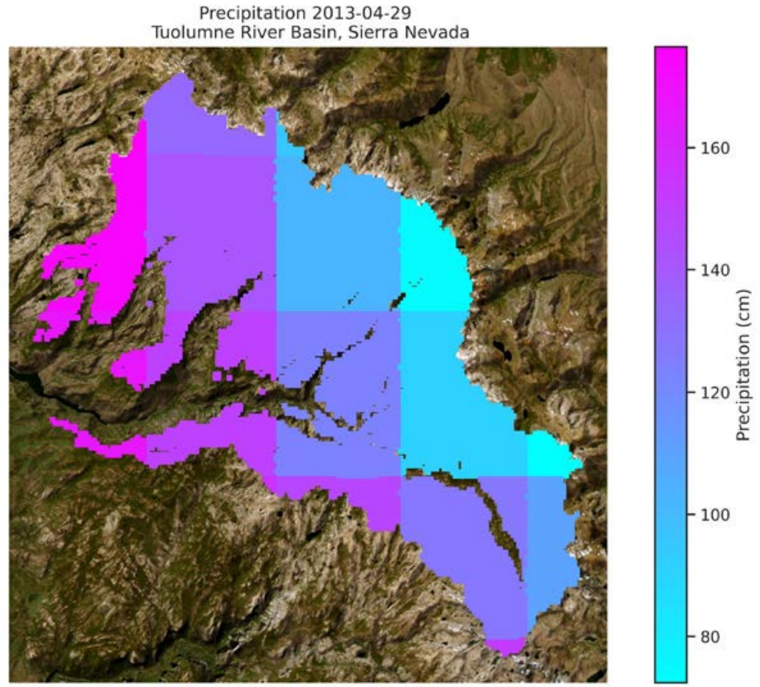
> 800,000 data points to train ML model

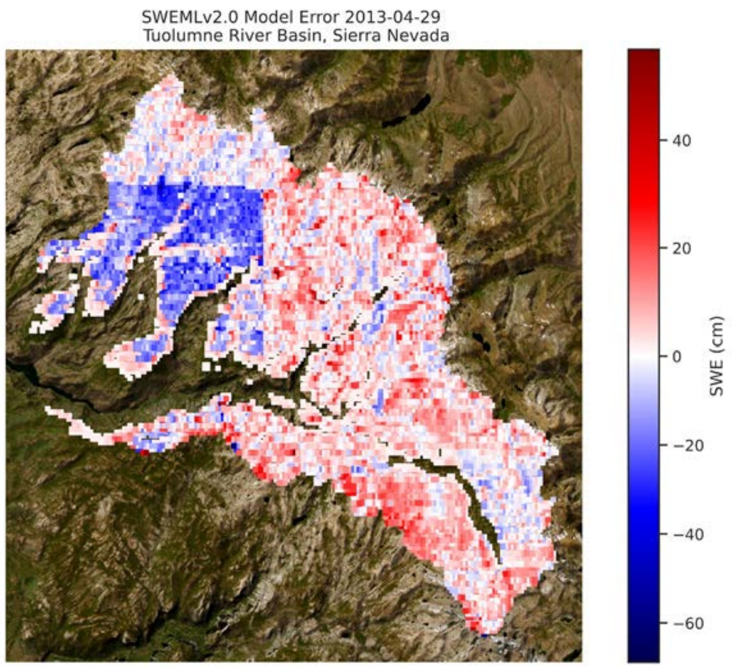
- Hold-one-out model evaluation
- Train on 67/33% of remaining data

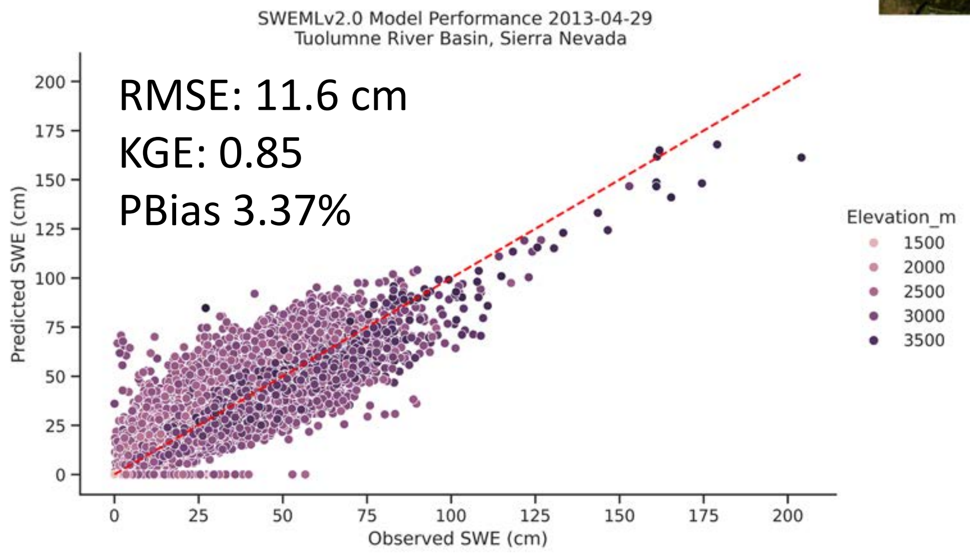


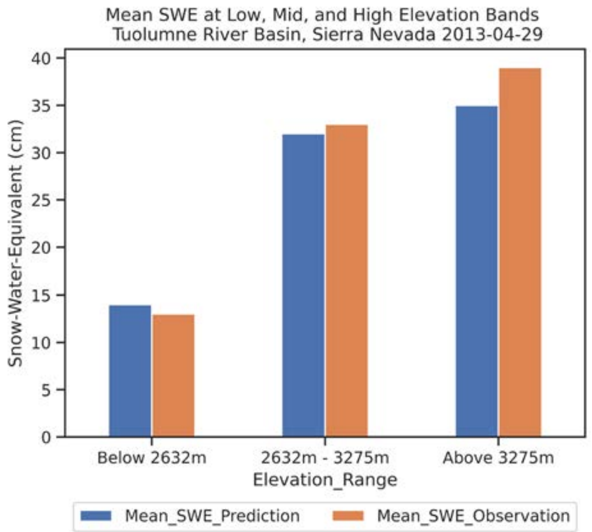
SWEMLv2.0 Evaluation: Tuolumne River Basin, Sierra Nevada

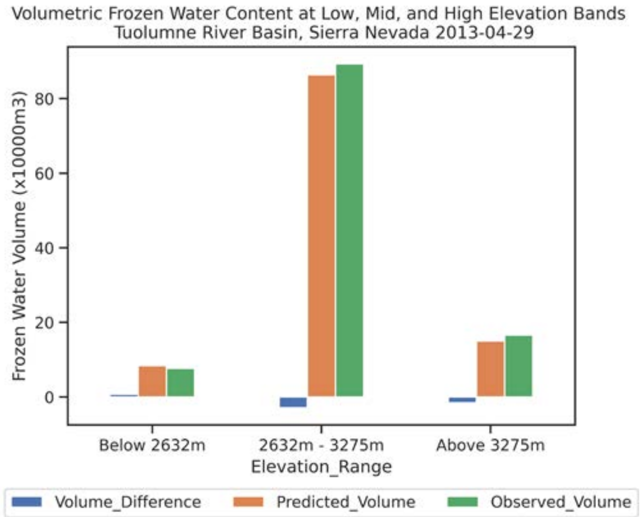




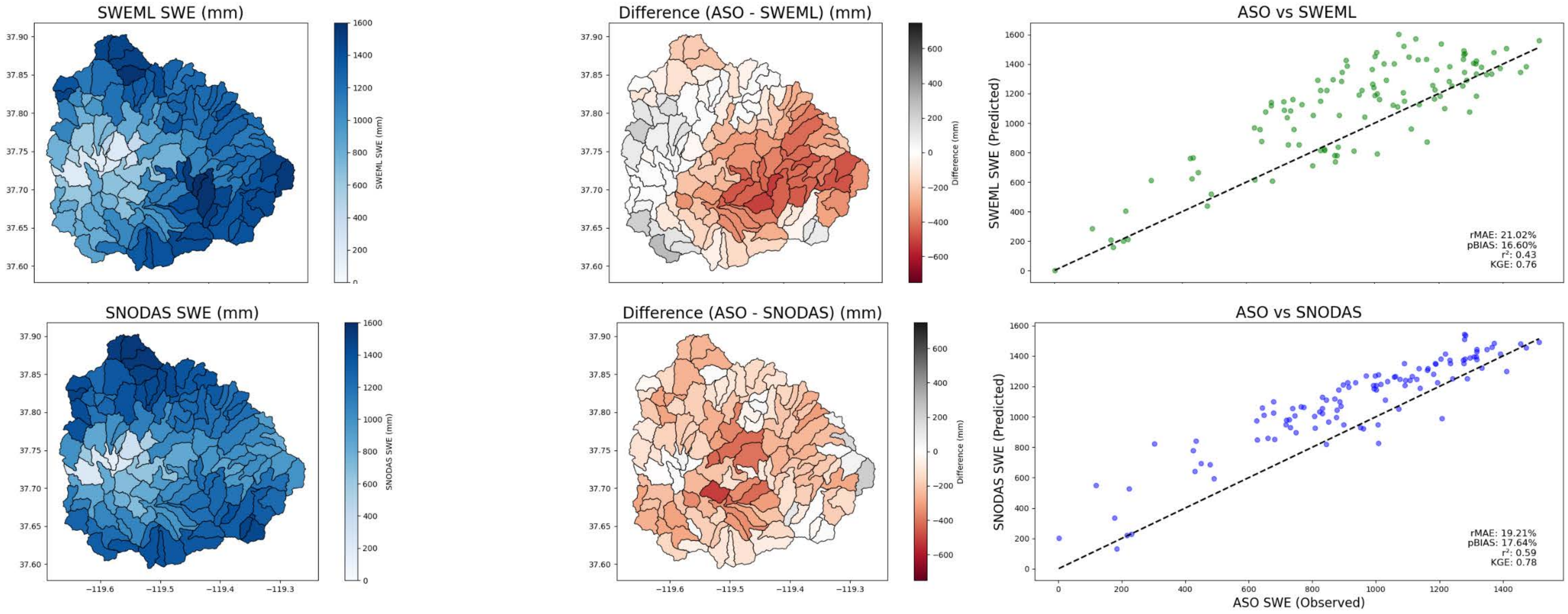








SWEMLv2.0: Comparison to SNODAS using NWM Hydrofabric



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Seasonal Snow and Glacier Measurements using Radar Remote Sensing

Rick Forster, Smriti Srivastava, Avina Khatri, and Jewell Lund

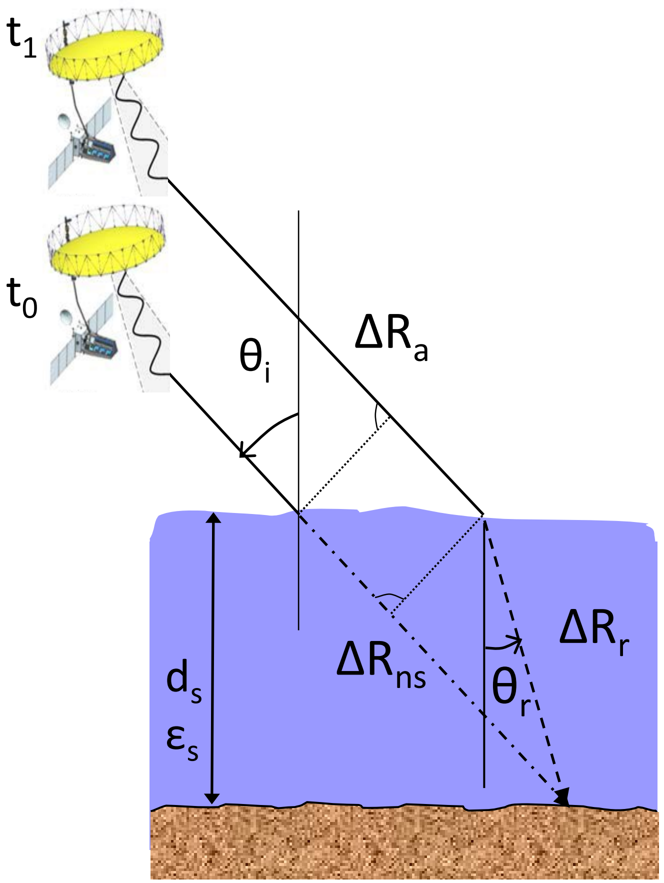
THE UNIVERSITY OF UTAH

School of Environment, Society & Sustainability
(formerly Department of Geography)

NASA

NISAR
NASA - ISRO SAR Mission

Measuring SWE from space at 25 m: An experimental approach



Interferometric Synthetic Aperture Radar (InSAR) measurement of snow depth/SWE change

(modified from Guneriussen et al., 2001)

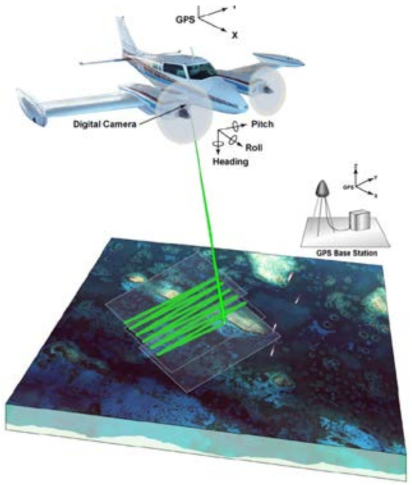
Radar and supporting Measurement Techniques used in Little Cottonwood Canyon

CarSAR (CRREL) L-band SAR

Ku-band SAR(CU Boulder)

Terrestrial Lidar Scanner (CRREL)

GPR (UNM) L-band

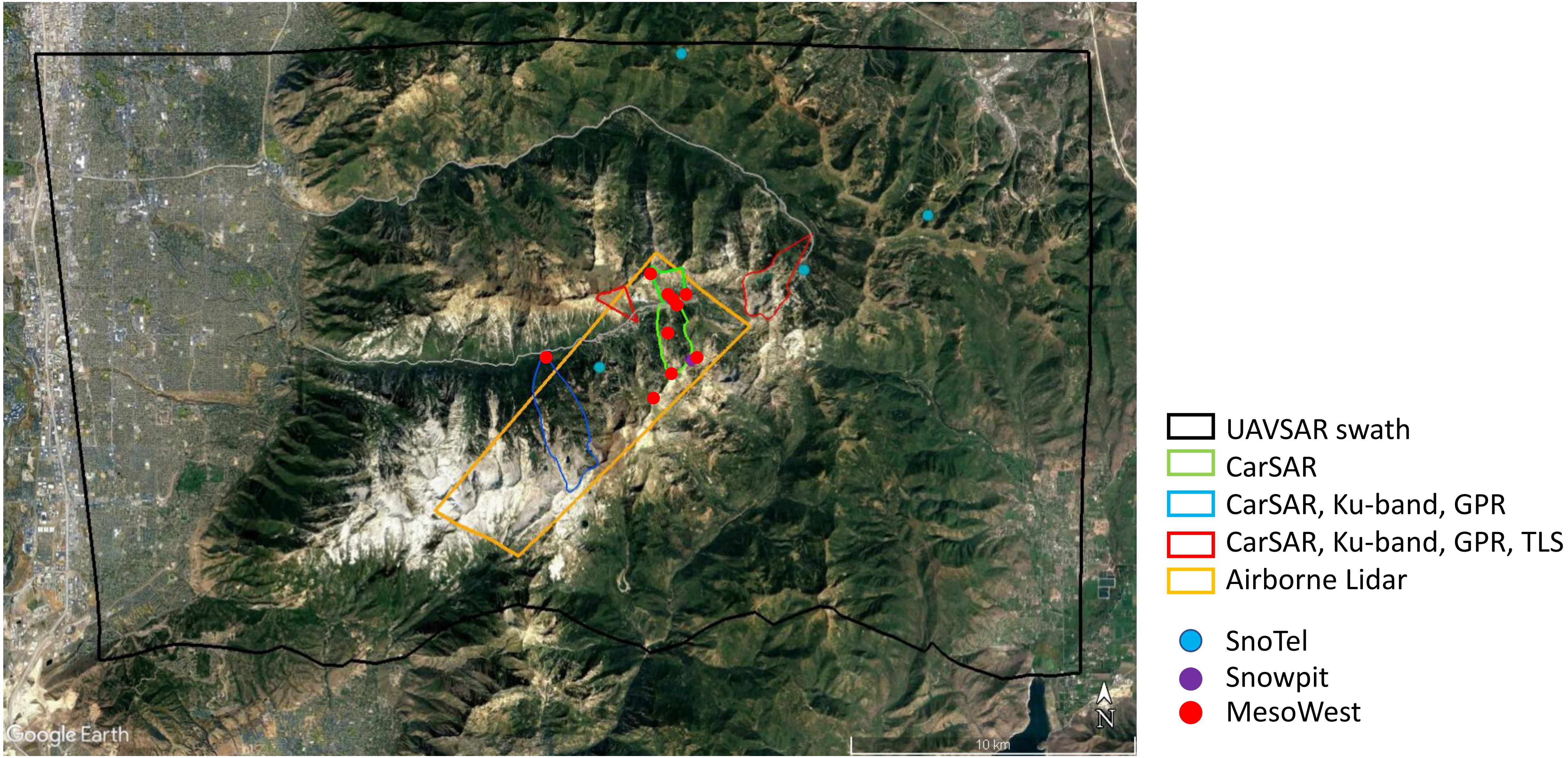


Airborne Lidar

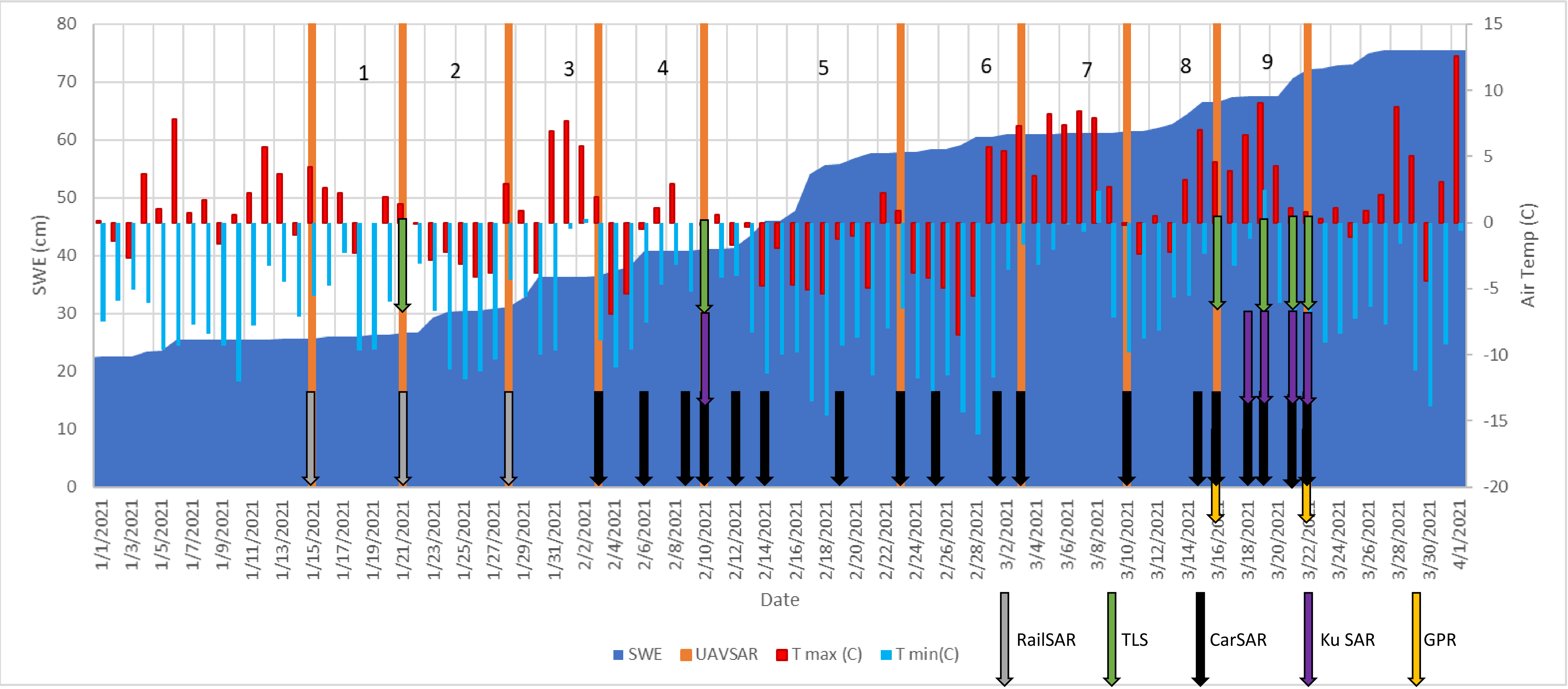
UAVSAR (NASA/JPL)
L-band SAR

Ground truth:
Snowpits
SnoTel
MesoWest

Little and Big Cottonwood Canyons



UAVSAR, ground-based radar and lidar



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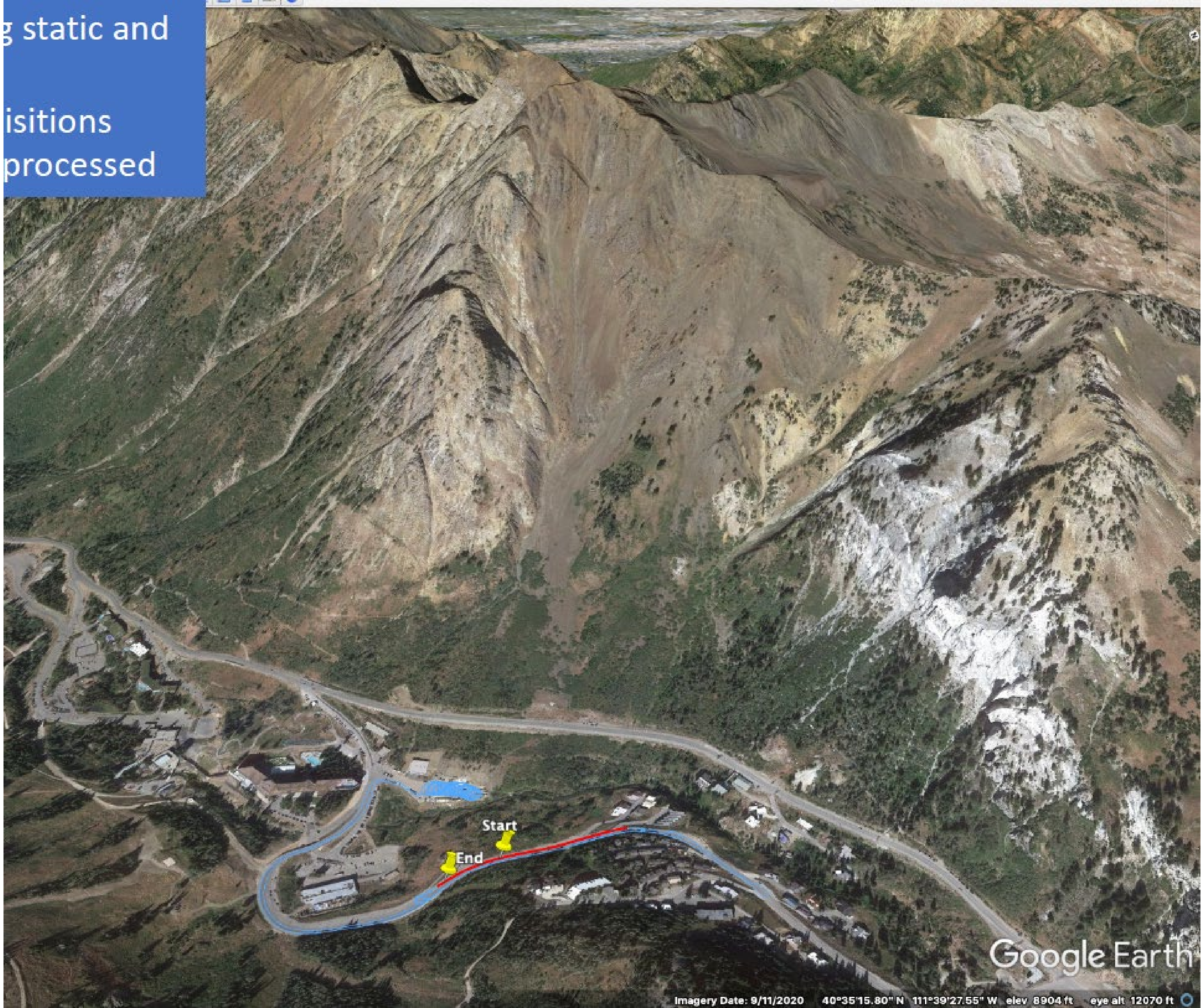

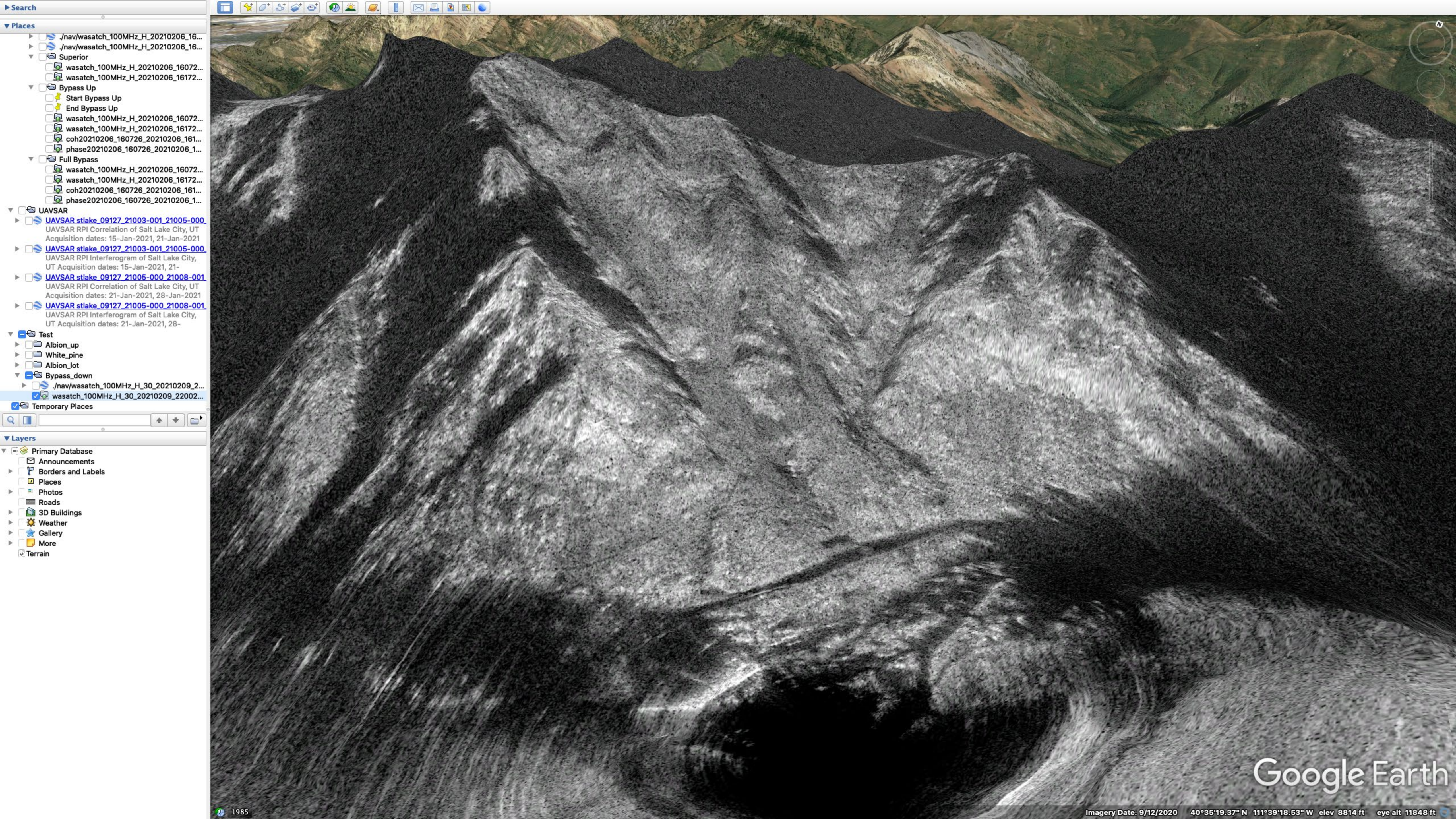
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wasatch_100MHz_H_20210206_16172...
Bypass Up
Start Bypass Up
End Bypass Up
wasatch_100MHz_H_20210206_16072...
wasatch_100MHz_H_20210206_16172...
coh20210206_160726_20210206_161...
phase20210206_160726_20210206_1...
Full Bypass
wasatch_100MHz_H_20210206_16072...
wasatch_100MHz_H_20210206_16172...
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phase20210206_160726_20210206_1...
UAVSAR
UAVSAR stlake_09127_21003-001_21005-000_
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UAVSAR stlake_09127_21003-001_21005-000_
UAVSAR RPI Interferogram of Salt Lake City, UT Acquisition dates: 15-Jan-2021, 21-
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UAVSAR RPI Correlation of Salt Lake City, UT Acquisition dates: 21-Jan-2021, 28-Jan-2021
UAVSAR stlake_09127_21005-000_21008-001_
UAVSAR RPI Interferogram of Salt Lake City, UT Acquisition dates: 21-Jan-2021, 28-
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White_pine
Albion_lot
Bypass_down
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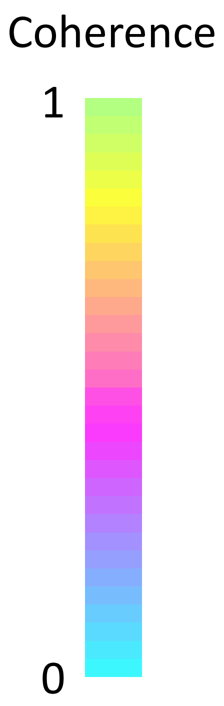
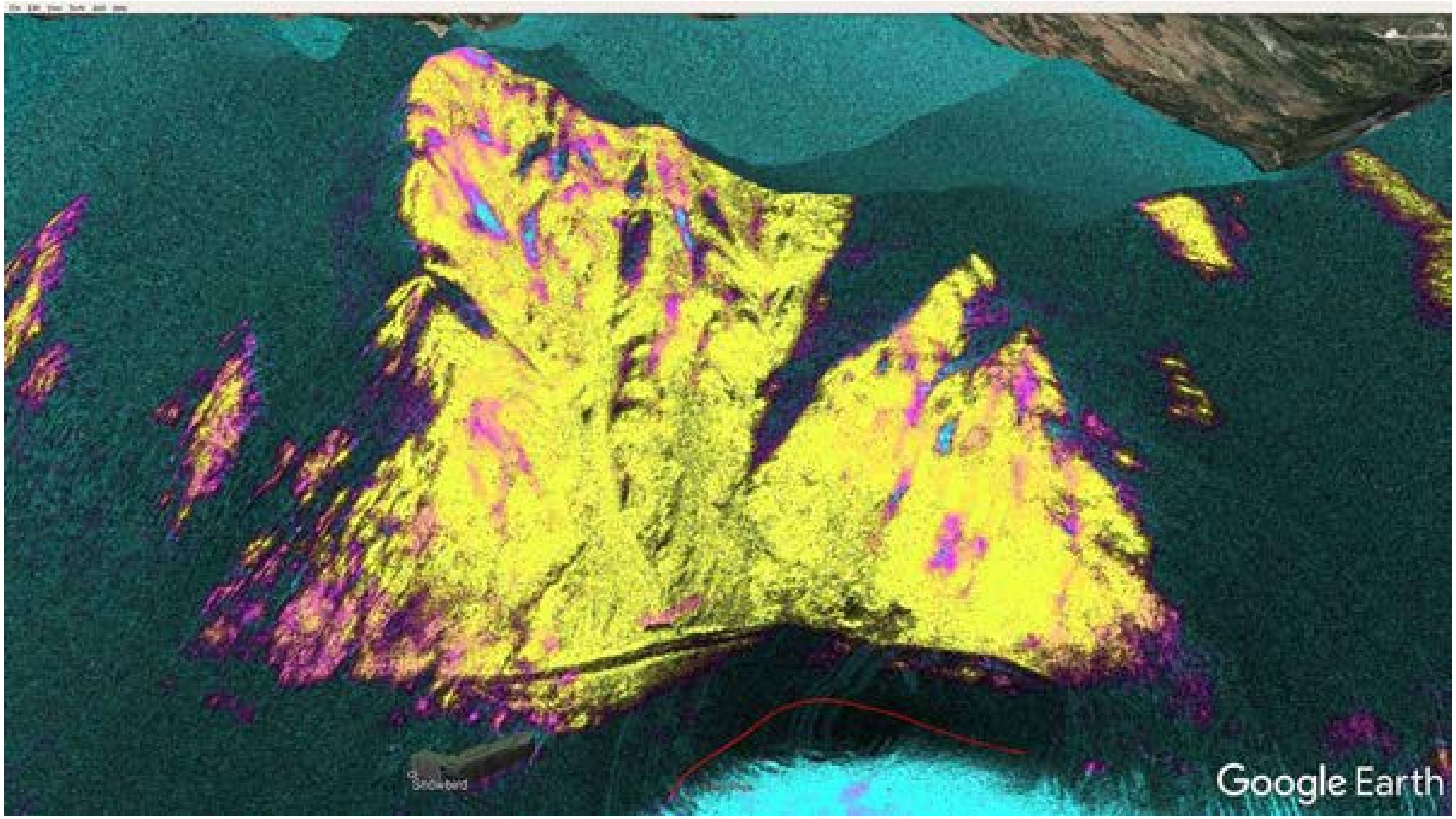
Temporary Places
Layers
Primary Database
Announcements
Borders and Labels
Places
Photos
Roads
3D Buildings
Weather
Gallery
More
Terrain
Google Earth
1985
Imagery Date: 9/12/2020
40°35'19.37" N 111°39'18.53" W elev 8814 ft
eye alt 11848 ft

Mt. Superior- Coherence from CarSAR

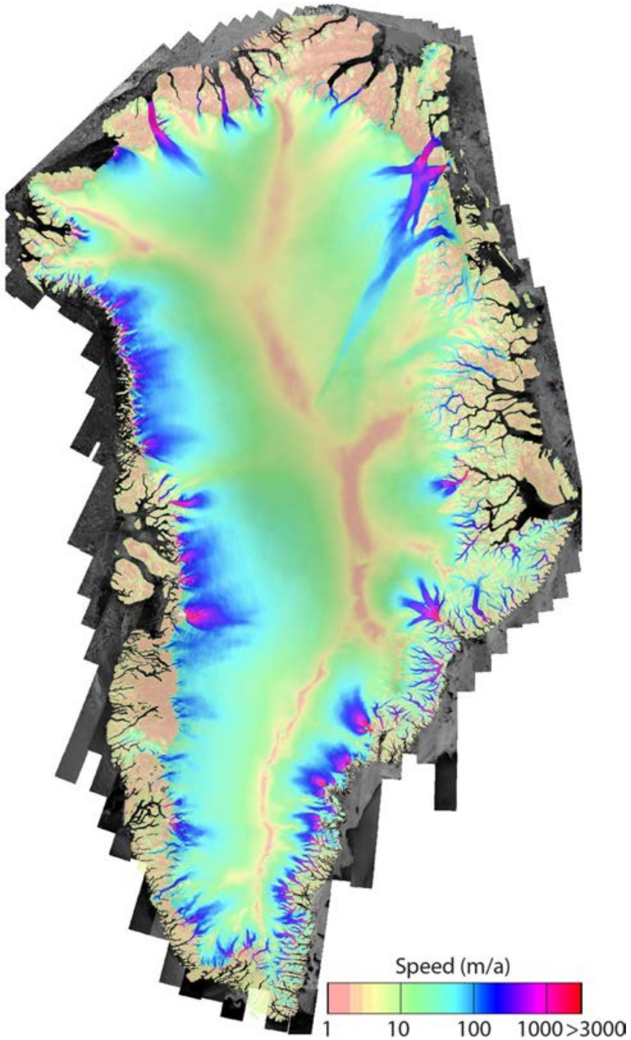
CarSAR pair spanning avalanche control work



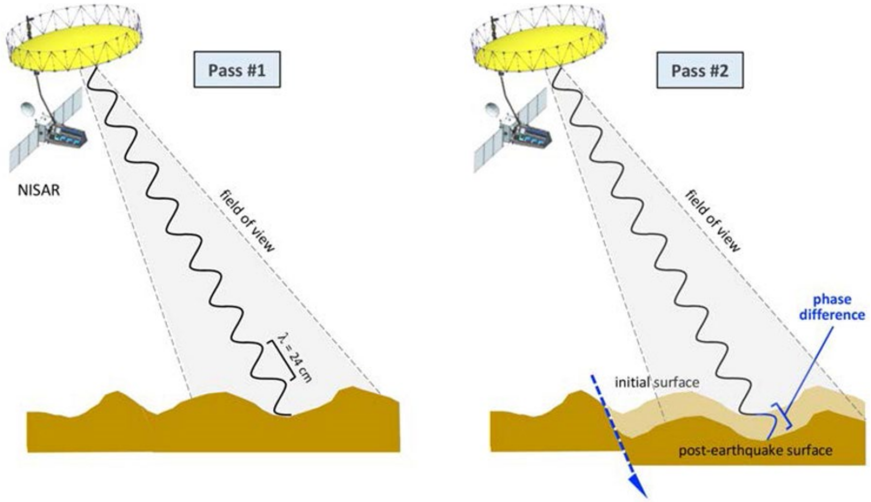


NASA ISRO Synthetic Aperture Radar (NISAR)

Scheduled to launch April 2025



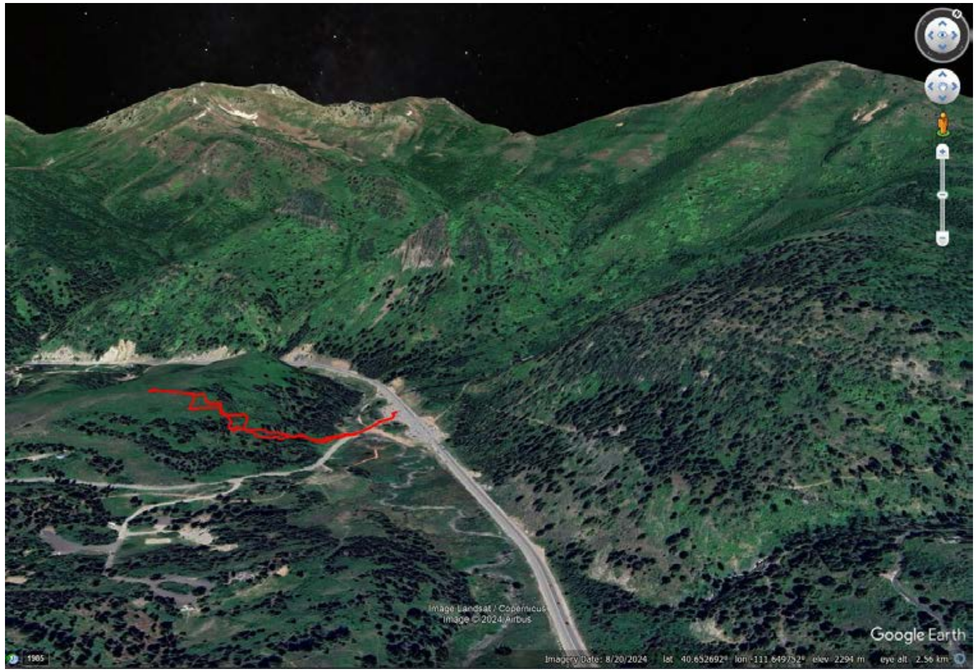
Joughin et al.,2017



NISAR displacement applications:
Glacier and Ice Sheet velocity
Global coverage every 12 days
Earthquakes, fluid withdrawal, volcanoes, etc.

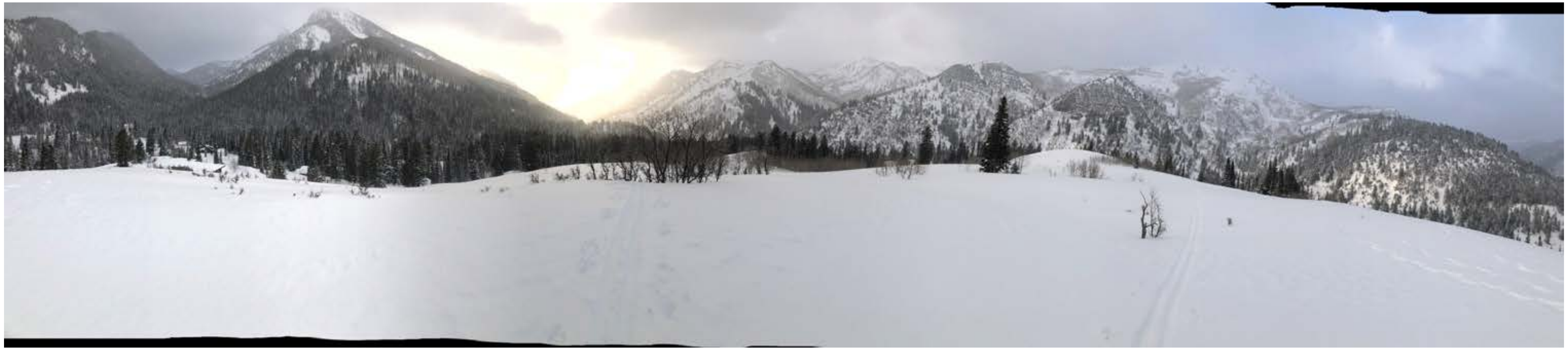
Snow Wetness from SAR

Big Cottonwood Canyon, plateau near Cardiff Fork



Satellite:
Sentinel -1, C-band (5.6 cm)
Every 6 to 12 days ~7am
25 m pixels

Ground truth:
Coincident snow wetness in snow pit every 10 cm depth



Lightning Talks

Paul Brooks; Court Strong, Ryan Johnson; Steve Burian	The SLCDPU-UU Partnership: Advancing Fundamental Understanding and Societal Application in Water Resources
Joshua Graham	Shoring Up: Art Education on the Edge of the Great Salt Lake
Nathan Lunstad	Integrated Water Distribution Systems
Zinan Yu	Phosphate Recovery from Wastewater
Ling Zang	PFAS Separation Technology
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Ramesh Goel	Harmful Algal Blooms
Brig Daniels	Legal Reforms and the Effort to Save Great Salt Lake
Emily Lewis	Water Policy

Phase Change Phenomena to Address Water Scarcity in a Decarbonizing World

Sameer R. Rao

Assistant Professor

Department of Mechanical Engineering

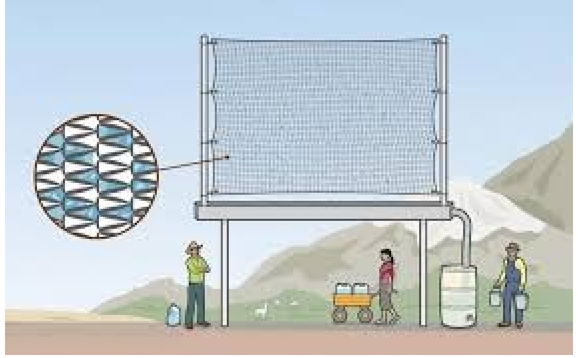
University of Utah

PEAK Water Sustainability Engine Kickoff

1/22/2025

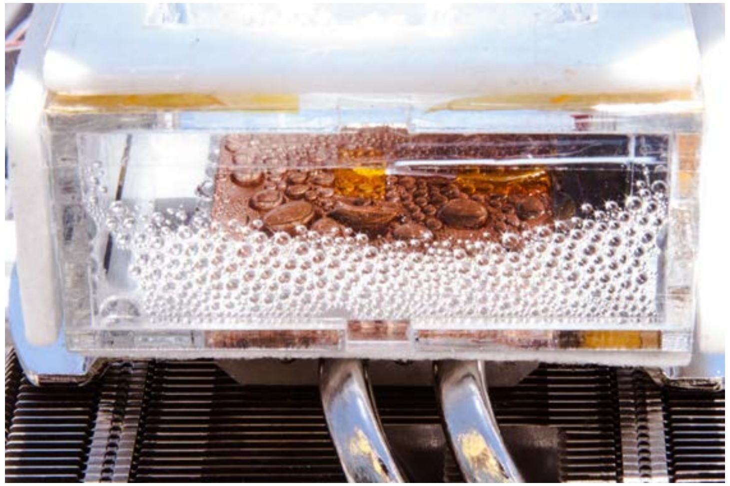
Atmospheric Water Harvesting

Atmospheric water harvesting

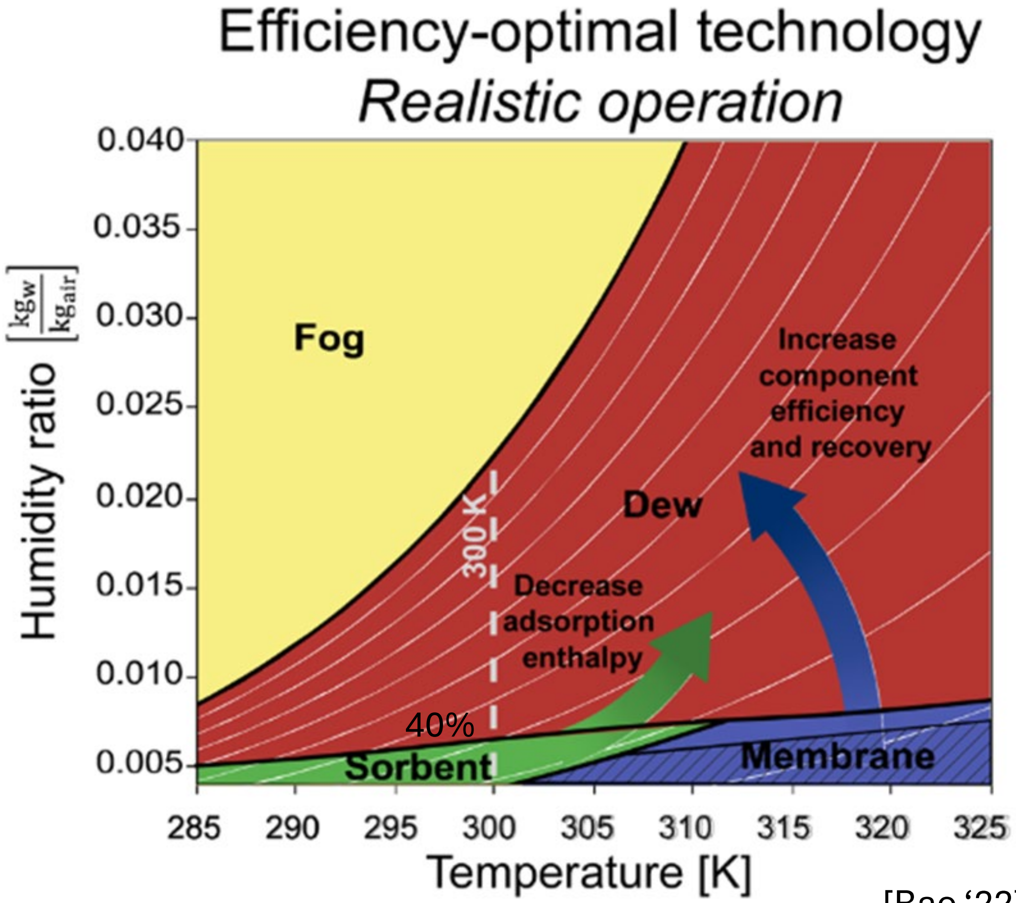


Fog harvesting:
- Passive
- Requires 100% RH

Refrigeration dewing:
- Vapor compression
- Most prevalent technology



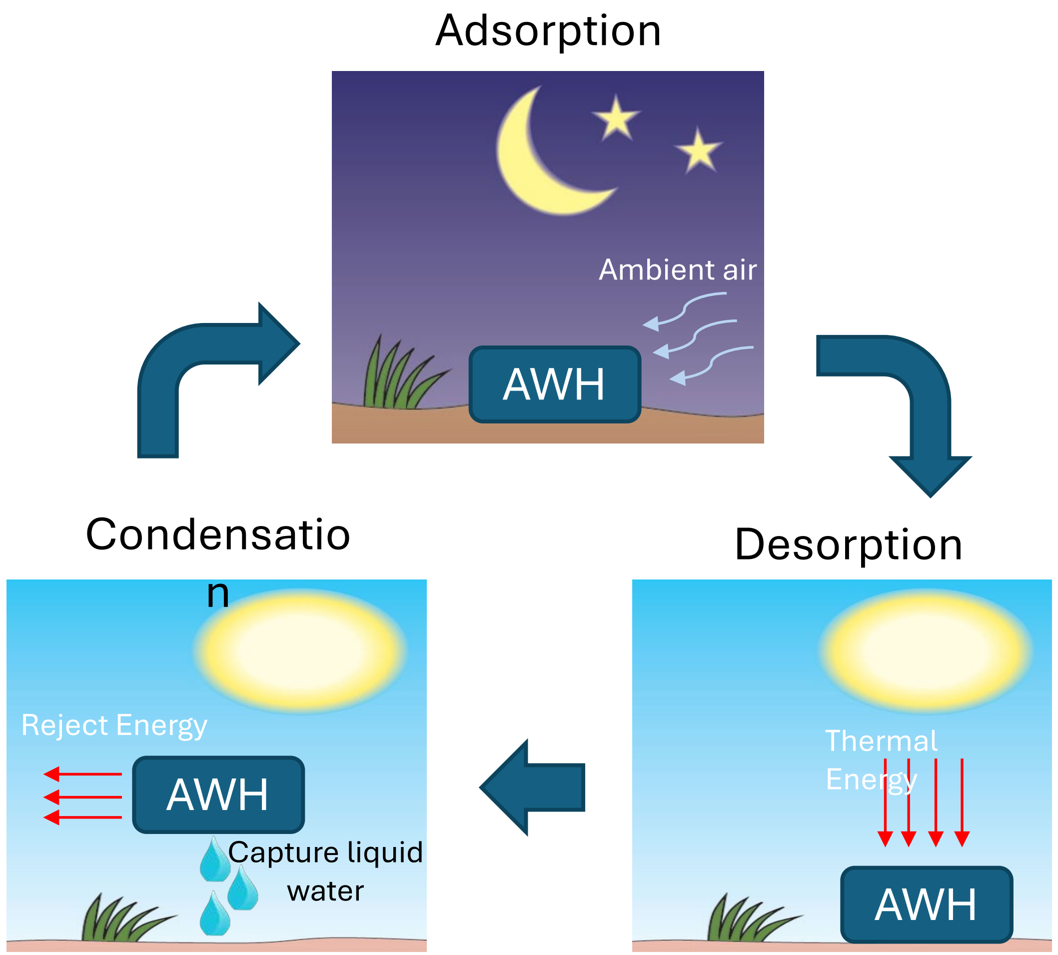
Sorption based AWH:
- Passive or active
- Needed to serve millions of people



[Rao '22]

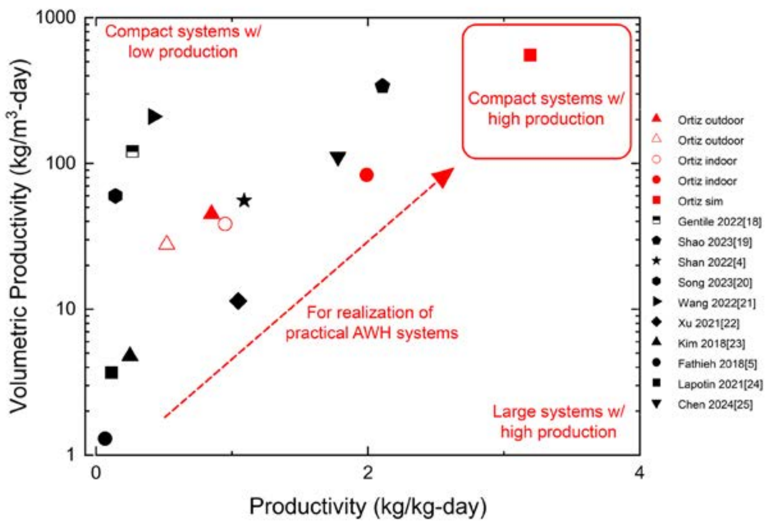
Sorption-based AWH

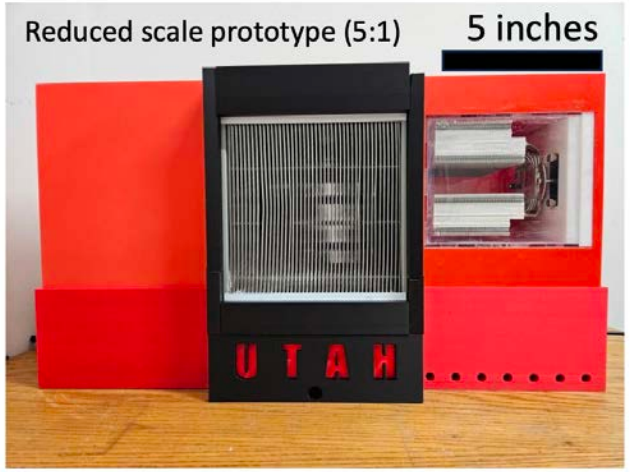
1. Sorbent material saturated
2. Rapidly release adsorbed water vapor
3. Condense vapor from the humid air stream
4. Repeat

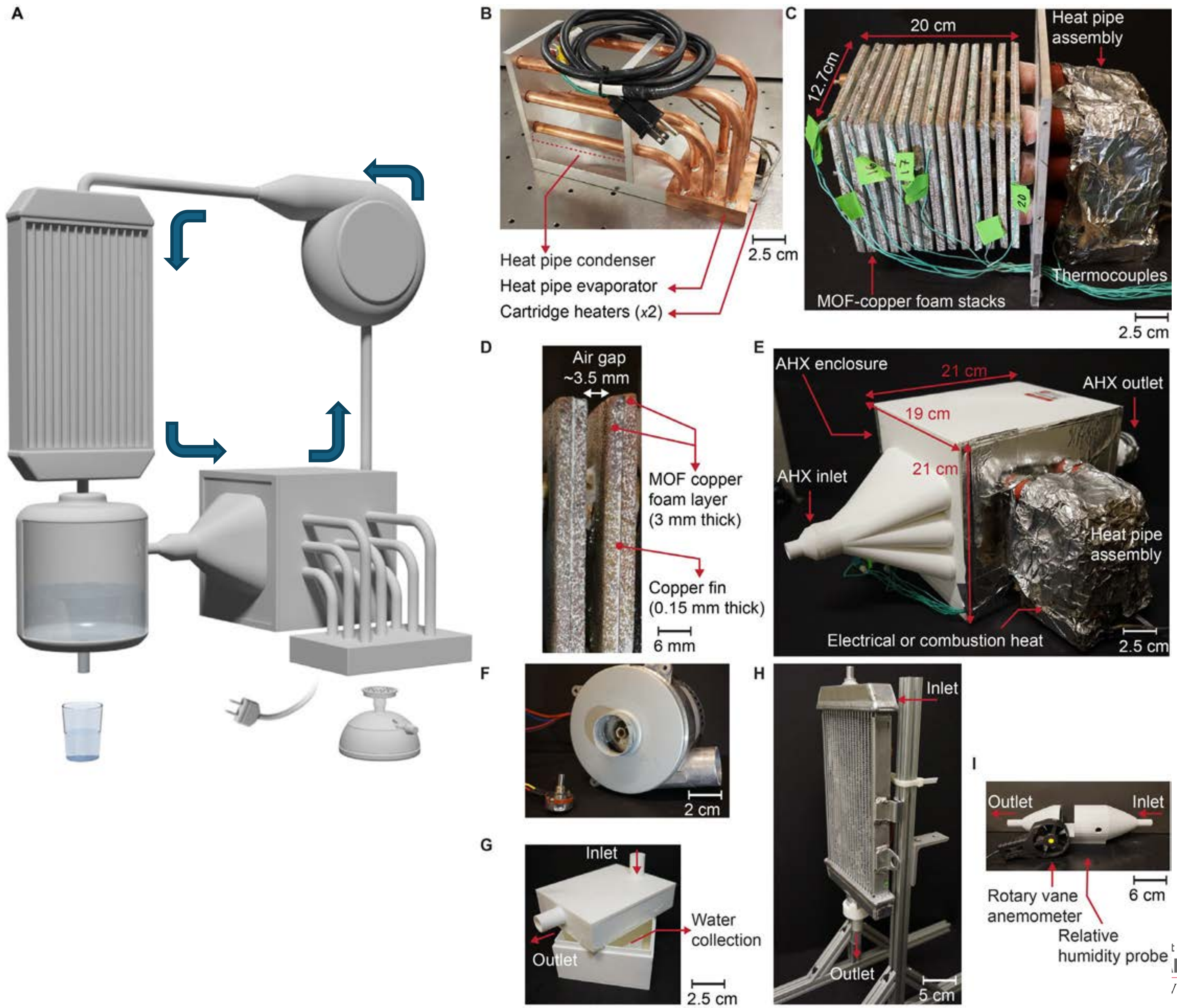


Technology development

Rao Lab







Spin off – Sorption Water Solutions

Sorption Water Solutions LLC

SWSIE

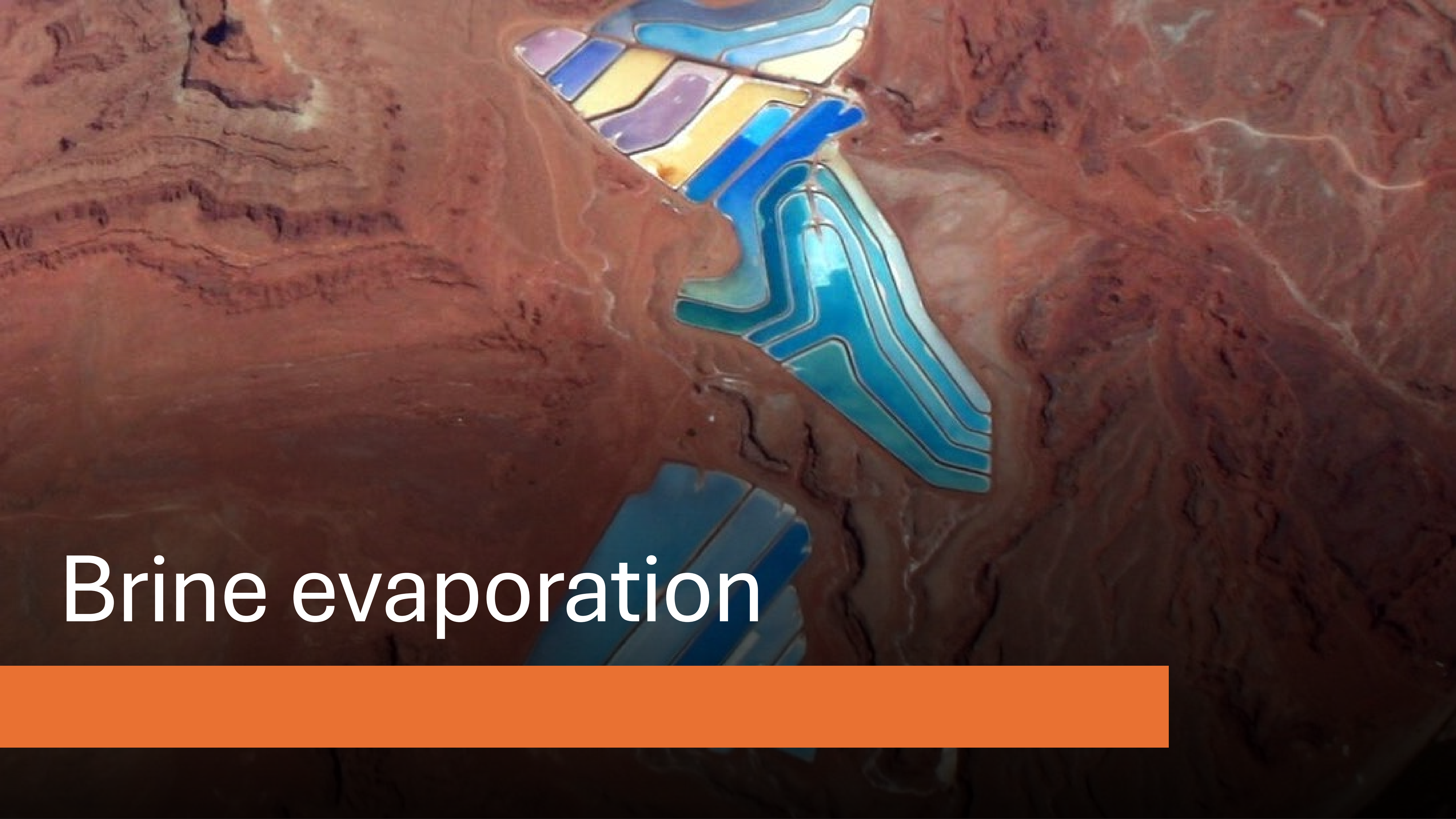
Capturing the Future of Clean Water

Nathan Ortiz
PhD Candidate
Founder

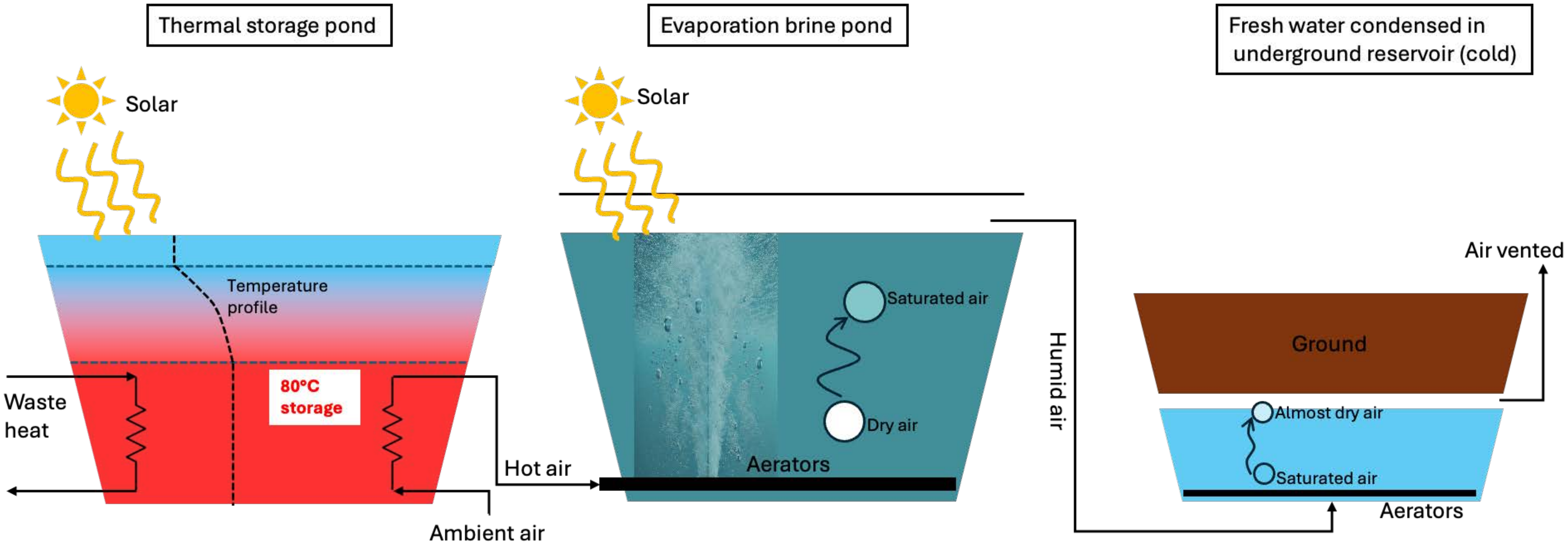
Sameer Rao
Assistant Prof.
Founder

Department of MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

Brine evaporation



BRINES: Brine Recovery and Integrated Evaporation Systems

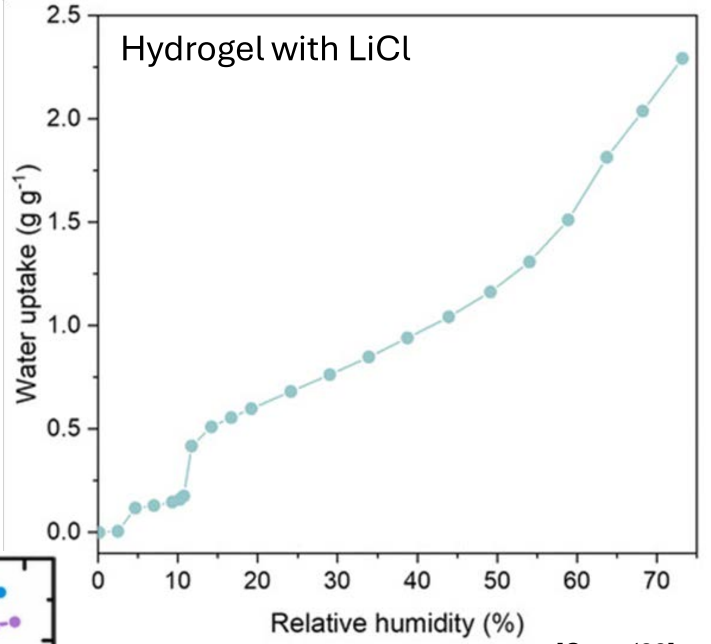


Backup

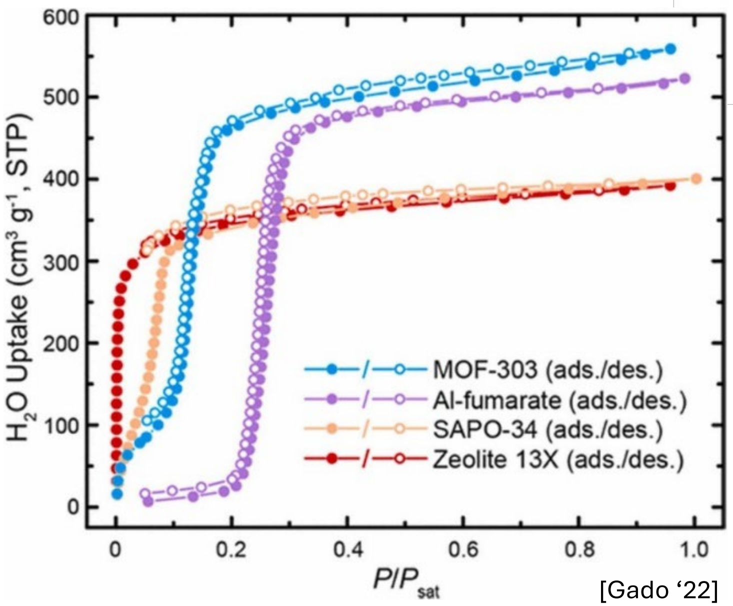
Sorption materials

Rao Lab

- Absorption materials
  - High uptake
  - Hygroscopic salts improve low RH performance
  - Leeching and scaling concerns
- Adsorption materials
  - Naturally strong adsorbers at low RH
  - Proven safe over 1000s of cycles



[Guan '22]



[Gado '22]

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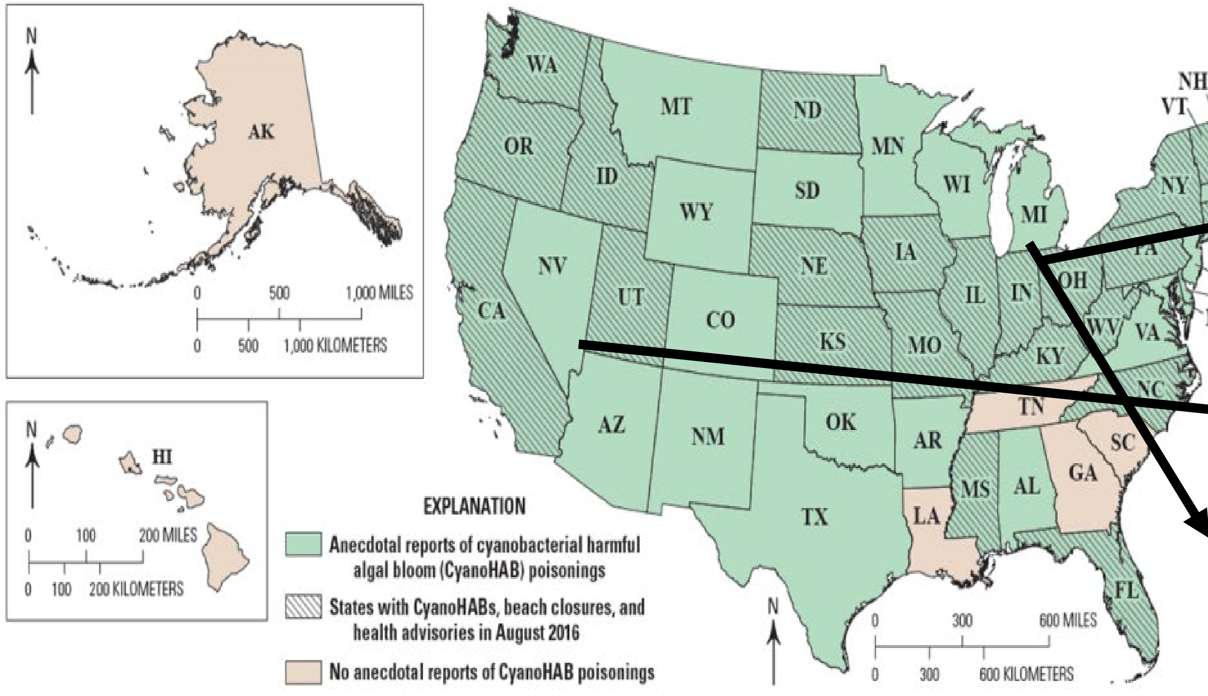
Harmful Algal Blooms

Ramesh Goel
The University of Utah
January 22, 2025
Peak Water Day

THE UNIVERSITY OF UTAH

Surface Water Quality: Worldwide Issue



Lake Erie

Lake St. Clair

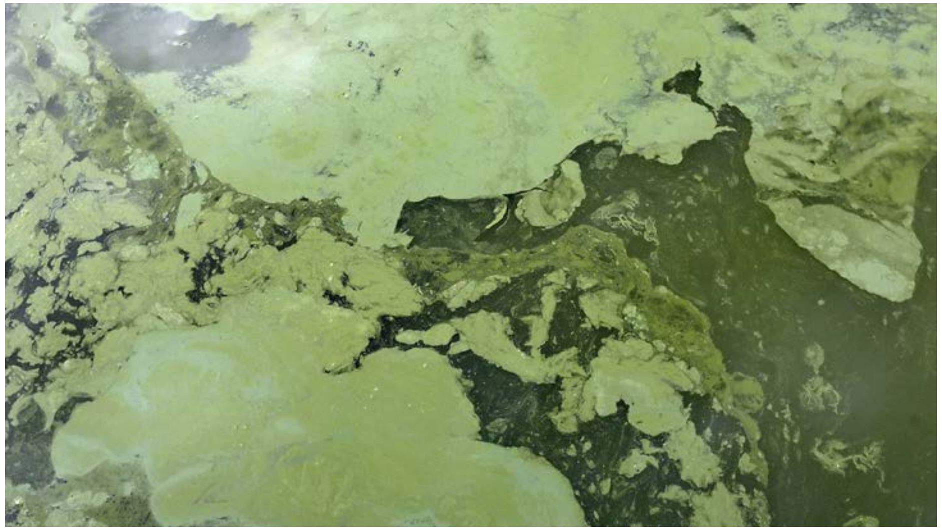
Lake Utah

Toxic cyanobacterial harmful algal blooms (CyanoHABs) have been implicated in human and animal illness and death in at least 43 States in the United States (Hudnell, 2008; Graham and others, 2009)

TYPES

Planktonic : Regulates position in the water column through buoyancy control.
Some planktonic cyanobacteria have gas vesicles that contribute to their buoyancy. These vesicles help them stay suspended in water and reach the surface.
Cyanotoxins are produced by many planktonic cyanobacteria like Microcystis, Dolichospermum, and Planktothrix.
Microcystis is a common bloom-forming genus, typically toxic, forming greenish, paint-like accumulations along shores.
Dolichospermum species create slimy summer blooms on the surface of eutrophic lakes, resembling green paint or large dark dots in water.
Planktothrix agardhii forms long, slender filaments that form dense surface scums, often detected by their strong earthy odor.

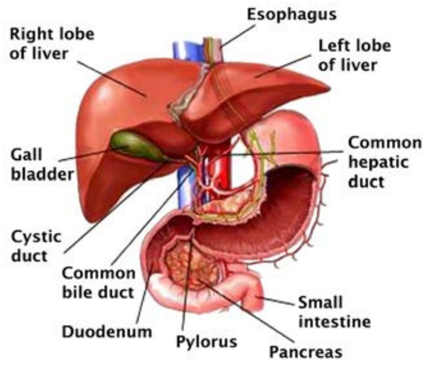
Benthic cyanobacteria grow on different substrates such as sand, cobbles, and aquatic plants.
These cyanobacteria can form thick mats vertically, reaching over 70 cm in thickness.
Common genera with toxin-producing benthic species include Nostoc, Oscillatoria, Phormidium (now Kamptonema/Microcoleus), Microcoleus, and Microseira (previously Lyngbya).
While benthic proliferations may include non-toxic species, toxin-producing ones can be dominant or co-dominant

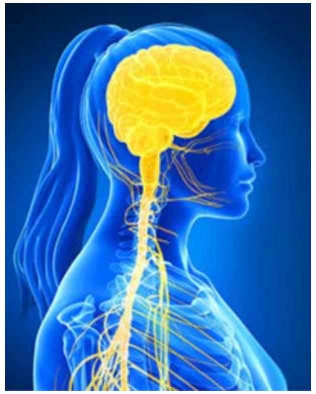


Algal bloom in Utah lake (Source : DEQ)

Benthic Cyanobacteria (source : ITRC)

Cyanotoxins



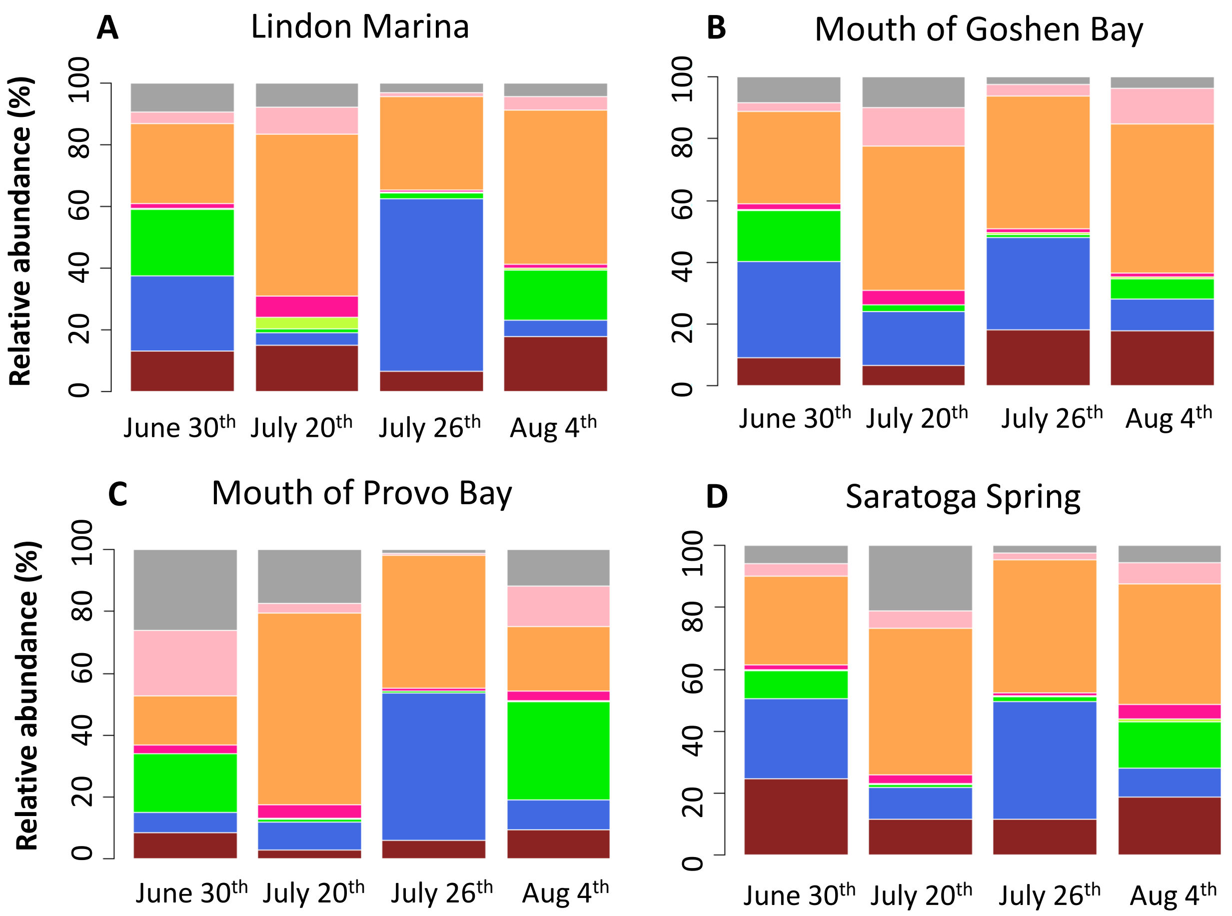


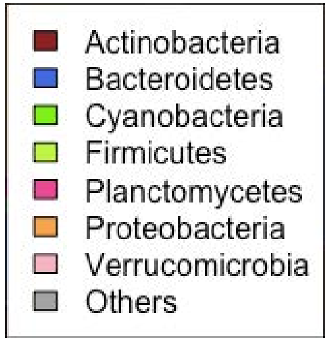
Type	Toxin	Associated Cyanobacteria
Hepatotoxins	Microcystins	*Microcystis, Oscillatoria, Anabaena,*
	Nodularins	*Nodularia spumigena*
	Cylindrospermopsin	*Cylindrospermopsis raciborskii, Aphanizomenon ovalisporum,*
Neurotoxins	Anatoxin-a	*Anabaena, Aphanizomenon*
	Saxitoxins	*Anabaena circinalis, Aphanizomenon flos-aquae*
	β-N-methylamino-L-alanine	may be produced by all 16 known groups of cyanobacteria
Dermatotoxins	aplysiatoxins lynbyatoxins	*Lyngbya majuscula*

- Cyanotoxins can harm organisms in various ways: liver damage, cell dysfunction, nervous tissue damage, and allergic reactions.
- Cyanotoxins include diverse compounds like peptides, alkaloids, and amino acids, posing risks to aquatic organisms and humans. Common cyanotoxins include : Microcystins, Cylindrospermopsins, Anatoxin-a, Guanitoxin, formerly known as anatoxin-a(S), Saxitoxins, Nodularins, Lyngbyatoxins.
- Cyanotoxins are released into water when cyanobacteria cells die, often due to water treatment or algaecide use.
- Different cyanobacteria species can produce multiple toxins, affecting aquatic life differently.
- Exposure to microcystins, a common cyanotoxin, can cause liver problems, oxidative stress, growth inhibition, reproductive issues, kidney damage, and even death.
- Neurotoxic cyanotoxins can cause symptoms such as dizziness, vision problems, and convulsions.

Phylum and Cyanobacterial Genus Level

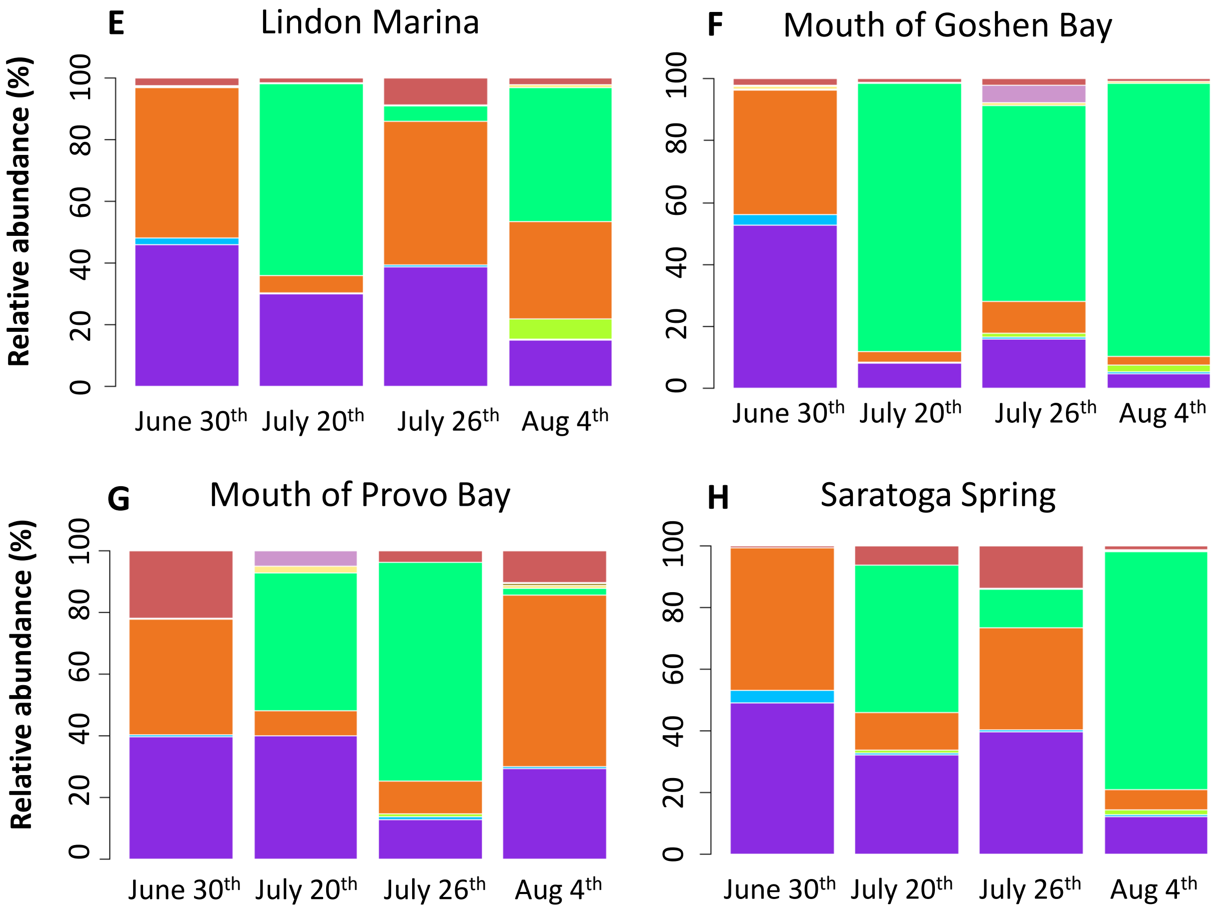
Phylum level



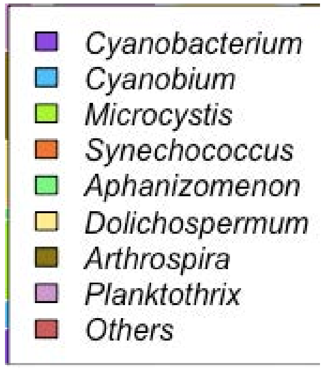


- Relative abundance of Cyanobacteria and bacterioplankton community was Negatively correlated.

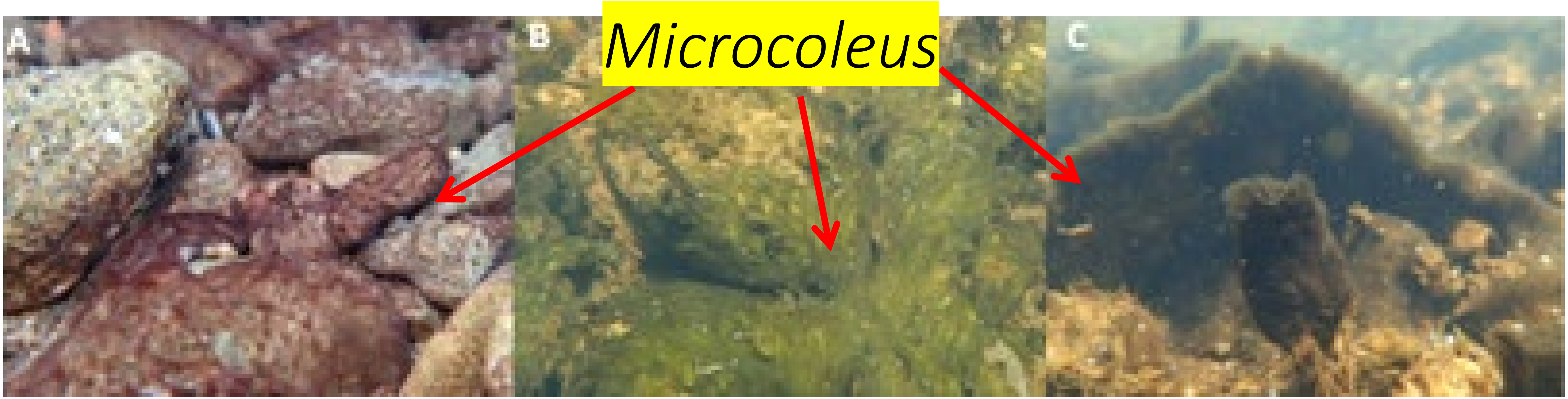
Cyanobacteria genus level

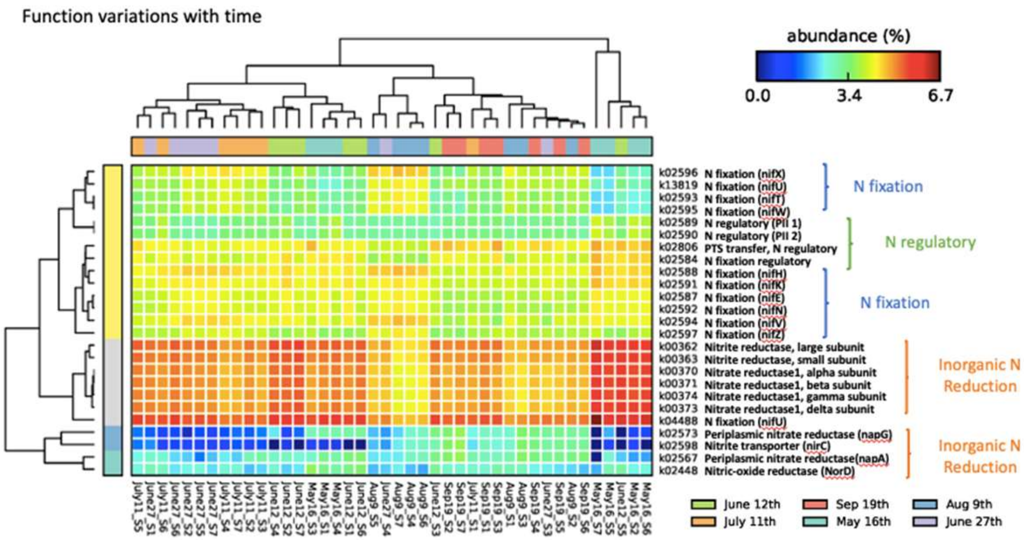


- *Synechococcus* and *Aphanizomenon* dominated different periods of the bloom.



Ongoing Research- Benthic cyanobacteria





Function Profiling

- It showed the N and P function variations at different bloom periods and sites.
- With the increase of relative abundance of the potential N-fixers (month August), the N-fixation functions also increased.
- The main nitrate and nitrite reductase subunits were relatively higher in May and early June and less detectable in August and September.
- The Pho regulon and ppGpp was activated in May. It suggested that phytoplankton responded to early summer nutrient stress and started to assimilate P.

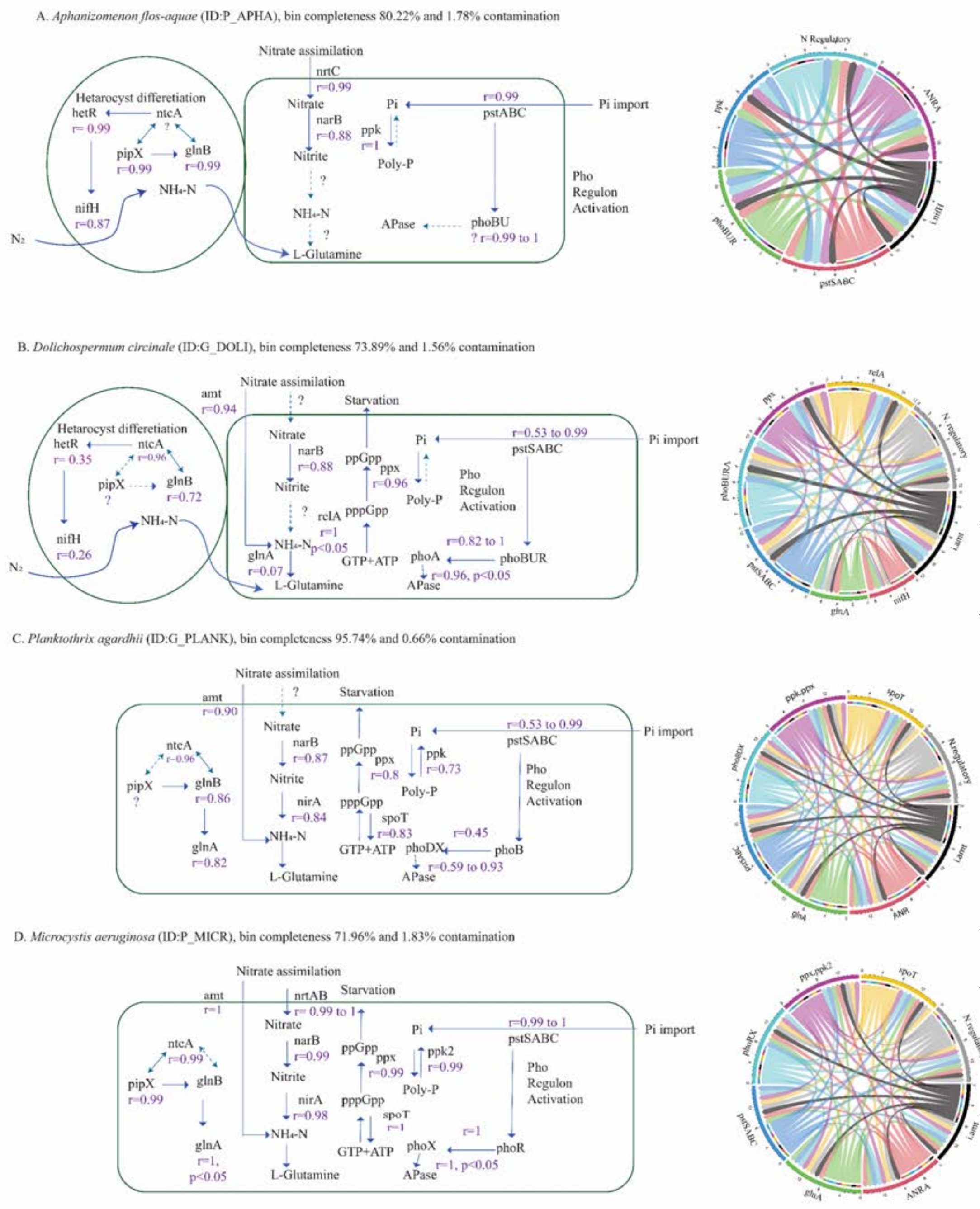
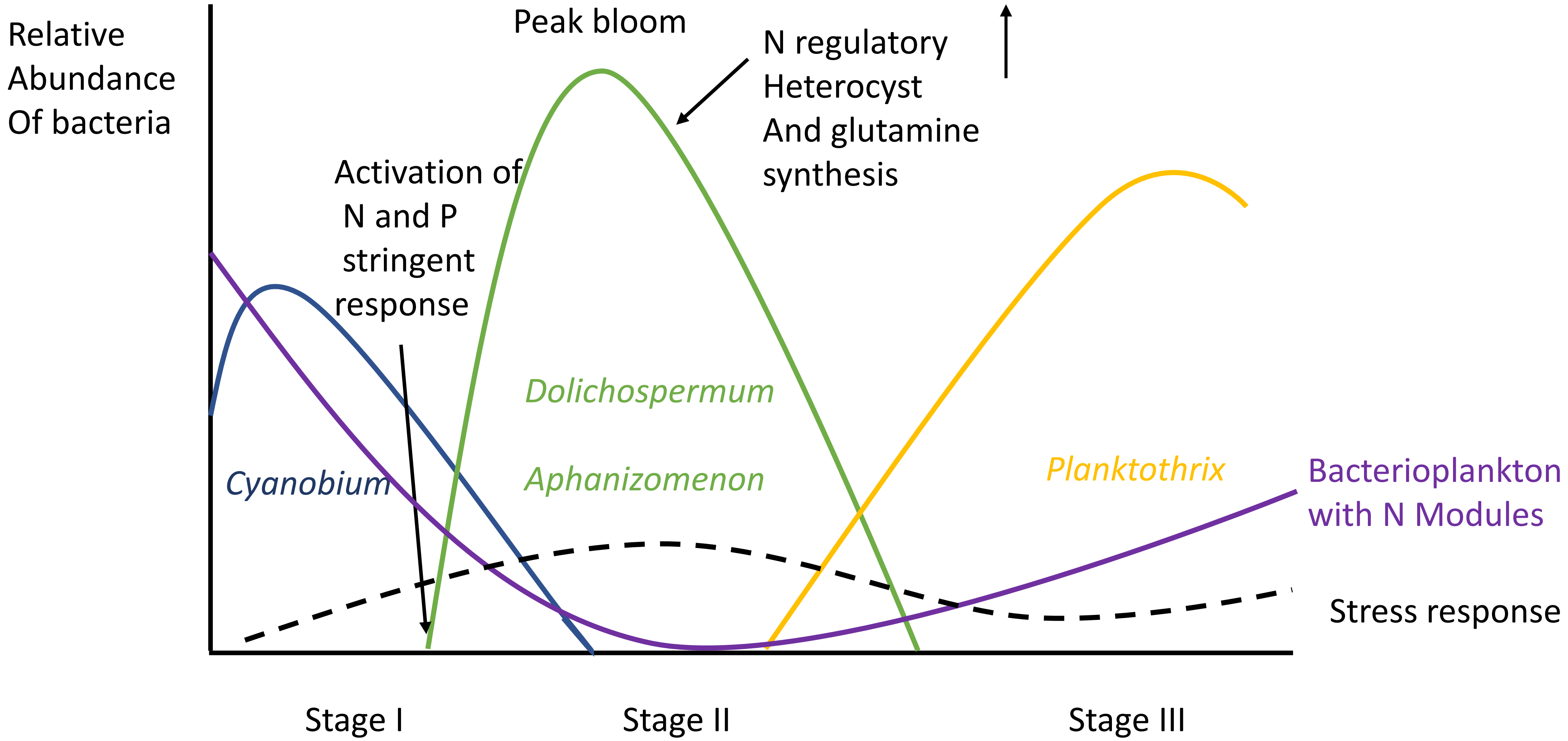


Figure. The construction of essential inorganic N cycling, inorganic P assimilation and stringent response metabolic pathways of dominant cyanobacterial MAGs and their gene expression correlations. (A) *Aphanizomenon flos-aquae* (ID: P_APHA), bin completeness 80.22% and 1.78% contamination. (B) *Dolichospermum circinale* (ID: G_DOLI), bin completeness 73.89% and1.56% contamination. (C) *Planktothrix agardhii* (ID: G_PLANK),

bin completeness 95.74 % and 0.66% contamination. (D) *Microcystis aeruginosa* (P_MICR), bin 71.96% completeness and 1.83% contamination. The schematic map on the lefthand shows the metabolic pathways. The Pearson correlation (r) and significance values (p) were calculated between genome relative abundance and expression quantification (TPM) of specific genes during a bloom period ((before, during and after the main bloom). The positive values demonstrate the positive correlation between genome and gene expression abundance, while the negative values show the opposite trend. The chord diagram on the righthand side show the correlation among different gene expressions during a bloom period.

Schematic Diagram of the Ecological Changes in Summer



THANK YOU!

QUESTIONS?

Department of
CIVIL & ENVIRONMENTAL ENGINEERING
THE UNIVERSITY OF UTAH

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Peak Water Engine
Water Law & Policy Perspectives
Collaboration for Complex Water Problems

Emily E. Lewis

Emily E. Lewis

Clyde, Snow & Sessions

- Director and Shareholder, Co-Chair of Natural Resources and Water Law Practice Group
- Adjunct Professor Law, SJ Quinney College Water Law
- Water Law Committee Chair, Utah Bar
- Podcast Host – Ripple Effect Podcast
- Strategic Projects
- General Gadfly

• eel@clydesnow.com
• (307) 690-6459

Experience and Areas of Expertise

- Municipalities and retail water supplies
- Water quality standards and water reuse
- Irrigation companies and agricultural water use
- Water Conservancy District and Federal wholesale water supplies
- Developers and exaction requirements
- Water distribution and reservoir operations
- Water markets and water transactions
- Prior Appropriation Doctrine
- Mining companies and extractive industries
- Innovative water policy recommendations

Legal and Water Policy Perspective

Complex water problems often benefit from a water law and policy perspective

- Does the project involve water rights – are they the “right” rights?
    - Do I need a water right?
    - Does a water right exist for what I want to do? (DLE?; atmospheric water harvesting?)
    - Prior Appropriation? Priority? Distribution Issues? Conveyance Questions?

- Are here other contracts/governing rules I should know about?
    - Federal Reclamation Contracts limit water use?
    - Irrigation Company Governance? Shares often confused with water
    - Reservoir operations?

- Are there legal or political barriers I am not seeing?
    - Cache Valley Water Bank – designed without considering irrigation company structure
    - Water Trading Platform – designed without considering Change Application Process

- How do I scale a project/concept in a way that meshes with existing law or process?
    - OpenET technologies and Saved Water Change Applications (tech and law meeting)
    - Water “politics” and taking progressive ideas “to the water user”

SAMPLE PROJECT:
GREAT SALT LAKE ADVISORY COUNCIL:
2020 LEGAL ANALYSIS – LEGAL STRATEGIES TO BRING WATER TO THE GSL

- Foundational Strategies
  - How do we change Utah Water law to allow for conserved water to be brought to Lake
- Operational Strategies
  - How do we manage our water differently to bring water to the Lake?
- Tactical Strategies
  - What activities can we do to "create" more water that could be brought to the Lake
- Organizational Infrastructure
  - How do we organize our decision makers to execute these strategies in a manner that prioritizes bringing water to the Lake

SAMPLE PROJECT:
2023 GREAT SALT LAKE BASIN INTEGRATED PLAN (GSLBIP)

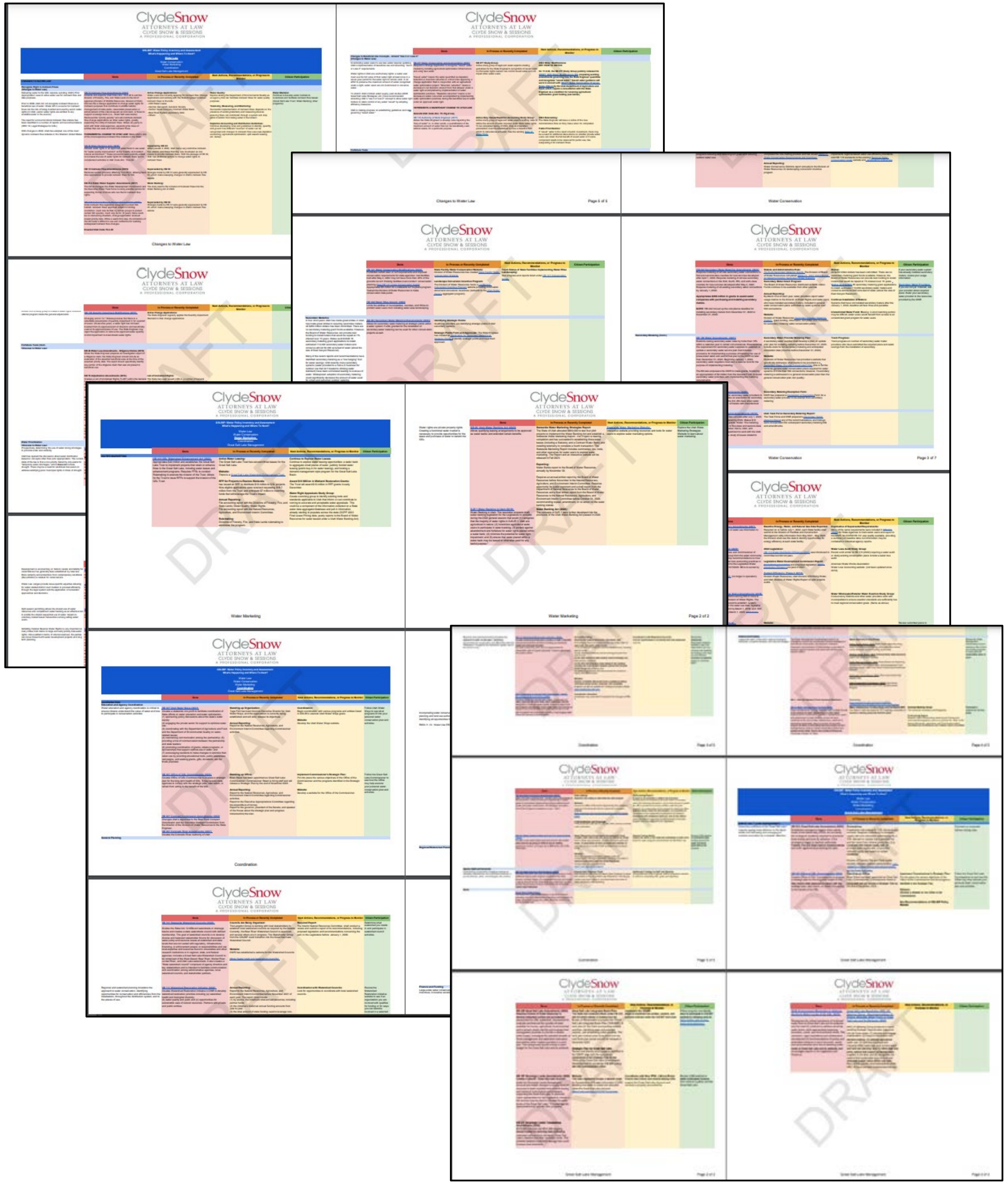
- HB 429 (2022)
- Released November 2023
- Approach
  - Inventory and categorize laws and policies
  - Review and status of law and link in associated programs
- Show Progress
  - What have we done
  - What are we working on
  - What Is Next

GREAT SALT LAKE BASIN INTEGRATED PLAN

Why and WOW!!!!!!

- WHY?
  - Physical Summary and Document
    - Comprehensive – programs
    - Interactive
    - Drop on someone's desk
  - Respond to public questions about action
  - Identify redundancies, gaps, and opportunities

- WOW!!
  - Good work team!! Accomplished a LOT in 5ish years
  - STATE WEBSITES!! –
  - Programs, Programs, and Programs
  - $$$$$$$ - So many 000,0000,000s

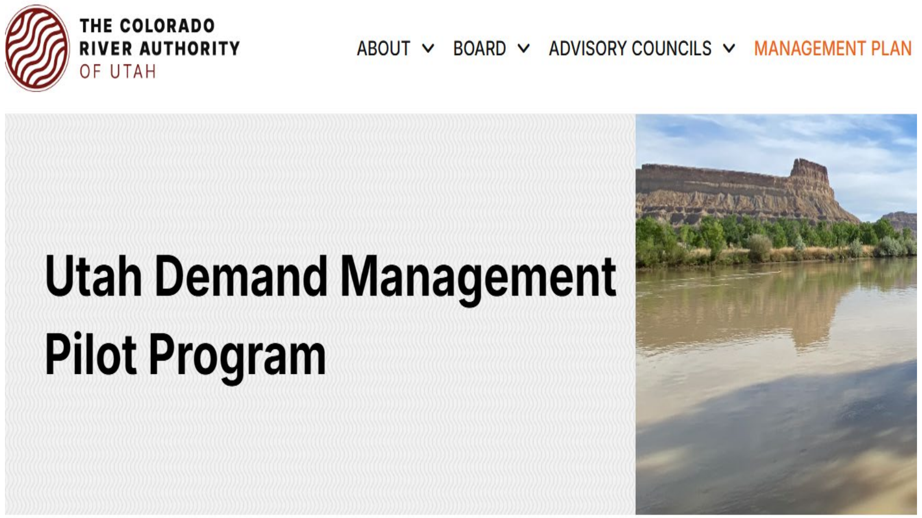


SAMPLE PROJECT:
2025 Colorado River Authority of Utah: Demand Management Pilot Program

- Employing OpenET to quantify water depletion from three pilot projects (fallowing land; irrigation conversion; and storage forbearance).

- Navigating Change Application process for having OpenET quantifications legally recognized and distributed to Lake Powell

- Working with team to understand storage facility operating principles and contracts to store quantified saved water (Federal Reservoirs and local reservoirs)



Conservation With a Purpose

SAMPLE PROJECT:
2025 Living Rivers Direct Lithium Extraction Law Suit

- Challenging of appropriation of new water from deep brine aquifers for the beneficial use of Direct Lithium Extraction

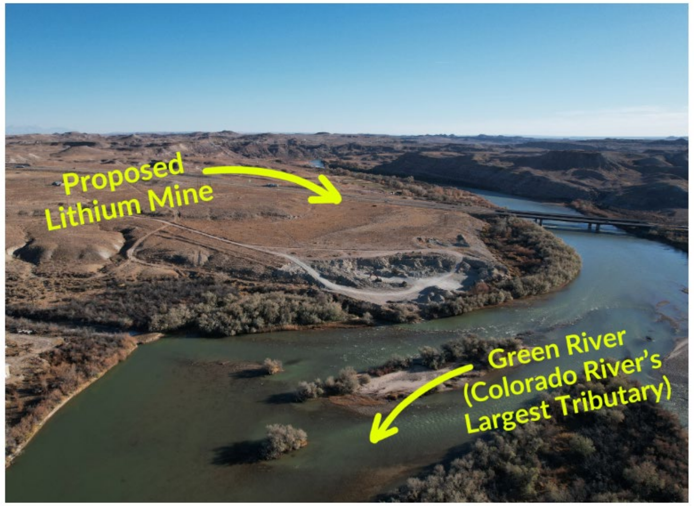
- Questions as to whether process complies with local area policy prohibiting water rights appropriated for “consumptive” uses when water is diverted from one aquifer and returned to another

- Questions as to whether the Appropriation violates the “public welfare” when no current authority exists under Division of Oil, Gas, and Mining (or any other agency) regulating extraction of lithium from deep brines
  – Robust process for processing lithium from GSL

Great Basin Water News

Coalition files lawsuit to challenge groundwater rights for lithium mine on Green River

GBWN October 16, 2024 0



The lawsuit asks important questions about regulating deep groundwater drilling along the banks of a major river. As companies push to meet the demands of the green energy transition, the effort ensures accountability for our communities — plant, animal and human.

SAMPLE PROJECT:
2024 Utah Statewide Water Marketing Strategies

- Multi- disciplinary Team setting up pilot projects to test Water Banking Act and create Water Marking Strategies

- Applying and creating new administrative processes for approving water banks

- Working with water users across the state to hear their concerns and preferences

- Working with engineering firm, hydrologists, and biologist to better understand stream flow in East Canyon and install proper stream gauges –contemplated contracts suited to trigger when certain stream targets were met


WATER MARKETING STRATEGIES
Top 10 Lessons Learned about Water Marketing

Utah Water Banking

1. **Moving from Curiosity to Clarity:** Water users are interested in "water marketing/water banks" but lack a clear understanding of the terms, the benefit, and next steps. Water is complex and discussions can quickly lose direction. Water users want step-by-step guidance on how to constructively explore and implement a water market. Utah's Statewide Water Marketing Strategies meet this need.
2. **A Voluntary, Flexible, and Timely Tool:** Water markets can address diverse water supply and demand imbalances. Once the mechanics of a water transaction are set up, water users can choose when and how to use it. Using existing law and known practices, voluntary water markets can quickly move water to new demands.
3. **Local, Local, Local:** Most water markets will meet local conditions. Successful water transactions require the expertise, participation, and endorsement of local water users. Water leasing is one tool to keep water rights and revenue in the local community.
4. **Someone Needs to Lead:** It takes significant time and resources to execute a water transaction. Having an engaged and committed local champion is invaluable in setting up a successful water market. Appoint representatives from participating groups to speed discussions.

Complex problems are complex for a reason – they challenge thinking and the status quo from multiple perspectives.

Incorporating a water law and policy perspective can help collaborative teams design solutions that work in the real world.

Expedite shared solution making.