



Center for Western Weather
and Water Extremes

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AT UC SAN DIEGO

Soil Moisture Observations to Support Water Management in the Upper Yampa: Accomplishments and Next Steps

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12th Annual Upper Colorado River Basin Water Forum
Colorado Mesa College, Grand Junction, CO, 31 Oct 2023

Photo courtesy of Chris Hysten



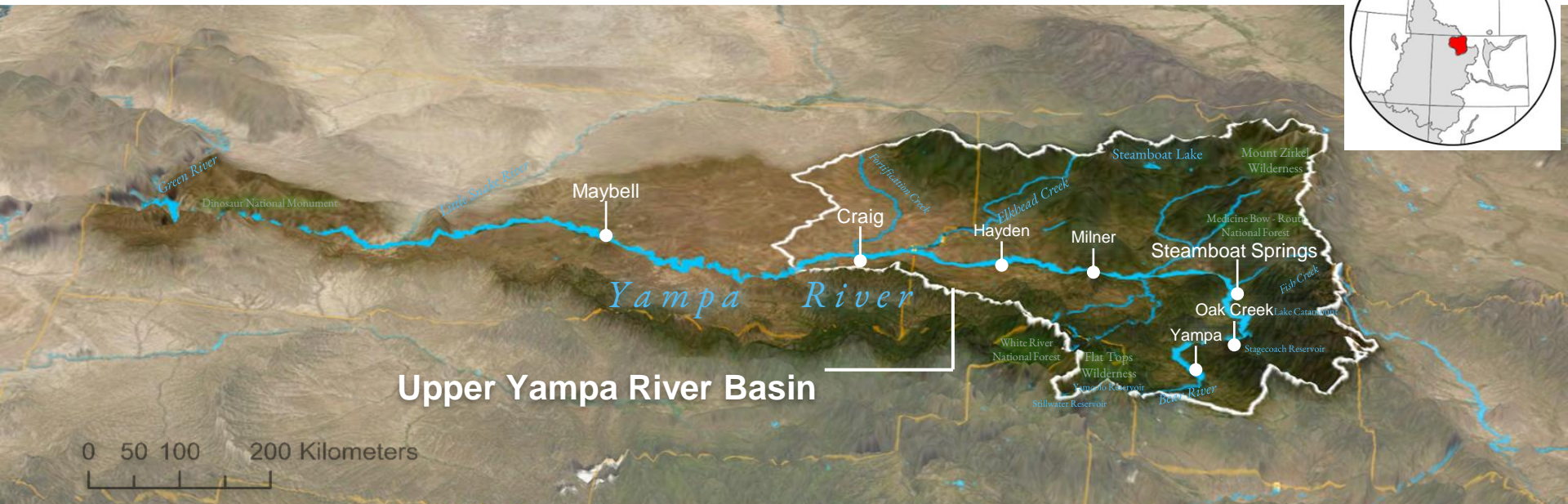
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Upper Yampa Soil Moisture Monitoring Network



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Upper Yampa Soil Moisture Monitoring Network



Key Sponsors:

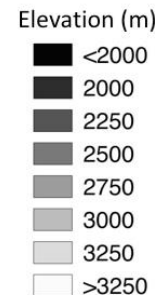
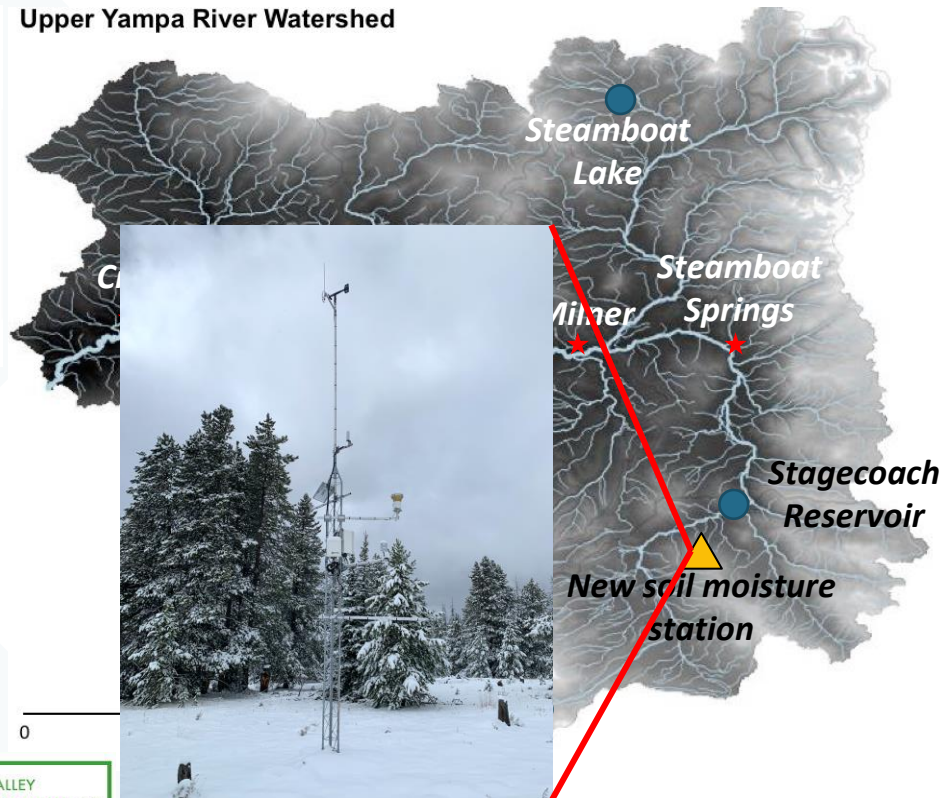
Upper Yampa Water Conservancy District

Colorado River District

Colorado Water Conservation Board



Upper Yampa River Watershed



Goal: Establish new long-term soil moisture measurements to provide data and scientific insight on the reduction of snowmelt runoff by dry soils

Phase II Components:

- Install 8 additional soil moisture monitoring stations.
- Replicate Phase I data dissemination methods to make data readily and openly accessible to water managers and users.
- With stakeholder input, demonstrate station utility in context of other observations in the basin.



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Soil Moisture Monitoring Network Goals

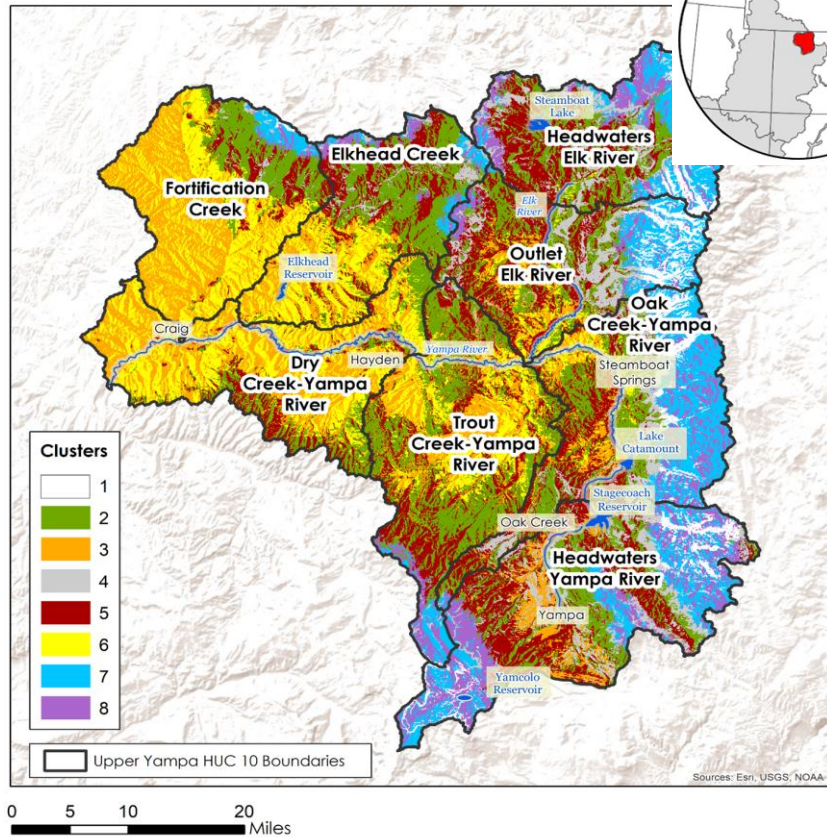
- Understand water supply during a changing climate
 - Establish a baseline for long term monitoring and future incorporation into hydrologic models
- Understand how soil moisture and snowpack relates to spring runoff and river flows
- Provide situational awareness to water managers and the community
- Provide data that can be used for research applications and improving process-based understanding



Station Siting

Cluster Analysis

Cluster	%	Summary
1	3.8	highest precip/elevation/slope, wide range of aspects, scrub, less dense forest
2	20	low-mid precip, low/mid elevation, forested, S/W aspect, low-mod slope,
3	16	low precip/elevation/slope, NE-SE facing, pasture/developed
4	8.6	low-mid precip, low/mid elevation, moderate slopes higher and more extreme when compared to similar clusters, S/W facing, forested
5	19	lowest-mid precip, low/mid elevation, lower slopes, E facing, mix of land cover
6	15	low precip/elevation/slope, W-facing, developed land/pasture
7	9.8	mid/high precip/elevation, some higher slopes, S/W facing, less dense forest
8	7.8	mid/high precip/elevation, some higher slopes, N/E facing, less dense forest



Station Siting

Additional considerations over the cluster analysis included:

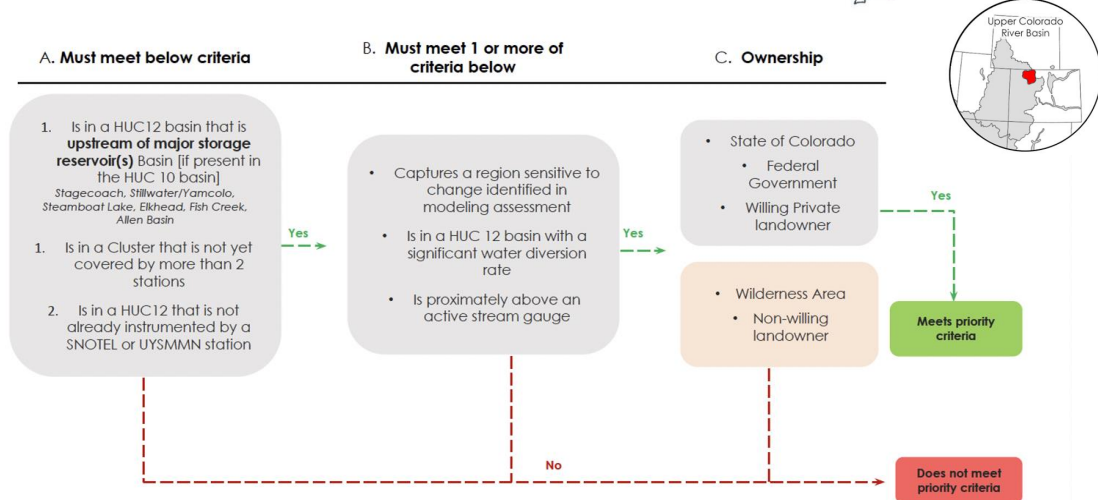
- Distribute sites across elevations and spatially throughout the watershed
- Prioritize stations that were within the CBRFC mid-elevation zone 6500-8500 ft (1981-2590 meters)
- Incorporate stakeholder and partner feedback

Upper Yampa River Basin Soil Moisture Network Site Selection Prioritization Process



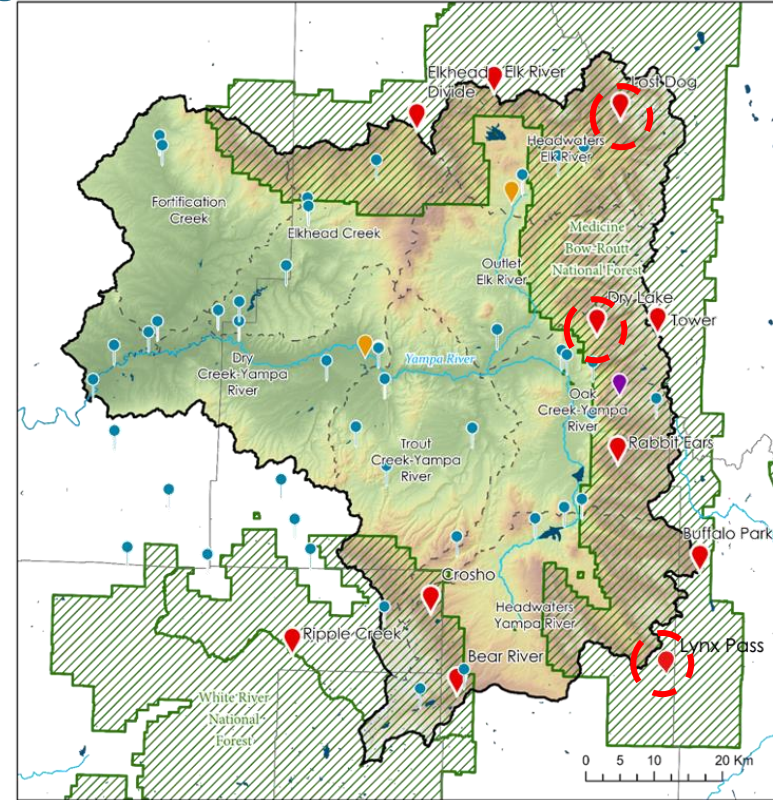
Priority Criteria

- Cover at least (1) per HUC 10 Basin
 - Ensure altitudinal diversity
- Prioritize regions that are important for water supply and management decisions
- Select station sites that cover at least (1) station per Cluster
- Consider regions that highlight as areas of change in atmospheric assessment/modeling



Existing Hydrometeorological Stations

- 12 SNOTEL Stations
 - 3 including soil moisture
 - Lynx Pass (607): since 2002
 - Lost Dog (940): since 1999
 - Dry Lake (457): since 2003
- Storm Peak Lab (various aerosol and meteorological sensors)
- 2 CoAg (ET and plant water use)
- 36 USGS Stations



Station Installation

Location: Upper Yampa Headwaters

40.22171, -106.86308

Elevation: 9488 ft/ 2982m

Measured Variables –in near real time:

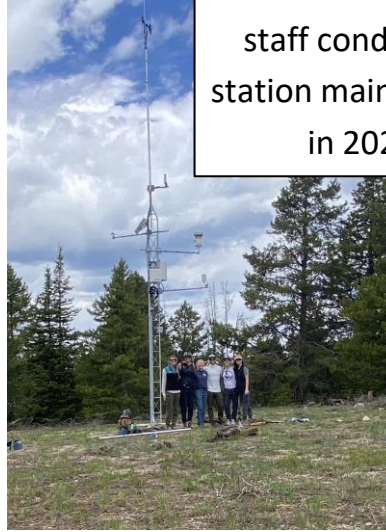
2-minute data

- Soil Temp and Moisture at 6 depths:
 - 2, 4, 6, 8, 20, 40 inches
- Air Temperature
- Relative Humidity
- Solar Radiation
- Precipitation
- Wind Speed and Direction at 10m
- Air Pressure
- Fuel Temperature and Moisture

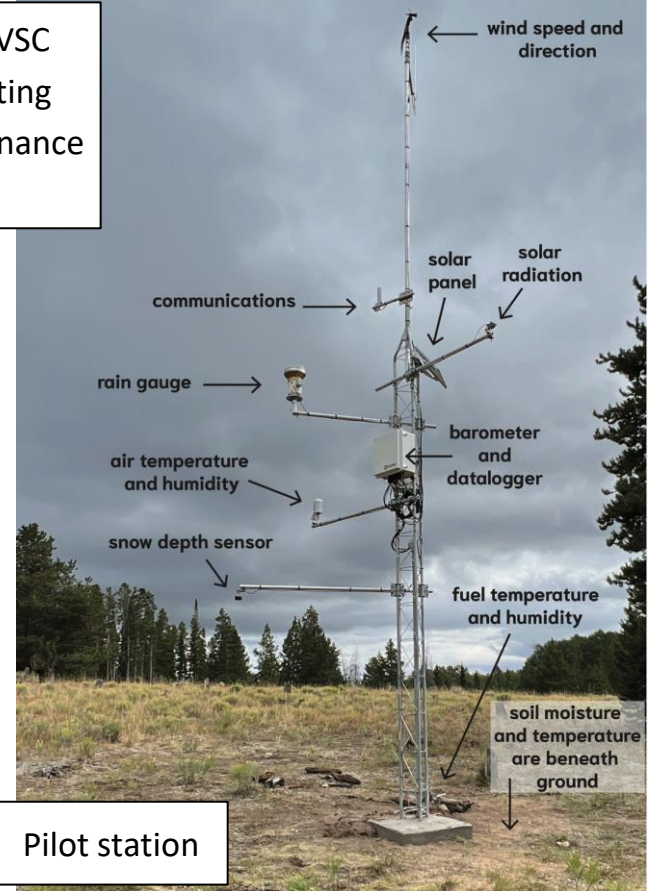
15-minute data

- Snow Depth

CW3E and YVSC
staff conducting
station maintenance
in 2023



Soil pit



Pilot station

Project Partnerships

- Colorado Basin River Forecast Center (CBRFC)
- Aspen Global Change Institute (AGCI)
- United States Forest Service (USFS)
- USDA- National Resources Conservation Service (NRCS)

CW3E/YVSC/CMC research intern conducting fieldwork in 2022



AGCI and YVSC staff visiting iRON site in 2021

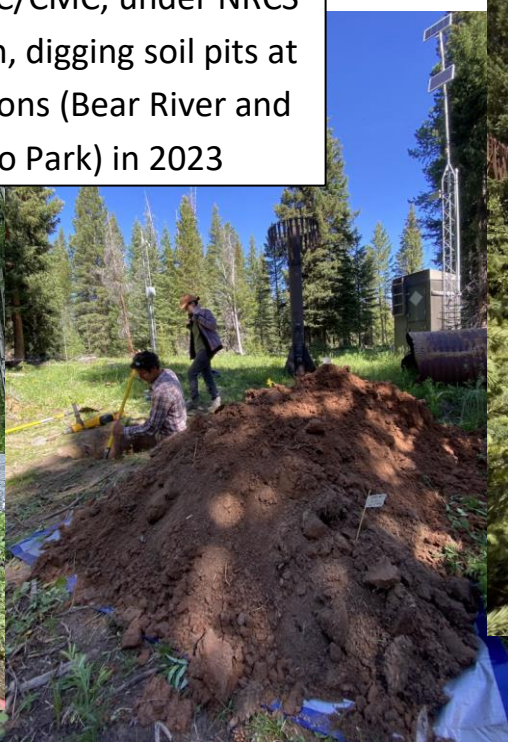


CW3E, YVSC, CMC, and NRCS staff at a SNOTEL site in 2023



USDA-NRCS Soil Pits

CW3E/YVSC/CMC, under NRCS supervision, digging soil pits at NRCS stations (Bear River and Buffalo Park) in 2023



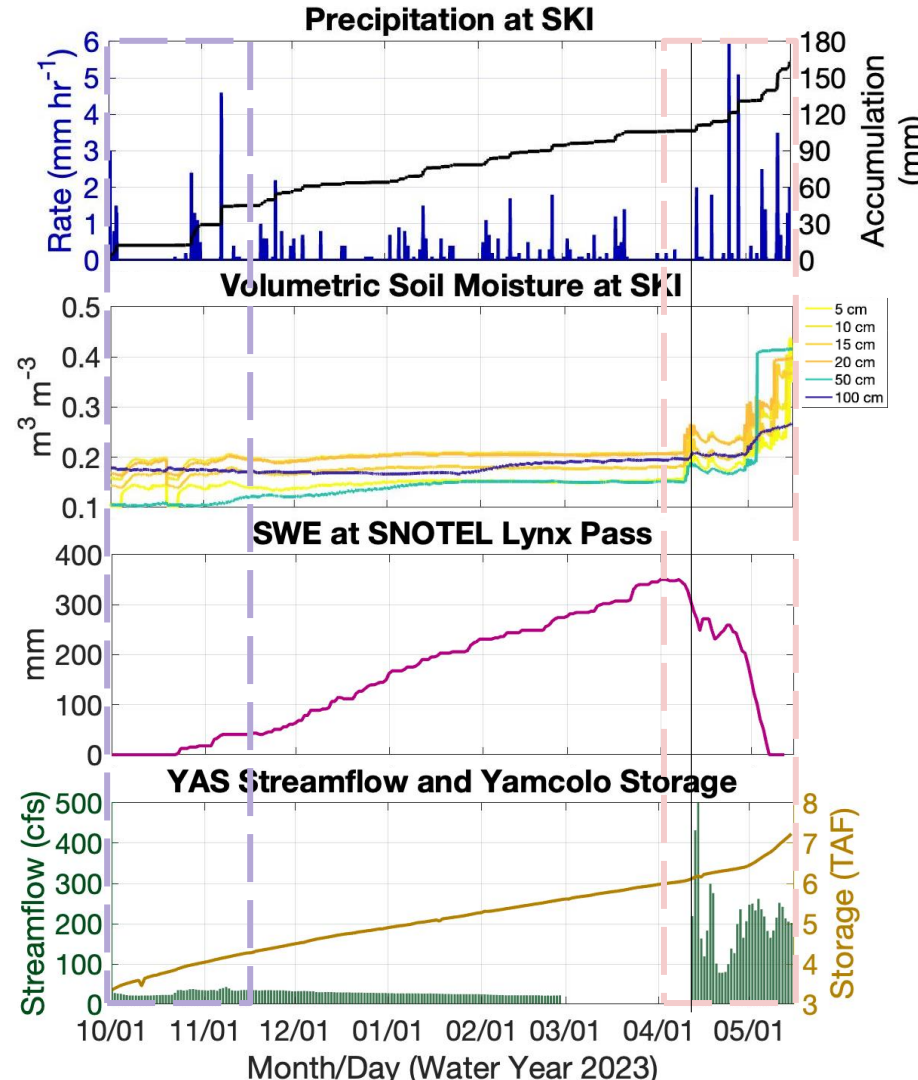
SKI: Observations in Water Year 2023

Fall wet-up period

- Initial soil moisture wet-up at 10-cm depth in Oct and at 50-cm depth in early Nov.
- Snow accumulation in early Nov at nearby SNOTEL Lynx Pass.

Spring snowmelt period

- Apparent snowmelt (SWE decrease) Apr-May.
- Soil moisture upticks across depths.
- Rapid streamflow and reservoir storage increases.



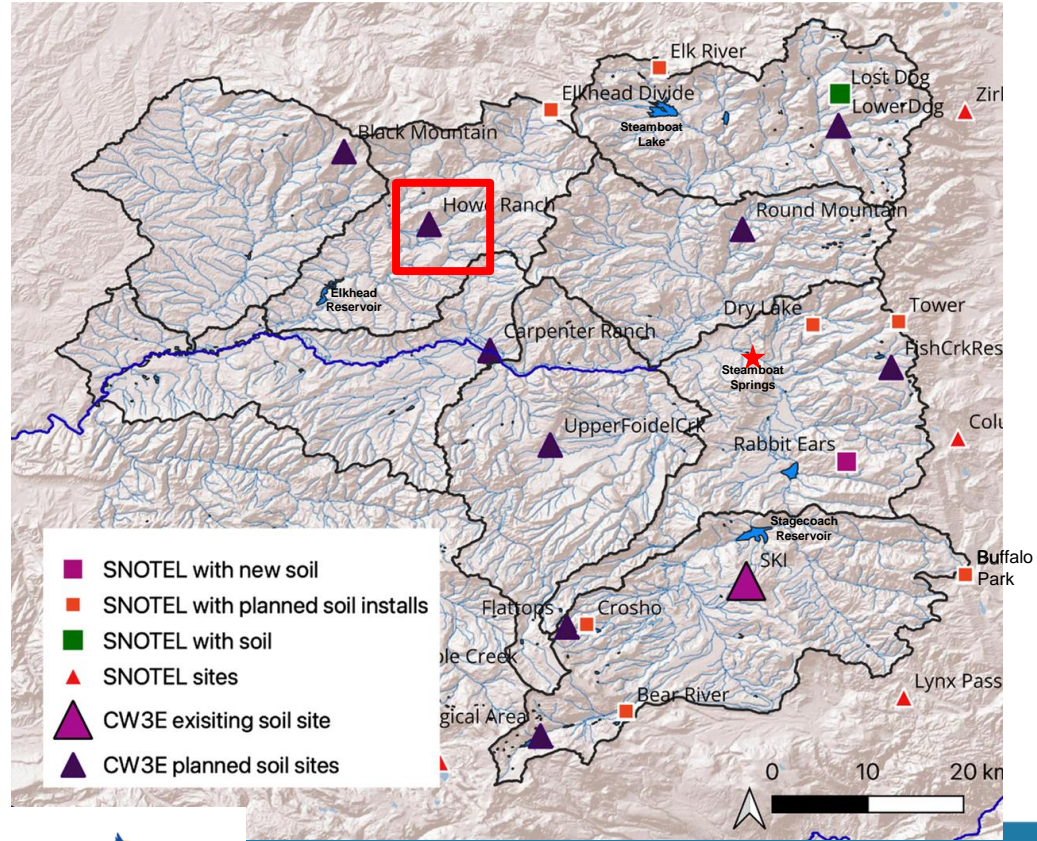
Station Installation Status - 2023

USDA-NRCS: SNOTEL

- Rabbit Ears SNOTEL - soil stack installed June 2023
- Additional soil stacks added at SNOTELs next summer.

CW3E/YVSC/CMC Sites

- One-two stations installed this coming week (Nov 2023)
- 6-7 stations to be installed summer 2024 – scouting with USFS complete



Summary – Next Steps

Installation and Data Utility

- One station available in NRT on CW3E website, MesoWest, NOAA PSL, MADIS
- Continuing analysis for the upcoming water year

Coordination with other networks

- Dashboards -> including one in prep with Upper Yampa
- iRON (AGCI), SNOTEL (USDA-NRCS)
- Explore connections via other events in the region

CW3E scientists prepare to launch a radiosonde at the Yampa Youth Water Festival in 2023



Community members at a field trip to Mt Werner Water during the Yampa Basin Rendezvous in 2023

