Mountain Hydrology LLC

Holistic Research to Support Resilient Water Management

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2024 Wind River Range Water Supply Forecasting: June 2024

Mountain Hydrology LLC presents the 2024 delivery of Wind River Range remotely sensed snow data and experimental seasonal water supply forecasts as part of the Bureau of Reclamation's Snow Water Supply Forecasting Project.

A key component of this project is the collection of airborne lidar data by Airborne Snow Observatories, Inc. (ASO) and snow density field measurements by Mountain Hydrology to estimate full-watershed snowpack storage at 3 meter spatial resolution. The first of three annual full-watershed snow water equivalent (SWE) maps is presented below. These data are assimilated into a physical water supply forecasting model, DHSVM-WSF (refer to supplementary setup materials) to generate probabilistic runoff forecasts. This report discusses the snowpack survey and runoff forecasting results.

Best, Eli Boardman
Chief Scientist and Founder, Mountain Hydrology LLC

Delivered: 10 p.m. MDT June 5th, 2024; updated 10 a.m. MDT June 7th

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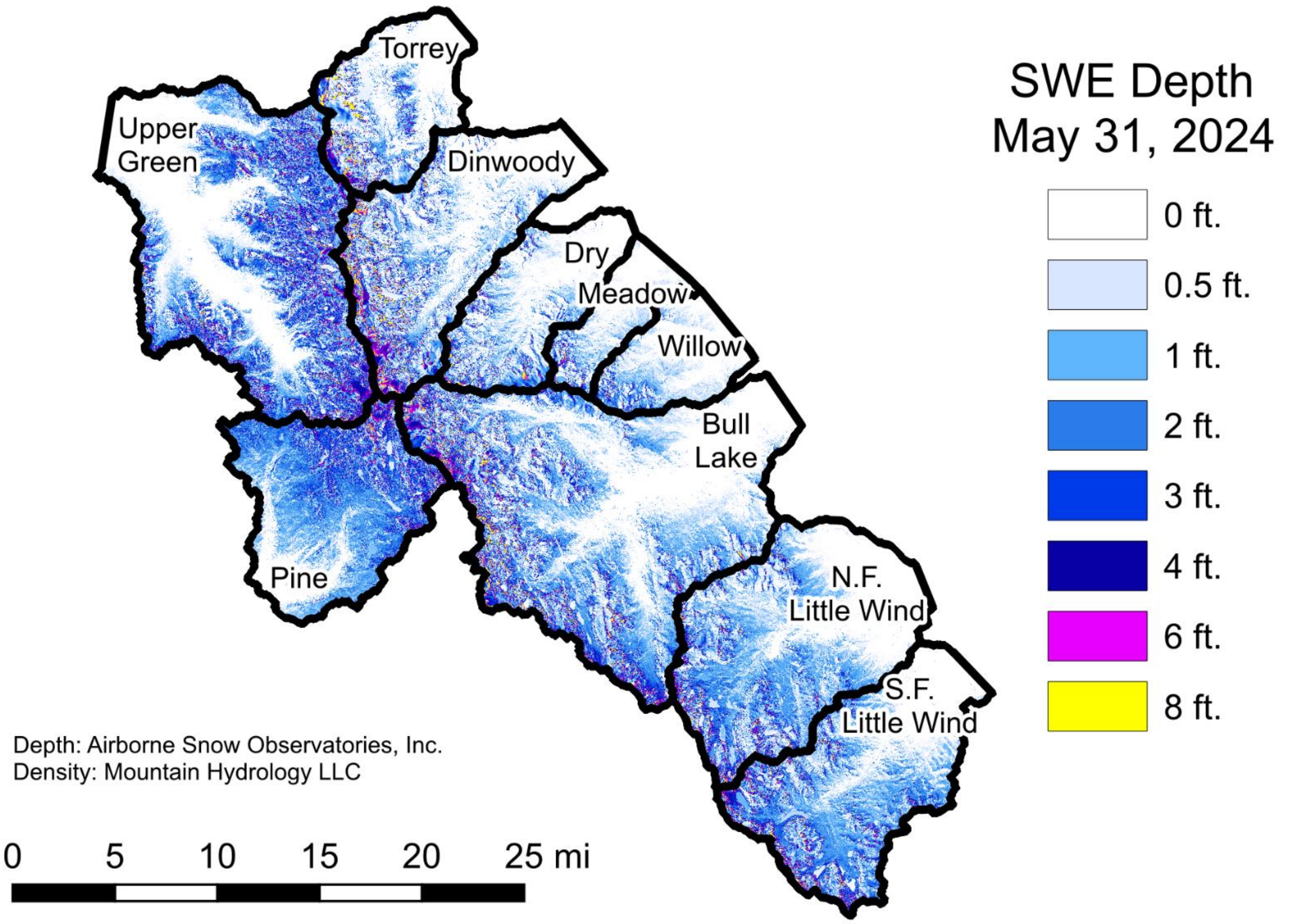


Note: ASO's official version of the snow depth map can be found at https://data.airbornesnowobservatories.com/.

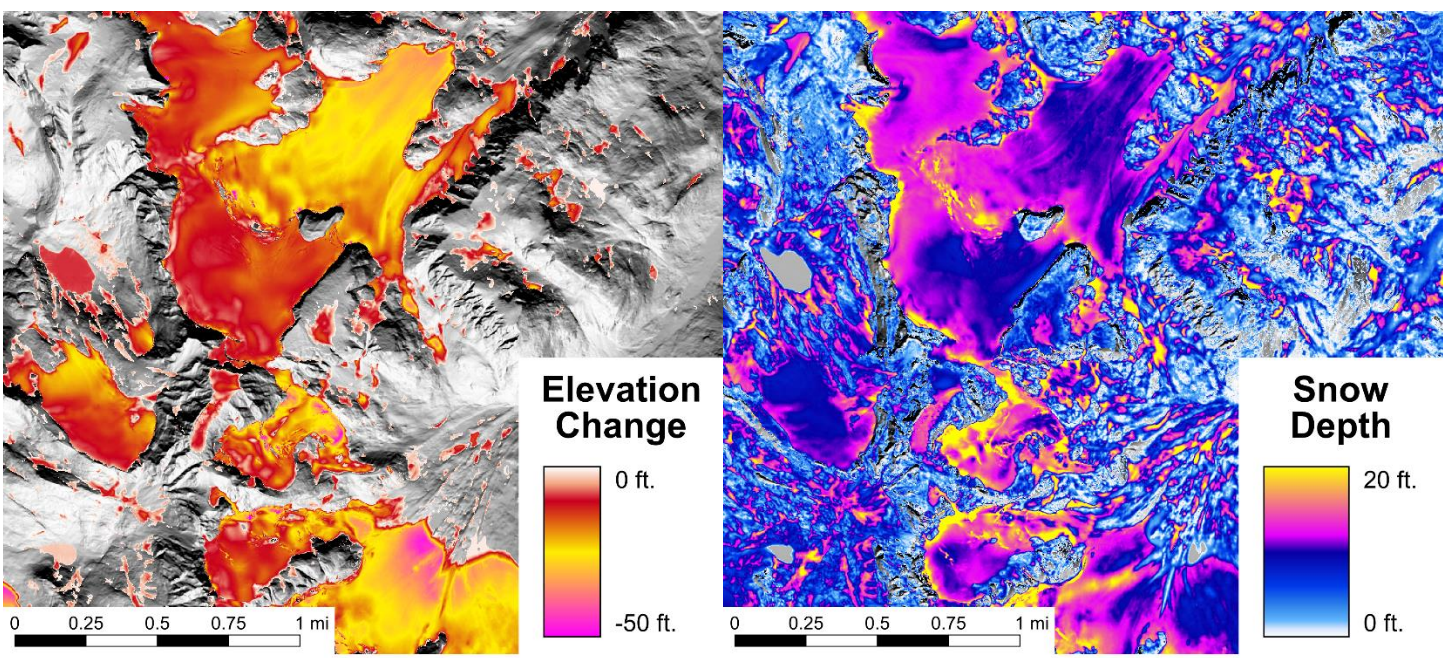
Snow Depth Survey

Mountain Hydrology contracted with Airborne Snow Observatories, Inc. (ASO) to obtain high resolution lidar-based snow depth maps for 8 key sub-watersheds in the Wind River Range. The survey was targeted for late May or early June based on local knowledge of snowmelt runoff timing and communication with managers, who noted that the SNOTELs typically melt out around late May, thus causing water management decisions to be made “in the dark.” This year, a single day of clear sunny weather permitted a perfectly timed ASO aerial acquisition on May 31st, 2024. The ASO team processed the data and delivered a 3 m snow depth map in the afternoon of June 4th.

One key improvement to the snow depth survey compared to the previous 2022 ASO flight is the inclusion of updated topographic data over persistent snowfields and glaciers, which are rapidly melting and changing elevation. Previously, the ablation of glaciers between 2019 (USGS lidar acquisition) and 2022 (first ASO acquisition) caused negative snow depths in most glaciated areas, which were masked to zero or imputed. Thanks to a generous in-kind commitment by ASO to help acquire updated glacier lidar data in October of 2023, this year the snow-off topography was freshly updated and the snow depth measurements on top of the glaciers were meaningful.

Another change compared to 2022 relates to the treatment of high altitude alpine lakes. ASO typically marks lakes as “no-data” in the snow depth maps, but in the Wind River Range, most of the lakes are small and are observed to only undergo minimal changes in water elevation (based on backcountry experience). Furthermore, deep snow can accumulate on top of the lakes. ASO graciously provided Mountain Hydrology with a pre-lake-mask snow depth product which was manually filtered by Mountain Hydrology using field knowledge to discriminate real snow accumulation from spurious elevation changes. The SWE data used hereafter make use of the unmasked dataset, but the official ASO version-of-record is the lake-masked map available from https://data.airbornesnowobservatories.com/.

Additional information on the ASO survey can be found in the ASO report available from the portal linked above.



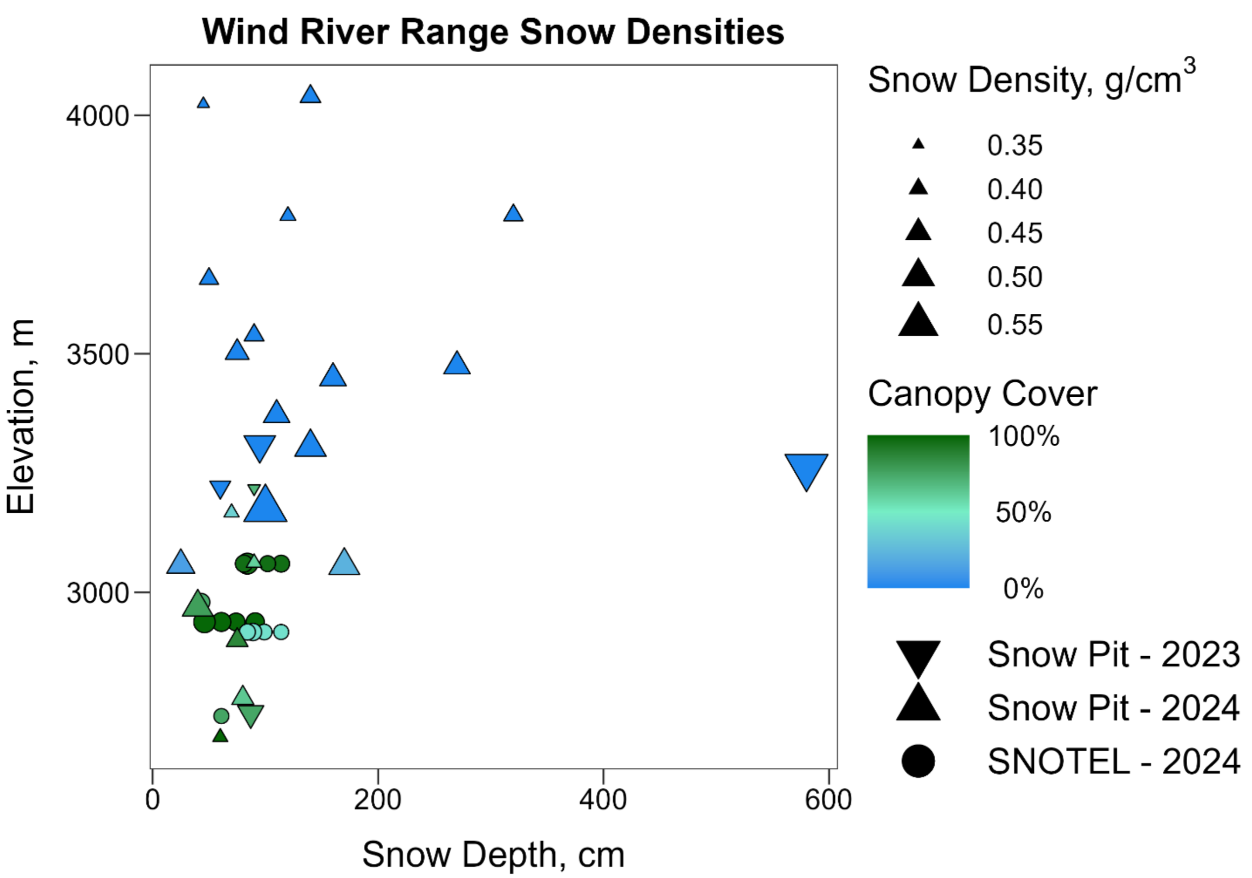
Glacier Ablation (2023 - 2019) **Seasonal Snow (May 31, 2024)**

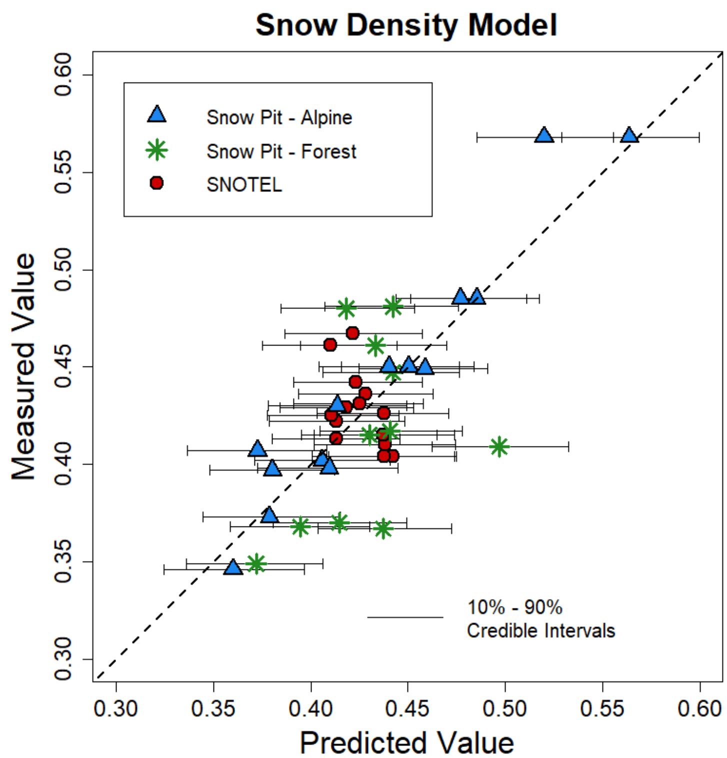
Snow Density Survey

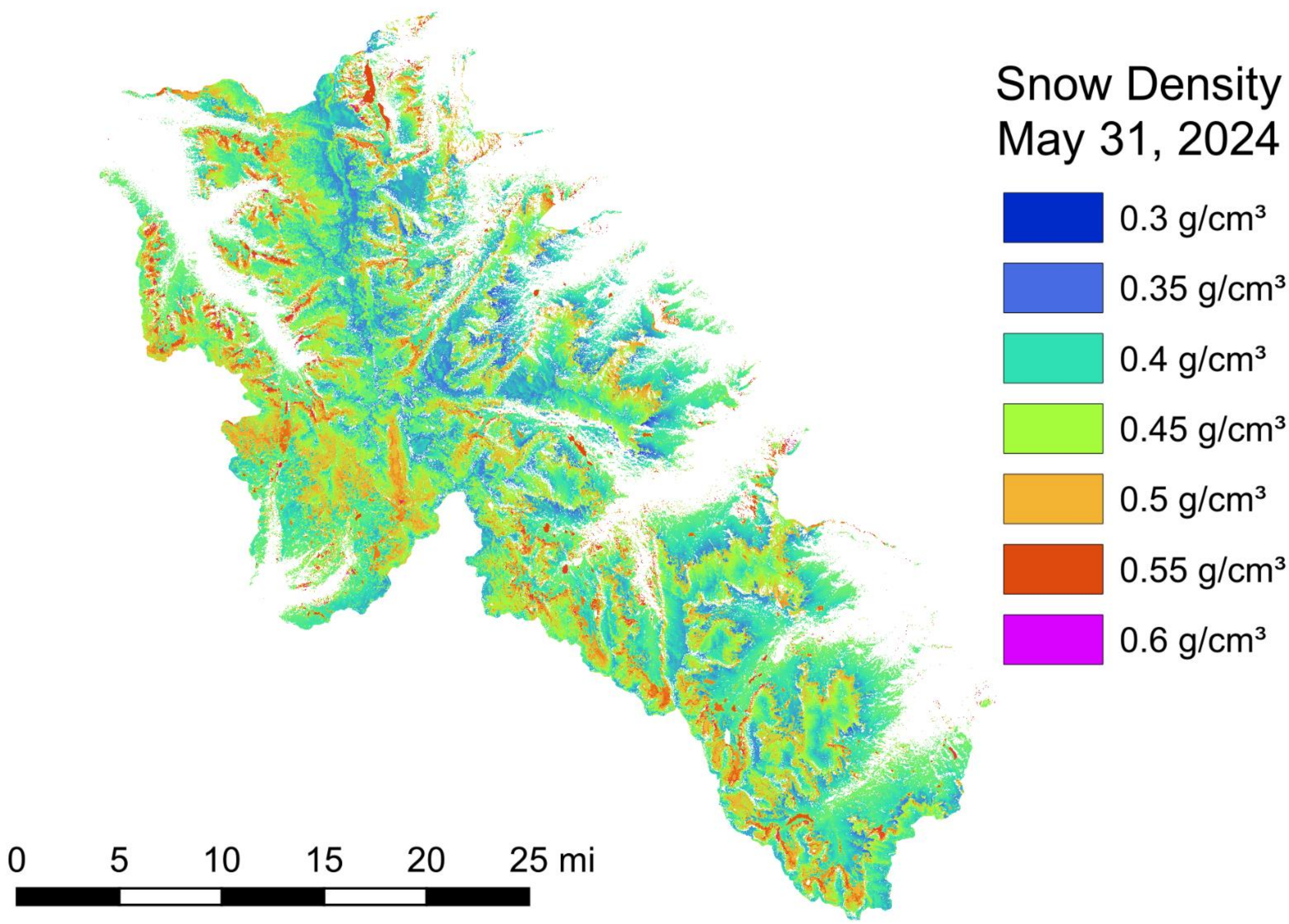
To estimate how much total water is stored in the snowpack, Mountain Hydrology collaborated with the University of Nevada, Reno, to organize a field crew to measure snow pit density profiles that can be used to constrain density variations across the landscape. The snow pits measurements funded by this project were located on the Wind River Indian Reservation by permission of the Office of the Tribal Water Engineer.

A total of 20 snow pit profiles were available from the current year (within a few days before, during, and after the ASO flight), with an addition 8 snow pit profiles from the same time of year in 2023. Three of the 2023 snow pits were determined to be inconsistent with current observations due to variations in the isothermal snowpack ripening elevation between years, so those older snow pit observations were excluded from further modeling. Thus, a total of 25 snow pit profiles were available to constrain densities from below 9,000 ft. to above 13,000 ft. and from just over 1 ft. of snow depth to more than 19 ft. of snow depth in deep drifts, including several major pits (8-10.5 ft. deep) at high elevations (11,500-12,500 ft.) and numerous pits in the forest. Finally, an additional 14 measurements from 5 total SNOTEL sites (NRCS site numbers 525, 923, 822, 944, 775) were obtained for the week leading up to the ASO flight. Observed heterogeneity in bulk (vertically integrated) snow density varied from 0.346 g/cm^3 in the shallow, high-elevation snowpack to 0.568 g/cm^3 in deep drifts at lower elevations. Snow in the forest was generally lighter.

Using the total of 39 snow density measurements, Mountain Hydrology constructed a Bayesian regression model as a function of elevation, snow depth, and canopy cover, which explained 93% of variability in above-treeline snow density variation and achieved a root-mean-square-error of 0.03 g/cm^3. This model was used to infer snow density across the ASO flight domain with the same variables. The resultant snow density map has a mean of 0.43 g/cm^3 with standard deviation of 0.04 g/cm^3. Multiplying the 3 meter density map by the 3 meter depth map produces a spatially complete estimate of snow water equivalent (SWE), as shown on the cover page.




Snow Density Model
Snow Pit - Alpine
Snow Pit - Forest
SNOTEL
10% - 90%
Credible Intervals
Measured Value
Predicted Value
0.30
0.35
0.40
0.45
0.50
0.55
0.60


Snow Density
May 31, 2024
0.3 g/cm³
0.35 g/cm³
0.4 g/cm³
0.45 g/cm³
0.5 g/cm³
0.55 g/cm³
0.6 g/cm³
0
5
10
15
20
25 mi

SWE Map Results

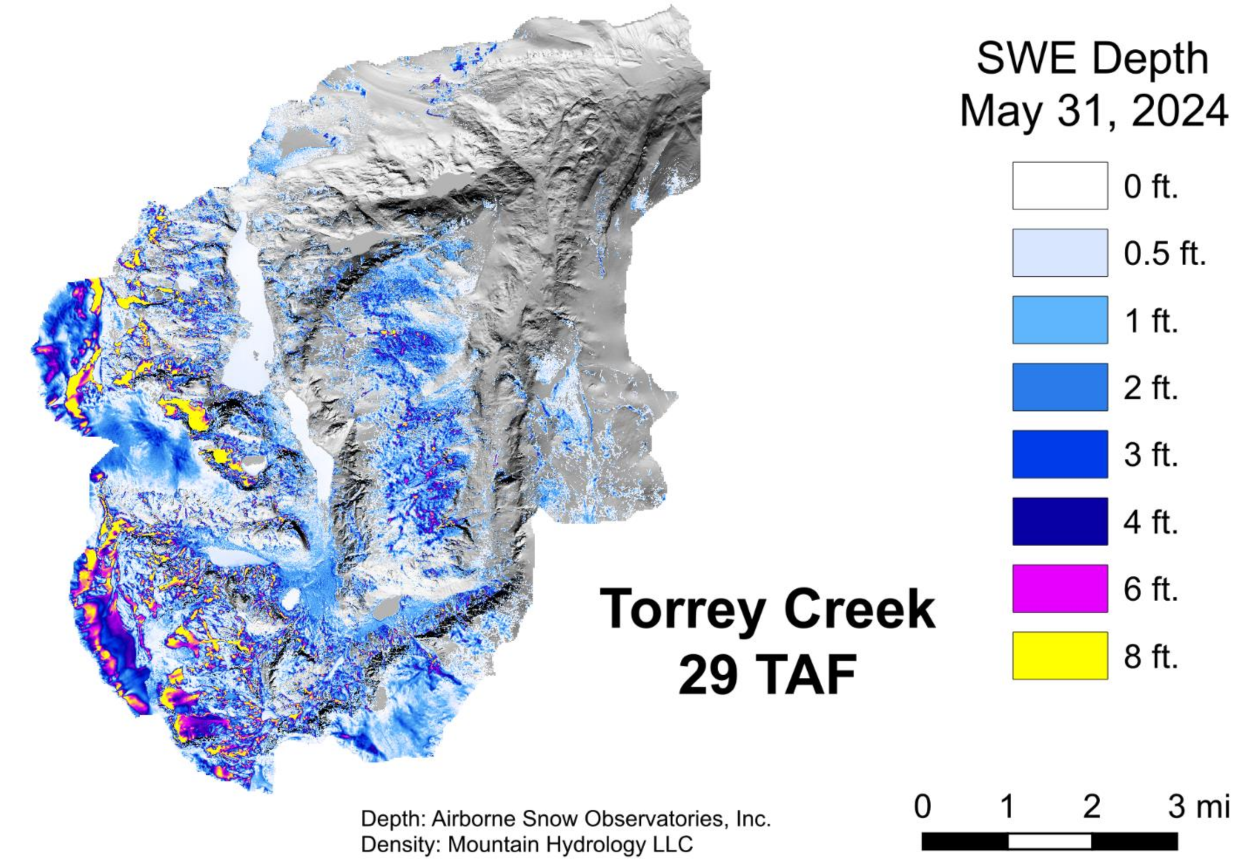
Across the 2,200 km^2 (850 mi^2) survey domain, the total SWE volume was 618,665 acre-ft. (619 TAF) of liquid water equivalent. The area-averaged mean SWE depth was 35 cm (1.1 ft.), with a 90th percentile of 96 cm (3.1 ft.) and a 99th percentile of 234 cm (7.7 ft.) at 3 meter horizontal resolution.

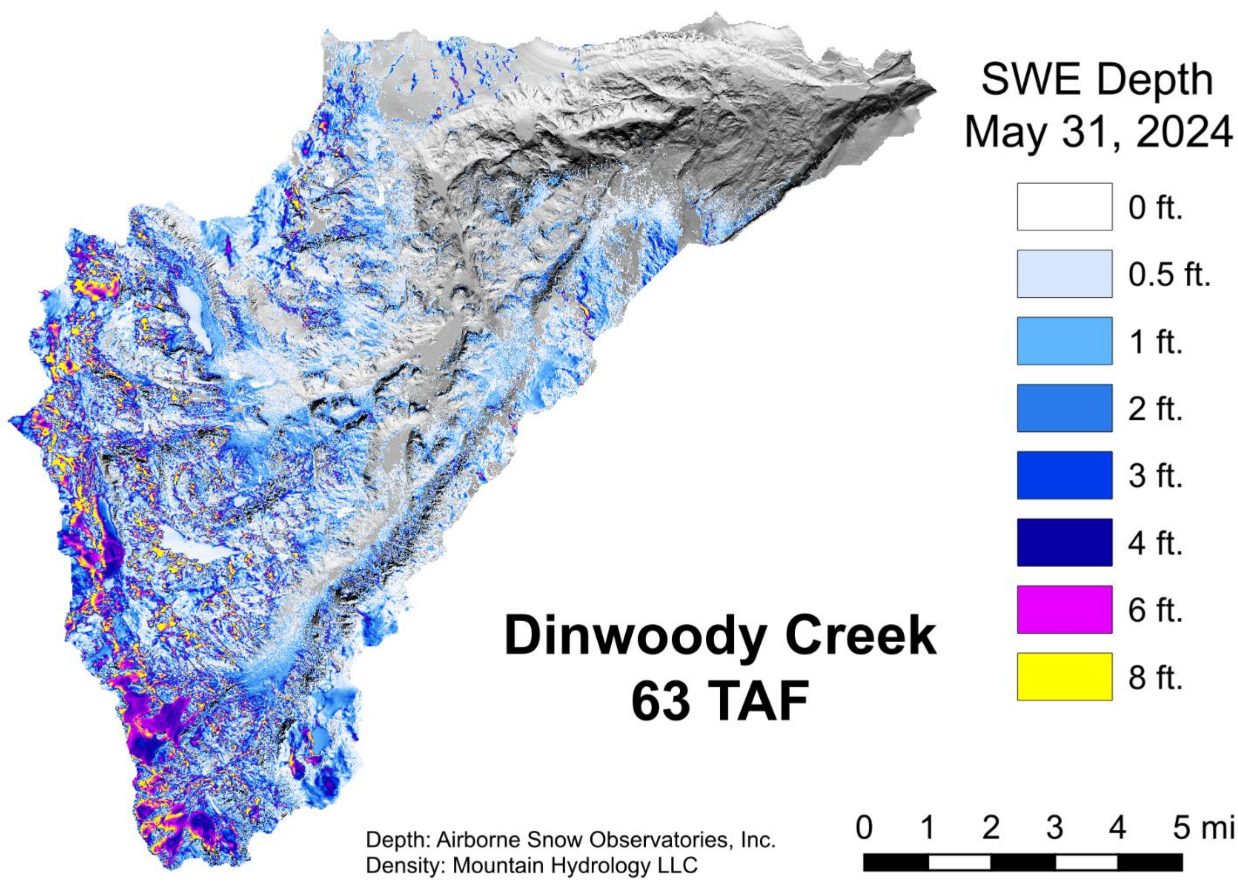
The following table gives estimated SWE volumes and area-averaged SWE depths for each sub-watershed:

Watershed	Airborne Snow Survey Date	SWE Volume	Mean SWE Depth
Torrey Creek	May 31, 2024	29 TAF	29 cm (0.95 ft.)
Dinwoody Creek	May 31, 2024	63 TAF	31 cm (1.02 ft.)
Dry Creek	May 31, 2024	22 TAF	19 cm (0.62 ft.)
Meadow Creek	May 31, 2024	7 TAF	8 cm (0.26 ft.)
Willow Creek	May 31, 2024	9 TAF	8 cm (0.26 ft.)
Bull Lake Creek	May 31, 2024	133 TAF	30 cm (0.98 ft.)
N.F. Little Wind R.	May 31, 2024	64 TAF	27 cm (0.89 ft.)
S.F. Little Wind R.	May 31, 2024	65 TAF	35 cm (1.15 ft.)
Upper Green River	May 31, 2024	135 TAF (At Roaring Fork confluence)	42 cm (1.38 ft.) (At Roaring Fork confluence)
Pine Creek	May 31, 2024	76 TAF	47 cm (1.54 ft.)

Note that the area-averaged SWE depths are affected by the position of stream gages, reservoirs, etc., since a larger low-elevation snow-free area will reduce the apparent mean SWE depth for a given watershed. Thus, the SWE volumes are more indicative of the amount of snow stored in a particular watershed.

Note also that the sum of sub-watershed SWE volumes is less than the total surveyed SWE volume because the total survey area extends slightly beyond the bounds of each watershed.


SWE Depth
May 31, 2024
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Torrey Creek
29 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0
1
2
3 mi


SWE Depth
May 31, 2024
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Dinwoody Creek
63 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0
1
2
3
4
5 mi

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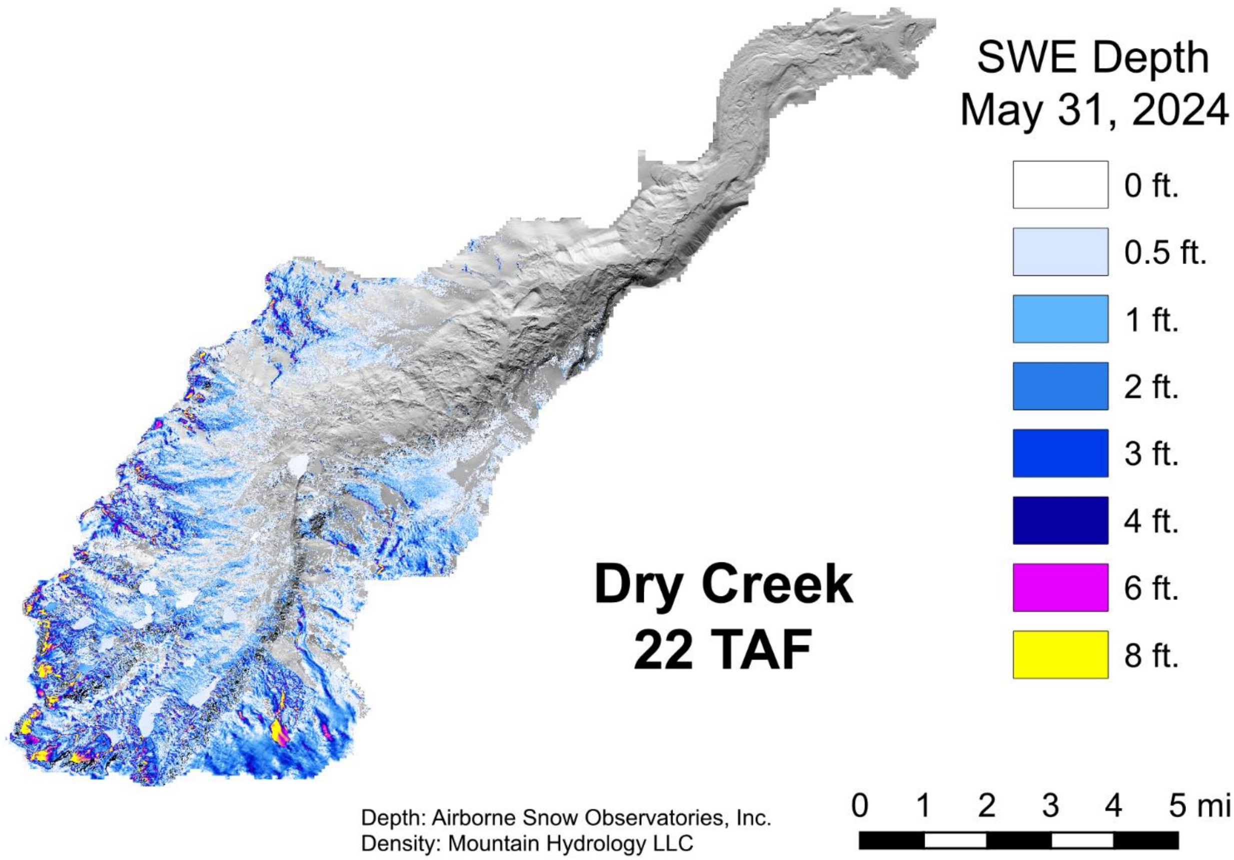
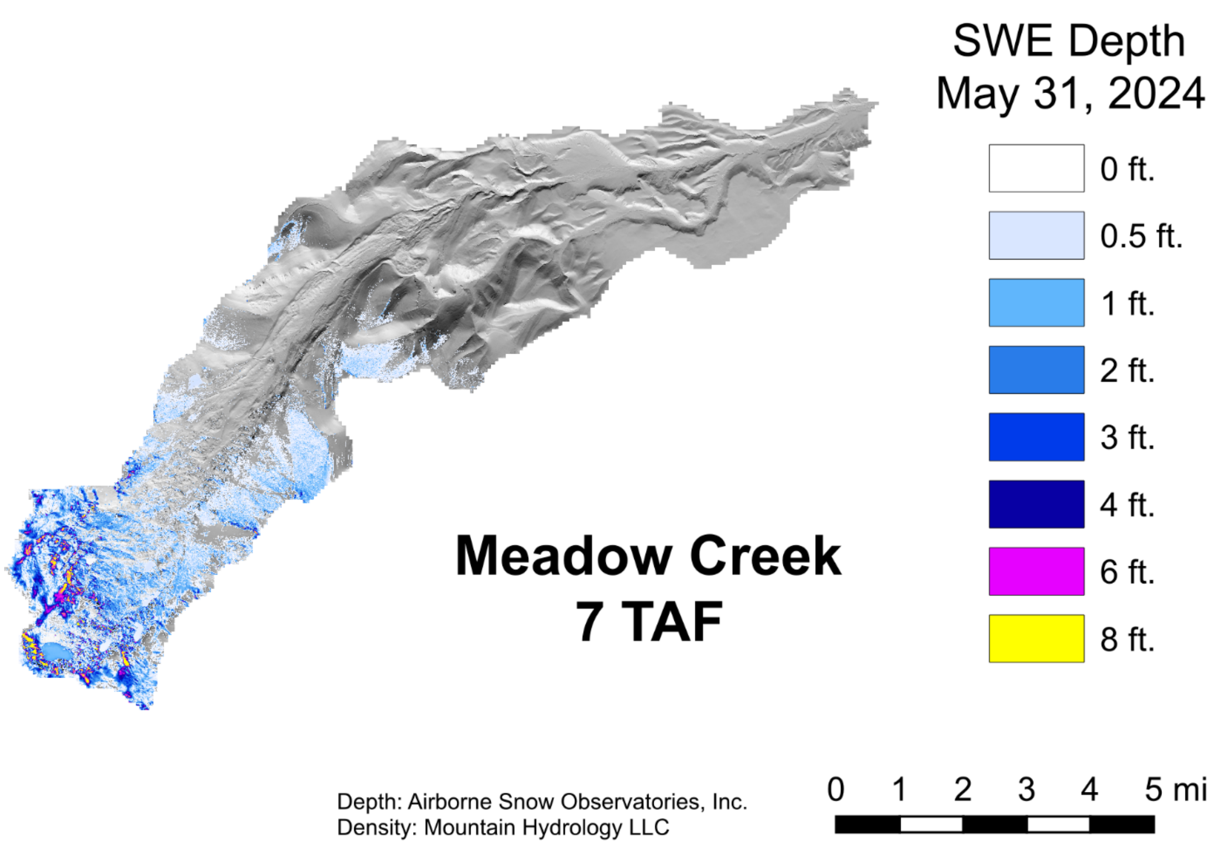
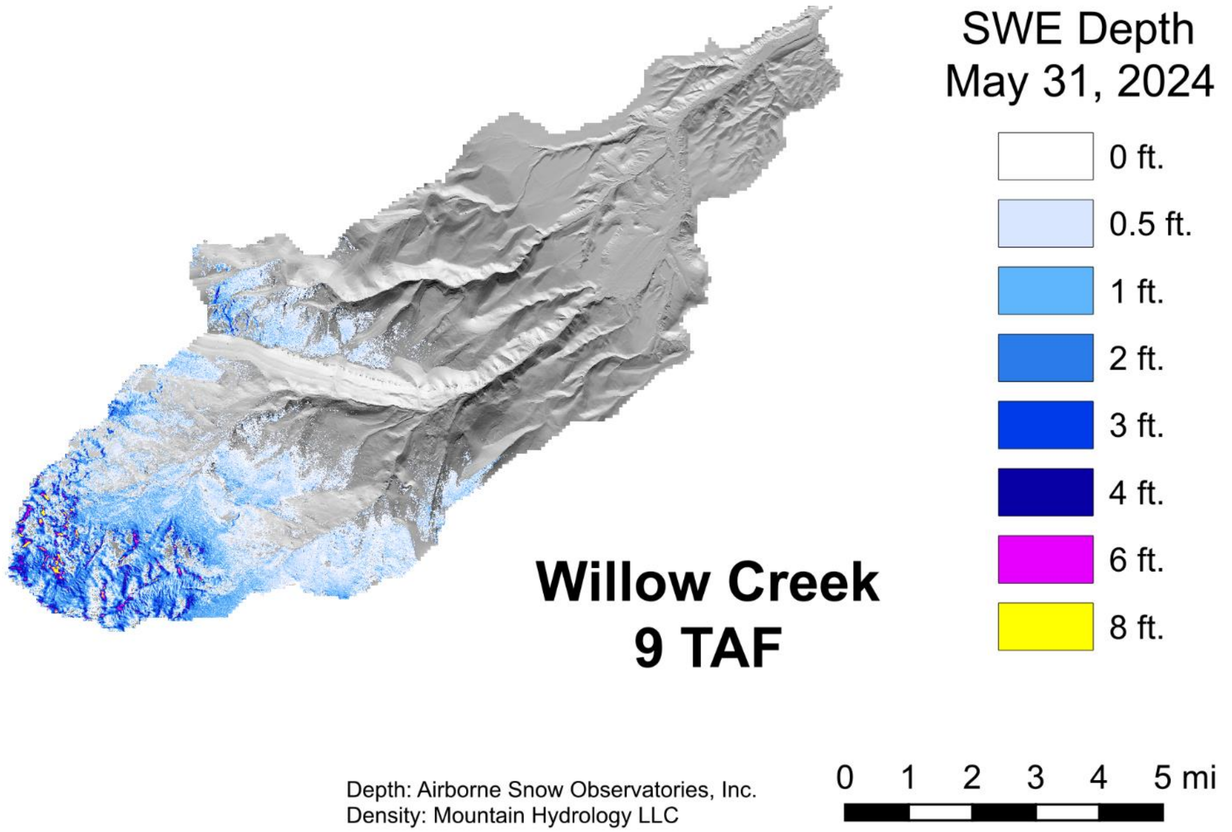
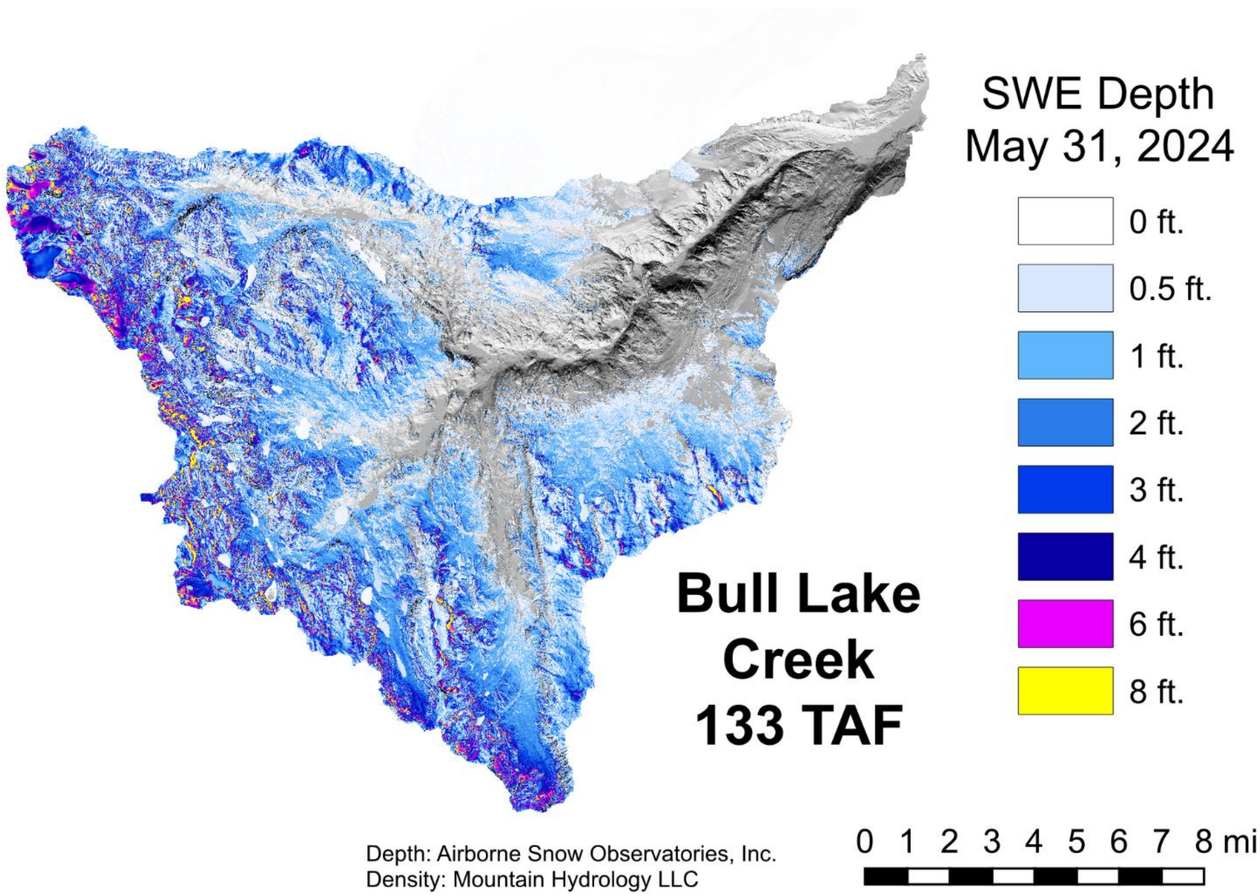
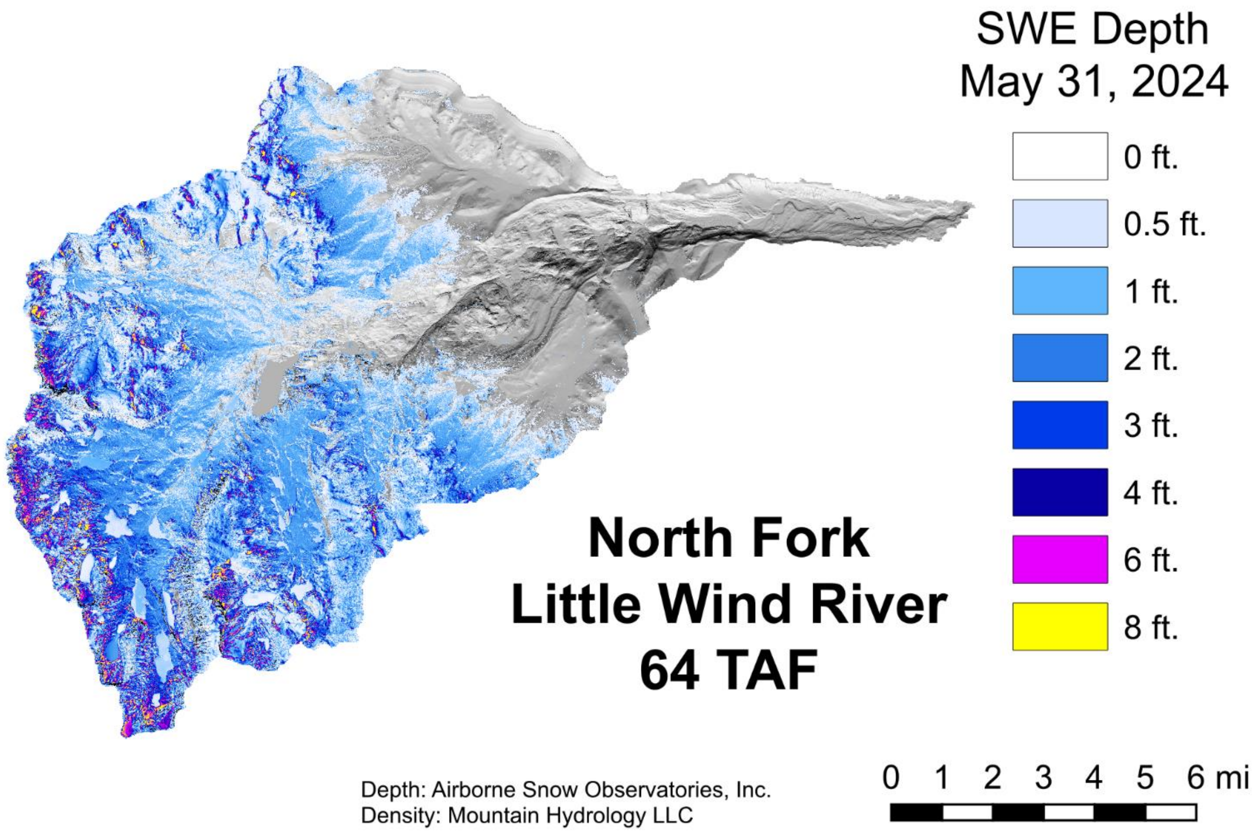
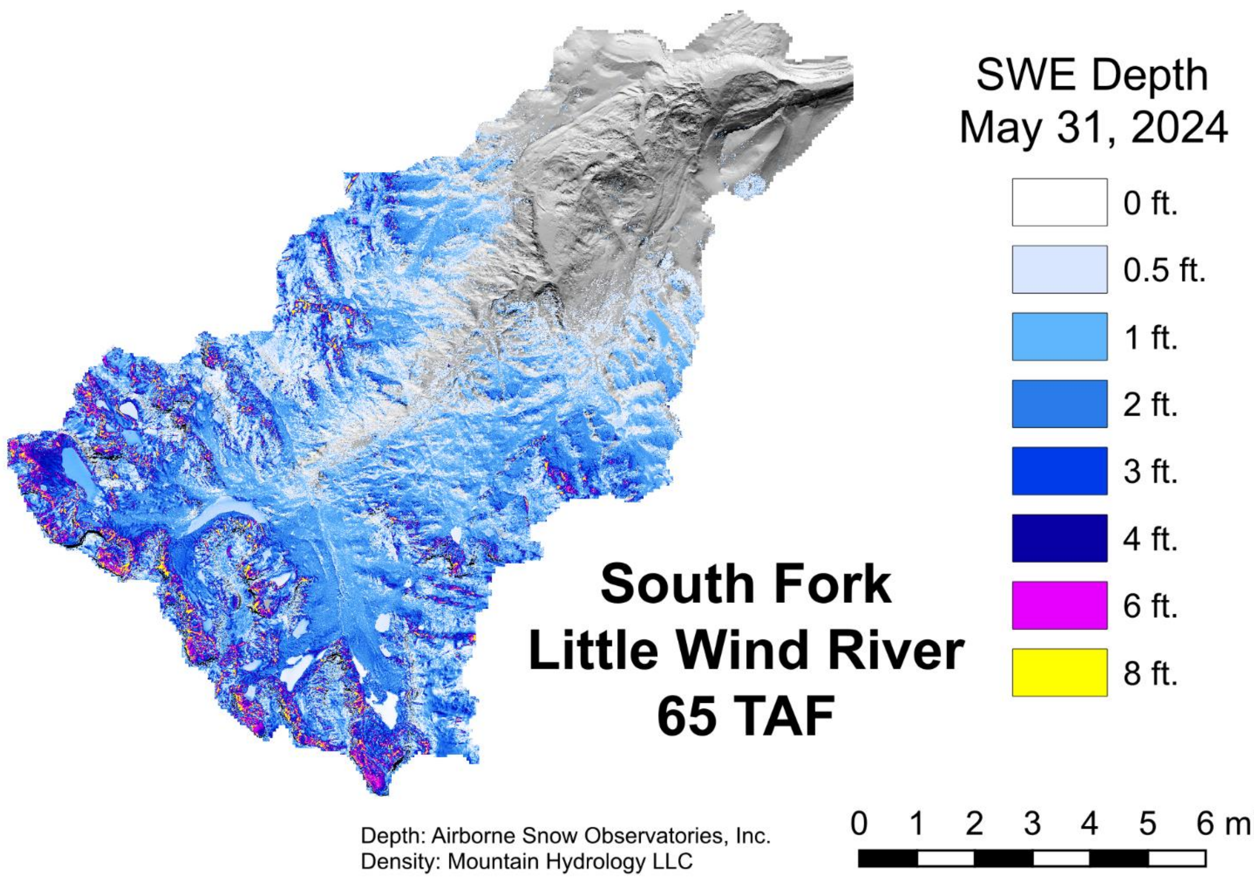





SWE Depth
May 31, 2024
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Willow Creek
9 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 mi


SWE Depth
May 31, 2024
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
Bull Lake
Creek
133 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 6 7 8 mi


SWE Depth
May 31, 2024
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
North Fork
Little Wind River
64 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 6 mi


SWE Depth
May 31, 2024
0 ft.
0.5 ft.
1 ft.
2 ft.
3 ft.
4 ft.
6 ft.
8 ft.
South Fork
Little Wind River
65 TAF
Depth: Airborne Snow Observatories, Inc.
Density: Mountain Hydrology LLC
0 1 2 3 4 5 6 mi

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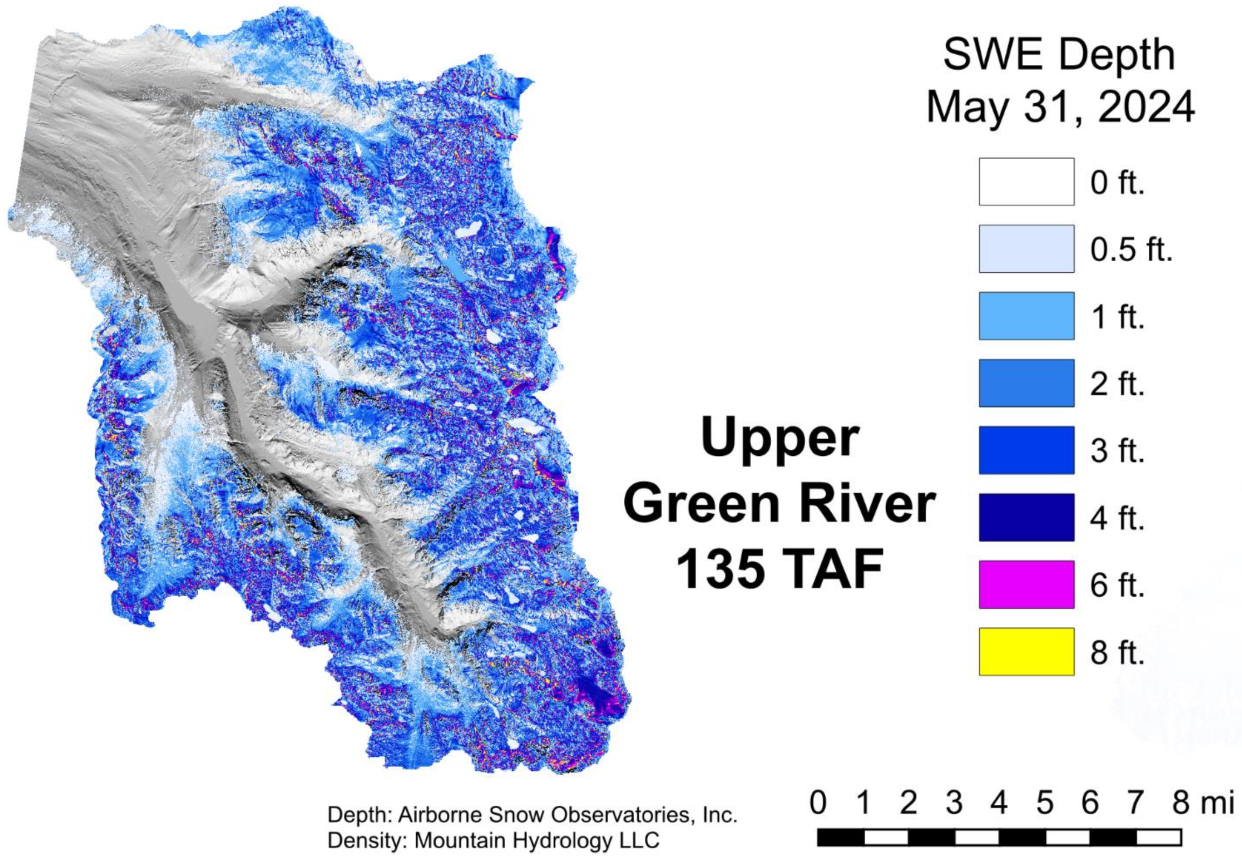
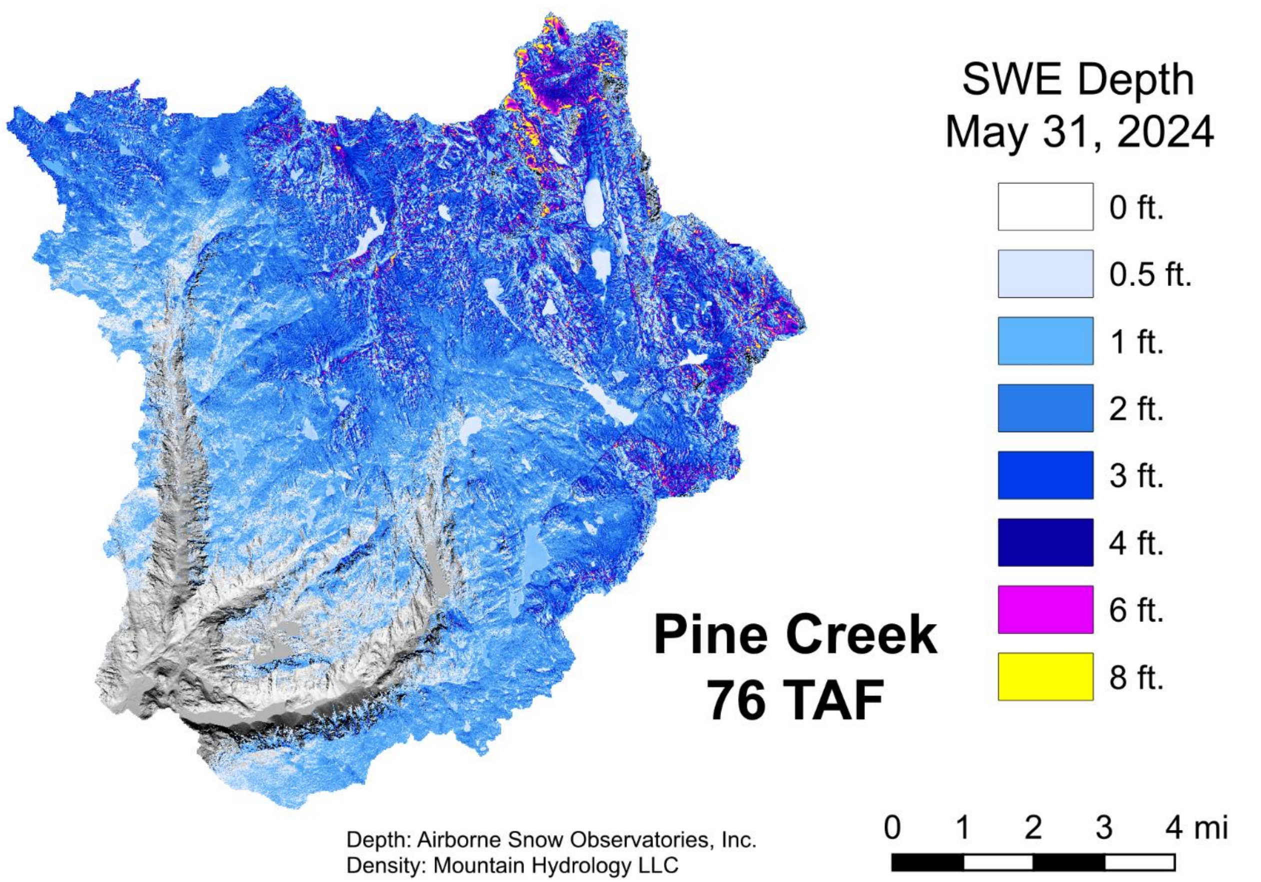




DHSVM-WSF Forecast Summary

The 3 meter SWE map captures the snowpack water storage and distribution on a particular date, but additional variables like evapotranspiration and groundwater are also important for predicting runoff. The SWE data are aggregated to 90 m resolution and assimilated into the DHSVM-WSF hydrological model using a process-based assimilation method (c.f. Western Snow Conference proceedings, 2024). Water supply forecasts are generated using a Bayesian ensemble of multiple models with 30-day subseasonal weather forecasts and 40 years of historical climatology (refer to DHSVM-WSF white paper for details: https://mountainhydrology.com/mh001_dhsvm-wsf/.

All forecasts listed below are for the June-September forecast period (inclusive), with issue date June 5th, 2024.

Watershed	Forecast Point	Airborne Snow Survey Date	Snowpack Water Storage	Runoff: 90% Exceedance	Runoff: 50% Exceedance	Runoff: 10% Exceedance
Torrey Creek	Gage (Private)	May 31, 2024	29 TAF	35 TAF	38 TAF	42 TAF
Dinwoody Creek	Gage USGS 06221400	May 31, 2024	63 TAF	74 TAF	88 TAF	104 TAF
Dry Creek	Canal USGS 06222500	May 31, 2024	22 TAF	15 TAF	22 TAF	29 TAF
Meadow Creek	Canal USGS 06223000	May 31, 2024	7 TAF	4 TAF	7 TAF	9 TAF
Willow Creek	Canal USGS 06223500	May 31, 2024	9 TAF	4 TAF	7 TAF	10 TAF
Bull Lake Creek	Reservoir USGS 06224000	May 31, 2024	133 TAF	128 TAF	156 TAF	185 TAF
N.F. Little Wind R.	Gage USGS 06228800	May 31, 2024	64 TAF	58 TAF	73 TAF	88 TAF
S.F. Little Wind R.	Reservoir USGS 06228350	May 31, 2024	65 TAF	50 TAF	67 TAF	86 TAF
Upper Green River	Gage USGS 09188500	May 31, 2024	135 TAF (At Roaring Fork confluence)	172 TAF (At Gage)	203 TAF (At Gage)	236 TAF (At Gage)
Pine Creek	Gage USGS 09196500	May 31, 2024	76 TAF	76 TAF	90 TAF	105 TAF

An exceedance probability of X% indicates that on average over many years, there is roughly an X% chance that the actual volumetric water supply in any particular year will be larger than the forecast exceedance value.

DHSVM-WSF Forecasts: Historical Comparison

For contextual interpretation, current forecasts for several key watersheds are shown here in a relative ranking with the most recent decade of observed runoff volumes:

Dinwoody Creek		
Water Year	**Water Yield (June – September)**	**Value Type**
2021	72 TAF	Historical
2016	73 TAF	Historical
2024	74 TAF	Forecast – 90% Exceedance
2022	81 TAF	Historical
2018	84 TAF	Historical
2015	85 TAF	Historical
2020	87 TAF	Historical
2014	87 TAF	Historical
2024	88 TAF	Forecast – 50% Exceedance
2019	90 TAF	Historical
2023	93 TAF	Historical
2024	104 TAF	Forecast – 10% Exceedance
2017	126 TAF	Historical

Bull Lake Creek		
Water Year	**Water Yield (June – September)**	**Value Type**
2021	120 TAF	Historical
2020	125 TAF	Historical
2016	127 TAF	Historical
2024	128 TAF	Forecast – 90% Exceedance
2015	133 TAF	Historical
2022	146 TAF	Historical
2014	154 TAF	Historical
2024	156 TAF	Forecast – 50% Exceedance
2018	157 TAF	Historical
2019	172 TAF	Historical
2023	182 TAF	Historical
2024	190 TAF	Forecast – 10% Exceedance
2017	285 TAF	Historical

DHSVM-WSF Forecasts: Historical Comparison

South Fork Little Wind River		
Water Year	**Water Yield (June – September)**	**Value Type**
2020	39 TAF	Historical
2021	44 TAF	Historical
2015	49 TAF	Historical
2024	50 TAF	Forecast – 90% Exceedance
2018	58 TAF	Historical
2022	59 TAF	Historical
2016	65 TAF	Historical
2024	67 TAF	Forecast – 50% Exceedance
2023	78 TAF	Historical
2019	79 TAF	Historical
2024	86 TAF	Forecast – 10% Exceedance
2017	129 TAF	Historical

Upper Green River		
Water Year	**Water Yield (June – September)**	**Value Type**
2021	146 TAF	Historical
2016	155 TAF	Historical
2024	172 TAF	Forecast – 90% Exceedance
2015	180 TAF	Historical
2022	185 TAF	Historical
2024	203 TAF	Forecast – 50% Exceedance
2020	208 TAF	Historical
2023	218 TAF	Historical
2019	224 TAF	Historical
2024	236 TAF	Forecast – 10% Exceedance
2018	248 TAF	Historical
2014	303 TAF	Historical
2017	414 TAF	Historical

DHSVM-WSF Forecasts: Monthly

Runoff timing is more uncertain than total runoff volume, but monthly values are given here for key watersheds:

Watershed	Month	Runoff: 90% Exceedance	Runoff: 50% Exceedance	Runoff: 10% Exceedance
Dinwoody Creek	June	28 TAF	34 TAF	41 TAF
Dinwoody Creek	July	24 TAF	30 TAF	36 TAF
Dinwoody Creek	August	12 TAF	15 TAF	20 TAF
Dinwoody Creek	September	6 TAF	8 TAF	12 TAF

Watershed	Month	Runoff: 90% Exceedance	Runoff: 50% Exceedance	Runoff: 10% Exceedance
Bull Lake Creek	June	70 TAF	86 TAF	104 TAF
Bull Lake Creek	July	33 TAF	43 TAF	54 TAF
Bull Lake Creek	August	11 TAF	15 TAF	22 TAF
Bull Lake Creek	September	7 TAF	10 TAF	15 TAF

Watershed	Month	Runoff: 90% Exceedance	Runoff: 50% Exceedance	Runoff: 10% Exceedance
South Fork Little Wind River	June	36 TAF	48 TAF	61 TAF
South Fork Little Wind River	July	7 TAF	12 TAF	20 TAF
South Fork Little Wind River	August	2 TAF	3 TAF	6 TAF
South Fork Little Wind River	September	2 TAF	3 TAF	4 TAF

Watershed	Month	Runoff: 90% Exceedance	Runoff: 50% Exceedance	Runoff: 10% Exceedance
Upper Green River	June	92 TAF	107 TAF	125 TAF
Upper Green River	July	46 TAF	61 TAF	76 TAF
Upper Green River	August	14 TAF	19 TAF	29 TAF
Upper Green River	September	9 TAF	15 TAF	20 TAF

DHSVM-WSF Forecast Analysis

Overall, there is still considerable snow storage in the Wind River mountains at the start of June 2024. Most SNOTEL sites are completely melted out, but these sites are not representative (they are concentrated at low elevations). Fieldwork has shown that snow above ~11,500 ft. is still below freezing, suggesting slower than normal melt potentially due to a cold May this year.

For Dinwoody Creek, June-September runoff fairly uncertain but centered in the middle of recent variability, i.e., wetter than the driest years (2016 and 2021, with 72 and 73 TAF respectively) and drier than the wettest year (2017, with 126 TAF). June runoff from Dinwoody is projected to be relatively high, with a median of 34 TAF that is higher than the June runoff in 5 of the past 10 years (2014, 2018, 2019, 2021, 2022). The Dinwoody watershed was still storing 63 TAF of water as snow at the beginning of June, and an additional 38 TAF of snow water storage (total) was present in the Dry Creek, Bob / Meadow Creek, and Willow Creek drainages.

For Bull Lake Reservoir, total summer inflow is expected to be at mid- to high-normal levels, neither approaching the drought end of 2021, 2020, and 2016 nor approaching the deluge of 2017. The Bull Lake Reservoir watershed was storing about 133 TAF of water as snow on May 31st, 2024, which is 86% of the 155 TAF reservoir storage capacity. Total June through September runoff is forecast to fall in the range of 128 to 185 TAF (90-10% exceedance levels), which is 83% to 119% of the reservoir storage capacity. The monthly June runoff forecast is clustered towards the top end of historical observations, with the 50% exceedance June inflow forecast of 86 TAF exceeding 8 out of the 10 past years (2017 and 2023 are the only wetter recent years, with 142 and 93 TAF of June inflow respectively). Nevertheless, the 90% forecast exceedance value for June inflow is below median at 70 TAF, with 8 of the last 10 years having more or less June inflow. This uncertainty is mostly a function of unknown snowmelt timing. The 10% exceedance forecast for June inflow is 104 TAF, which is still 27% lower than the very wet June 2017. Looking towards July, the forecast becomes relatively more uncertain, but overall trends towards median, with 3 of the past 10 years above the 10% exceedance value: the 90-10% exceedance levels are 33 to 54 TAF, and recent variability for July runoff is 24 TAF (2021) to 89 TAF (2017).

For Washakie Reservoir (South Fork Little Wind River), June-September runoff in the drought years of 2015, 2020, and 2021 was 49, 39, and 44 TAF respectively, compared to the 90% lower bound of 50 TAF of forecast runoff this year. The Washakie Reservoir watershed was still storing 65 TAF of water as snow at the beginning of June, and most of this water is projected to become streamflow in June. The June reservoir inflow is projected to be higher than the drought years of 2015 (35 TAF), 2020 (25 TAF), and 2021 (32 TAF), with a 90% lower bound of 36 TAF this year, although it could be almost as low as the 2015 inflow. The uncertainty in monthly inflow volumes is largely attributable to uncertainty in snowmelt and runoff timing—with warmer conditions, June runoff could approach the highest levels seen in the past decade (10% exceedance level of 61 TAF compared to maximum in past 10 years of 78 TAF in 2017). Depending on snowmelt timing and summer precipitation, late-summer reservoir inflows could be as low as 2020 or 2015 (~ 2 TAF in September) or as high as 2019 or 2023 (~3-4 TAF in September). In summary, snowpack storage is relatively high, with snow storage accounting for more than 800% of the Washakie Reservoir volume at the start of June (65 TAF of snow water storage in the South Fork Little Wind River, and 8 TAF capacity of Washakie Reservoir). Warm conditions are expected to cause the snow to melt relatively rapidly, leading to above-average June runoff. Late summer streamflow could still reach drought levels depending on summer precipitation and snowmelt timing.

DHSVM-WSF Comparison to Operational Forecasts

The only publicly available volumetric water supply forecasts for the Wind River Range at the time of writing are statistical forecasts from the Natural Resources Conservation Service (NRCS), available online at https://nwcc-apps.sc.egov.usda.gov/imap/. NRCS forecasts are available for Dinwoody Creek, Bull Lake Creek, the Upper Green River, and Bull Lake Creek. The latest available date as of June 5th, 2024, was the May 1st issue date, and as of June 7th, the June 1st issue date is newly available.

For Dinwoody Creek, the May 1st NRCS forecast predicts 81 / 93 / 106 TAF (90 / 50 / 10% exceedance levels) for total runoff on the May-September period. On this same time period, DHSVM-WSF with ASO-based SWE map assimilation predicts 82 / 98 / 115 TAF at the same exceedance levels, which is remarkably similar but marginally wetter on the upper exceedance side (by about 8%). For the NRCS June 1st forecast, the June-July volume is forecast to be 45 / 52 / 60 TAF, compared to the DHSVM-WSF June-July volume forecast of 54 / 64 / 74 TAF, which is about 20-23% wetter.

For Bull Lake Creek, the May 1st NRCS forecast predicts 140 / 164 / 190 TAF (90 / 50 / 10% exceedance levels) for total runoff on the May-September period. On this same time period, DHSVM-WSF with ASO-based SWE map assimilation predicts 149 / 181 / 214 TAF at the same exceedance levels, which is again consistent with the NRCS forecast although about 6-13% wetter. For the NRCS June 1st forecast, the June-July volume is forecast to be 88 / 108 / 132 TAF, compared to the DHSVM-WSF June-July volume forecast of 107 / 130 / 153 TAF, which is about 16-22% wetter.

For the Green River at Warren Bridge, the May 1st NRCS forecast predicts 149 / 186 / 225 TAF (90 / 50 / 10% exceedance levels) for total runoff on the May-July period (does NOT include August-September). On this same shortened time period, DHSVM-WSF with ASO-based SWE map assimilation predicts 208 / 243 / 279 TAF at the same exceedance levels, which is much wetter, by as much as 24% on the upper end and 40% on the drier exceedance side. For the NRCS June 1st forecast, the June-July volume is forecast to be 110 / 140 / 170 TAF, compared to the DHSVM-WSF June-July volume forecast of 145 / 168 / 193 TAF, which is about 14-32% wetter and 25% less uncertain.

For Pine Creek, the May 1st NRCS forecast predicts 66 / 79 / 92 TAF (90 / 50 / 10% exceedance levels) for total runoff on the May-July period (does NOT include August-September). On this same shortened time period, DHSVM-WSF with ASO-based SWE map assimilation predicts 78 / 91 / 105 TAF at the same exceedance levels, which is notably wetter by about 14-18%. For the NRCS June 1st forecast, the June-July volume is forecast to be 40 / 56 / 72 TAF, compared to the DHSVM-WSF June-July volume forecast of 68 / 80 / 92 TAF, which is about 28-70% wetter and 33% less uncertain.

Overall, the operational NRCS forecasts support the overall range of values and uncertainty ranges provided by DHSVM-WSF with ASO-based SWE map assimilation. However, the experimental forecasts presented here tend to suggest generally more runoff this year compared to the May 1st issue date of the NRCS forecasts, particularly on the Green River side of the mountains.

DHSVM-WSF Comparison to Empirical Estimates

Finally, a back-of-the-envelope empirical forecast can be derived by calculating either the difference or ratio of runoff in 2022 relative to the 2022 ASO SWE map. However, the 2022 ASO data collection had numerous issues caused by cloud cover and glacier ablation, and densities were not constrained with high-elevation fieldwork, so this prior dataset is more uncertain and should be considered in context. The SWE volumes used for this section are reanalyzed by Mountain Hydrology in 2024 using a variety of machine learning tools and prior fieldwork to bias correct and fill gaps in the original ASO dataset; these 2022 SWE volumes are considerably different from the official version on the ASO website.

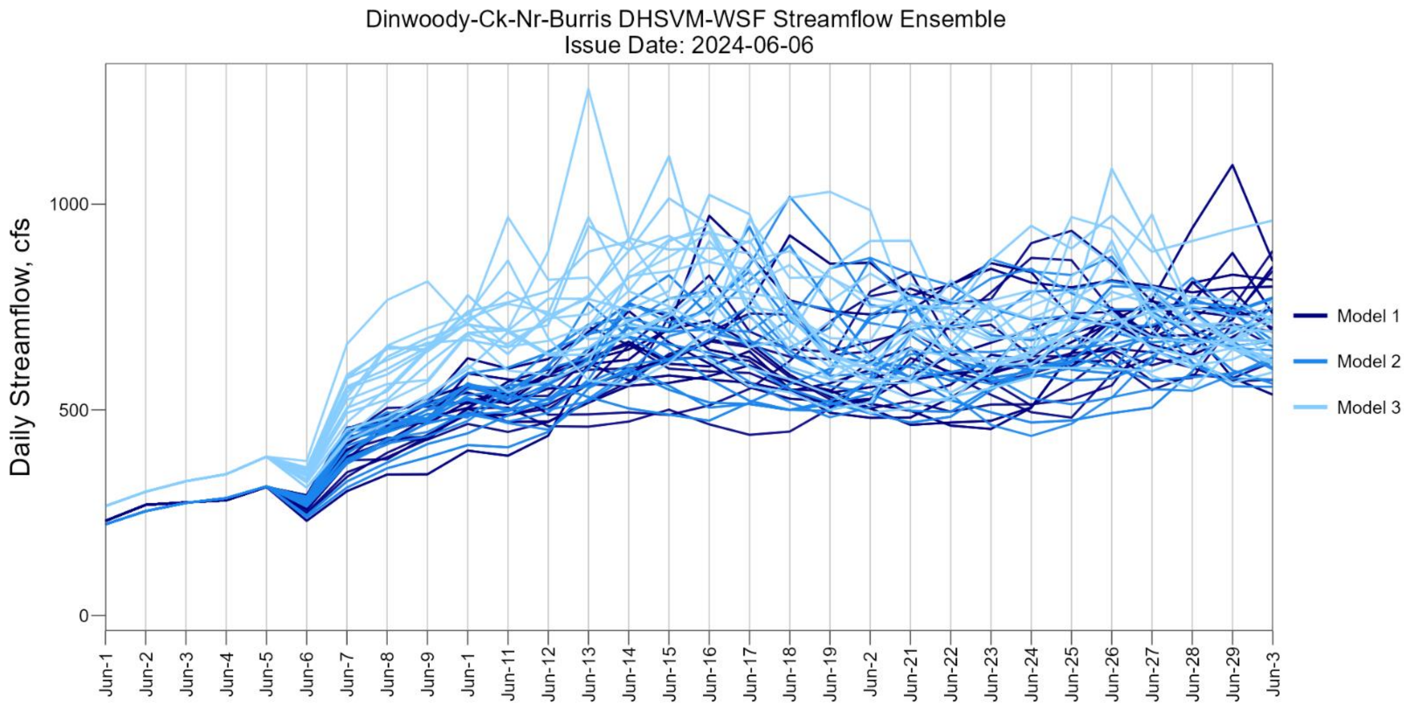
The table below compares different back-of-the-envelope scenarios for the relationship between snow water equivalent (SWE) and cumulative runoff (Q) for the June-September period.

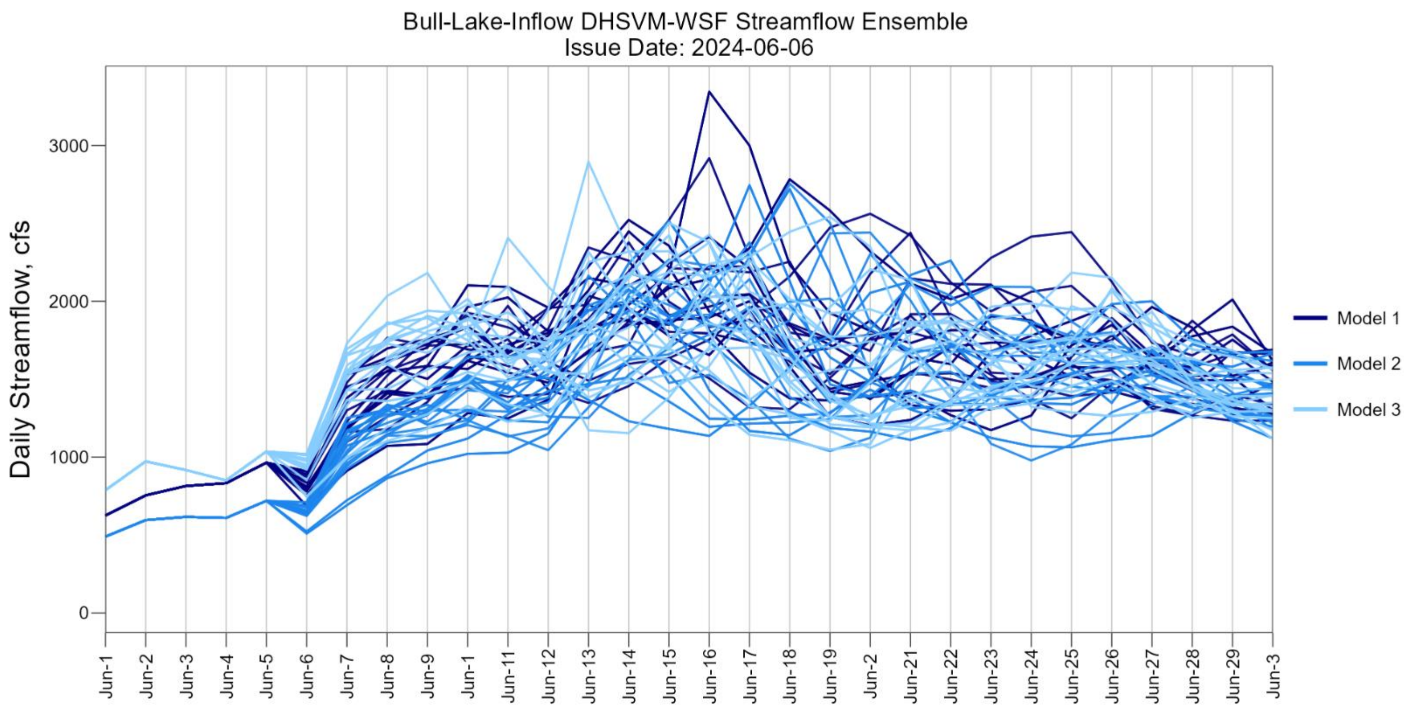
Watershed	SWE Volume: June 11, 2022 (Reanalyzed!)	SWE Volume: May 31, 2024	Relation 1: Q / SWE, 2022	Relation 2: Q – SWE, 2022	Relation 1: Q pred. 2024	Relation 2: Q pred. 2024	DHSVM-WSF Median Q pred. 2024
Torrey Creek	19 TAF	29 TAF	1.9	17 TAF	56 TAF	46 TAF	38 TAF
Dinwoody Creek	47 TAF	63 TAF	1.7	35 TAF	109 TAF	97 TAF	88 TAF
Dry Creek	17 TAF	22 TAF	Q Not Meas.	Q Not Meas.	-	-	22 TAF
Meadow Creek	6 TAF	7 TAF	Q Not Meas.	Q Not Meas.	-	-	7 TAF
Willow Creek	6 TAF	9 TAF	Q Not Meas.	Q Not Meas.	-	-	7 TAF
Bull Lake Creek	100 TAF	133 TAF	1.5	46 TAF	195 TAF	179 TAF	156 TAF
N.F. Little Wind R.	SWE Not Meas.	64 TAF	Q Not Meas.	Q Not Meas.	-	-	73 TAF
S.F. Little Wind R.	SWE Not Meas.	65 TAF	-	-	-	-	67 TAF
Upper Green River	110 TAF (At Roaring Fork confluence)	135 TAF (At Roaring Fork confluence)	1.7 (At Gage)	76 TAF (At Gage)	229 TAF (At Gage)	211 TAF (At Gage)	203 TAF (At Gage)
Pine Creek	67 TAF	76 TAF	1.3	20 TAF	99 TAF	96 TAF	90 TAF

The back-of-the-envelope Q / SWE and Q – SWE relationships generally indicate higher runoff than the DHSVM-WSF median for this year, though this could be attributable to uncertainty in the 2022 SWE map. The Q – SWE relationship shows reasonable agreement with the process-based model in most watersheds, particularly the Dinwoody Creek (9% different), Green River (4% different), and Pine Creek (7% different), so this simple SWE vs. Q relationship may increase confidence in the upper bound and overall predictive interval generated by DHSVM-WSF.

DHSVM-WSF Peak Flows

The high snowpack storage and abnormally warm early June conditions will lead to high flows in the immediate future. The following plots summarize projected daily streamflow for key sub-watersheds. Note that streamflow magnitude and timing on a daily timestep is much more uncertain than seasonal cumulative volumes, and these projections are subject to change based on updated weather forecasts.





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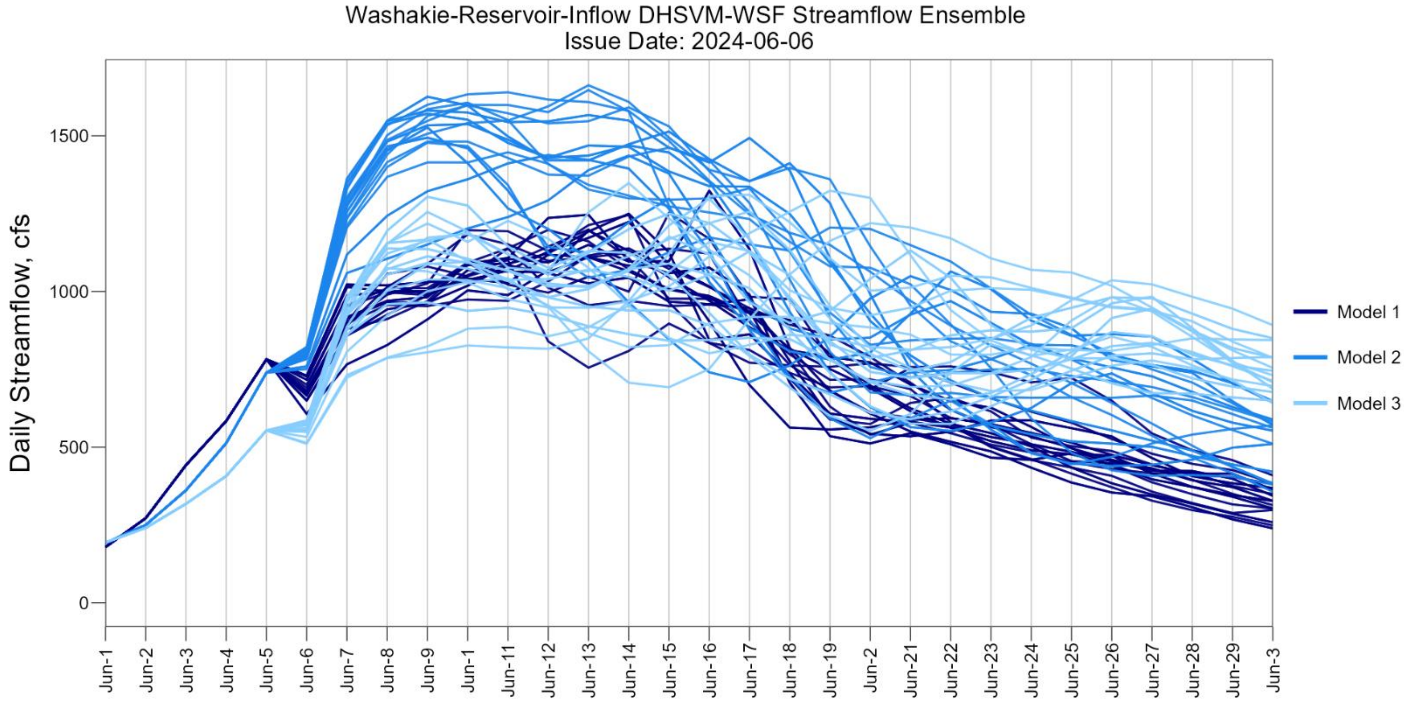
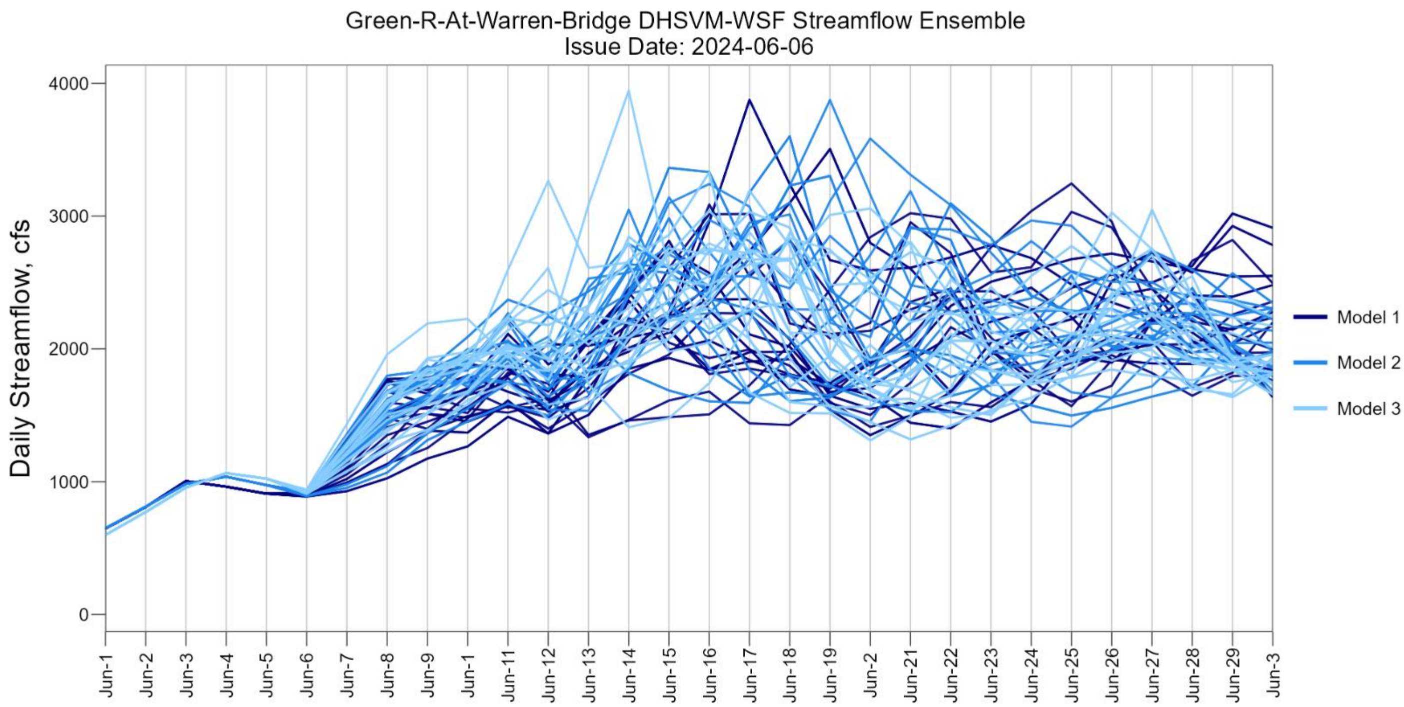
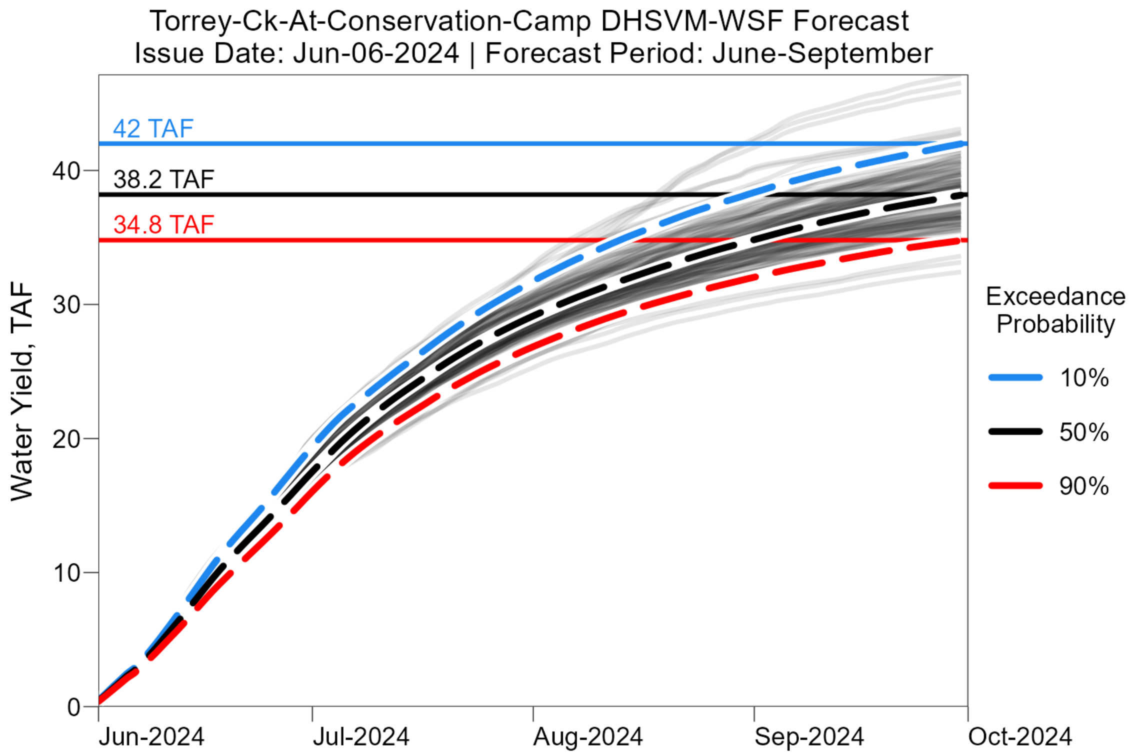
DHSVM-WSF Peak Flows

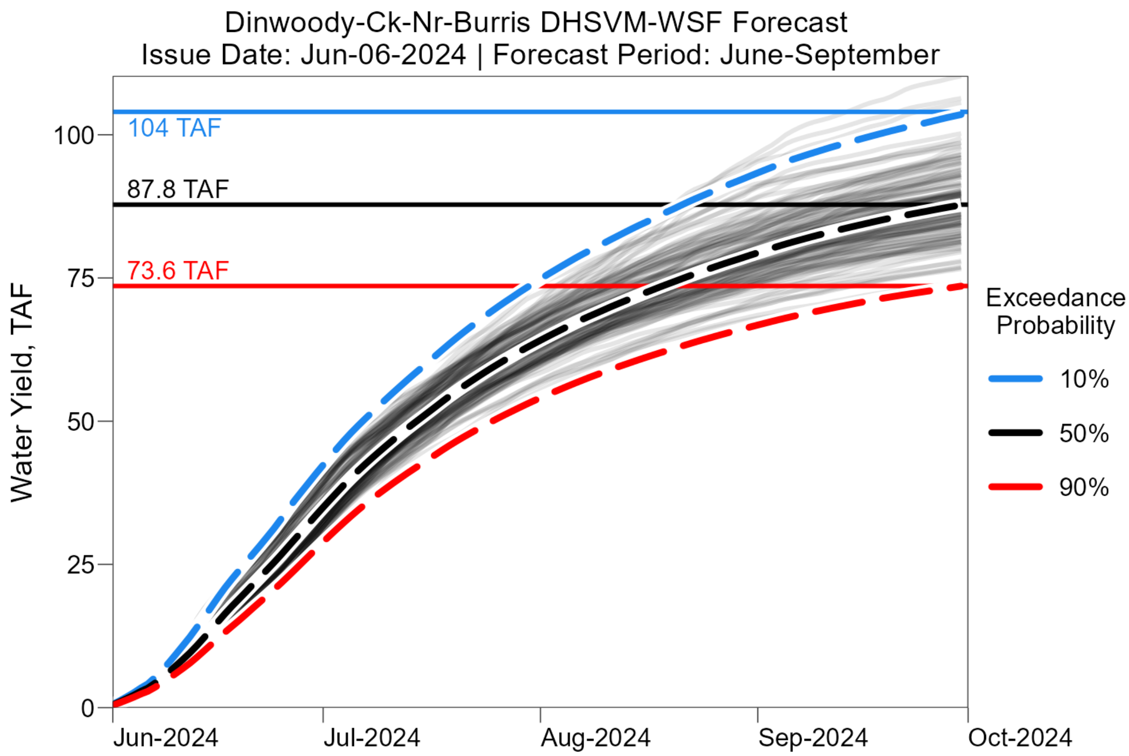




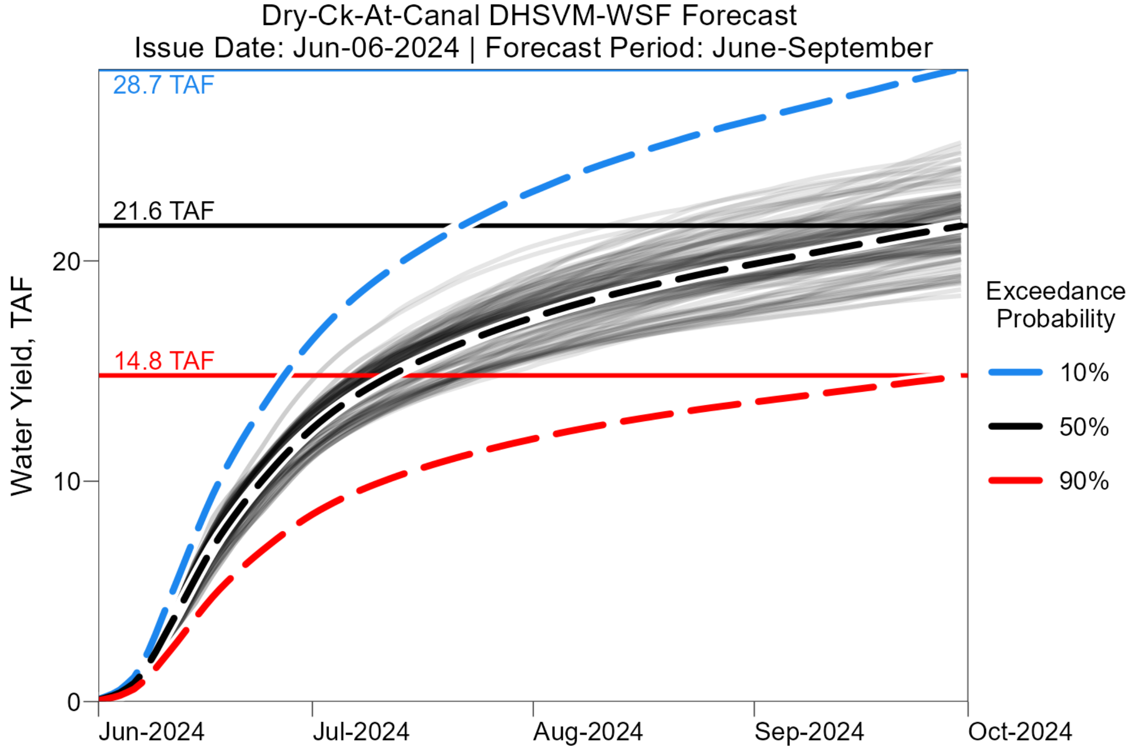
DHSVM-WSF Forecast: Torrey Creek



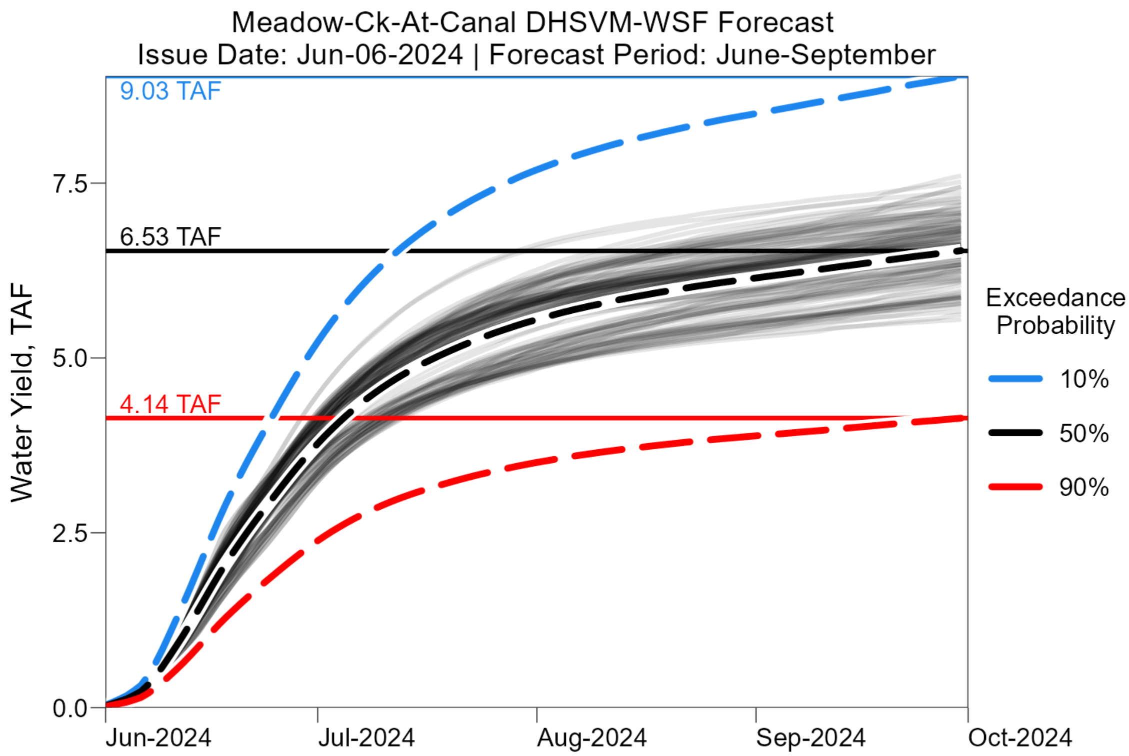
DHSVM-WSF Forecast: Dinwoody Creek



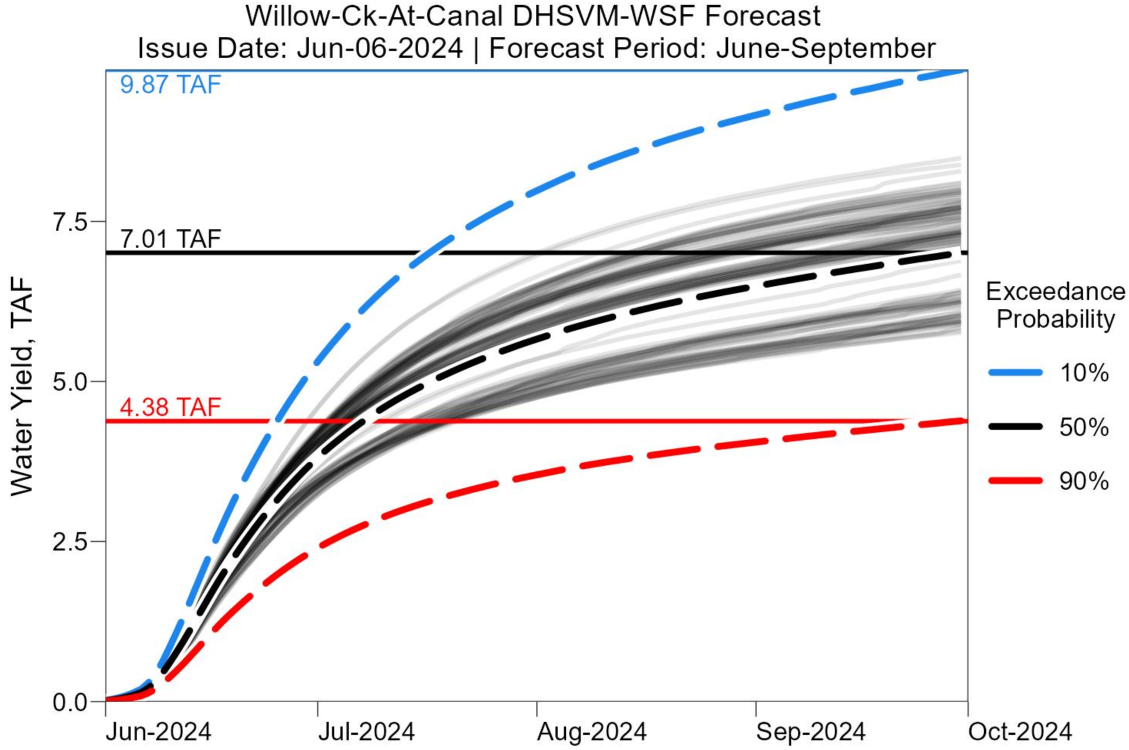
DHSVM-WSF Forecast: Dry Creek



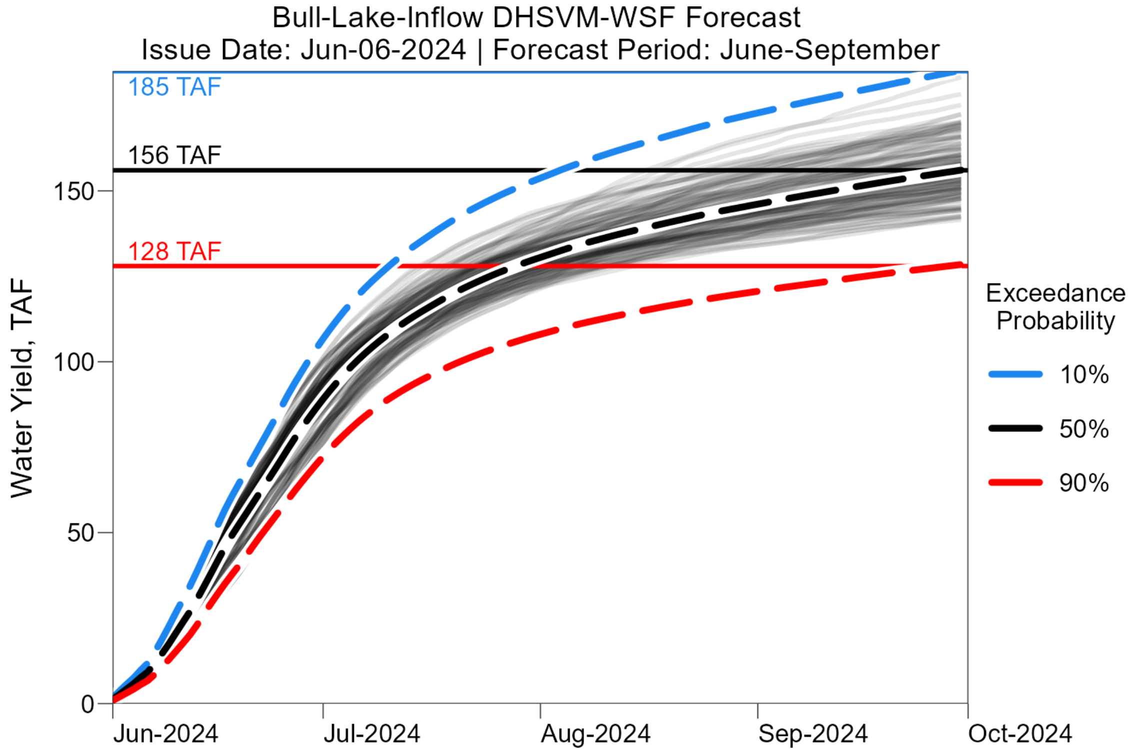
DHSVM-WSF Forecast: Meadow Creek



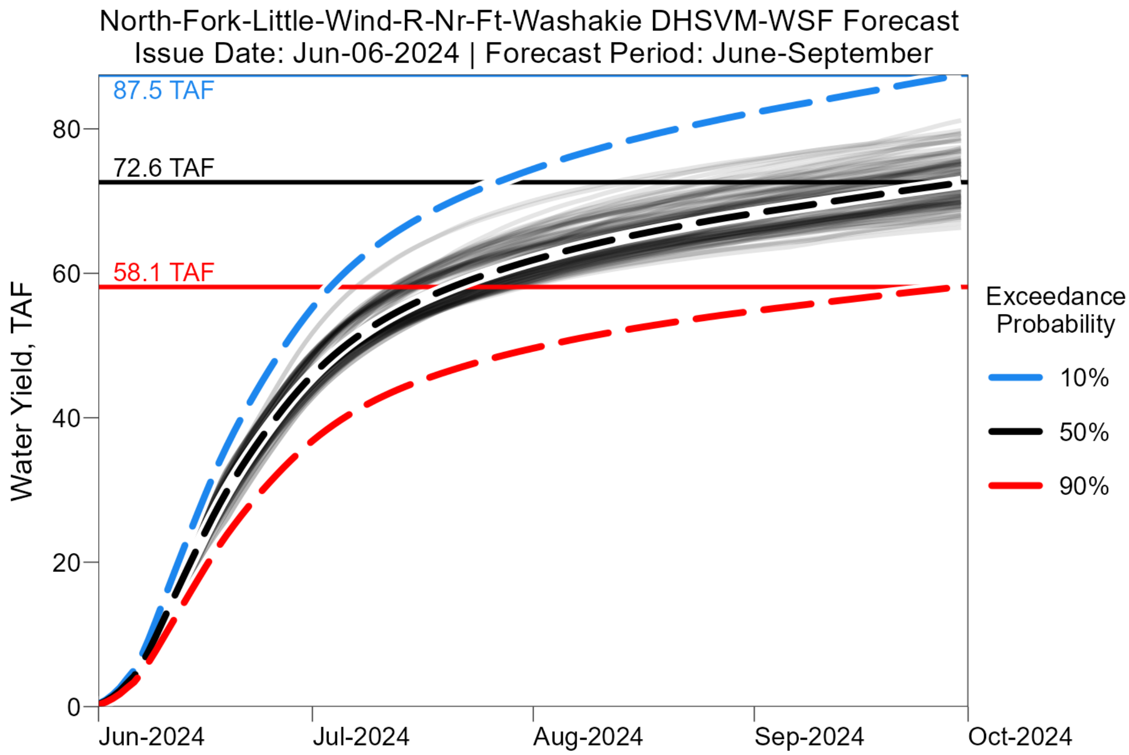
DHSVM-WSF Forecast: Willow Creek



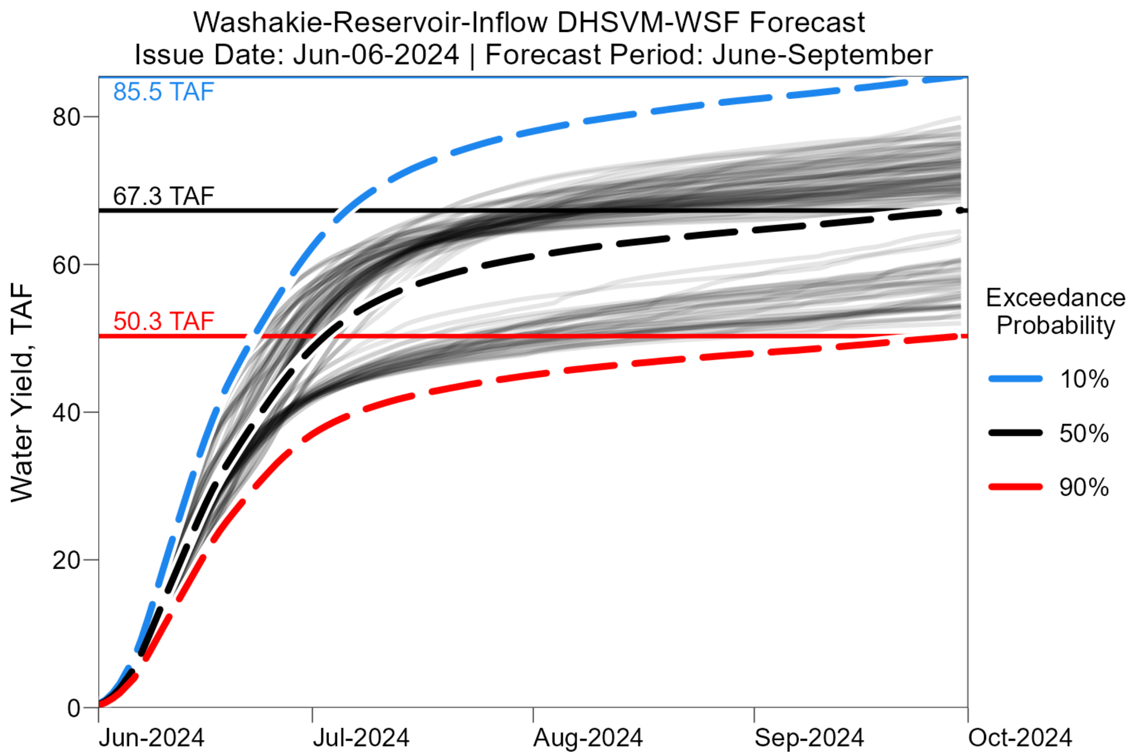
DHSVM-WSF Forecast: Bull Lake Creek



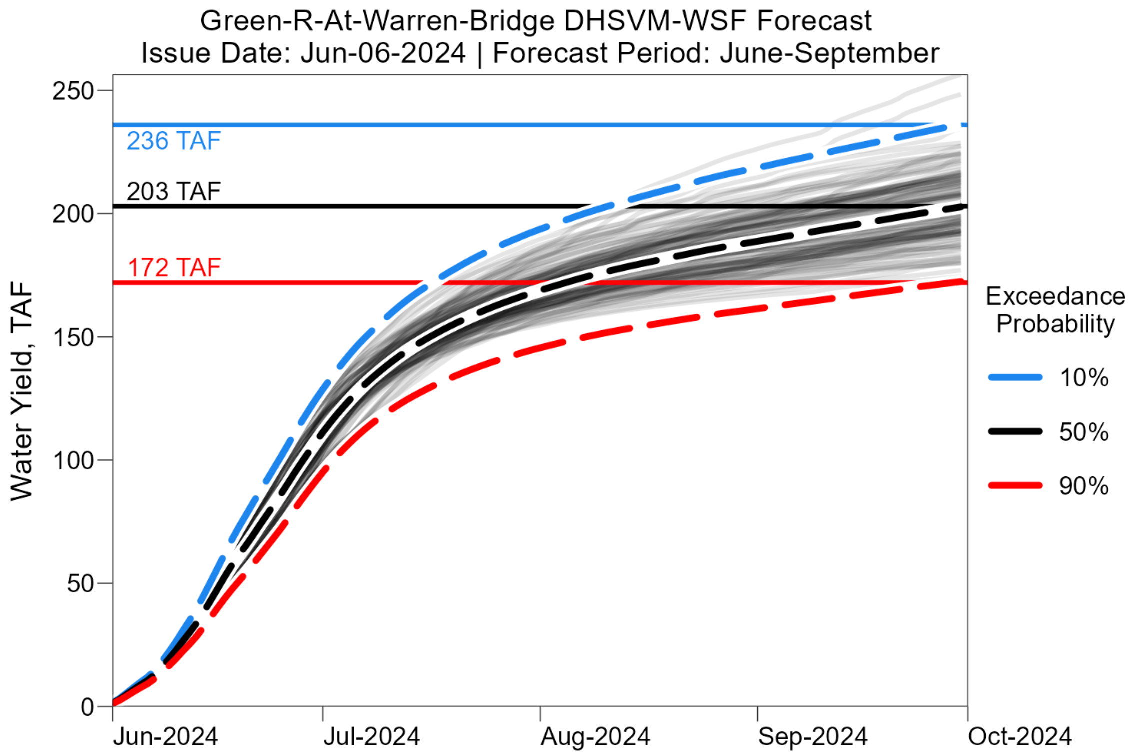
DHSVM-WSF Forecast: North Fork Little Wind River



DHSVM-WSF Forecast: South Fork Little Wind River



DHSVM-WSF Forecast: Upper Green River



DHSVM-WSF Forecast: Pine Creek