Items for the April 2024 WRWG Meeting

- River Watch items of interest:
  - April sampling for the six lower UWP River Watch sites will be done between the 5th and the 7th. Science on the Fly samples will be collected in this same period.
  - We received the supplies for high-flow nutrient samples which will be collected in May and June.
- Snowpack, Precipitation and Streamflow:
  - As of March 30th, for the 2024 Water Year, the 15 Gunnison Basin SNOTEL sites had an average of 15.9 inches of SWE. This was 106% of the basin median and up from 98% of the median on 1 March. In the Uncompahgre watershed the Red Mtn Pass SNOTEL reported 20.3 inches of SWE on March 30th, which was 91% of its median and nearly identical to the 1 March percentage. Higher SWE depths, up to 125% of medians, were generally in the northeast part of the basin.
  - Streamflow on the Uncompahgre at the USGS gauge near Ridgway has been almost entirely below the median curve since 1 January. On 30 March the flow was about 45 cfs, compared to the median flow of about 65 cfs. Cow Creek and Dallas Creek streamflows have also been below median or average values since 1 January. On 30 March both creeks were running about 15 cfs below "normal". Ridgway Reservoir storage has continued to steadily increase since the first of the year, and as of 30 March storage was 66,700 acre-feet. The median storage curve begins a decline on about 23 March, so the current storage is about 4,000 acre-feet above the median.
- A look at SWE, streamflow and metal loads in the upper Uncompahgre watershed:

The snow water equivalent (SWE) that accumulates over the winter in the Uncompahgre watershed is obviously the main source of water that contributes to streamflow in the Uncompahgre River and its tributaries. The amount of SWE should be related to the magnitude of the streamflow, and also to the amount (mass) of various harmful metals entering the river. The following analyses make use of data from the highest SNOTEL site (Red Mtn Pass) in the watershed, the USGS stream gauge near Ouray, and the metals data from the River Watch site collocated with the USGS gauge to look at how SWE, streamflow and metal loads are related. Note that metal load or mass is the concentration of a metal (mass per unit volume) multiplied by streamflow (volume of water per second).

The analyses were performed over water years which start October 1st and end September 30th. We are currently in water year (WY) 2024. The Red Mtn Pass SNOTEL parameter used to characterize each water year was maximum SWE which typically occurs in April, but can occasionally occur in March or May. SNOTEL data were available from 1981 through 2023. Streamflow at the USGS gauge was averaged over the main runoff months of April through July, and also over the base flow months of November through February. Streamflow data were available for WYs 2001 through 2023. The River Watch site (USGS gauge 3586) was established in 2002 and metals concentration data were available from 2002 through 2022. The complete comparisons of SWE, streamflow and metal loads were therefore done for WYs between 2002 and 2022.

The complete history of maximum SWE (Max SWE) at the Red Mtn Pass SNOTEL is shown in Figure 1. A trend line indicates a gradual decline in Max SWE starting near 30 inches and ending in 2023 at about 23 inches. Also note that eight of the 12 values exceeding the 75th percentile occurred prior to the

period of interest from 2002 onwards. Although not shown in Figure 1 there was no trend in Max SWE from 2002 through 2022, and the median was 24.30 inches compared to the 1981 to 2001 median of 27.30 inches.

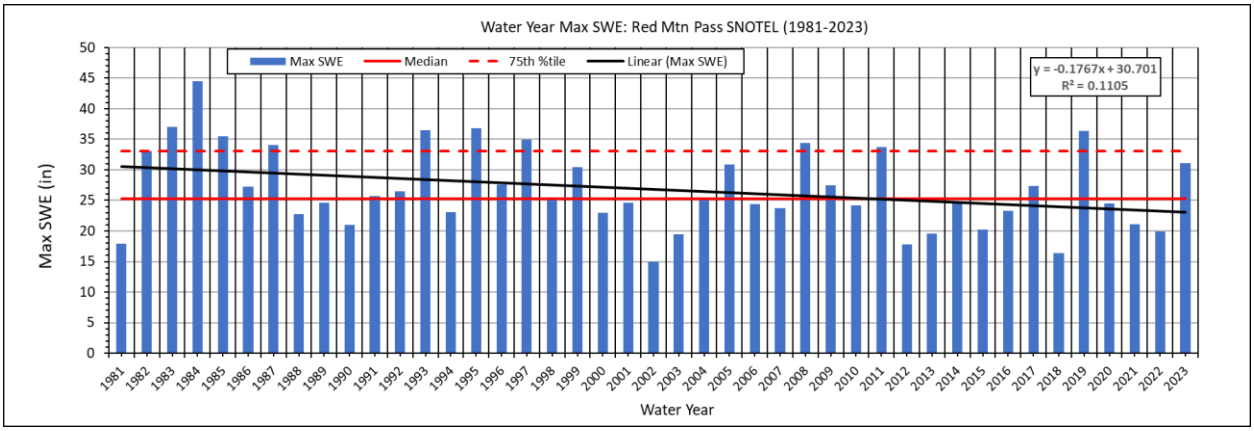

Figure 1. Max SWE observed at the Red Mtn Pass SNOTEL for water years 1981 through 2023. Median is shown by the solid red line, 75th percentile by the red dashed line, and a trend line by the solid black line.

Using the daily average discharge at the USGS gauge, the monthly average discharges for periods April to July and November to February were calculated for each water year. The monthly averages were then summed to get total average discharges for the two periods: runoff period and base flow period. Figure 2 shows the comparison of Total Avg Discharge versus Max SWE for the April to July runoff period for water years 2002-2023. A linear fit to the data had a relatively high R-squared value of 0.81. The

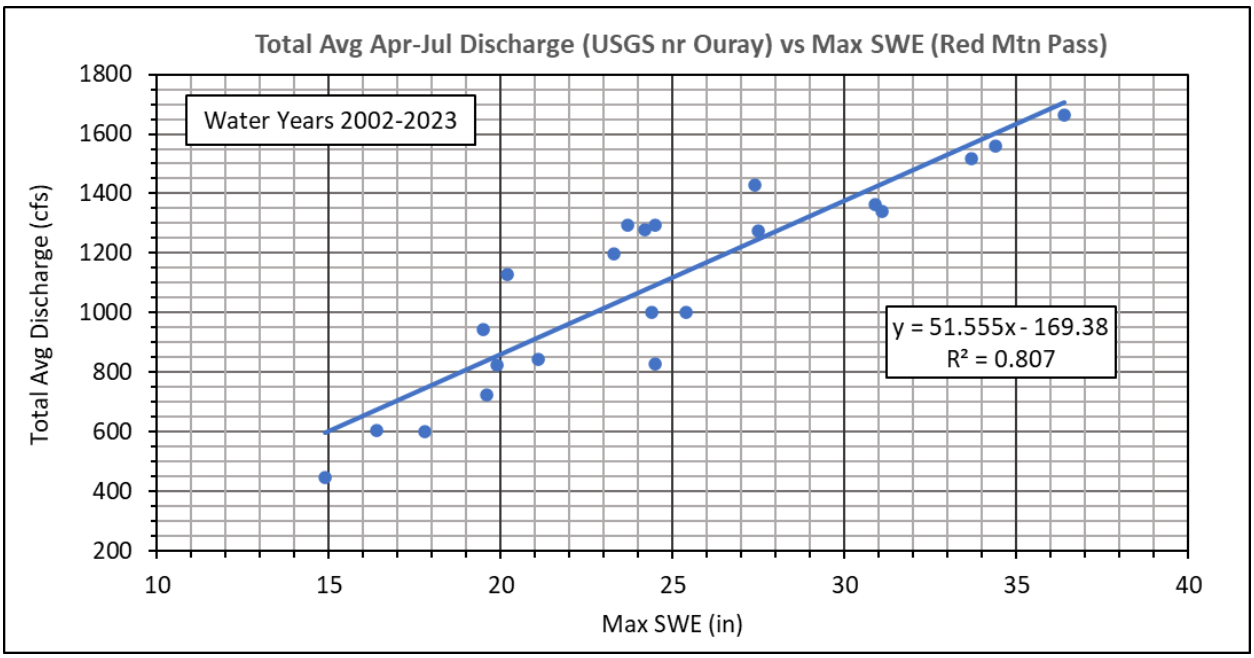

Figure 2. April-July Total Avg Discharge at USGS gauge near Ouray versus Max SWE at the Red Mtn Pass SNOTEL. Blue line is a linear fit to the data. Data period covers water years 2002 through 2023.

strong correlation between discharge and SWE suggests there will also be positive correlation between discharge and metal load. To date the metal loads for each water year have not been computed, but the loads grouped by high SWE years and low SWE years are presented below.

Figure 3 shows the comparison between Total Avg Discharge and Max SWE for the November to February period. In contrast to the runoff period there was no correlation between the two variables for the base flow period on the Uncompahgre River, indicating base flow for a given water year has little to do with snowpack accumulation during that water year. The timeline of discharge and SWE in Figure 4

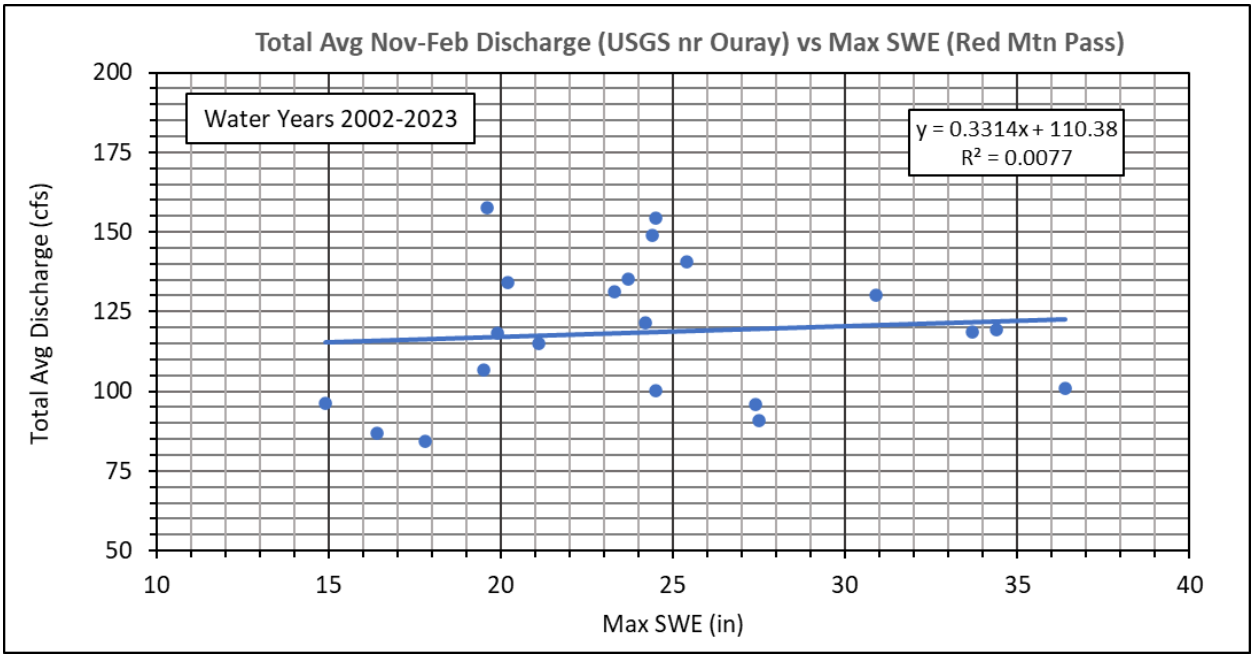

Figure 4. November to February Total Avg Discharge at USGS gauge near Ouray versus Max SWE at the Red Mtn Pass SNOTEL. Blue line is a linear fit to the data. Data period covers water years 2002 through 2023.

further illustrates the lack of correspondence. Some periods like 2002 through 2005 show consistent increases in both variables, while other periods like 2013 through 2017 show marked decreases in discharge with gradual increases in SWE.

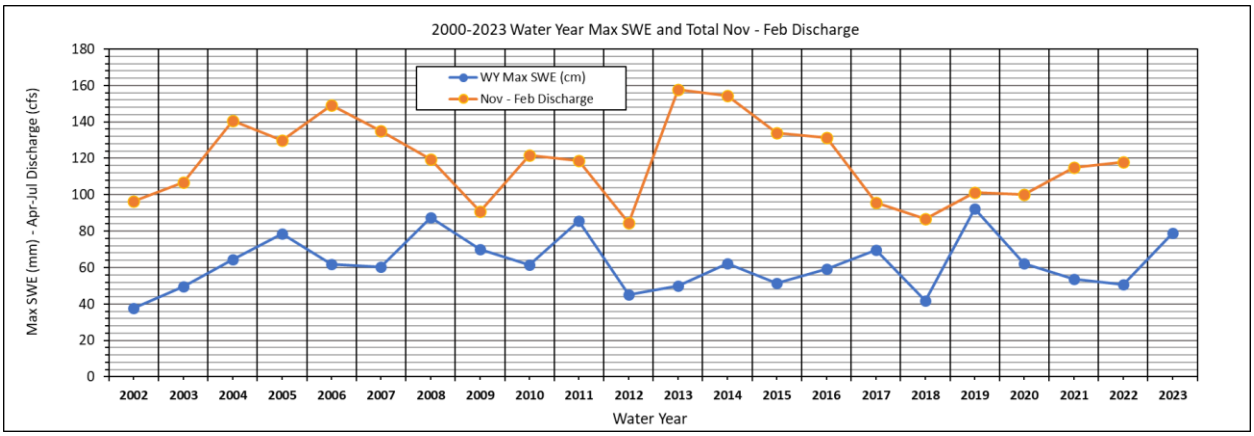

Figure 3. November to February timelines of Total Avg Discharge and Max SWE (cm) for water years 2002 through 2023.

For examining the impact of Max SWE on metal loads, data for the six highest Max SWE water years (2005, 2008, 2009, 2011, 2019, 2023) were compared to data for the six lowest Max SWE water years (2002, 2003, 2012, 2013, 2018 and 2022) between 2002 and 2023. [*It turned out that metals data for 2023 were not available when the analysis was performed, so only the five highest SWE years were used.*] Tables 1 and 2 show examples of the calculations of Total Avg Discharge, Avg Concentration, and

Avg Load for dissolved zinc (Zn-D) for the April-July and Nov-Feb periods. Table 1 presents results for the high Max SWE years and Table 2 shows results for the low Max SWE years. For the April to July runoff period the high SWE years had an average discharge about 2.1 times that of the low SWE years. Despite having a somewhat lower average Zn-D concentration, the high SWE years had an average 4-month Zn-D load about 1.8 times that of the low SWE years.

The average April to July Zn-D load of 25,468 lbs (Table 1) represents a load of 208.8 lbs/day. Daily loads for the other three partitions were obviously much lower. This river segment (COGUUN03b_A) and the segment below it (COGUUN03c_A) were both found to attain the aquatic life standard for Zn-D in the latest water quality assessment by the WQCD. Although the WQCD assessment used data for all months, the load calculations in Tables 1 and 2 indicate that the loads of Zn-D at the USGS site are insufficient to bring Zn-D concentrations to levels that exceed the aquatic life standard.

Table 1. Average discharge, average Zn-D concentration and average Zn-D load computed using data from High SWE water years. First three columns are results from the April-July period, and last three columns are results from the Nov-Feb period.

Six highest SWE WYs: Discharge, Zn Concentration, and Zn Load					
Discharge Data: USGS gauge near Ouray Metal Concentration Data: River Watch Site USGS Gauge 3586					
SWE Data: Red Mountain Pass SNOTEL: High SWE Range (27.5 - 36.4 inches)					
Apr-Jul Discharge	Apr-Jul Zn-D Conc	Apr-Jul Zn-D Load	Nov-Feb Discharge	Nov-Feb Zn-D Conc	Nov-Feb Zn-D Load
Avg Discharge (cfs)	Avg Zn-D (µg/L)	Avg Zn-D Load (lbs)	Avg Discharge (cfs)	Avg Zn-D (µg/L)	Avg Zn-D Load (lbs)
363.3	109.150	25,468	28.1	154.155	2,863

Table 2. As in Table 1 except showing results using data from the six Low Max SWE water years.

Six lowest SWE WYs: Discharge, Zn Concentration, and Zn Load					
Discharge Data: USGS gauge near Ouray Metal Concentration Data: River Watch Site USGS Gauge 3586					
SWE Data: Red Mountain Pass SNOTEL: Low SWE Range (14.9 - 19.9 inches)					
Apr-Jul	Apr-Jul	Apr-Jul	Nov-Feb	Nov-Feb	Nov-Feb
Avg Discharge (cfs)	Avg Zn-D	Avg Cu-D Load (lbs)	Avg Discharge (cfs)	Avg Zn-D	Avg Cu-D Load (lbs)
172.7	123.350	13,785	26.6	122.011	2,269

In the WQCD assessment the median total iron (Fe-T) concentration in segment COGUUN03b_A was found to exceed the aquatic life standard of 2971 µg/liter. Tables 3 and 4 show the load calculations for Fe-T for the high SWE and low SWE years. The much larger average discharge between the runoff periods and the base flow periods again lead to much greater Fe-T loads during runoff for both the high Max SWE years (Table 1) and the low Max SWE years (Table 2). Note, however, that the average Fe-T concentrations were significantly greater during base flow periods and exceeded the aquatic life standard.

Table 3. Average discharge, average Zn-T concentration and average Fe-T load computed using data from High SWE water years. First three columns are results from the April-July period, and last three columns are results from the Nov-Feb period.

Six highest SWE WYs: Discharge, Fe Concentration, and Fe Load					
Discharge Data: USGS gauge near Ouray Metal Concentration Data: River Watch Site USGS Gauge 3586					
Apr-Jul	Apr-Jul	Apr-Jul	Nov-Feb	Nov-Feb	Nov-Feb
Avg Discharge (cfs)	Avg Fe-T (µg/L)	Avg Fe-T Load (lbs)	Avg Discharge (cfs)	Avg Fe-T (µg/L)	Avg Fe-T Load (lbs)
363.3	2422.9	522,025	28.1	4181.9	66,374

As with zinc loads, the average Fe-T load for the high Max SWE years during the runoff period was nearly two times greater than the average load for the low Max SWE years. Fe-T loads during base flow months were similar for the two Max SWE categories, the high Max SWE load being somewhat greater due to a much higher average concentration.

Table 4. As in Table 3 except showing results using Fe-T data from the six Low Max SWE water years.

	Six lowest SWE WYs: Discharge, Fe Concentration, and Fe Load				
Discharge Data: USGS gauge near Ouray Metal Concentration Data: River Watch Site USGS Gauge 3586					
Apr-Jul	Apr-Jul	Apr-Jul	Nov-Feb	Nov-Feb	Nov-Feb
Avg Discharge (cfs)	Avg Fe-T (µg/L)	Avg Fe-T Load (lbs)	Avg Discharge (cfs)	Avg Fe-T (µg/L)	Avg Fe-T Load (lbs)
172.7	2542.6	279,233	26.6	3031.9	55,415

Calculations were also done for other metals with quite similar results since in all cases the large difference in average discharge during runoff months, between high and low Max SWE years, is the same. One set of calculations for total iron was done using average discharges and average concentrations for all months. The results are shown in Figure 5. The average high Max SWE iron load was about 1.65 times the iron load for low Max SWE years.

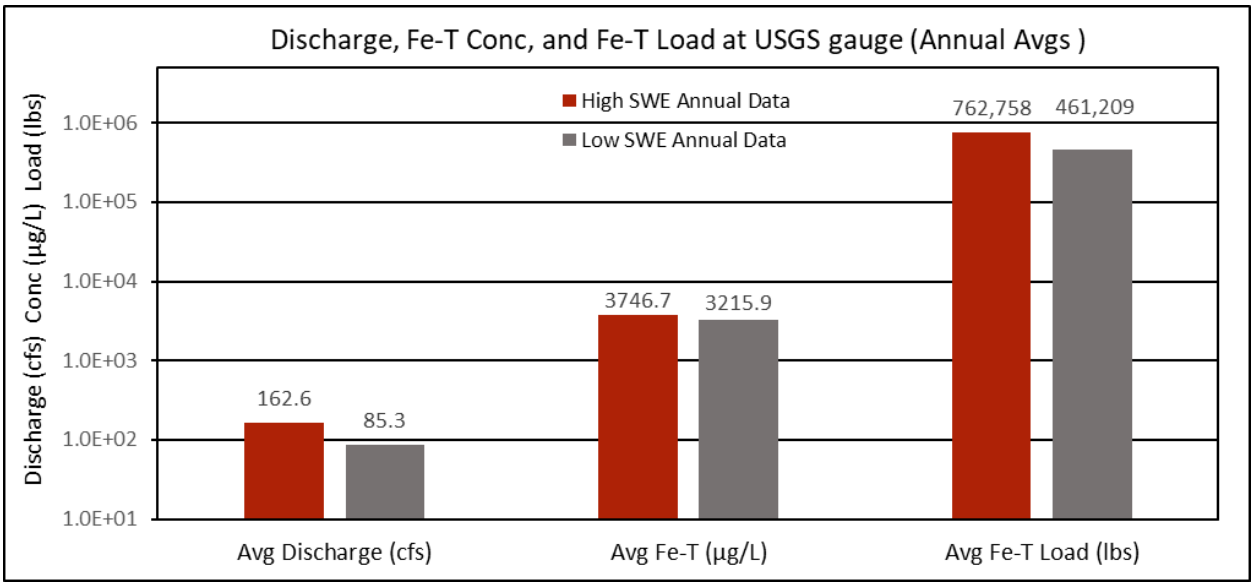

Figure 5. Average discharge, Avg Fe-T concentration, and Avg Fe-T load for all months in the high and low Max SWE water years.