LBD 2018 ANNUAL OPERATIONS REPORT

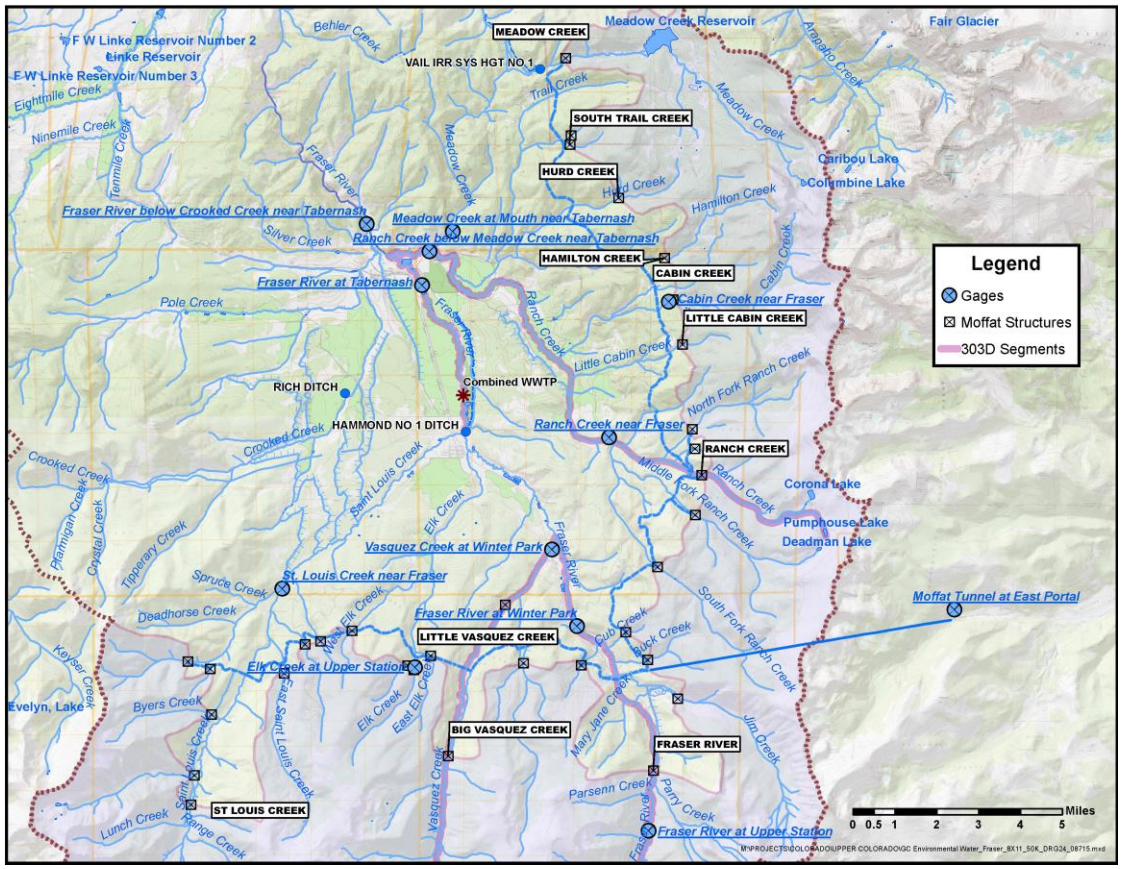
November 30, 2018

Introduction

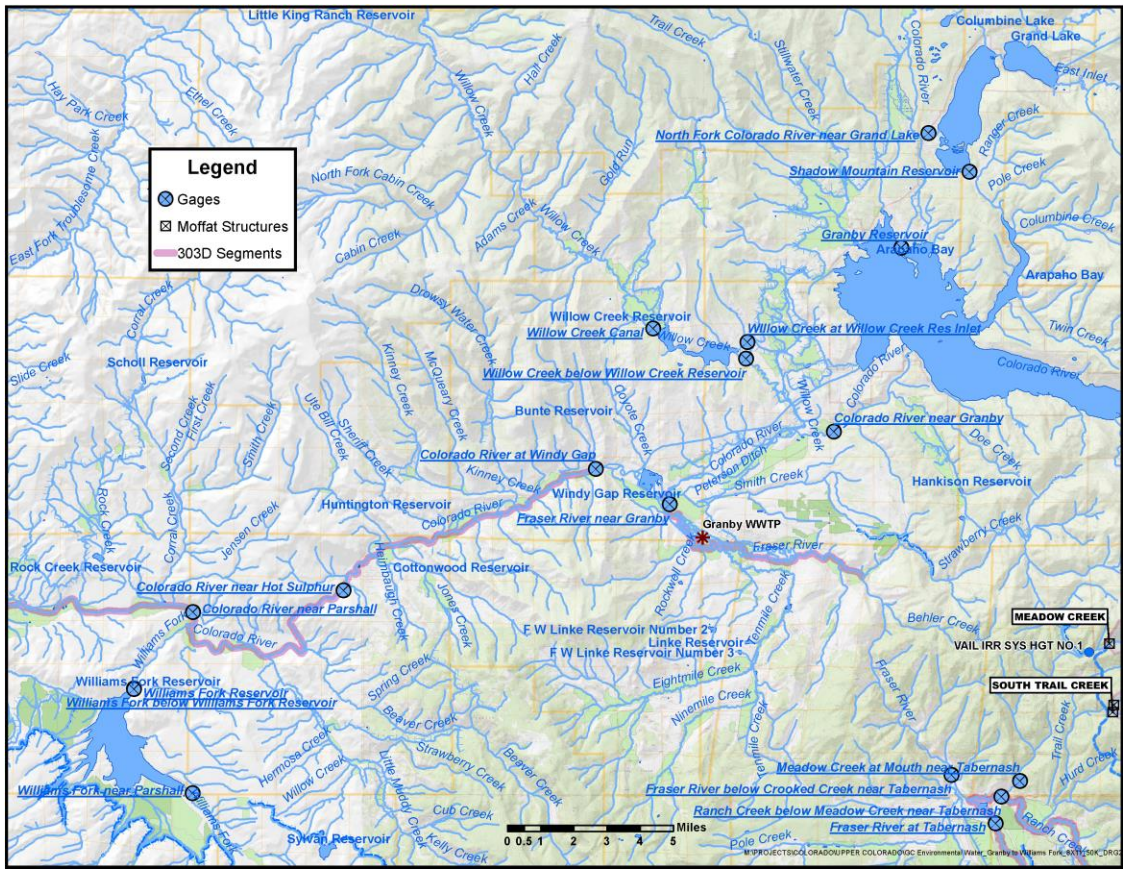
Learning By Doing (LBD) Operations Guidelines require that each year the Operations Subcommittee submit an Operations Report to the LBD Management Committee. This report summarizes 2018 LBD related operations, including:

- Denver Water Moffat System undiverted flows totaling approximately 17,000 acre-feet (af) during runoff season and maintenance bypasses totaling 900 af from the Fraser Collection System,
- Municipal Subdistrict pumping at Windy Gap Reservoir of 4,000 af to Granby Reservoir for west slope use (3,000 af for Middle Park and 1,000 af for Grand County) and subsequent release of 1,000 af for Grand County as direct delivery to the Grand Valley Irrigators, and
- Release of 5412 af from the Endangered Fish Pool in Granby Reservoir for the Upper Colorado River Endangered Fish Recovery Program (Recovery Program).

A list of LBD potential water sources can be found in Attachment A at the end of this report.



Fraser River Collection System

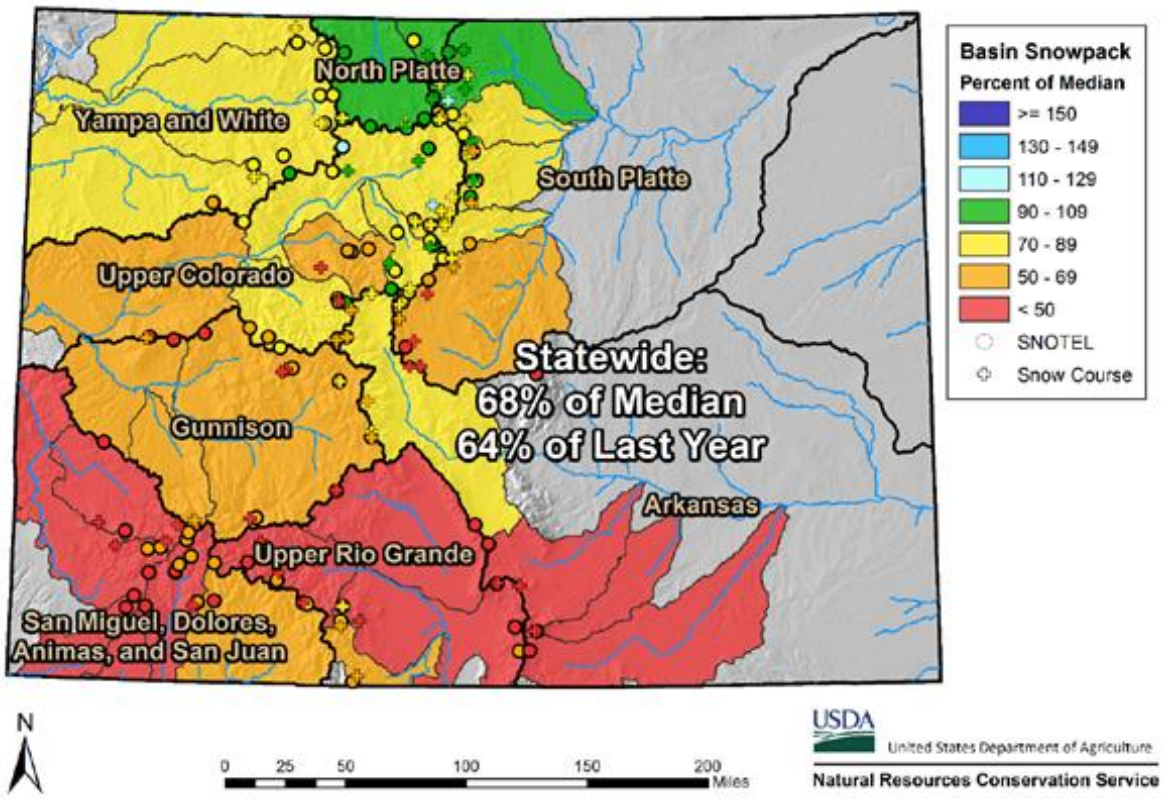


Colorado River from Granby Reservoir to Williams Fork

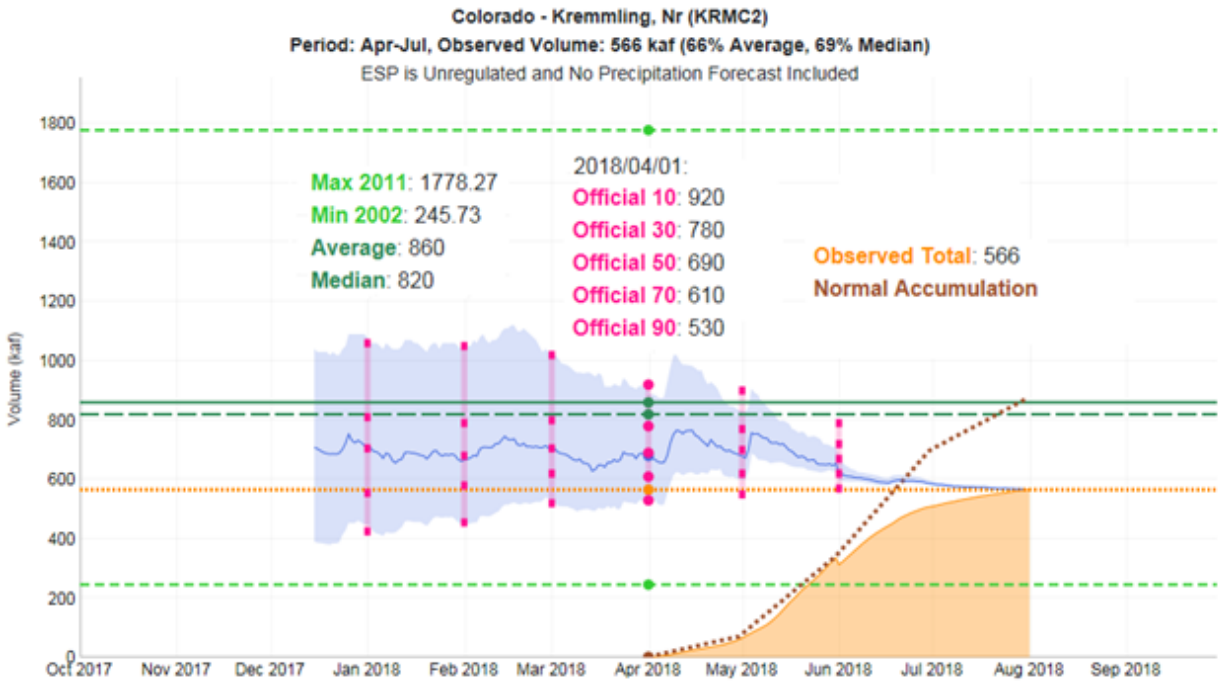
2018 Snowpack and Water Supply Forecasts

On the following page is an NRCS map depicting April 1, 2018 Snow Water Equivalent (SWE) for major basins and SNOTEL sites in Colorado. Snowpack in the Colorado River and South Platte River basins was 78 percent and 81 percent of average respectively.

The Colorado Basin River Forecast Center (CBRFC) April 1, 2018 Ensemble Streamflow Prediction (ESP) Most Probable Runoff Forcast at Kremming was 80 percent of average (690 thousand acre-feet [kaf], see graph on the next page). The actual runoff above Kremmling was 66 percent of average (566 kaf). The highest April 1 Sub-basin Runoff Forecast within the LBD Cooperative Effort Area was in the Fraser River basin at 92 percent of average (actual 84 percent), and the lowest forecast was in the Muddy Creek basin at 57 percent of average (actual 62 percent). The April 1 Most Probable Runoff Forecast into Granby Reservoir was 85 percent of average (actual 75 percent)



NRCS April 1, 2018 Snowpack Summary



CBRFC 2018 Evolving Water Supply Forecast at Kremmling

Runoff Operations

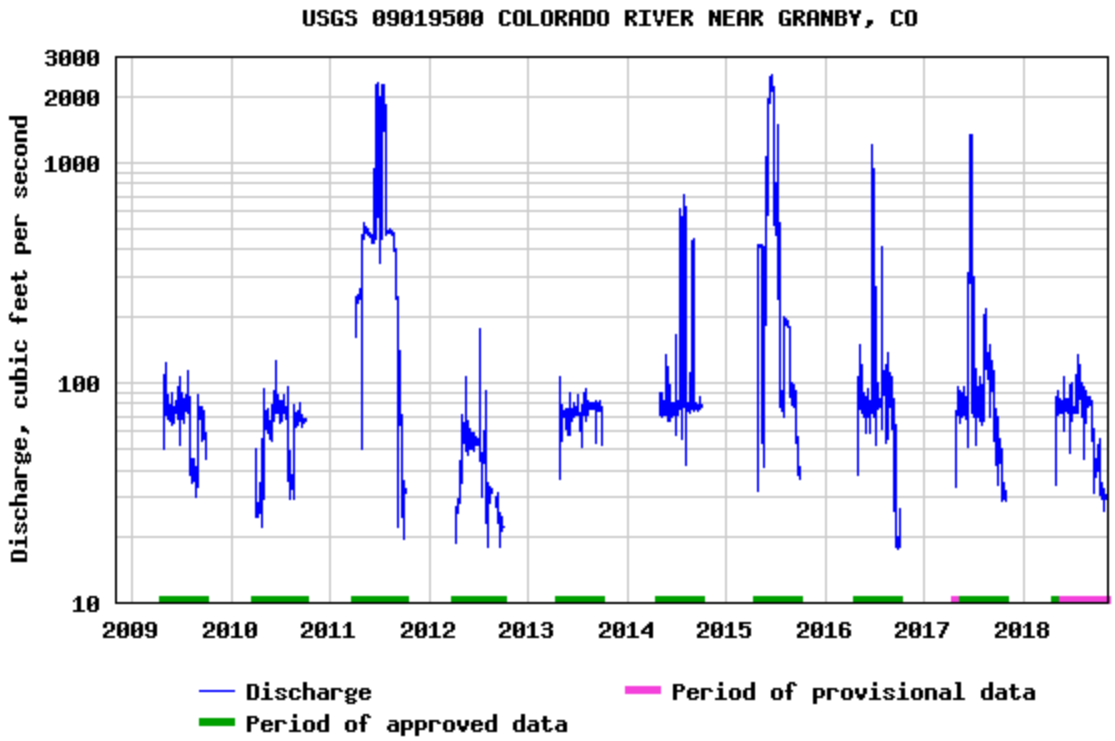
The Operations Subcommittee held weekly teleconference calls to discuss runoff operations beginning May 2nd. Discussion included the potential for Coordinated Reservoir Operations (CROS), Granby fill and Windy Gap pumping status, Moffat undiverted flow potential, Fraser-Jim Creek siphon maintenance, and Wolford Reservoir maintenance drawdown operations.

CROS

As part of the Endangered Fish Recovery Program, when the projected Cameo peak flow is above 12,700 cfs, Denver Water, the River District and the Bureau of Reclamation (Reclamation) participate in CROS to benefit the Endangered Fish in the Grand Valley area by augmenting peak runoff (May-June). However, the 2018 peak flow in the Grand Valley was less than 7,000 cfs; therefore, no CROS operations were dictated.

Granby Fill and Windy Gap Pumping Status

Granby Reservoir spilled in 2011, 2014, 2015, 2016 and 2017 (see graph below). The 2018 CBT AOP April 1 Most Probable Forecast model predicted that neither Willow Creek nor Granby Reservoir would spill. The model allowed for pumping at both Willow Creek and Windy Gap Pump Stations. Reclamation's model for water availability doesn't take into account the physical operation at Windy Gap; therefore, Northern Water's model was used to estimate available water for Windy Gap pumping. Using a Most Probable available volume of 34,500 af, the Reclamation model predicted a Granby spill of 21,200 af. Therefore, the target pumping volume (difference) was 13,300 af. Willow Creek and Windy Gap Pump Stations began pumping to Granby Reservoir in late April. Windy Gap pumping had not occurred since 2013. The first 3,000 af pumped in 2018 was credited to Middle Park under the 1980 and 1985 Agreements for uses allowed per the agreements (all beneficial uses, except for instream uses and industrial uses). A portion of any unused Middle Park water may become available to Grand County in August 2019 for delivery to downstream users, thus increasing Colorado River flows.



Colorado River near Granby Streamflows 2009 to 2018

An earlier and drier than expected runoff allowed for additional pumping beyond the most probable scenario. In mid-May Windy Gap pumping was reduced to allow a 50-hour period to satisfy the flushing flow requirement as per the Windy Gap Firming Project (WGFP) Fish and Wildlife Mitigation Plan. The Municipal Subdistrict stopped Windy Gap pumping in late May due to hydrologic uncertainty. After reassessing hydrology and operations, pumping resumed on June 4th. Reclamation provided a preliminary June 1 CBT forecast indicating that there would be at least 1 foot of unused storage (approx 7,000 af) in Granby Reservoir. The forecast also included reduced Adams Tunnel diversion to allow for Big Thompson River power skim operations, which could be foregone to avoid spilling pumped water.

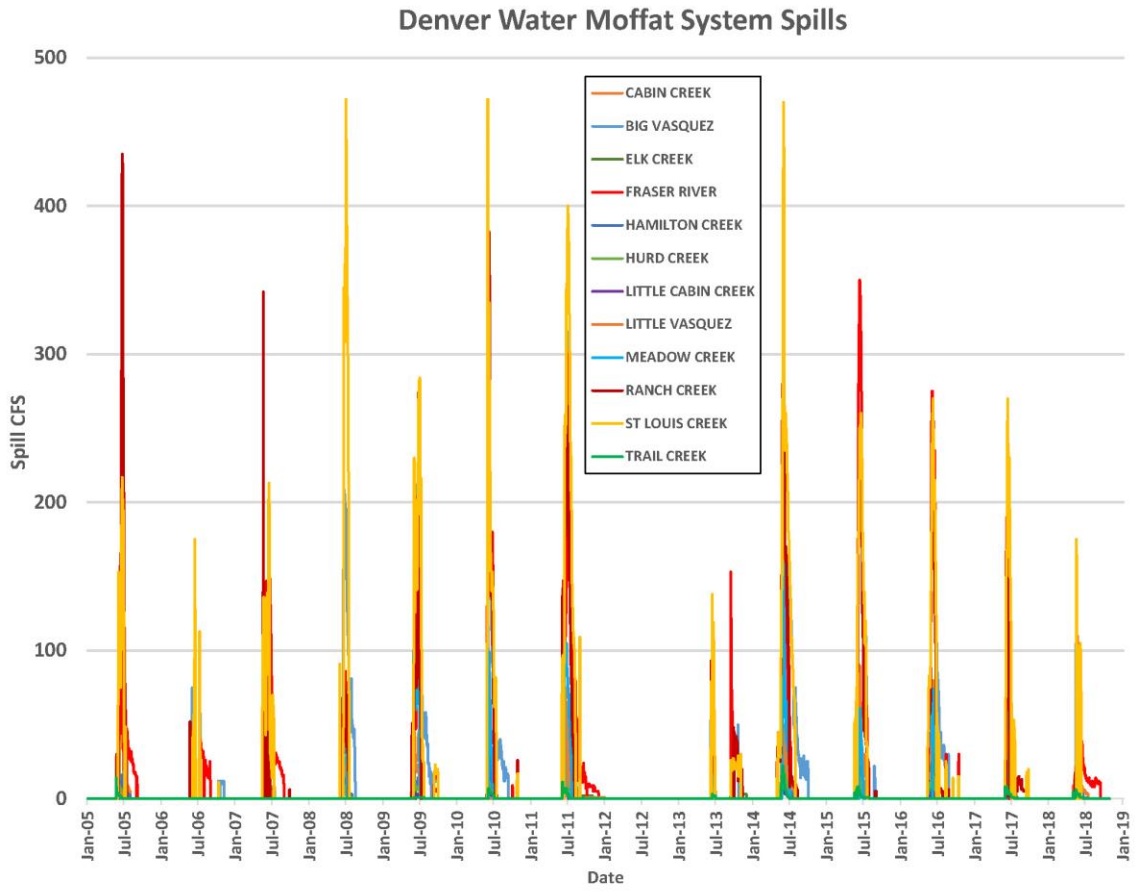
The Municipal Subdistrict reached out to Grand County regarding the potential for pumping 1,000 af of Variable Water Supply into Granby Reservoir, pursuant to paragraph III.F.3.c.i of the WGFP IGA. In early June, after consulting with the Subdistrict, Reclamation and the River District, Grand County elected to have this water pumped to Granby Reservoir. Windy Gap ceased pumping on June 14, bringing the total pumped volume to 26,235.8 af.

Except for 2012, Moffat Collection System undiverted flows have occurred in every year since 2005, with 2018 undiverted flows occurring at every stream bypass location (see graph below). Based on Denver Water's April 1st forecast, a dry year scenario precluded Moffat System undiverted flows, but the wet year scenario allowed for undiverted flows

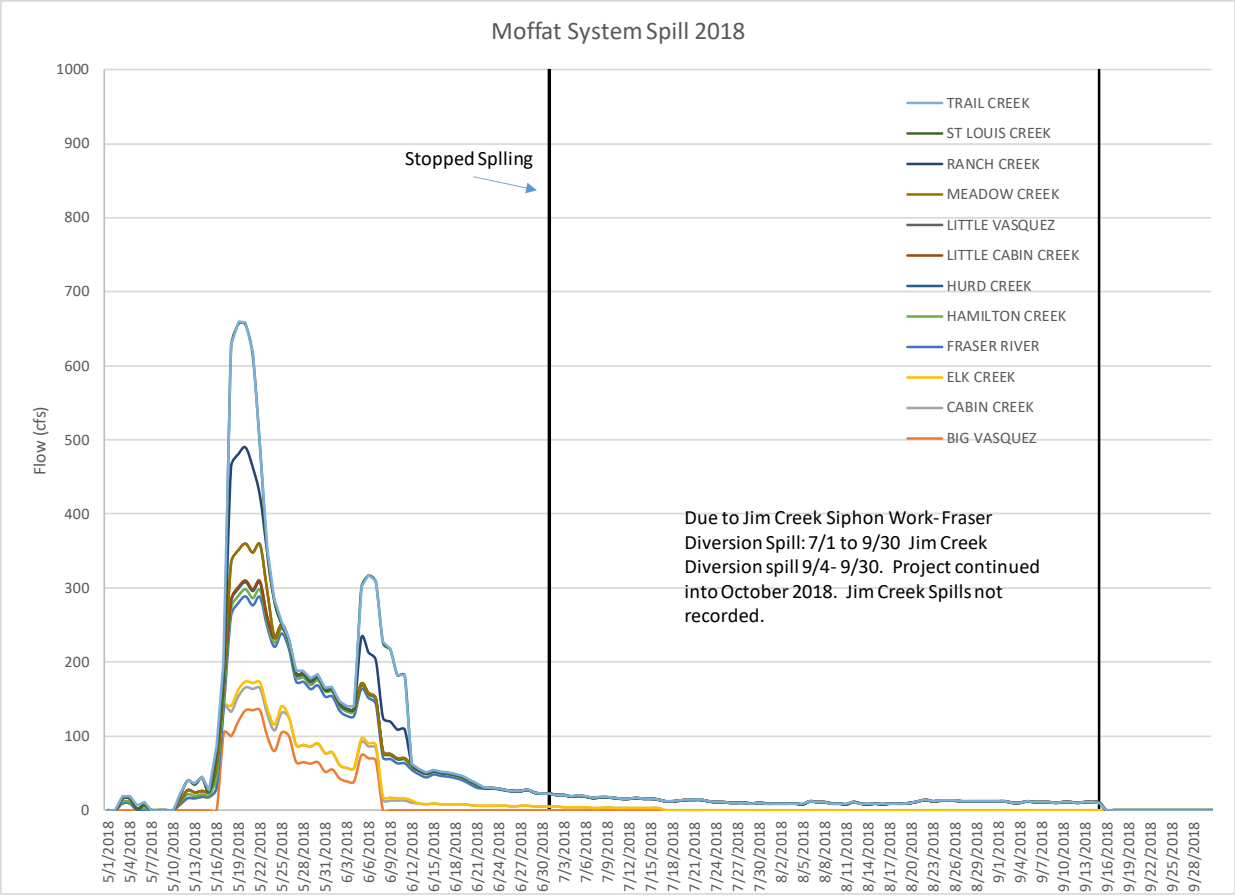
totalling about 40,000 af. The average year scenario forecast reflected undiverted flows of just a few thousand acre feet.

Moffat Undiverted Flow Potential

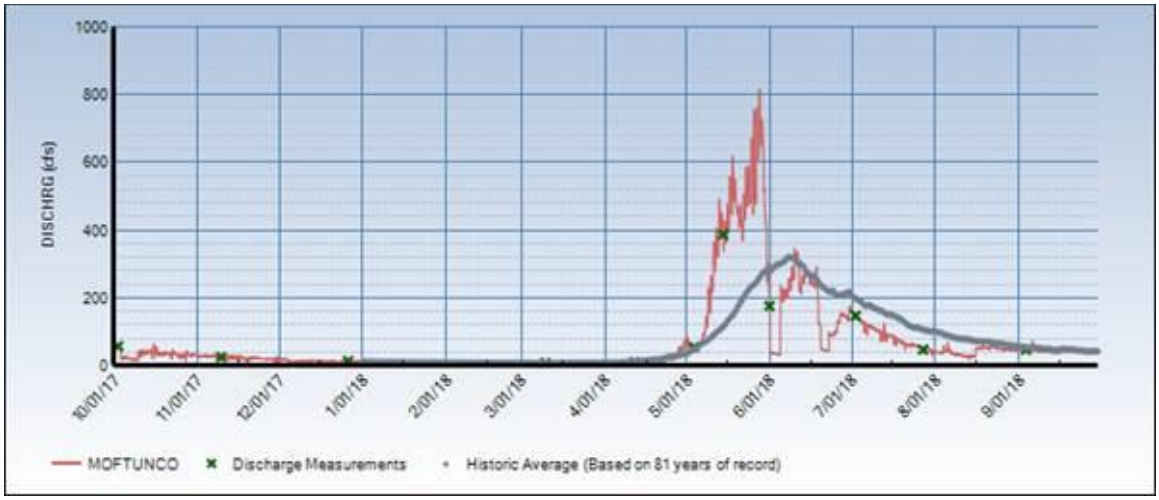
Denver Water started to bypass flow on May 11th starting with Cabin, Hurd, Hamilton and Ranch Creeks. By May 18th the remainder of the diversions, except for Meadow Creek Reservoir, were bypassing. In late June, Denver Water was called out in the South Platte Basin, so undiverted flow levels dropped in order to fill storage and meet demands on the East Slope. The Ranch Creek tributaries and the Fraser River diversion were the last part of the system to bypass flows. By July 1st all undiverted flows had stopped except for those needed for the Jim Creek siphon rehabilitation work. Denver Water bypassed just over 17,000 af between early May and late June (see graph below).



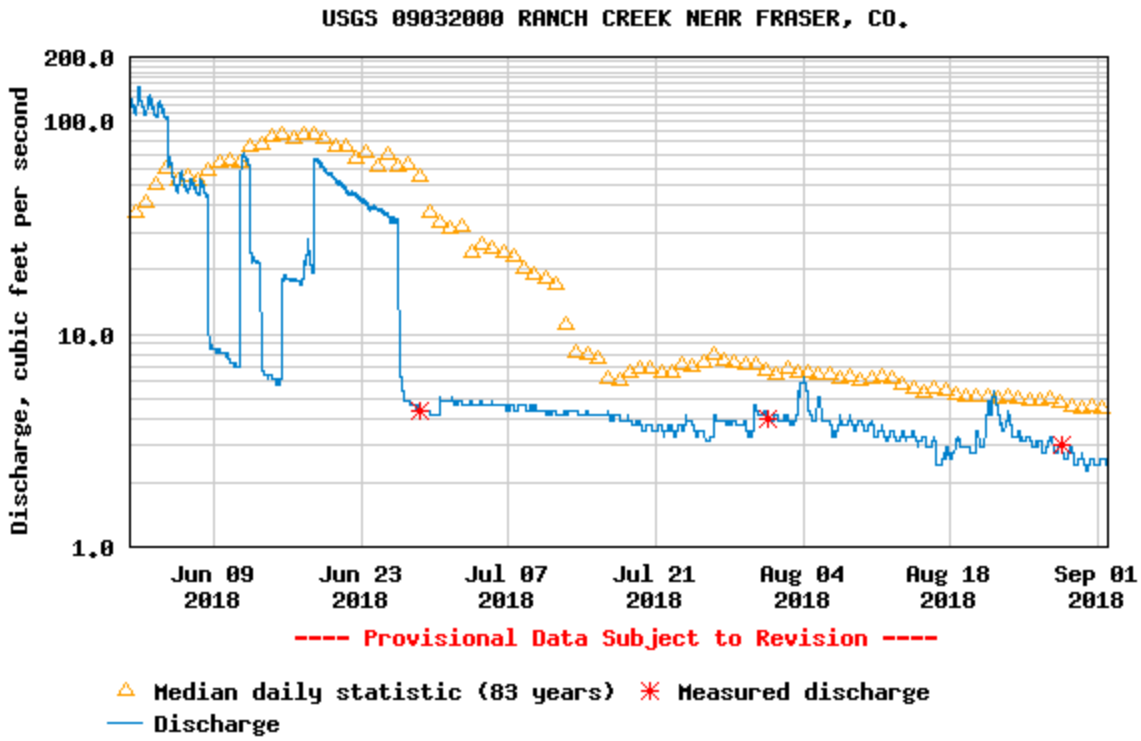
Moffat System Undiverted flows 2005 to 2018



Denver Water Moffat System Undiverted flows in 2018



Moffat Tunnel Diversions in 2018

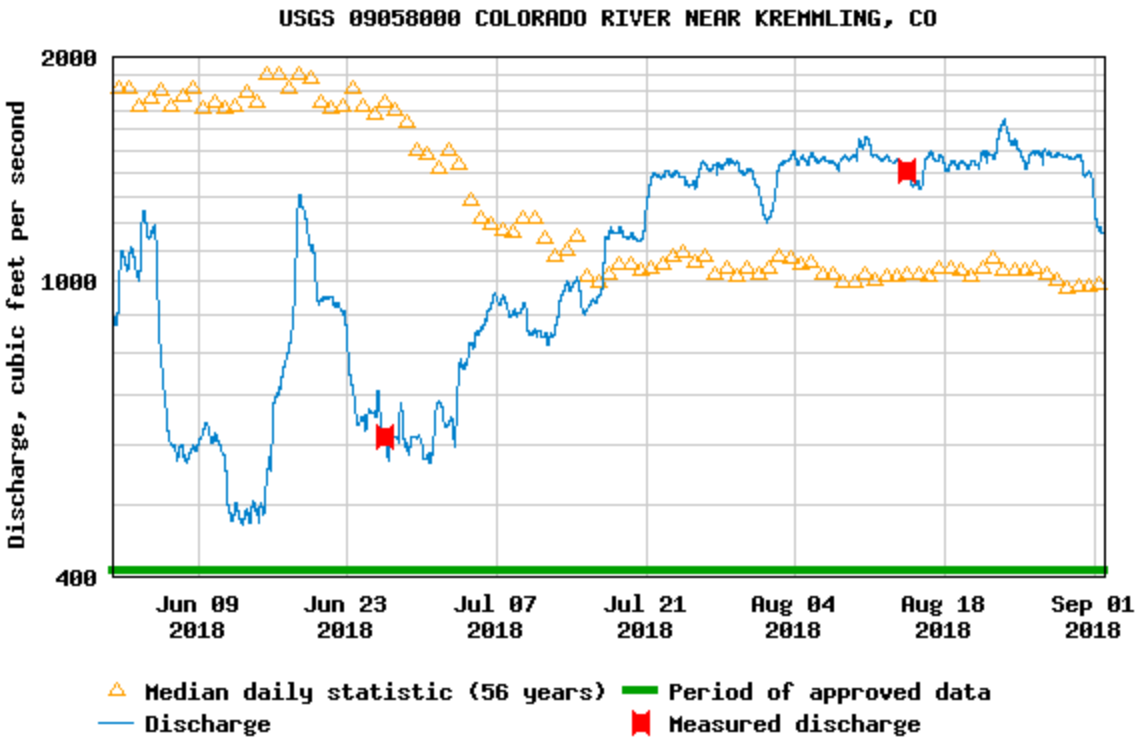


USGS Gage at Ranch Creek near Fraser

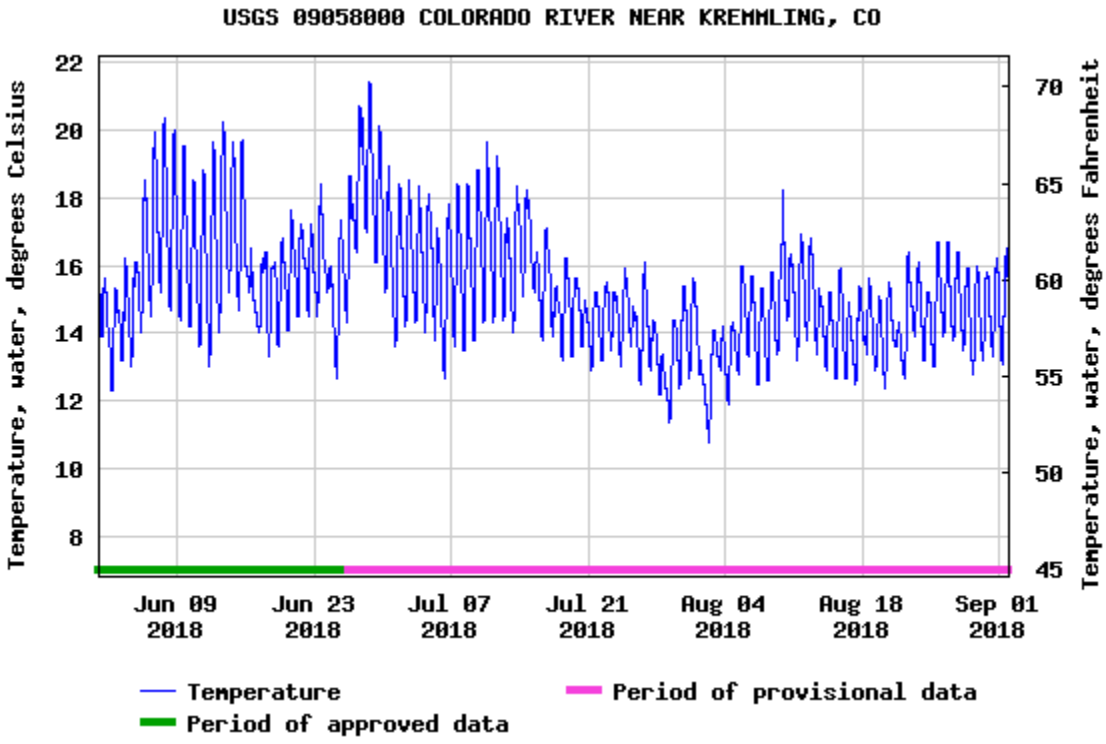
Wolford Reservoir Maintenance Drawdown Operations

The River District discussed plans to drawdown Wolford Mountain Reservoir starting in mid-July to 20 feet below full pool by September 1st. The maintenance drawdown was necessary to remove instrumentation peninsulas constructed in the upstream shell of the dam in 2012.

On June 13th the Colorado River near Kremmling gage dropped to 482 cfs, and maximum water temperatures reached 70˚F at Catamount Bridge. These conditions raised public concerns and prompted the Operations Subcommittee to hold a check-in call June 14th. Several operational factors influenced streamflow in the Upper Colorado River at this time. Windy Gap pumping was wrapping up as Granby fill forecasts suggested the Reservoir would fill on native inflow. Wolford Reservoir was spilling and maintenance work in the outlet precluded release of additional cooler water from the reservoir. Moffat Tunnel was taking all available water, anticipating bypassing flows to the Fraser River when Ralston Reservoir filled. Williams Fork Reservoir was ramping up outflow as it approached physical fill. Finally, Green Mountain Reservoir was releasing its minimum plus a small amount for contracts as hot and dry conditions persisted. Conditions improved over the following week due to a June 15th rain event along with a number of changes in operations. Windy Gap pumping ceased June 14th allowing Windy Gap Reservoir to refill and spill, bypasses increased at Williams Fork Reservoir as it neared physical fill, and the Moffat System was mostly turned out June 19th.



USGS Steamflow Gage Colorado River near Kremmling



Colorado River near Kremmling Water Temperatures

The Shoshone Senior Hydropower Call came on June 30th with Green Mountain as the Swing Right. Deliveries from Green Mountain to the Calling Right greatly benefited conditions on the Colorado River below Kremmling. Wolford Mountain Reservoir began Endangered Fish releases July 4th and, more importantly, maintenance drawdown releases July 16th. Maintenance releases averaged 206 cfs above demands through the end of August. These releases were protected to the 15-Mile Reach, and together with the unprecidented draw on the Green Mountain Reservoir Historic Users Pool (HUP), kept conditions in the Colorado River below Kremmling healthy. Climatology remained hot and dry, and the Cameo Call came on July 17th with Green Mountain Reservoir as the Swing Right. For several days in late July the Junior Cameo Call controlled administration above Shoshone.

In-Season Operations

Pursuant to the 2012 Colorado River Cooperative Agreement (CRCA), each year beginning with the year Denver Water's Moffat Project (aka Gross Reservoir Expansion Project) becomes operational, Denver Water will commit to distributing 1,000 af of water from its Fraser Collection System, which is a part of its larger Moffat Collection System, to streams in Grand County for the purposes of benefiting the aquatic environment. Although the Moffat Project was not yet operational, in 2015, 2016 and 2017 Denver Water worked with Grand County and LBD to coordinate voluntary bypasses ("Voluntary Water") from its Fraser Collection System to benefit the aquatic environment, targeting Ranch Creek and tributaries.

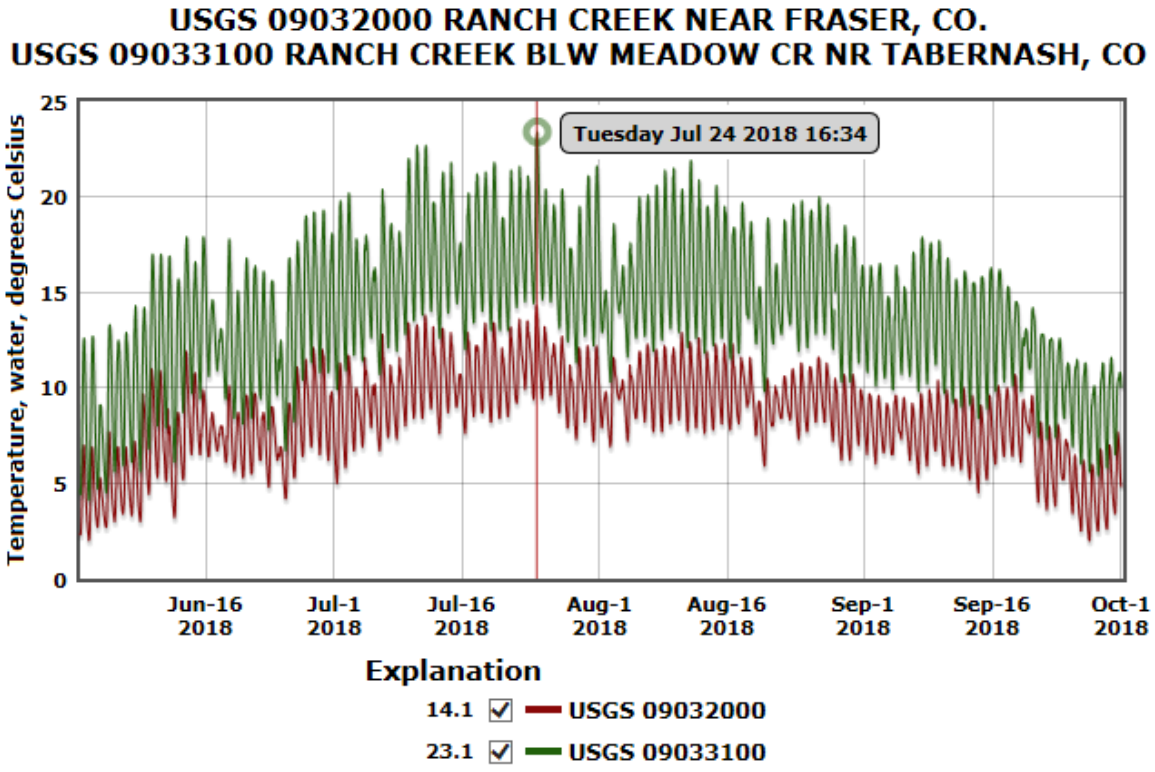
The Operations Subcommittee began weekly teleconference calls to discuss in-season operations on Wednesday July 3rd. Each week prior to the LBD operations call, Denver Water circulated a call sheet by email, Grand County (Katherine Morris) sent DM and MWAT temperature charts of Ranch Creek below Meadow Creek Reservoir (see below), and the River District (Don Meyer) forwarded notes from the Wednesday morning HUP call, including weather and flow forecasts and graphs of discharge flows below Grand County facilities.

Unlike in the previous three years, Denver Water was unable to offer Voluntary Water to address stream temperature issues when water temperatures were elevated and approaching state standards. However, the Jim Creek siphon rehabilitation project caused Denver Water to bypass about 900 af from July through September (a nominal 10 cfs at Jim Creek and Fraser diversions), enhancing flows and moderating temperatures on the Fraser River.

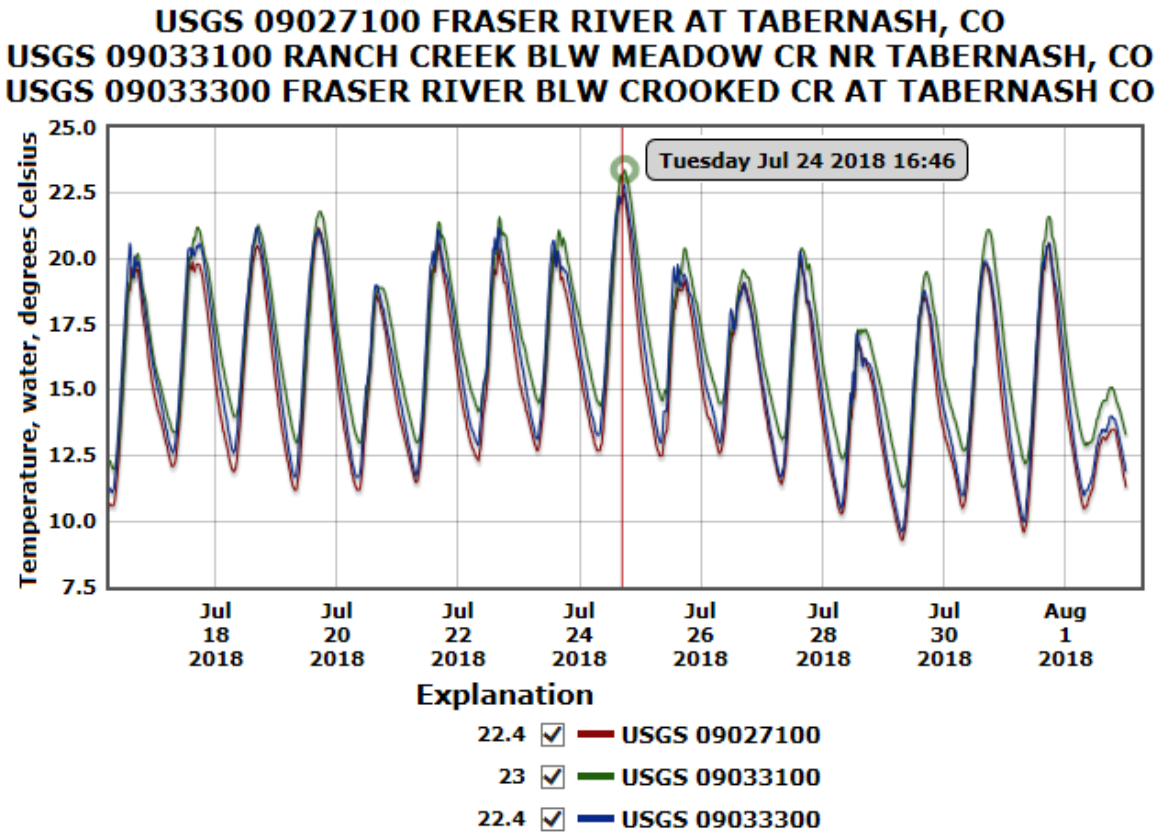
The Jim Creek siphon rehabilitation project consisted of relining the Jim Creek siphon and putting in a head gate on the Fraser River side of the system for improved siphon bypass pipeline operation. Because of dry conditions, a scheduled outage of the Foothills Water Treatment Plant and the Jim Creek siphon project, Denver Water did not have operational flexibility during the irrigation season to provide Voluntary Water for Learning By Doing.

During the first phase of the project the Fraser River diversion was bypassed to keep the siphon dry for the project. The Jim Creek division was operated to keep the work area at the bottom of the siphon dry. Phase 1 lasted from July 1 to September 4, longer than originally thought due to unexpected conditions with the old coating in the siphon. Phase 2 involved work in the canal on both sides of the siphon and required both the Fraser River and Jim Creek diversions to be bypassed. In late July, Denver Water concluded that the Jim Creek diversions were going to continue longer than anticipated, and Denver Water determined it had the operational flexibility to bypass water being diverted at Jim Creek elsewhere in the system if temperature standards were being exceeded. By late July however, conditions in the Fraser Basin were such that temperature standards were being met. Denver Water expected to bypass between 6,000 and 20,000 af of water between July 1 and mid-October during this project. Due to dry conditions and the delayed start to Phase 2, approximately 700 af was bypassed above the minimum bypass required from the Fraser River diversion and around 200 af is estimated to have been bypassed at the Jim Creek diversion, resulting in an additional 900 af of bypass flows in the Fraser River.

Water temperatures were monitored at several USGS real-time gaging locations on Ranch Creek near Fraser, Ranch Creek near Tabernash, Fraser River near Tabernash and Fraser River below Crooked Creek near Tabernash. As can be seen in the graph below, daily maximum temperatures were 9˚ C (16˚ F) higher in lower Ranch Creek than upstream at Ranch Creek near Fraser.

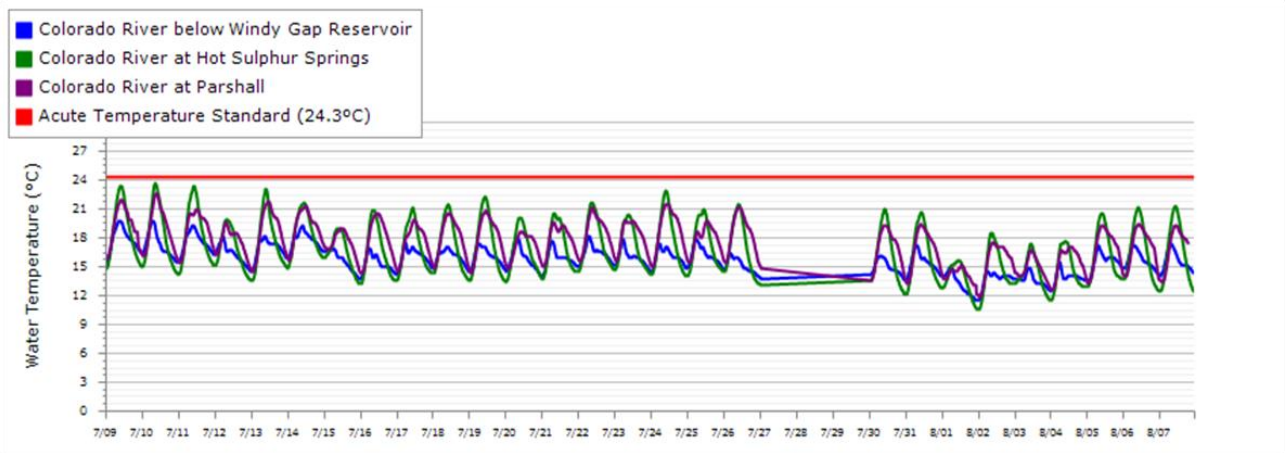


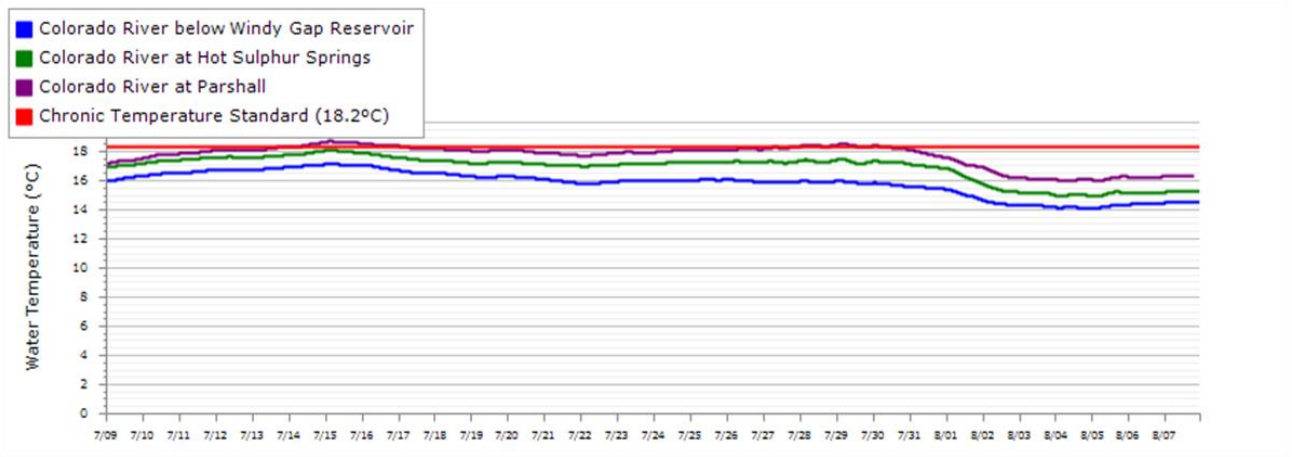
Temperature Increase on Ranch Creek from Fraser to Tabernash



Temperature on Ranch Creek and Fraser River near Tabernash

Water temperatures were also monitored at Northern Water's temperature gage below Windy Gap (see graphs below).





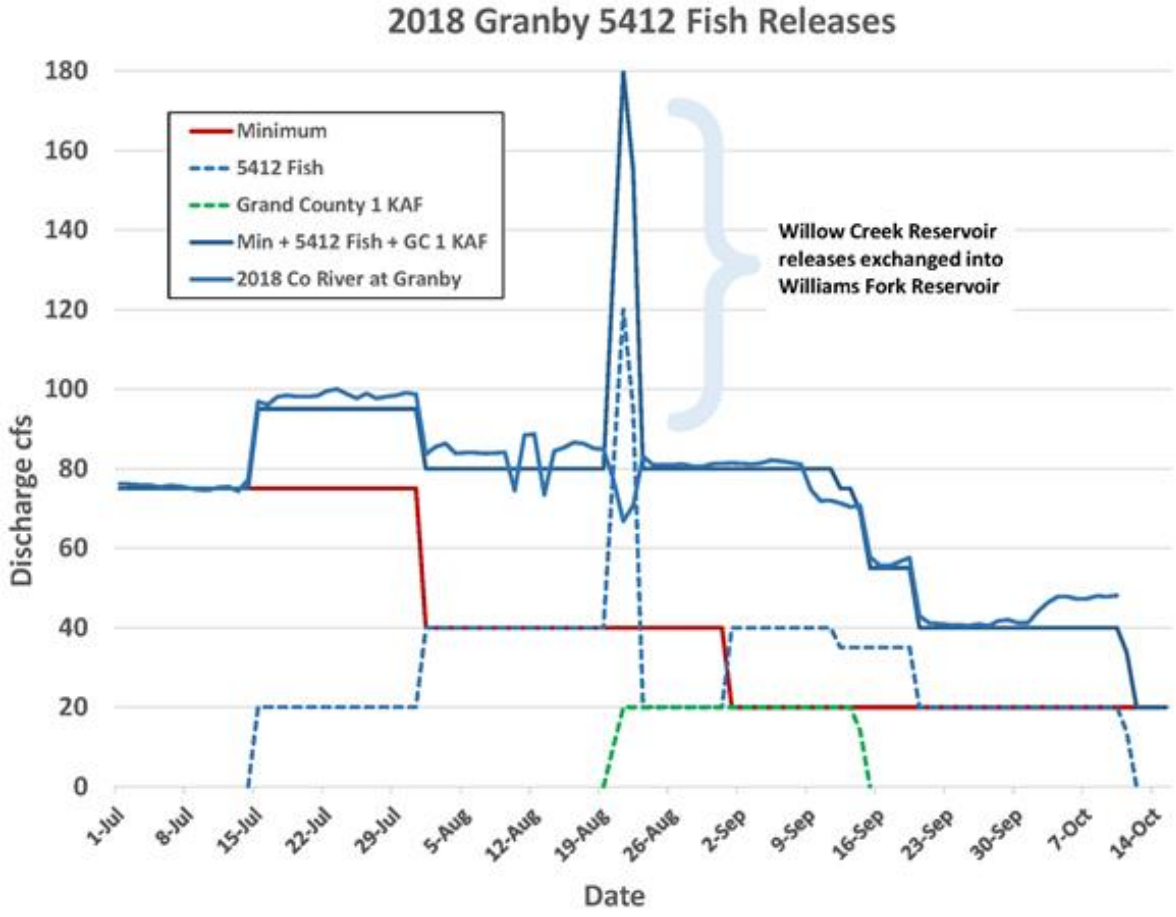
Northern Water Real-time Temperature Gages

In-Season flows below Granby Reservoir are generally dictated by minimum streamflow criteria per the 1961 Principles. In early June, Reclamation considered declaring 2018 a water short year, potentially impacting Granby outflow by 15 percent (64 cfs rather than 75 cfs) in a worst-case scenario. Reclamation, after considering forecasting variability and good initial water storage conditions, decided against this declaration. Late season water supply flexibility is provided below Granby through the availability of 5412.5 af (5412 water) to the Endangered Fish Recovery Program. This water can be released at times when the Recovery Program doesn't need it in the 15-Mile Reach, and exchanged into Williams Fork and/or Wolford Reservoir for later release for the Endangered Fish. The typical release schedule maintains 75 cfs at the USGS Granby gage in August and September, but there is flexibility to alter the schedule based on local stream conditions and water needs in the 15-Mile Reach.

In dry years the NEPA Record of Decision for the Granby 5412 water prescribes a release rate of 22 cfs starting July 15th. In 2018, early runoff and dry conditions contributed to the decision by the Recovery Program, in consultation with LBD, to start the Granby 5412 water on July 20th at a rate of 20 cfs.

In late summer, several exchanges were coordinated during HUP calls to mitigate potential impacts to the Colorado River during stream habitat enhancement activities on Williams Fork below Williams Fork Reservoir, and to allow for gage maintenance activities below Granby Reservoir, see graph below. During reduced Williams Fork Reservoir operations to facilitate project mapping, Northern Water and the Recovery Program demonstrated creative flexibility by releasing 120 cfs of 5412 water from Willow Creek Reservoir for two days, maintaining adequate flows below Williams Fork Reservoir. Most of this water was exchanged into Williams Fork Reservoir as 5412 water and released later to the 15-Mile Reach. During construction of the stream habitat enhancement features on Williams Fork, Denver Water and Reclamation exchanged water from Green Mountain to Williams Fork Reservoir, and this water was paid back later.

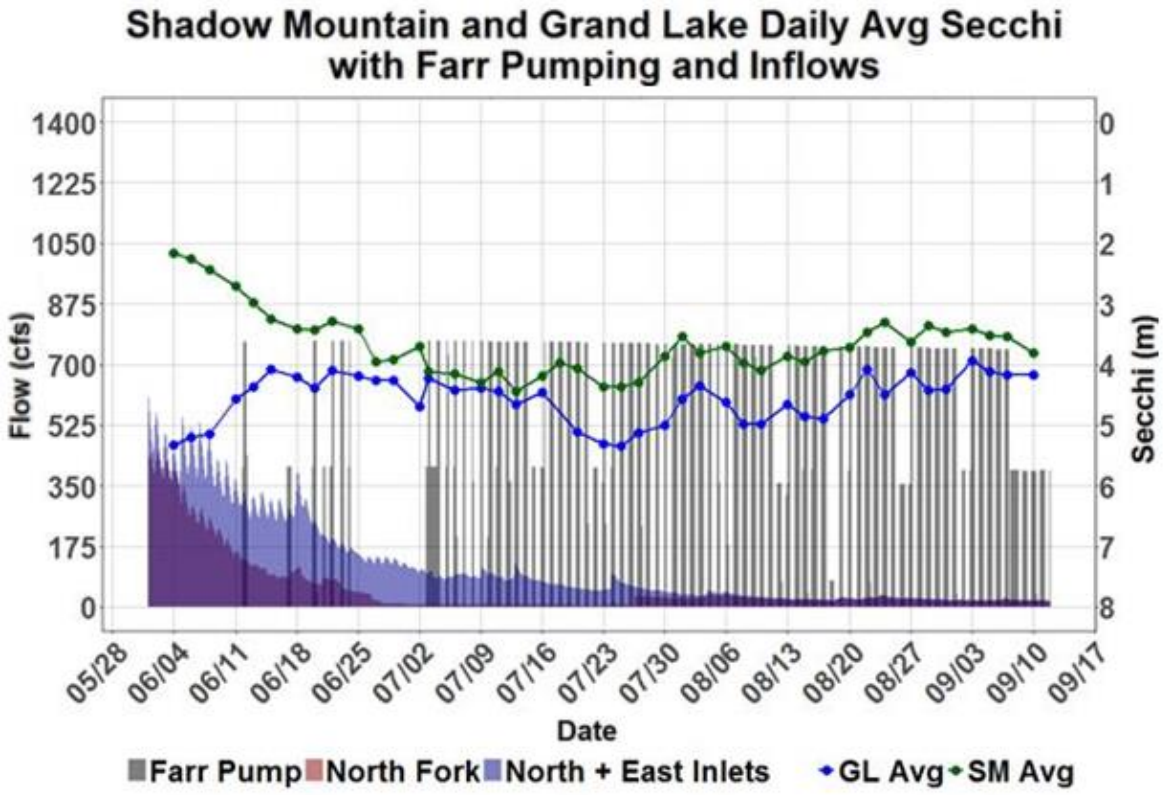
In coordination with Recovery Program release of the 5412 water, the Grand County 1,000 af was released from Granby Reservoir for 25 days in August and September at a time when water was critically needed (see graph below). This water was delivered directly to the Grand Valley Irrigators (substitution for Green Mountain Reservoir HUP direct deliveries) as a mechanism for beneficial use below Kremmling, as provided for in paragraph III.F.4.a of the WGFP IGA.



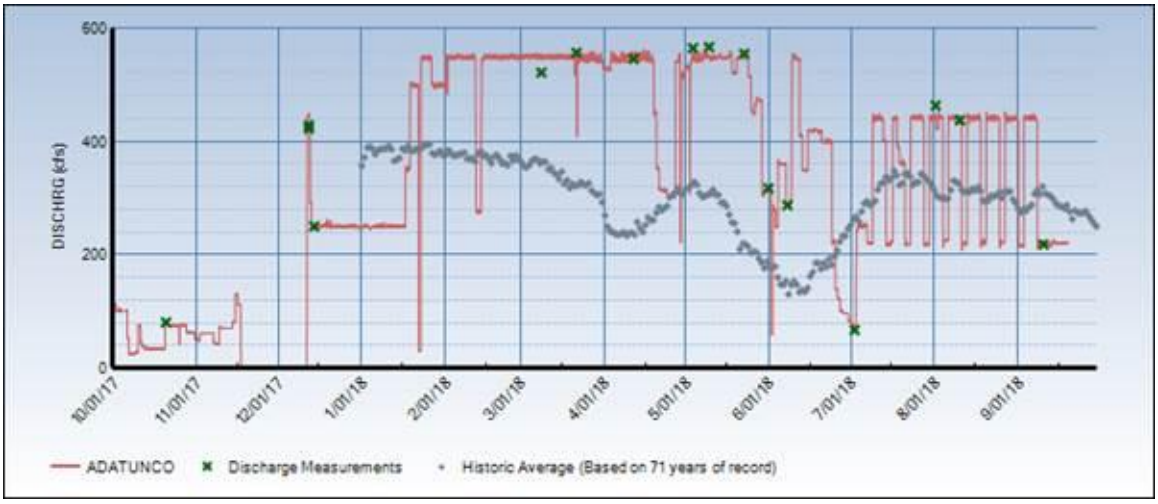
2018 Granby 5412 Releases

The 2018 Grand Lake Adaptive Management was an overall success this year, and involved some unique hydrology. A below-average winter snowpack resulted in a lower-than-average runoff volume, a two-peak runoff pattern, and a very low post peak runoff volume. Throughout the July 1–September 11 season, Reclamation scheduled Adams Tunnel diversions to follow a pattern of 220 cfs on weekends (Saturday/Sunday) and 440 cfs during weekdays (Monday-Friday). Clarity in both Shadow Mountain Reservoir and Grand Lake were excellent this year, with Grand Lake having an average clarity of 4.58 meters, and Shadow Mountain never dropping below 3 meters. Both bodies of water saw low algal productivity and did not encounter any dissolved oxygen issues. The exact drivers behind this years' excellent clarity is being investigated during post-season modeling investigations. Variables of interest include this summer's low overall

precipitation, reduced sediment/nutrient loading due to runoff patterns, as well as smoke effects from summer wildfires.

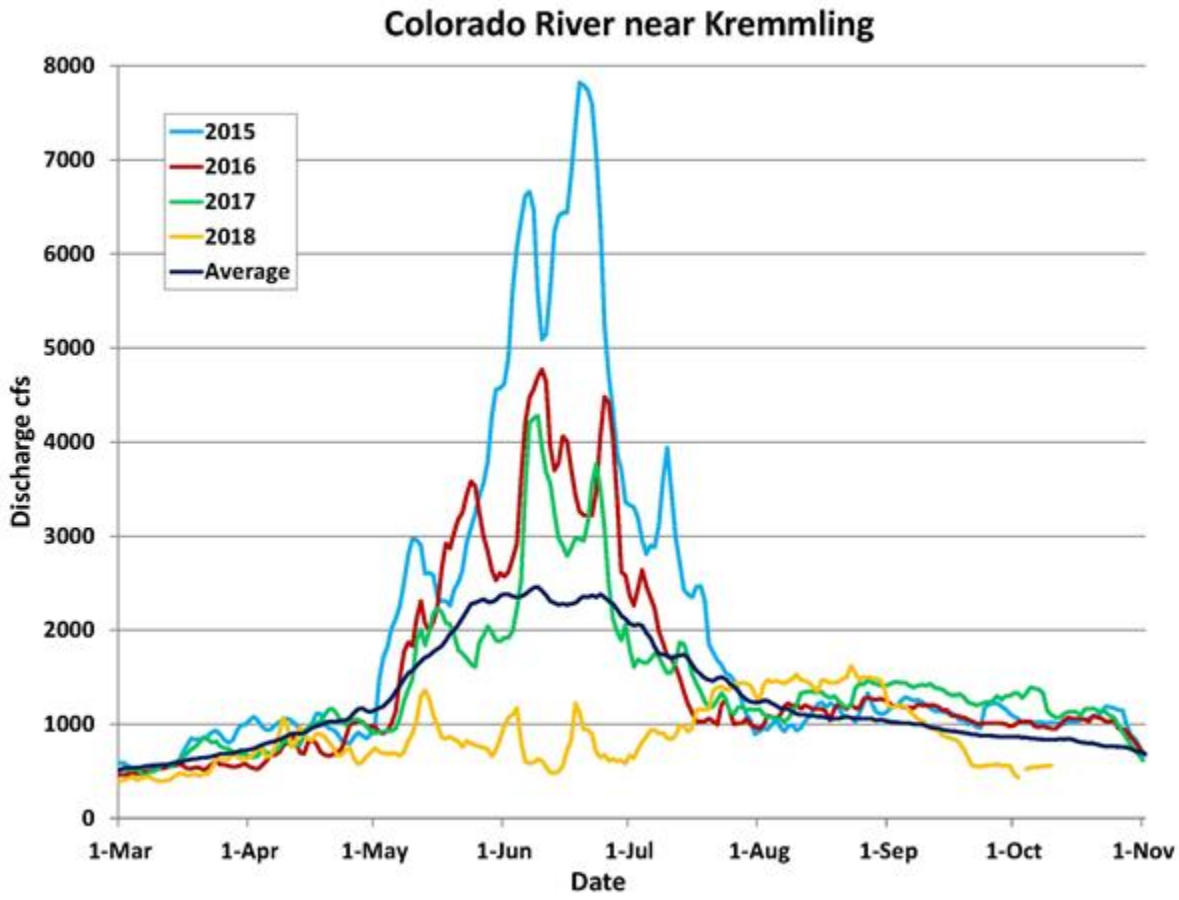


Three Lakes Clarity Operations and Monitoring



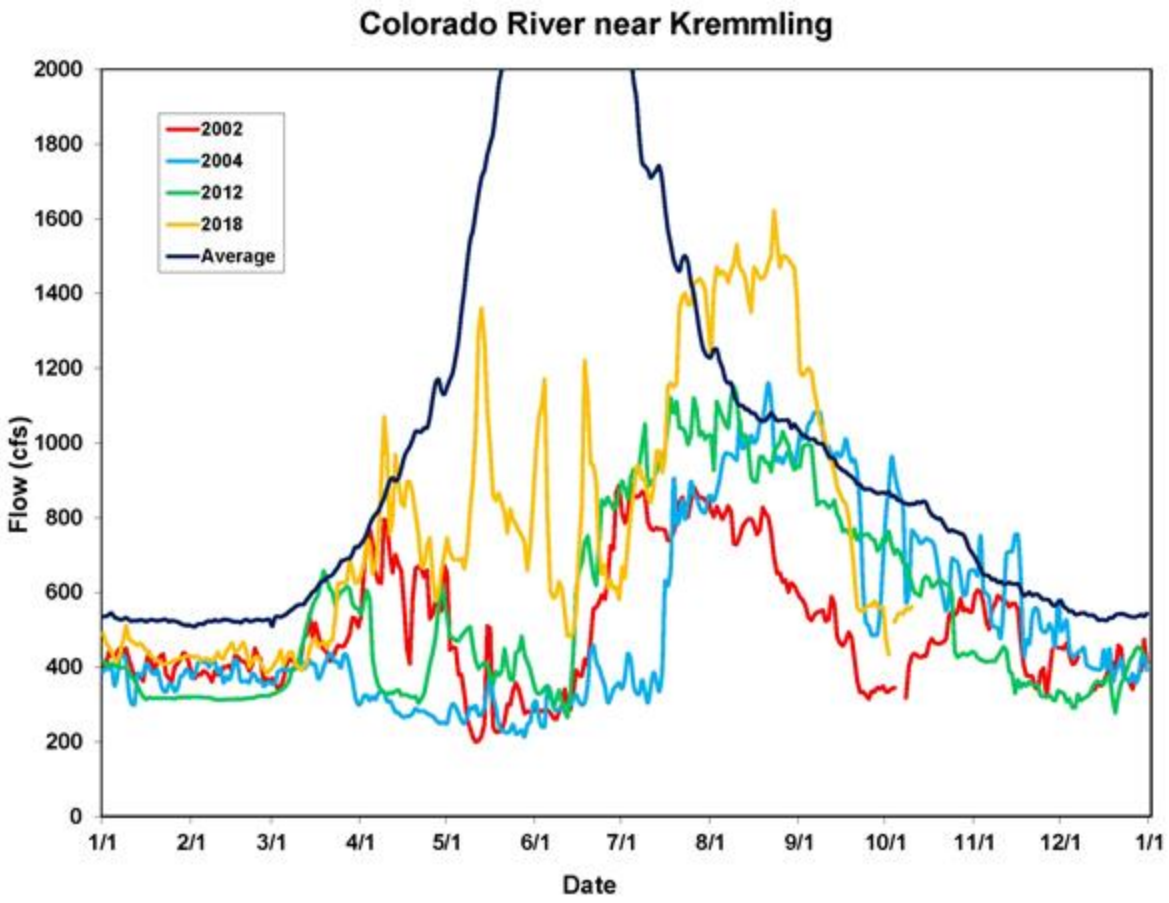
Adams Tunnel Diversions

Flows on the Colorado River near Kremmling declined in three consecutive years from 2015 to 2018 (see graph below). However, during August 2018 flows were greater than in the three previous years due to Wolford maintenance releases and an unprecidented draw on the Green Mountain Reservoir HUP Pool.



Comparison of 2015 thru 2018 Flows at Colorado River near Kremmling

A comparison of flows on the Colorado River below Kremmling for recent very dry years is shown in the graph below. Flows were generally greater in 2018 than in 2002, 2004, and 2012 due to better snowpack, earlier runoff and greater draw on upper basin reservoirs as mentioned above.



Comparison of Recent Very Dry Year Flows at Colorado River near Kremmling

Next Steps

The Operations Subcommittee will review streamflow and water temperature data collected in 2018 and work with the Monitoring Subcommittee to determine appropriate data collection strategies for 2019.

LBD will consult with Fish and Wildlife Service (Don Anderson) in July 2019 on his preliminary plan for 5412 af releases from Granby Reservoir and 6,000 af releases from Wolford Reservoir. Release schedules will be discussed during weekly State of the River (SOR) and HUP calls or offline, and can change from week to week. Updates should be provided to the Operations Subcommittee during weekly LBD calls.

It is possible for Denver Water to make direct deliveries from Meadow Creek Reservoir into tributaries of Ranch Creek; however, there is no measuring capability and no legal mechanism for delivery at this time. Grand County Mutual Ditch and Reservoir Company (GCMDRC) is investigating the feasibility of delivering Vail Ditch water into the Upper Fraser under a pilot project with the potential to make it available to LBD.

Denver Water was unable to provide 2016 stream temperature modeling because CDPHE and USFS did not collect stream temperature data loggers at the end of 2016, and by the time loggers were retrieved later in the summer of 2017, much of the data was lost due to attrition. Data loggers placed by these two agencies in 2017 were retrieved in late 2017 and stream temperature data was provided to Denver Water. Denver Water has submitted a draft report documenting modeling using 2017 data to LBD for review.

Water Year 2018 was an historic drought year presenting many challenges, especially to the HUP managing entities, but there were challenges to LBD as well, including consideration of Windy Gap pumping into Granby Reservoir for Grand County and subsequent release scheduling. Operations in the LBD Cooperative Effort Area are often driven by decisions negotiated during the HUP weekly calls or offline. It was suggested that LBD operations calls be scheduled before, rather than after the HUP weekly calls, so that LBD concerns can be presented during the HUP discussion.

Attachment A

LBD Water Sources and Quantities Offering Flexibility

1. Moffat Collection System Voluntary/Enhancement Water

    - 1,000 af environmental bypass
    - Surplus water not needed in a given year by Denver Water

2. Northern/Subdistrict Water

    - Grand County's 4,500 af "bucket"
        - 570 af (3.8% of Windy Gap Pumping in excess of 15,000 af, up to 1,500 af)
        - MPWCD possible end of year transfer of 1,200 af
        - End of year pumping, must pay for pumping (DW allocated $1M pumping fund)
    - MPWCD's "bucket"
        - 700 af variable water subject to Granby spill and use restrictions

3. Endangered Fish Water

    - 5,412.5 af for endangered fish. Fish and Wildlife Service (FWS) can call for this water. The water may be released from Granby at a time when FWS doesn't need it for endangered fish, and booked back to Williams Fork and/or Wolford Reservoir, until FWS puts in a call. Releases depend on the type of hydrologic year and the targeted streamflow in the Colorado River downstream of Granby and in the 15-mile reach, but a typical release schedule maintains 75 cfs at USGS Granby gage from Aug 1 through mid-September

4. Williams Fork Reservoir Storage

    - 1,000 af environmental water (CRCA) stored when 1,000 af environmental water is bypassed during a mainstem Colorado River Call. 2,500 af maximum carryover, first to spill, notification of anticipated spill

Note: In 2018, the only water available to LBD was the 5,412.5 af Endangered Fish Water and the 1,000 af Grand County Water pumped from Windy Gap in Granby. Denver Water did not make available any Voluntary Water from the Moffat System.