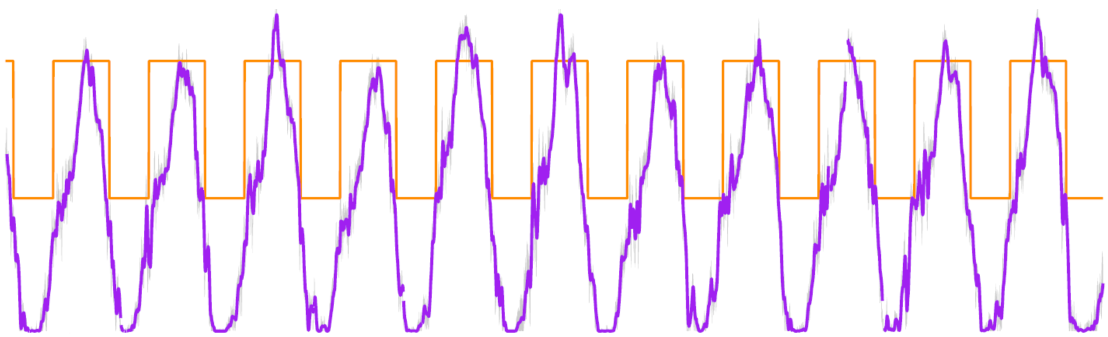
Wild and Scenic Group Water Temperature Data Inventory and Evaluation



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1 BACKGROUND

The Wild and Scenic Management Plan (Plan) was adopted by the U.S. Bureau of Land Management (BLM) and U.S. Forest Service (USFS) on June 12, 2015 to protect the outstandingly remarkable values (ORVs) identified by BLM and USFS for the Colorado River from its confluence with the Blue River to near Glenwood Springs, Colorado. The Plan was proposed by and is being implemented as a Wild and Scenic management alternative by a stakeholder group (SG) representing a broad range of interests. Stakeholders include east slope and west slope water users/water conservancy and conservation districts, landowners, trans-mountain diverters, local government, state interests, conservation/environmental/fishing groups, and recreational float-boating. The Plan aims to protect all ORVs identified in the federal agencies' Eligibility Reports[1], while focusing on ORVs for recreational fishing and float-boating on the Colorado River between Gore Canyon and Glenwood Springs. The SG's intention is to implement the Plan in a way that can "[…] balance permanent protection of the ORVs, certainty for the stakeholders, water project yield, and flexibility for water users."

The Plan establishes provisional Resource Guides to assist with protection of the ORVs in the Upper Colorado Wild & Scenic Segments (W&S segments). The provisional Resource Guides are "[…] one source of information among others for informing SG discussions under the Plan. The Resource Guides are not intended to be used as a test for Plan success, nor for use by permitting agencies or entities as the criterion for evaluating a project's effects on the ORVs." The Plan identifies a Resource Guide for water temperature, an important criterion for protecting aquatic life on the W&S segments. The Plan states that, during the provisional period:

> *"The Resource Guides for temperature are the CDPHE stream temperature water quality standards for Daily Maximum (DM) and Maximum Weekly Average Temperature (MWAT) for the portion of the stream segment that CDPHE has designated COUCUC03 (Mainstem of the Colorado River from the outlet of Granby Reservoir to the confluence with the Roaring Fork River) that is within Wild and Scenic Segments 4 through 7."*

Temperature data compiled by the SG Monitoring Committee covering the period from 2012-2017 shows multiple exceedances of the Water Quality Control Commission (WQCC) table value standards for water temperature within segment COUCUC03. The purpose of this work is to characterize these historical water temperature patterns and identify additional steps that can be taken in the future to enhance the SG's understanding of water temperature drivers in the river segments covered by the Plan.

[1] BLM Kremmling and Colorado River Valley Field Offices Final Wild and Scenic Rivers Eligibility Report 2014. https://ia802807.us.archive.org/4/items/finalwildscenic1225unse_1/FinalWildScenicRiverSuitabilityReportKremmlingCoRivervalley_88073731.pdf

White River National Forest Wild and Scenic Eligibility Report for Deep Creek and Colorado River https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5286435.pdf

This work was built around four primary objectives:

1) Compile and summarize historical water temperature data,
2) Identify possible thermal stressors and drivers of temperature patterns on W&S segments
3) Identify important data gaps, and
4) Provide recommendations for future studies and monitoring.

2 DATA SOURCES

Numerous entities currently or historically maintained temperature monitoring sites on the W&S segments and several upstream reaches. In recent years, Grand County Water Information Network (GCWIN) staff moved to consolidate monitoring sites between Grand County and other entities such as Northern Water Conservation District. Most datasets were moved into unified digital repositories. GCWIN previously maintained the Water Information Library and Unified Reference (WILbUR), a database and web application for storing, retrieving, and visualizing water quality data in Grand County. Use of WILbUR was discontinued in 2018 and GCWIN staff began migrating data into the Colorado Data Sharing Network (CDSN), an instance of Gold System's AWQMS database (http://coloradoframework.org/resources/cdsn/). CDSN provides a web portal and dashboard tool to access and visualize data from the underlying AWQMS database. An application program interface (API) enables automated data retrieval from the database GCWIN staff conducts regular review and QA/QC of temperature monitoring data prior to database submission, largely completing a key time-intensive task for all data users. The U.S. Geological Survey (USGS), another important data collection agency, also maintains continuous temperature loggers at numerous streamflow gauging and water quality sites throughout the upper Colorado River basin. Data collected by USGS is accessible for manual retrieval from the National Water Information System website or via automated calls to a set of web services.

Combined searches in AWQMS and NWIS yielded 76 GCWIN-archived sites and 11 USGS-operated sites in the upper Colorado River basin above Glenwood Springs. The focus of this project is on water temperature conditions in the Colorado River and significant tributaries to W&S segments 4-7. Segments of the mainstem Colorado River and tributaries immediately upstream of Segment 4 were also deemed relevant to this assessment. Flows from the Colorado River, Williams Fork River, Blue River, and Muddy Creek are expected to exert some control on the upstream thermal boundary condition for the W&S segments. As a result, this analysis also reports on select monitoring locations in the mainstem Colorado and at the tributary mouths for each of these streams. Sub-setting the available temperature monitoring sites with continuous data records to meet these criteria yielded a list of 28 sites: seven USGS-operated sites and 21 GCWIN-archived sites. Historical data associated with the GCWIN-archived sites may have originally sourced from Grand County, Northern Water, Denver Water, GCWIN, BLM, Trout Unlimited, or the W&S stakeholder group (Figure 1, Table 1). Non-archived data from a small number of Colorado Parks and Wildlife (CPW) monitoring locations may become available in the future.

Sites considered in this assessment typically reported data in either a 15-minute or 30-minute time step. Data record length ranged from 1 to 13 years, depending on the site (Figure 2). Continuous data from most sites is only available for the summer and fall seasons. A small number of USGS sites produce continuous data year-round. Data records are sporadic prior to

2010. The spatial and temporal resolution of GCWIN's data coverage on the mainstem Colorado above the W&S segments improved after 2010 but coverage within segments 4-7 remained inconsistent. The most reliable data records for W&S segments 4-7 come from the two USGS-operated stations that bracket the Segment boundaries—one at the top of Gore Canyon and the other in Glenwood Canyon at No Name. BLM operated temperature monitoring sites at Pumphouse and Radium for several years. USGS began operating a streamflow gauge and temperature monitoring station at Catamount in 2016, adding a useful midpoint to the reach extending from State Bridge to Dotsero. However, intra-segment data availability remains inconsistent in timing and location.

2.1 Credible Data Criteria

Water quality data collection practices and data quality routinely vary with the intended users and purposes. Data useful in Clean Water Act assessment and reporting, state or federal permitting, or for other legal contexts may require higher standards for documentation of collection practices, handling/cleaning, archiving, and reporting. Water Quality Control Division (WQCD) identifies minimum criteria for water quality data used in support of state regulatory purposes as part of its biennial Clean Water Act 303(d) Listing Methodology. Section III-B of the 2018 listing methodology describes these requirements, including general requirements for collection and reporting, sampling and analysis plans (SAP), period of record reporting, and data representativeness.

The data criteria described by the State of Colorado are generally targeted towards discrete sampling events (i.e. grab sample methods) but also accommodate semi-quantitative or narrative information derived from other bioassessment techniques. The more-recent advent of cheap in-situ monitoring technologies generating continuous time series data presents a unique challenge for data management and use. Additional guidance for monitoring and assessment procedures are provided by WQCD Policy 06-1 Temperature Criteria Methodology, Regulation 31 Table I Footnote 5, and WCQD's Operating Procedures for the Collection of Stream Water Temperatures Utilizing the Deployment of Temperature Data Loggers.[2] GCWIN and BLM do not maintain a complete SAP for continuous temperature monitoring sites. Both entities maintain site location metadata and thorough records on logger operation, calibration, and deployment. Data produced at sites operated by the W&S stakeholder group were subjected to QA/QC procedures by GCWIN staff. USGS operates temperature and discharge sites as part of the National Water Information System (NWIS), subject to the agencies' own rigorous data collection, management, and archiving protocols. Water temperature data archived by GCWIN, federal or state agency partners, and municipal governments or special districts generally meet the intent of the State's data criteria purposes.

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[2] CDHPE Temperature standards and guidelines for monitoring and regulatory assessment are variously laid out in these policies: WQCD Policy 06-1: Temperature Criteria Methodology
https://www.colorado.gov/pacific/sites/default/files/Policy%2006-1-2017.pdf
Regulation 31 5 CCR 1002-31: Basic Standards and Methodologies for Surface Water
https://www.sos.state.co.us/CCR/GenerateRulePdf.do?ruleVersionId=7455&fileName=5%20CCR%201002-31
Standard Operating Procedures for Collection of Stream Water Temperature
https://www.colorado.gov/pacific/sites/default/files/SOP%20-%20Temperature%20Data%20Loggers%20-%20121714.pdf

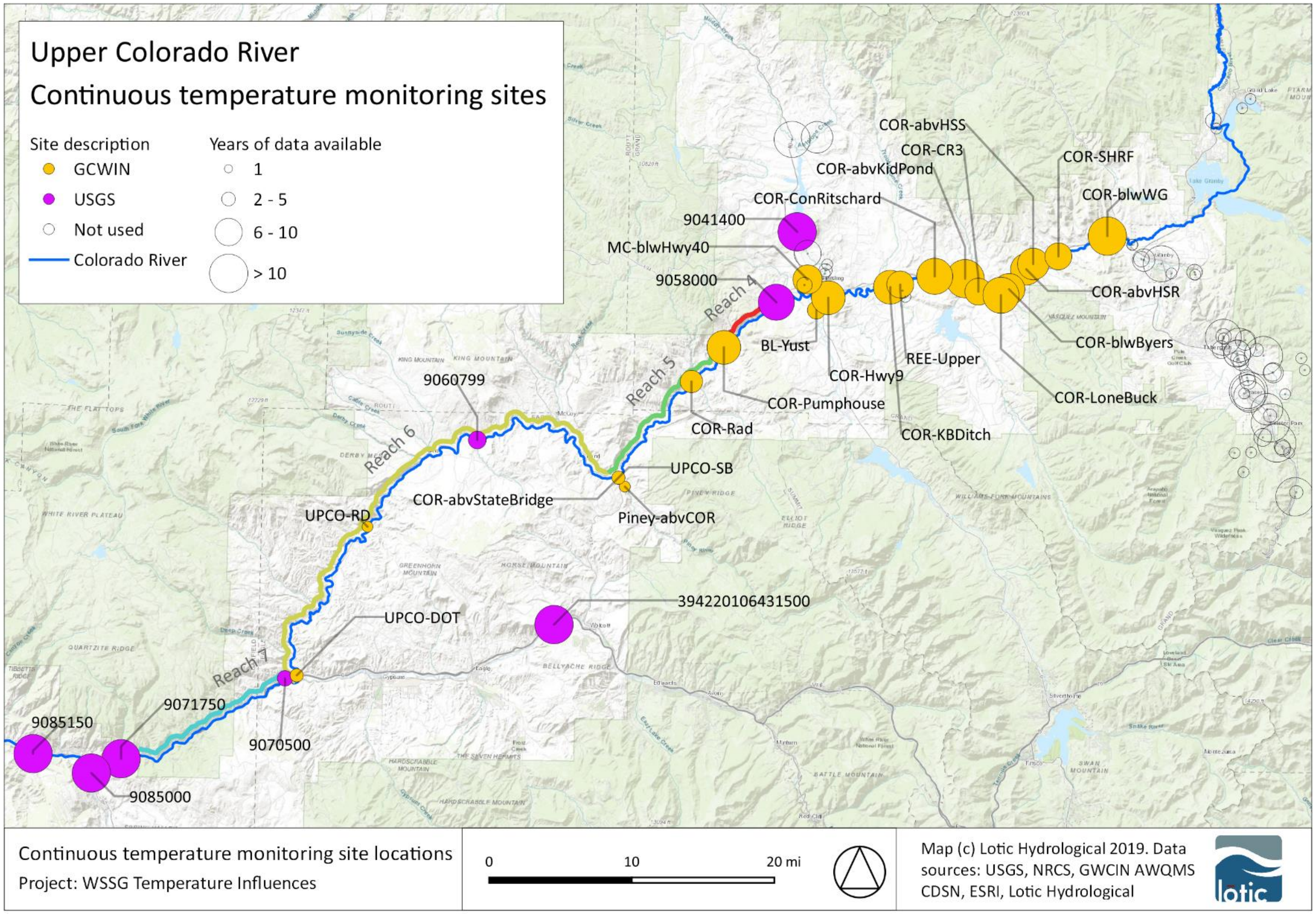

Figure 1. Monitoring site location map.

Table 1. Monitoring site location descriptions.

Site ID	Site Name	Org.	Lat.	Long.	W&S	Tier	Start	End	Stream Gauge	Gauge Name	Air Site	Air Site Name
09041400	MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO	USGS	40.08736	-106.067667		CS2	10/1/2007	3/20/2019	090041400	MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO	054664	KREMMLING
09058000	COLORADO RIVER NEAR KREMMLING, CO	USGS	40.03665	-106.44003	4	CS2	4/1/2008	3/20/2019	09058000	COLORADO RIVER NEAR KREMMLING, CO	054665	KREMMLING
09060799	COLORADO RIVER AT CATAMOUNT BRIDGE, CO	USGS	39.89110	-106.83169	6	CS2	10/21/2016	3/20/2019	09060799	COLORADO RIVER AT CATAMOUNT BRIDGE, CO	054665	KREMMLING
09070500	COLORADO RIVER NEAR DOTSERO, CO	USGS	39.64461	-107.07801	7	CS2	10/9/1996	9/16/1998	09070500	COLORADO RIVER NEAR DOTSERO, CO	057618	SHOSHONE
09071750	COLORADO RIVER ABOVE GLENWOOD SPRINGS, CO	USGS	39.55887	-107.29089	7	CS2	10/1/2007	3/20/2019	09070500	COLORADO RIVER NEAR DOTSERO, CO	053359	GLENWOOD SPGS #2
09085000	ROARING FORK RIVER AT GLENWOOD SPRINGS, CO.	USGS	39.54359	-107.329	7	CS2	10/1/2007	3/20/2019	09085000	ROARING FORK RIVER AT GLENWOOD SPRINGS, CO.	053359	GLENWOOD SPGS #2
09085150	COLORADO R ABV SOUTH CANYON CR NR GLENWOOD SPGS CO	USGS	39.56167	-107.40667		CS2	10/1/2007	3/20/2019	09085100	COLORADO RIVER BELOW GLENWOOD SPRINGS, CO	053359	GLENWOOD SPGS #2
394220106431500	EAGLE RIVER BELOW MILK CREEK NEAR WOLCOTT, CO	USGS	39.705	-106.72583		CS1	10/1/2007	3/20/2019	394220106431500	EAGLE RIVER BELOW MILK CREEK NEAR WOLCOTT, CO	058575	VAIL
BL-Yust	Blue River at Yust Ranch 100 feet downstream of Trough Road Bridge	GCWIN	40.029249	-106.387		CS1	5/27/2010	10/22/2018	09057500	BLUE RIVER BELOW GREEN MOUNTAIN RESERVOIR, CO	054664	KREMMLING
COR-abvHSR	Colorado River upstream of Hot Sulphur Springs Resort	GCWIN	40.07378	-106.10989		CS2	5/4/2008	10/13/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM
COR-abvHSS	Colorado River upstream of Hot Sulphur Springs Water Treatment Plant	GCWIN	40.07930	-106.10077		CS2	7/29/2006	10/29/2015	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM
COR-abvKidPond	Colorado River upstream of Kids Fishing Pond downstream of Parshall CO	GCWIN	40.06342	-106.19073		CS2	7/26/2005	9/16/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM

Site ID	Site Name	Org.	Lat.	Long.	W&S	Tier	Start	End	Stream Gauge	Gauge Name	Air Site	Air Site Name
COR-abvStateBridge	Colorado River upstream of State Bridge	GCWIN	39.85554	-106.64448	5	CS2	7/30/2009	10/13/2009	09058000	COLORADO RIVER NEAR KREMMLING, CO	054664	KREMMLING
COR-blwByers	Colorado River downstream of Byers Canyon	GCWIN	40.05328	-106.13238		CS2	8/19/2008	10/1/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM
COR-blwWG	Colorado River downstream of Windy Gap at Hitching Post	GCWIN	40.10851	-106.00315		CS2	7/26/2005	8/16/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	053500	GRAND LAKE 6 SSW
COR-ConRitschard	Colorado River at public fishing access east of Con Ritschard Ranch	GCWIN	40.06545	-106.23097		CS2	9/6/2006	10/13/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM
COR-CR3	Colorado River at CR3 bridge at Bar Lazy J Ranch	GCWIN	40.05042	-106.17296		CS2	7/13/2007	10/18/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM
COR-Hwy9	Colorado River upstream of Hwy 9 bridge in Kremmling CO	GCWIN	40.04210	-106.37140		CS2	7/30/2006	10/20/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	054664	KREMMLING
COR-KBDitch	Colorado River at CR39 bridge upstream of KB Ditch	GCWIN	40.05377	-106.28945		CS2	8/18/2007	10/13/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	054664	KREMMLING
COR-LoneBuck	Colorado River at Lone Buck downstream of CPW Office	GCWIN	40.04710	-106.14304		CS2	7/29/2006	10/18/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM
COR-Pumphouse	Colorado River downstream of Gore Canyon and upstream of Pumphouse	GCWIN	39.98990	-106.50840	5	CS2	7/30/2006	10/18/2017	09058000	COLORADO RIVER NEAR KREMMLING, CO	054664	KREMMLING
COR-Rad	Colorado River at Radium	GCWIN	39.95467	-106.55049	5	CS2	6/15/2012	10/20/2017	09058000	COLORADO RIVER NEAR KREMMLING, CO	054664	KREMMLING
COR-SHRF	Colorado River at Sheriff Ranch at Silver Doctor Cabin before Hot Sulphur Springs CO	GCWIN	40.08736	-106.06767		CS2	6/24/2010	10/13/2017	09034250	COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.	059096	WILLIAMS FORK DAM
MC-blw Hwy 40	Muddy Creek downstream of Hwy 40 bridge	GCWIN	40.060299	-106.39919		CS1	6/18/2008	10/20/2017	09041400	MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO	054664	KREMMLING
Piney-abvCOR	Piney River upstream of Colorado River confluence	Gcwin	39.84664	-106.63589		CS1	7/30/2009	9/22/2009	09059500	PINEY RIVER NEAR STATE BRIDGE, CO	054664	KREMMLING

Site ID	Site Name	Org.	Lat.	Long.	W&S	Tier	Start	End	Stream Gauge	Gauge Name	Air Site	Air Site Name
UPCO-DOT	Upper Colorado River upstream of Dotsero	GCWIN	39.64792	-107.06286	6	CS2	6/29/2012	11/14/2016	09058000	COLORADO RIVER NEAR KREMMLING, CO	057618	SHOSHONE
UPCO-RD	Upper Colorado River downstream of Red Dirt Creek	GCWIN	39.80058	-106.97403	6	CS2	5/23/2013	11/14/2016	09058000	COLORADO RIVER NEAR KREMMLING, CO	057618	SHOSHONE
UPCO-SB	Upper Colorado River upstream of State Bridge	GCWIN	39.85556	-106.64453	6	CS2	7/23/2012	11/14/2016	09058000	COLORADO RIVER NEAR KREMMLING, CO	054664	KREMMLING

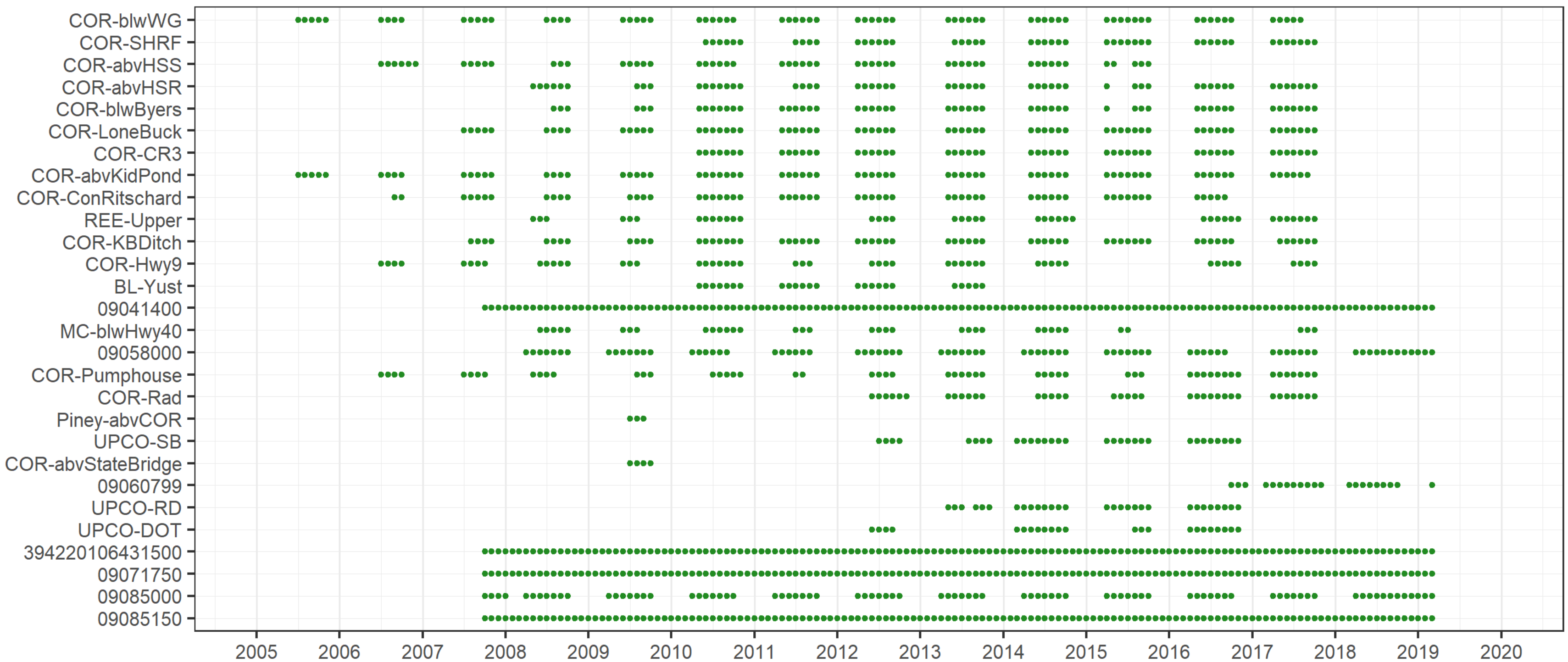

Figure 2. Monthly data availability, by year, for 28 sites included in the data review. Data were sourced from GCWIN via CDSN, and USGS NWIS.

3 REGULATORY FRAMEWORK ANALYSES AND SUMMARIES

Data used in analysis were retrieved via the APIs to the CDSN AWQMS or USGS NWIS online repositories. Versions of the compiled data records used in the analyses described here are included in project packet submissions as individual site .csv files. Users requiring original unformatted data should obtain it directly from either CDSN or USGS repositories.

3.1 Dataset Compilation and Analysis

Program scripts developed in the R programming language (R Core development Team, 2018) performed automated database calls and evaluated temperature data against WQCD's water temperature standards. Analysis steps followed WQCD's regulatory data assessment framework identified in Regulation 31 and associated documents. This included the application of warming event criteria as well as air temperature, low flow, and shoulder season excursions to identify dates where stream temperatures exceeded standards but were otherwise excused by outlier climatic or hydrologic conditions. Daily Maximum (DM) and Weekly Average Temperature (WAT) statistics were calculated per direction in Regulation 31 and Policy 10-6. The DM is calculated as the daily maximum of 2-hour rolling averages. The WAT is calculated as the 7-day moving-window average of average daily temperature observations. The Maximum Weekly Average Temperature (MWAT) is the maximum WAT computed over non-overlapping 7-day periods. Although multiple days in a row may produce a WAT statistic that exceeds the standard, regulatory MWAT exceedances for 305(b)/303(d) assessment are only tallied on non-overlapping 7-day periods. This work uses the convention of referring to any days during which the estimated WAT or DM statistic is higher than the applicable standard as *exceedances*, and referring specifically to counts of non-overlapping MWAT exceedances that are also unexcused by warming events or other excursion types as *regulatory exceedances.*

In the 2018 Listing Methodology, WQCD adopted the *warming event* framework in an effort to capture how the combined influence of magnitude and duration of temperature interact to impact streams via a cumulative degree-day approach. Per direction from WQCD staff, once the DM or WAT statistic is estimated for available dates in the time series, the warming event criteria is applied. Excursions are then identified in the following order: air temperature, low flow, shoulder season. Warming events are applied as a cumulative degree-day tally that excuses exceedances until the cumulative sum reaches a particular threshold for either DM or WAT standards. For example, two consecutive days in which WAT values exceed the standard by 2 degrees will sum to 4 degrees in the running tally. Once this tally reaches 13.5 degrees, seasonal WAT exceedances are no longer excused by the warming event. The degree day warming event threshold for DM exceedances is 2.4 degrees.

Air temperature excursion date percentiles were estimated from regional surface monitoring stations using the web service provided by the Colorado State University Colorado Climate Center.[3] WQCD specifies that air temperature sites should be representative of climate near the stream temperature monitoring location and typically within 30 linear miles to account for localized climatic variations in the mountains. All stream and air temperature sites were mapped

[3]Colorado State University Colorado Climate Center web portal. https://climate.colostate.edu/data_access.html

in a GIS. Stream temperature sites were assigned either to the closest air temperature site or another qualifying site within a 30-mile buffer, if that site was considered more-representative due to its proximity, topography, elevation, etc. Batch routines were created in the R programming language to retrieve data from each air temperature monitoring site using the Climate Center's API. Air temperature time series data were mapped to time series values of DM and WAT for each site. Monthly air temperature percentiles were estimated for the period of record and dates meeting the excursion criteria identified in Regulation 31 and the 2018 Listing Methodology were flagged. Flagged dates were then compared to the exceedance data record and used to exclude qualifying dates of DM and WAT exceedances. Individual DM exceedances coinciding with air excursion dates were excused. Air temperature excursions excuse WAT exceedances for an additional 7-day period beginning with the initial air temperature excursion date.

Low flow excursions occur when daily stream flow falls below critical low flow criteria identified in Regulation 31 section 9(1). Flows falling below the 1-day in 3-year empirically-determined flow (1E3) excuse individual DM exceedances, while individual daily average flows below the 30-day in 3-year flow (30E3) excuse 7 days of MWAT exceedances. Daily average streamflow data were retrieved programmatically with R scripts from the USGS NWIS system. Web tools provided by CSU's eRAMS project (Wibble et al., 2014) were queried to provide the 1E3 and 30E3 design flows at select gauge sites in the project area associated with each temperature monitoring site. These online tools allowed for interactive selection of gauge sites and provided a low-flow analysis algorithm based on EPA's DFLOW tool to estimate CDPHE biological low flows and other regulatory design flows of interest. Each temperature site was associated with an applicable gauge site; then the 1E3 and 30E3 design flows from the streamflow gauge were used to identify low flow excursions. Not all temperature sites had a suitable gauge site location, in these instances, the low flow excursion was not applied. Due to the relatively small contribution of tributaries and lack of significant diversions on W&S segments 4-7, the gauge at Colorado River near Kremmling CO (USGS 0905800) was used to compute low-flow excursions for Segments 4-6 (i.e. between Gore Canyon and Dotsero). The gauge at Colorado River Near Dotsero (USGS 09070500) was used to calculate low-flow excursions in Segment 7 (i.e. Glenwood Canyon). Although stream flow measurements at the recently-established Catamount gauge (09060799) are closer to temperature monitoring sites at State Bridge, Red Dirt, and Dotsero, the short gauge record at this location makes it unsuitable for long term flow record analysis and it remains a reasonable assumption that when flow criteria are hit at the Gore Canyon gauge, they are also in effect downstream in late summer, when the Piney River and other local tributaries provide negligible additional flow contributions. Time series of low flow excursion dates were mapped to series of DM and WAT values in the same manner as air excursion data. DM and WAT exceedances occurring during days flagged as low flow excursions were excused.

It is important to note that this analysis seeks to align with the way WQCC considers temperature in its regulatory framework in order to provide context for fishery health and stream management discussions, but was not conducted as part of a regulatory assessment, rulemaking hearing, or otherwise intended to supplant similar or additional analyses performed by WQCD. Analyses were scripted in the R statistical computing environment for efficient batch repetition of numerous sites and large datasets. This also allows for relatively rapid repetition of analyses should additional data sets become available for the project area in the future, if standards or regulatory assessment methods change, or should the SG require additional assessment work. Due to slight differences in the way moving calculation windows progress along the discontinuous datasets and on the delineation of time periods used to estimate air temperature or low flow percentiles, the exact dates of excused and unexcused exceedances reported in analyses conducted using the WQCD's Excel macro tool and the analyses conducted may not perfectly match in all cases. These differences should not be viewed as a deficiency in the custom scripts developed here. Rather, the root of differences lies in selection of slightly-different but equally-valid computational methods to perform tasks not articulated by the WQCC or WQCD guidance documents. Fidelity in the timing, magnitude, and frequency of flagged exceedances reported by both methods should remain high.

3.2 Results

Individual site analysis reports were generated for sites on the mainstem Colorado within the W&S segments, significant tributaries, and the mainstem Colorado River upstream from Segments 4-7 (i.e. between Windy Gap and Kremmling) (Appendix A). Each site report displays thermographs for the DM and WAT statistics (Figure 3). A date-aligned hydrograph of stream flows for the period of record is also included if a stream gauge site is reasonably co-located with the temperature monitoring site and covers the temperature monitoring period. In cases where regulatory exceedances occurred, summary tables of exceedance dates and frequencies were also produced.

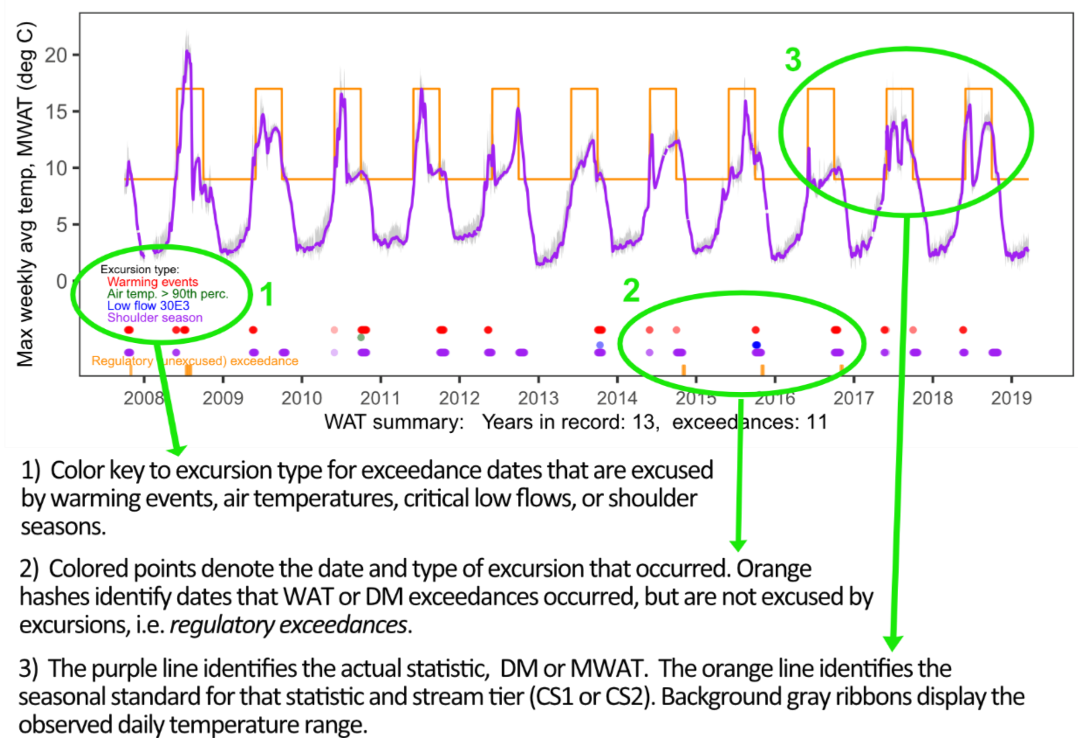

Figure 3. Thermograph figure explanatory key.

Data produced at the Colorado River Near Kremmling (09058000) and at the Colorado River Above Glenwood Springs (09071750) effectively bracket the W&S segments. Both of these sites are operated by USGS. The Colorado River Near Kremmling site is located below the Blue River confluence and immediately above Gore Canyon. This site includes a streamflow gauge and temperature sensor. The Colorado River Above Glenwood Springs site is located at the near No Name creek and supports a temperature and conductivity sensor but no streamflow measurement. Discharge at this site is estimated from the nearest upstream gauge, Colorado River Near Dotsero (09075000). The only significant tributaries between the gauge site and temperature site are Grizzly and No Name Creeks, which both provide negligible discharge to the Colorado mainstem during summer and fall periods. Several other sites in Segments 4-7 have been operated by BLM and the stakeholder group over recent years; however, none provides the extensive and continuous data record available at these two USGS sites.

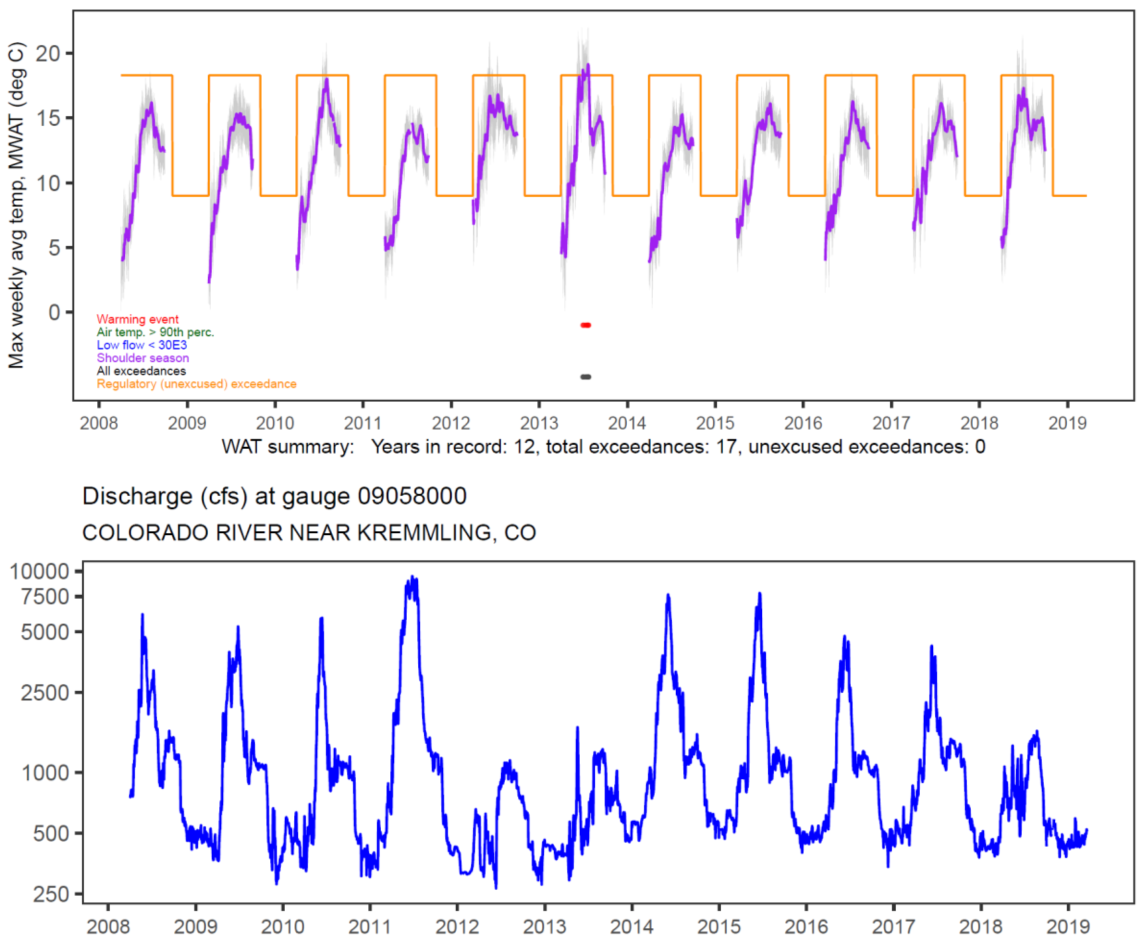

Figure 4. Time series of computed WAT values and daily average discharge observations from Colorado River near Kremmling (09058000)

The data produced at these sites provide useful bookends for the assessment of temperature patterns in the W&S segments, however they are unsuitably located to analyze influences of major tributaries like the Eagle River. Few exceedances occur below the Blue River confluence at the beginning of W&S segment 4 (Figure 4). In contrast, temperature issues are observed at No Name frequently and throughout the period of record (Figure 6). More exceedances are associated with low flow summer seasons such as 2012, 2013, and 2018, but this site regularly experiences warm stream temperatures even during more typical flow years.

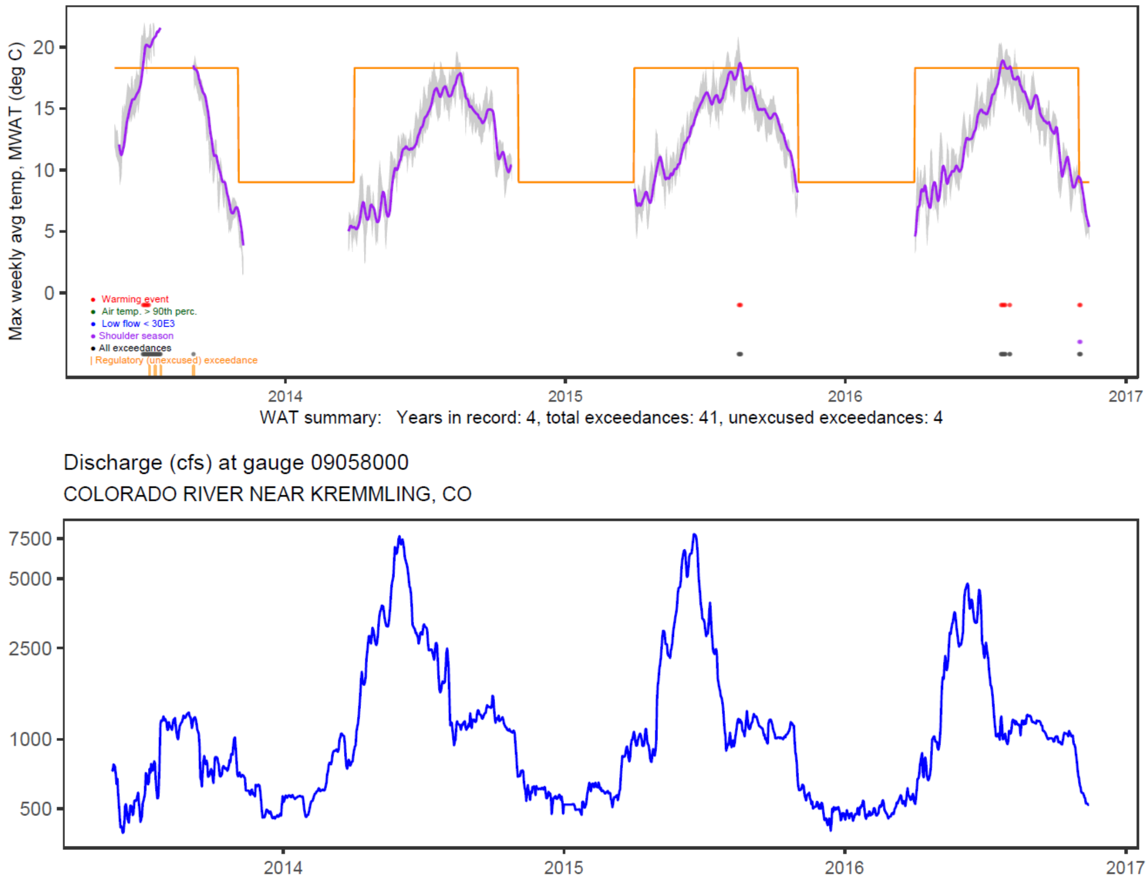

Figure 5. Time series of computed WAT values and daily average discharge observations from UPCO-RD, Colorado River downstream of Red Dirt Creek. Data from 2013 was incomplete at the height of the season due to sensor sedimentation.

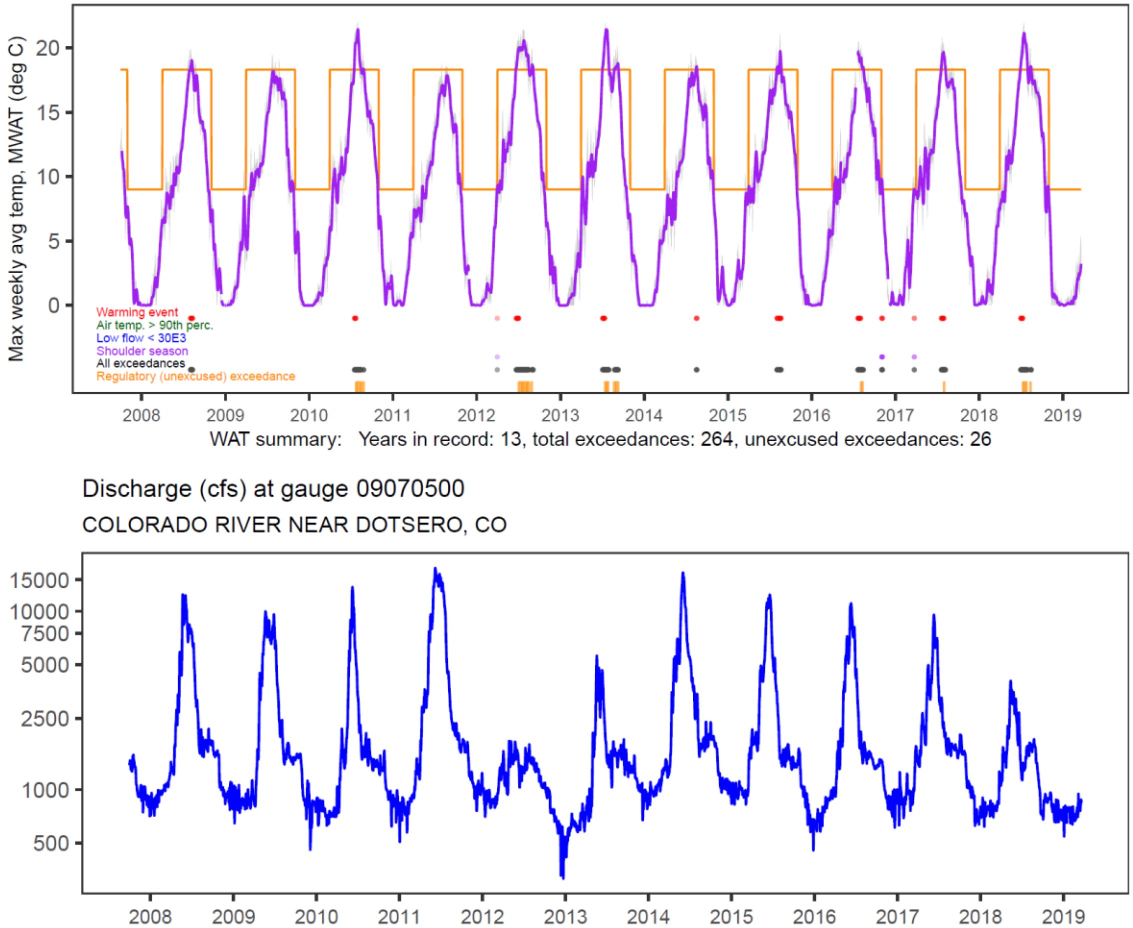

Figure 6. Time series of computed WAT values from Colorado River above Glenwood Springs (09071750) and daily average discharge observations from Colorado River Near Dotsero (09070500).

Locations between Windy Gap and the Williams Fork (i.e. COR-blwWG to COR-CR3) experienced WAT exceedances on a regular basis during the period of record (Figure 7). Monitoring sites on Muddy Creek below Wolford Mountain also showed regular shoulder season issues throughout the period. Data is more sporadic between State Bridge and Dotsero (i.e. 09058000 to 09071750). However, regular exceedances are observed from Catamount downstream to No Name in multiple years, with an increasing annual and intra-annual frequency in the downstream direction. Once warming event and excursion event criteria are applied (Figure 8), it becomes apparent that many sites with regular exceedances may actually meet regulatory standards in most years, with the river system being subject to high degree of natural temperature variability. Standards remain unmet at the downstream end of the W&S segments in low flow years (i.e. 2012, 2013, 2018) and in a limited number of typical or average flow years (2010, 2016, 2017).

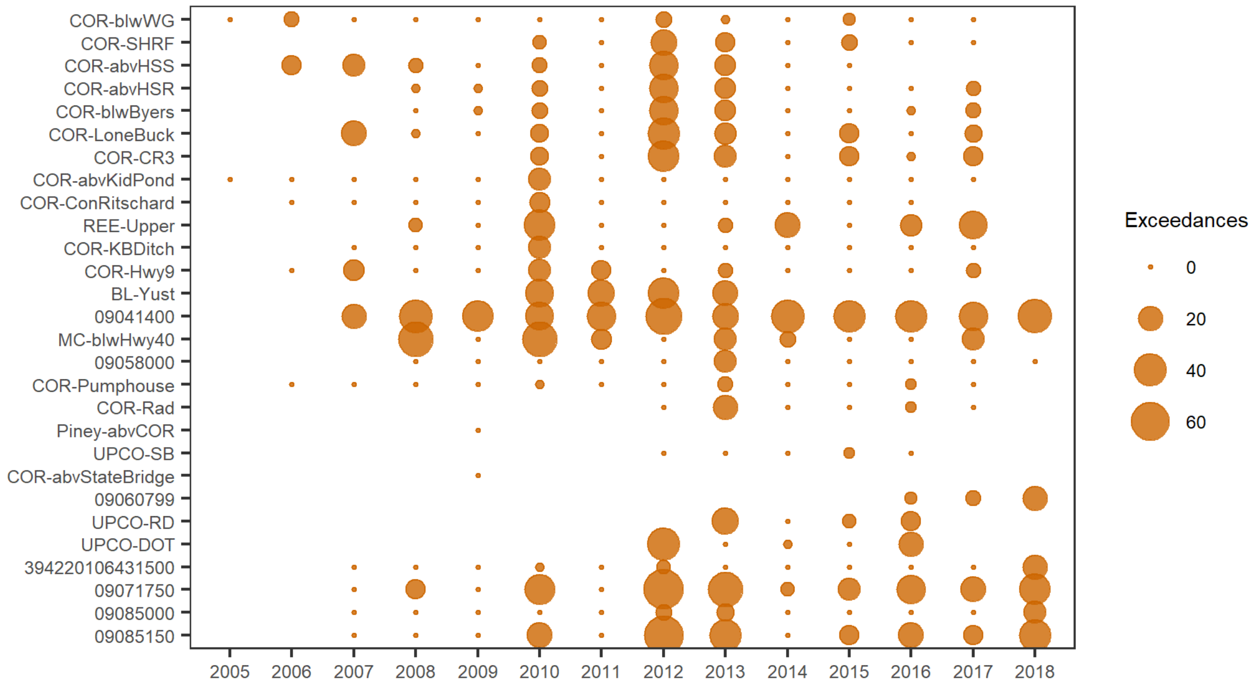

Figure 7. Observed daily exceedance counts (no excursions applied) by location and year.

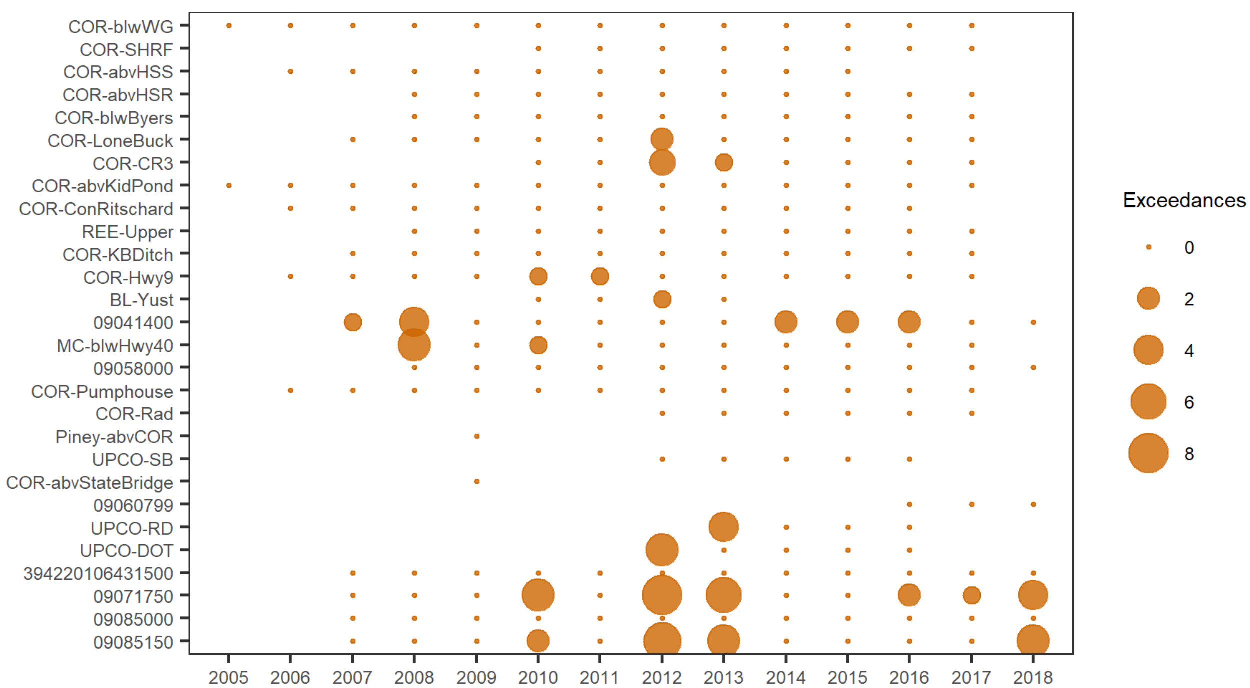

Figure 8. Unexcused (regulatory) exceedance counts (all excursions applied) by location and year.

Seasonal peak water temperatures typically occur in mid- to late July in most locations but may occur as late as mid-August in some locations and in some year types (

Figure 9). WAT exceedances are observed upstream at times to Catamount (09060799) and as far upstream as State Bridge. Water temperature fluctuations in the August-September (e.g. 2013) period may reflect the impacts of flow augmentation from upstream reservoirs.

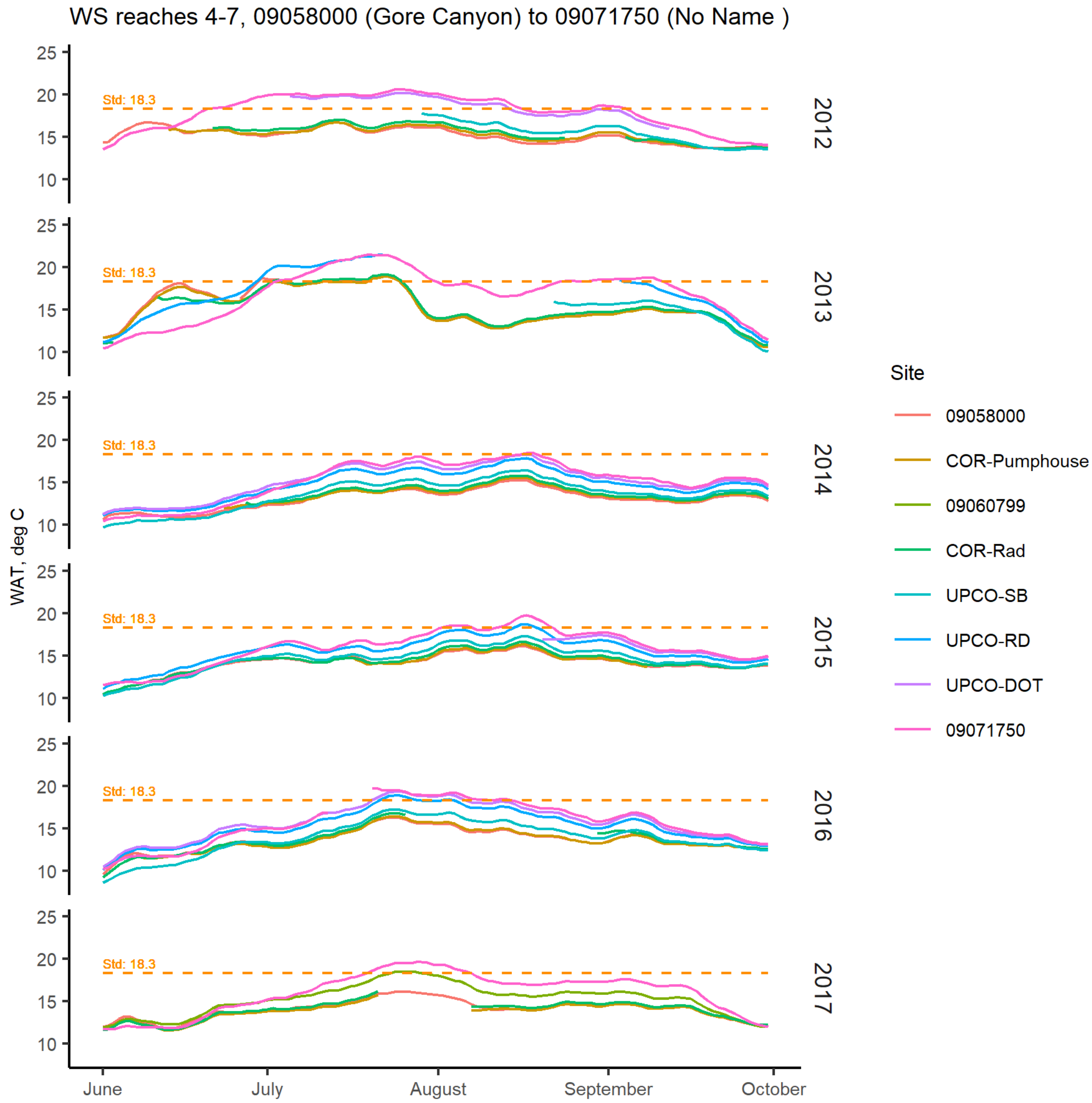

Figure 9. Wild and Scenic reaches 4-7 summer/fall WAT thermographs for years 2012-2017. Dashed red line represents the WQCD chronic water temperature standard.

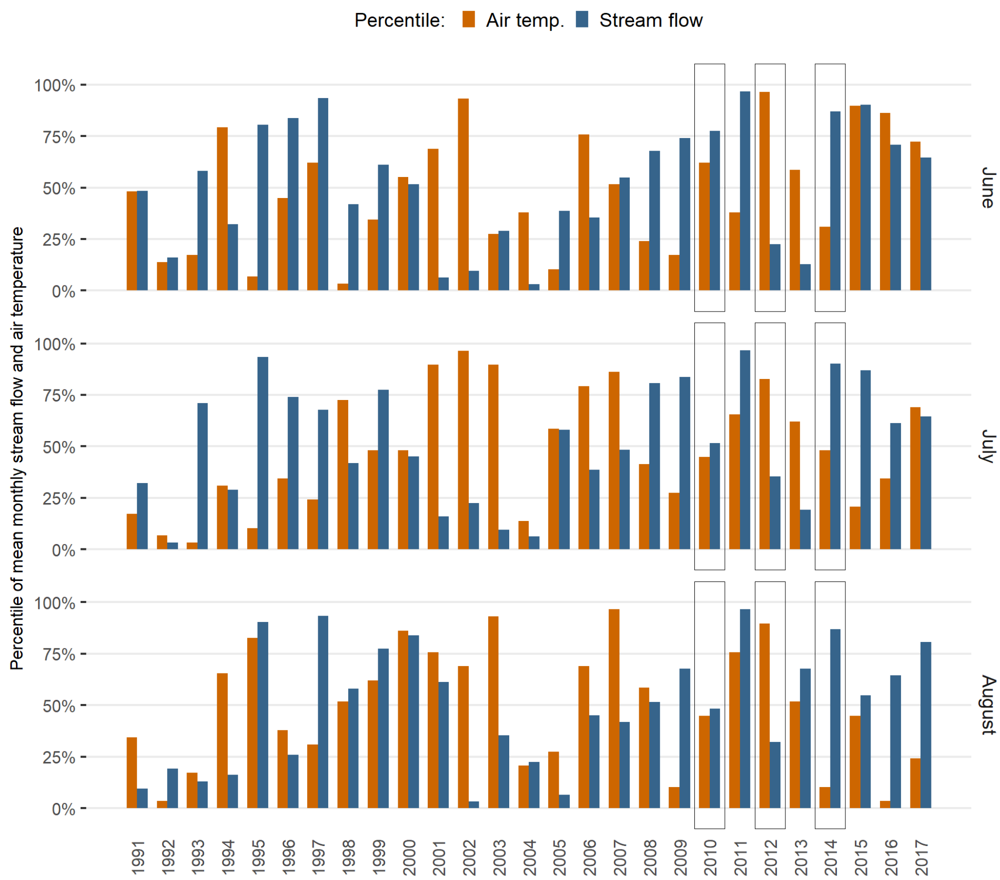

Figure 10. Monthly air temperature (Kremmling station) and streamflow volume (USGS 0905800) percentiles for the Upper Colorado. For the months of July and August, 2010 was characterized by typical flows and air temperatures, 2012 was characterized by lower flows and warmer air temperatures, and 2014 was characterized by higher flows and lower air temperatures. These percentiles are only valid for the period of record 1991-2017 at the Kremmling air temperature gauge; meteorological and flow record for differing periods will produce different results.

Longitudinal profiles of WAT values (Figure 11) display a continuous warming trend from Windy Gap to Gore Canyon, with evidence of temperature buffering or cooling at sites immediately downstream of major tributary inflows. The thermal influences of reservoir operations at sites below the Blue River and Williams Fork are particularly pronounced during summer months, when their inflows appear to be significantly cooler than the mainstem Colorado. During spring and fall, temperature differentials between the mainstem and tributaries are less pronounced and the effect is less visible. Unfortunately, the Blue River mouth monitoring site (BL-YUST) only has seasonal data from 2010 to 2013. Unique to that site, observed exceedances occur in the shoulder season, indicating that Green Mount Reservoir's probable influence is to cool summer temperature and warm spring and fall water temperatures above those typical of the region. Below Gore Canyon, temperatures increase only slightly to the Piney River. The highly-confined canyon topography from Gore to Rancho del Rio likely inhibits significant solar gain in this reach. Water temperatures rise more steadily in the downstream direction between State Bridge and Dotsero. In typical years, WAT exceedances regularly occur in Reach 7. In warm, low flow years like 2012, WAT exceedances persist upstream into reach 6, although the spatial resolution of monitoring sites is insufficient to pinpoint accurately how far upstream temperatures exceed MWAT standards, or describe the influence of major tributaries like the Eagle River.

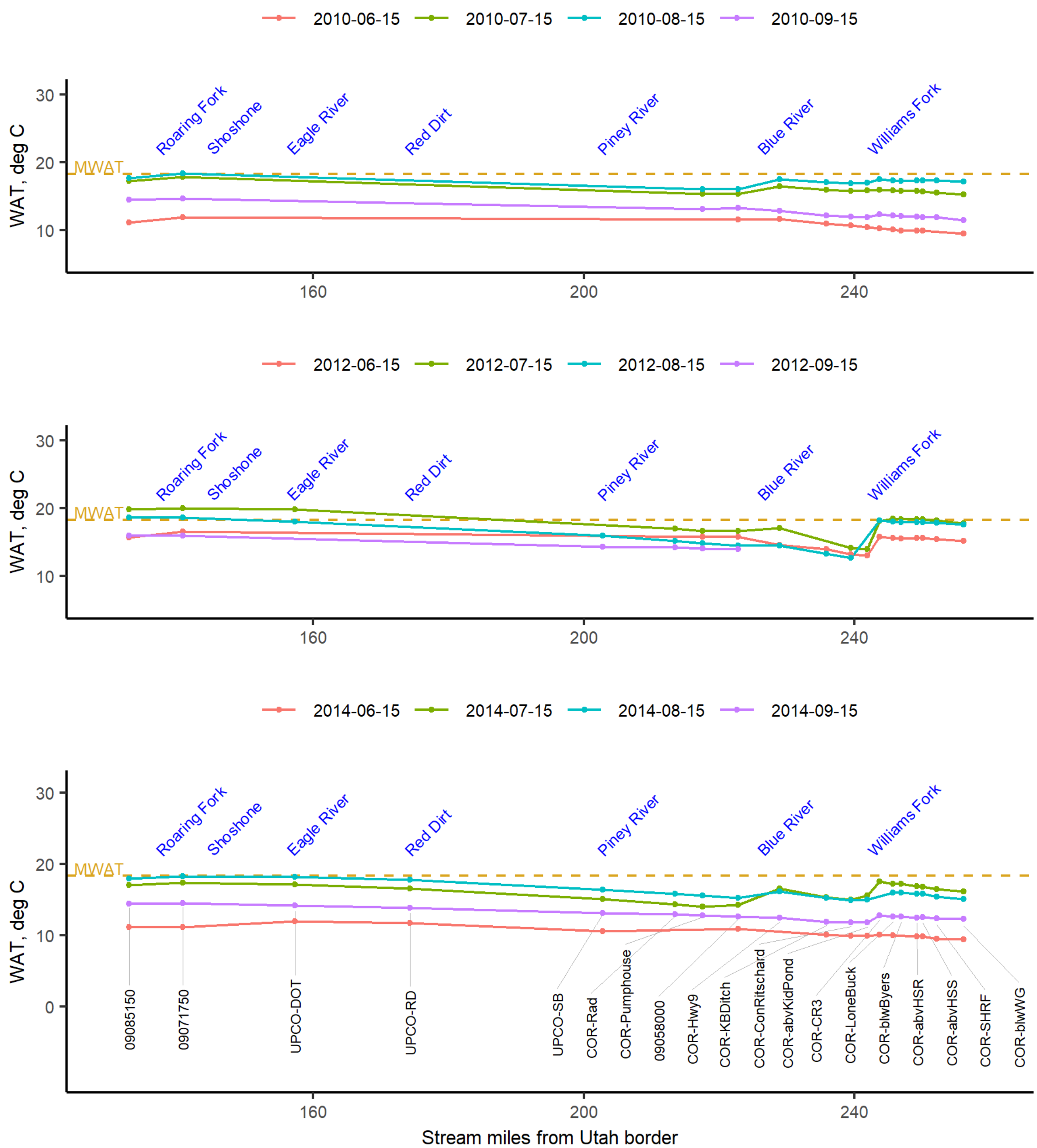

Figure 11. Longitudinal (upstream (right) to downstream (left)) temperature profiles for mid-month dates in select years: 2010, 2012, and 2014.

4 POTENTIAL THERMAL INFLUENCES

Several potential sources of thermal influence were assessed through consideration of the results presented above and qualitative consideration of the physical characteristics of the W&S

segments. Quantitative evaluation of the relative strength of various thermal influences was well beyond the scope and budget of this effort. However, a brief discussion of the role that tributary and groundwater flows, surface water diversions, and regulated streamflow may play in driving thermal regimes within the W&S segments is provided below.

4.1 Tributary and groundwater inflows

The drainage between the Blue River confluence and the Eagle River confluence covers approximately 1,200 square miles, 30% of the total drainage area of the Colorado River above the Eagle River confluence. However, the region's moderate elevations and lack of snowpack-generating mountain ranges means that areas upstream (i.e. Grand County and Summit County) contribute disproportionately higher volumes of annual flow. Significant snowpack accumulates in the northwest section of the Gore Range, including the Piney River and Sheephorn Creek drainage. However, the majority of that range drains to the Blue and Eagle rivers. Regions of the southeast Flattops also drain to the W&S segments via Sweetwater Creek, Deep Creek, Grizzly Creek, and No Name Creek. None are larger than 3rd Strahler order streams; i.e., they are small headwaters with relatively insignificant flow volumes. Due to their rapid descent in confined valleys from higher elevations to the Colorado River, tributary water from these creeks is probably cooler than the mainstem throughout the summer months. Their small flow contributions relative to the mainstem Colorado River mean it is unlikely that any single stream individually produces a large temperature signal in the W&S segments.

The Piney River contributes the most notable annual volume to the Colorado River in the W&S segments above the Eagle River. Based on median reported flows for the Piney River Near State Bridge (09059500), the stream typically contributes about 50-150 cfs in July and 20-50 cfs throughout August. Typical managed flows in the Colorado River near Kremmling (09058000) decline from a median of ~1500 cfs in early July and ~1000 cfs through August. This means Piney River typically contributes around a little over 10% to downstream flows during runoff and as little as 2% later in the summer. Few other contemporary tributary flow records exist. USGS web tools identify inactive gauge sites at Colorado River Near Radium (09058030, 1981-1990), Rock Creek at McCoy (09060770, 1983-1997), Big Alkali Creek below Castle Cr Near Burns (09060950, 1981-1986), and Grizzly Creek Near Glenwood Springs (09071300, 1976-1996)[4]. Records for these sites were not reviewed in depth for this report, however gauge records at Rock Creek at McCoy were accessed online to understand typical flows in the lower elevation tributaries. Median daily flows for August and July were approximately 20 and 17 cfs between 1983 and 1997. Below Dotsero, the addition of Eagle River water diminishes the relative flow contributions and temperature influences of small tributaries from the Flattops like Grizzly and No Name Creeks. Although the lower Eagle between the Town of Eagle and the Colorado River is wide, slow, shallow, and subject to warming, no data records were found below Wolcott to estimate potential impacts to the Colorado mainstem at Dotsero.

Total tributary contributions to the Colorado River mainstem were estimated between Gore Canyon and Dotsero by analyzing differences in flows measured above Gore Canyon with flows calculated above the confluence with the Eagle River (WS reaches 4-6). The discharge estimate

[4] Active and inactive USGS gauge sites identified using the National Water Information System (NWIS) Mapper, https://maps.waterdata.usgs.gov/mapper/index.html, accessed 4/19.

above the Eagle River confluence was constructed by subtracting the daily mean flow at the Eagle River Near Gypsum (09070000) from the Colorado River at Dotsero (09070500), located just downstream of the confluence.

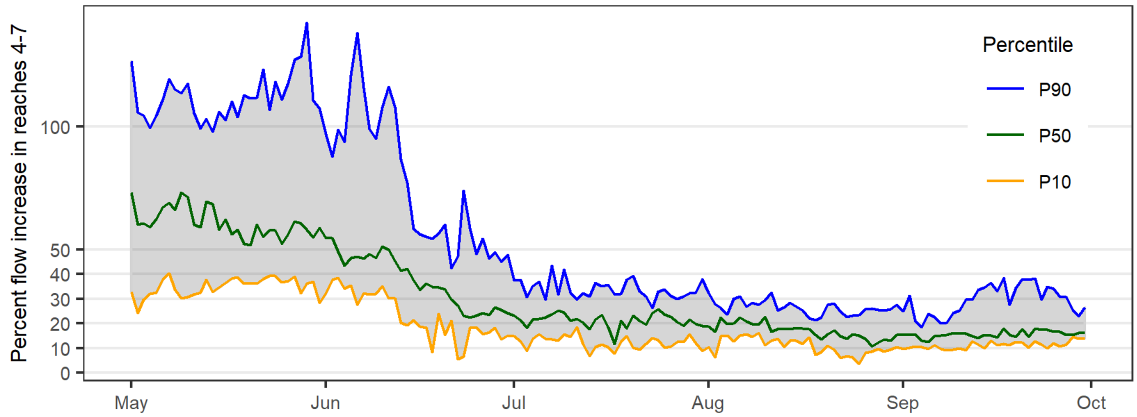

Figure 12. Estimated streamflow gains for the Colorado River between Gore Canyon and the Eagle River. Gains were calculated for the period extending from 2009-2018 and summarized as the 90th percentile (P90), median (P50), and 10th percentile of percent downstream flow increases.

A simple differencing of upstream and downstream flows in reaches 4-6 provides an estimate of tributary and groundwater gains to the mainstem Colorado between the Blue and Eagle Rivers. (Figure 12). During runoff periods (April-July), tributary and groundwater flows typically contribute up to 60% of the local flow in Reaches 4-6, declining to around 25% by end of July. During spring runoff in some years, tributary and groundwater flows may more than double the incoming flow above Gore Canyon. Once peak flows subside, tributary and groundwater flows typically contribute an additional 18-22% of the flow available at the downstream end of the reach during July and August when temperature issues are most prevalent. Tributary and groundwater flows account for as little as 8-10% and as much as 30% of the mainstem flow during the later summer period, depending on the year type (

Figure 13).

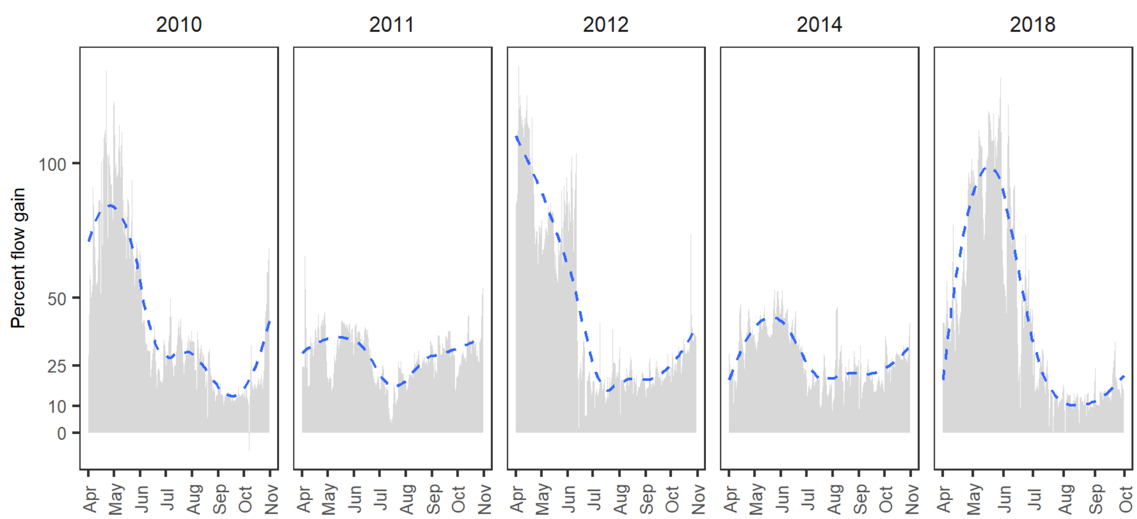

Figure 13. Streamflow gains for selected index years. 2010 was a typical flow year. 2011 and 2014 were high flow years. 2012 and 2018 were low flow years. The dashed blue line is a Loess smooth of the time series values. Tributaries and groundwater provide a significant fraction of mainstem flow in the early portion of dry summers.

The local flow contribution does not directly track with snow years due to the managed nature of upstream flows, the paradoxical effect of the Cameo/Shoshone calls on the late summer flow regime, and the timing of major upstream withdrawals and reservoir filling operations from the seasonal hydrography. Local tributary contributions have likely become a more-significant contribution (by percentage) to mainstem flow during annual runoff periods due to the attenuation and reduction of peak runoff magnitudes from reservoirs and transmountain diversions in spring and early summer. Depending on local snowpack conditions and the timing of downstream water calls, the relative importance of local contributions may also increase or decrease mid-summer. In years with poor or non-existent low and mid-elevation snowpack and dry summers, the tributaries to the W&S segments may exhibit extremely low flow levels. In these same year types, the calls by the Cameo and Shoshone water rights simultaneously work to increase mainstem Colorado River flows through the W&S segments. In these instances, the discharge contribution and temperature influence of tributaries is probably negligible. In years with ample low and mid-elevation snowpack combined with a late downstream water calls, more water may be held back or diverted upstream of the W&S reach, and the tributary impacts to flow and temperature would become more important. Most tributary streams source in elevations ranging from 7,000 to 11,000 feet, falling steeply in tightly confined valleys to the Colorado River and exhibiting distinctly snowmelt-driven flow regimes and low water temperatures. Overall, the influence of these small-order tributaries to mainstem Colorado River temperature is likely to be in the cooling direction but small in magnitude. The only available data found to support this conceptual framework comes from Piney River in 2009 (

Figure 14), which exhibits temperatures a few degrees lower than the Colorado River. No discernible effect was observed on the mainstem Colorado River.

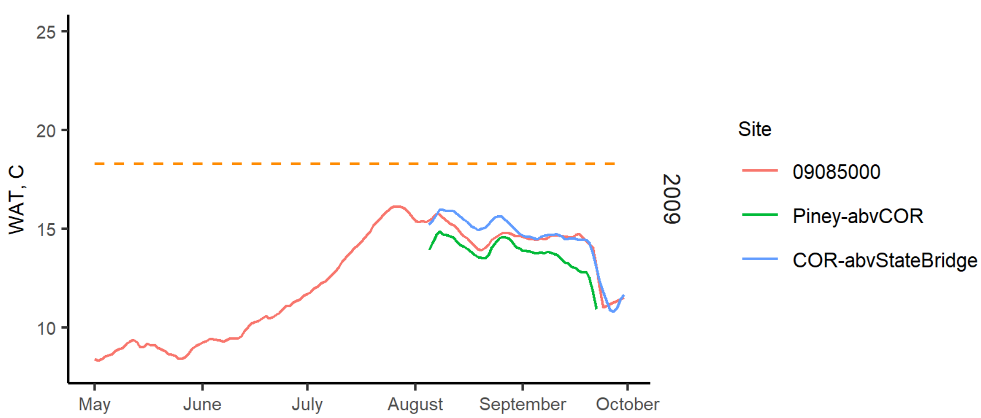

Figure 14. Thermographs for the Piney River and the Colorado River at State Bridge during the summer of 2009.

Local groundwater systems are not currently well-characterized but, conceptually, should feature a lag in timing and effect to the mainstem Colorado. The bedrock underlying the region is heavily faulted, tilted, and fractured; containing only a thin and frequently-discontinuous soil cover. The phreatic zone (area of saturated groundwater flow) is similarly thin and discontinuous on hillslopes above tributaries and the main river. Water moving through these zones supports low-order perennial tributaries and is observed as springs and seeps in topographically favored zones such as slope breaks or along geologic formation boundaries. Upstream of Gore Canyon, a limited segment of alluvial valley bottomlands occurs up to Parshall with widths ranging from 0.25 to 1 mile. The majority of alluvial floodplain and terrace in these zones has been converted from riparian forest or low mesic terraces and now supports irrigated pasture and hay production. Groundwater discharge back to surface streams from flood and sprinkler irrigation may exhibit a lagged effect on stream discharge, slightly bolstering late summer and fall groundwater return flows. The most-probable effect on instream temperature is a slight cooling in the summer and early fall, and a slight warming in the later fall. Compared to the typical flow volumes of the W&S reaches during these time periods and the predominately pass-through/transport nature of flow in the region, the overall groundwater effect is unlikely to be large. However, no datasets were found to support or refute this conceptual framework for the region.

4.2 Surface Water Diversions

Water extraction can play a significant role in stream temperature regime dynamics when it reduces local flows by a significant proportion. The resulting reduction in average flow depths and wetted areas can increase a channel's sensitivity to insolation. The Colorado Decision Support System[5] (CDSS) provided information about surface diversion structures and associated rights in the W&S segments as well as reaches of the Colorado River between Kremmling and Windy Gap. Depending on how structures and water rights are filtered from CDSS by geography, type, and active status, slightly different totals from those reported here will occur. The net absolute rights were summed for active diversion structures to understand the potential for water depletions on the W&S segments (Table 2). The factors driving timing and magnitude of actual diversions from year to year are complex and may vary greatly between peak flows to late summer baseflows in any given year. This analysis did not consider water right priority, call histories, or actual historical use records; it only provides a relative picture of the locations of surface water diversions and their potential for impacting mainstem streamflows in a manner that might influence temperature conditions.

Table 2. Aggregated surface water diversion rights associated with the Wild and Scenic segments.

Reach	Net Absolute	Net Conditional	Net Apex Absolute	Net Apex Conditional
Windy Gap to Gore Canyon	280	5	88	0
Wild and Scenic 4-7	70	626	146	2

A rapid evaluation of surface water diversions suggests that local water uses are insufficient in volume relative to typical summer streamflows to produce major temperature impacts. CDSS identifies only two active structures in Segments 4-7 with total water rights nearing 10 cfs. More

[5] Colorado Decision Support System web application available at https://dnrweb.state.co.us/cdss, accessed 4/2019

than a dozen structures are associated with rights between 1-10cfs, and the remaining structures have water rights totaling < 1 cfs (Figure 15). The sum total of net absolute rights in the W&S segments remains an order of magnitude below typical July and August streamflows in the mainstem Colorado River. Many diverters only pull their full allocation (maximum allowed diversion under their Net Absolute right and associated conditional or Apex rights) during the early-summer runoff period and actual diversions are typically reduced somewhat from the decreed rate later in the summer. Compared to other regions in the Colorado Basin, the rugged and confined-valley topography of the W&S segments supports minimal irrigated cropland acreages that source water from the mainstem Colorado and its tributaries (Figure 16). A small number of diversions above Segments 4-7 between Windy Gap and Kremmling may contribute somewhat to localized temperature issues, as well as impacting the baseline temperature regime for water entering Segments 4-7. However, it is likely that when flow conditions on the mainstem Colorado River reach levels low enough that these diversions and associated return flows can exhibit large localized impacts, flow augmentation to the Colorado from the Blue River and Muddy Creeks will often offset or negate their relative downstream influence on Segments 4-7, although releases to Muddy Creek from Wolford Mountain during shoulder seasons can provide a warming influence

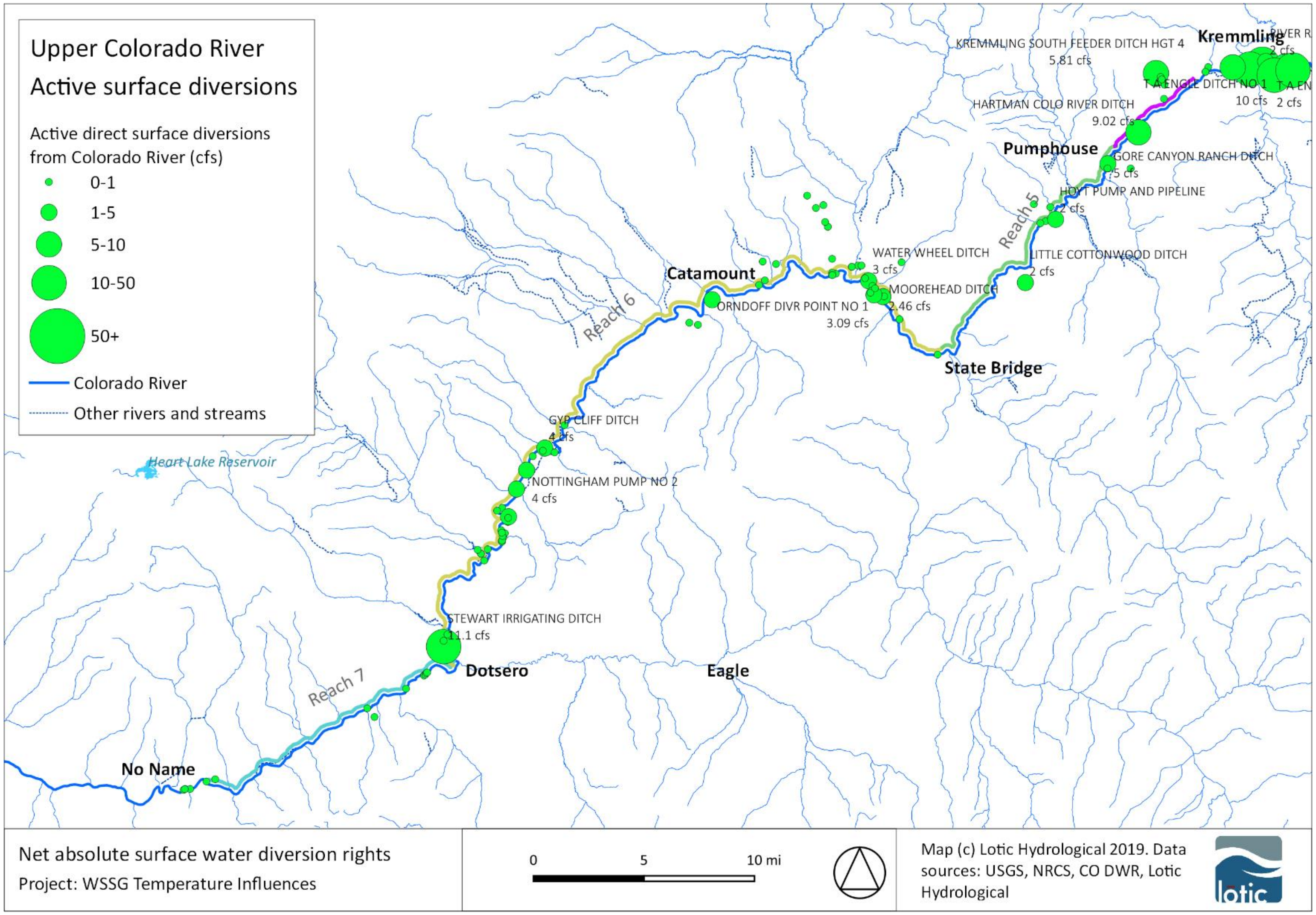

Figure 15. Wild and Scenic project area surface diversions, net absolute rights.

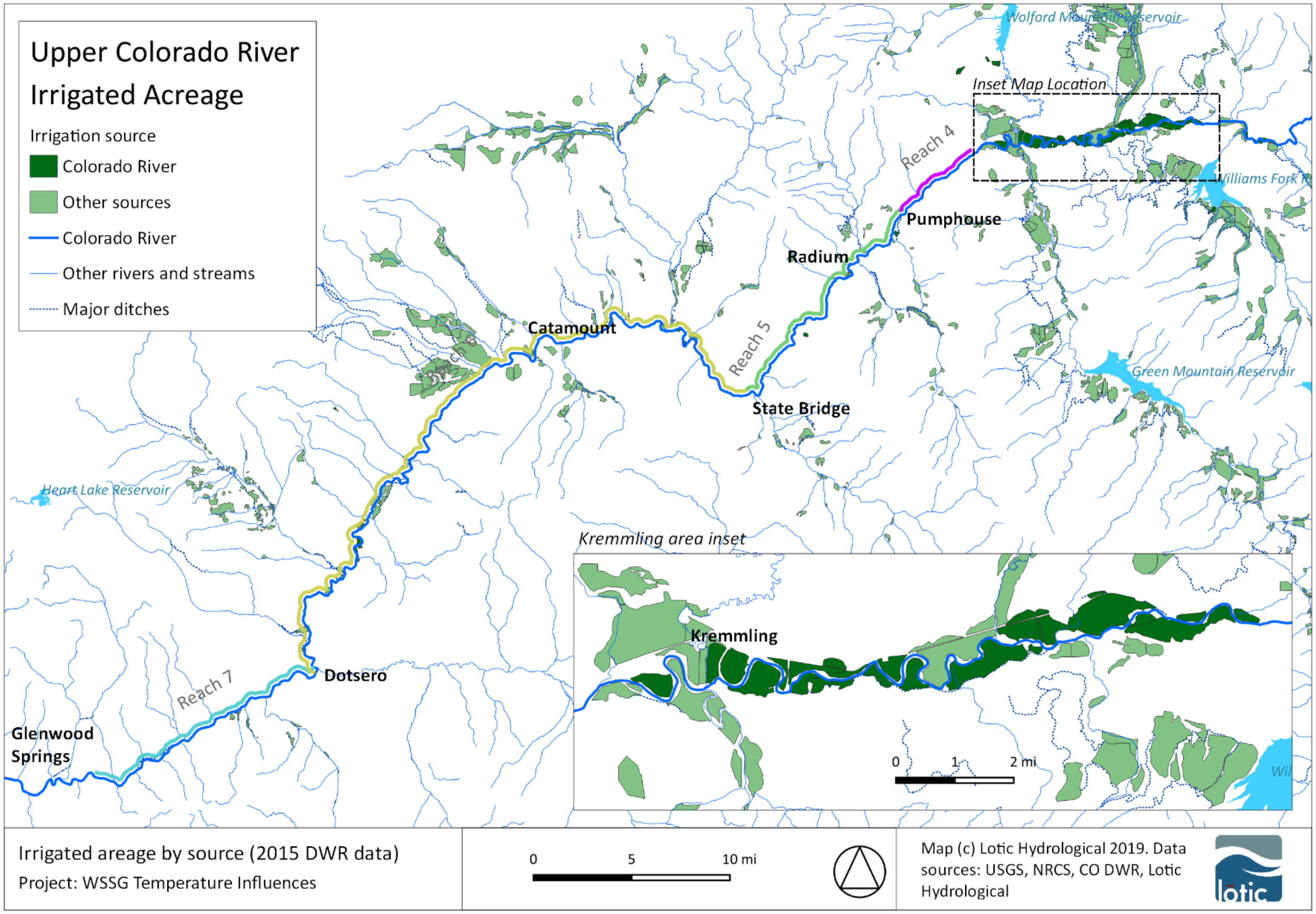

Figure 16. Wild and Scenic project area irrigated acreage and source.

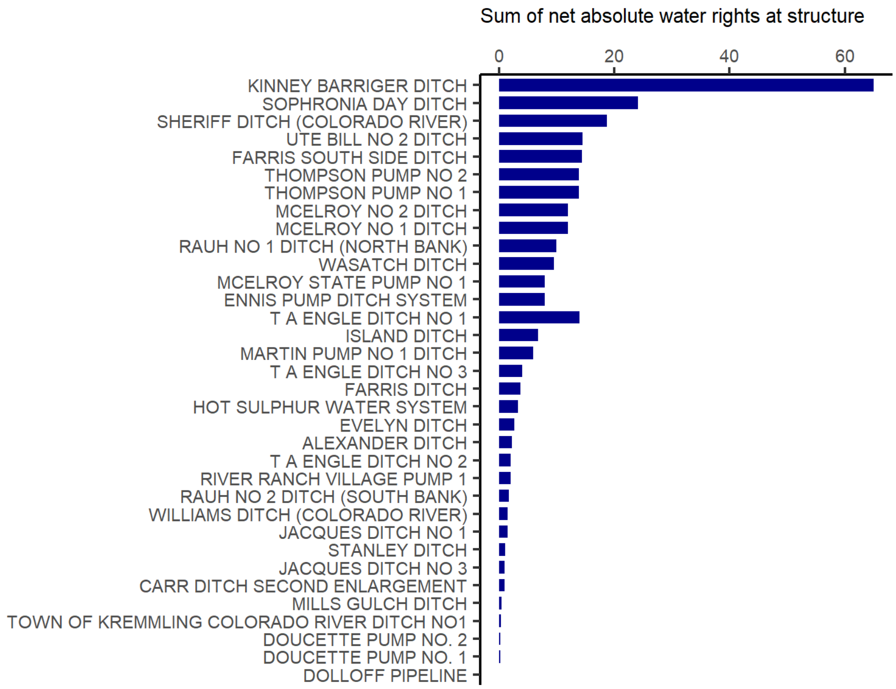

Figure 17. Aggregated net absolute rights at Colorado River-sourced surface structures in upstream reaches between Windy Gap and Gore Canyon. Each structure may be associated with multiple water rights. The total alloation of absolute rights for all structures included in this DWR database extract is 280 cfs.

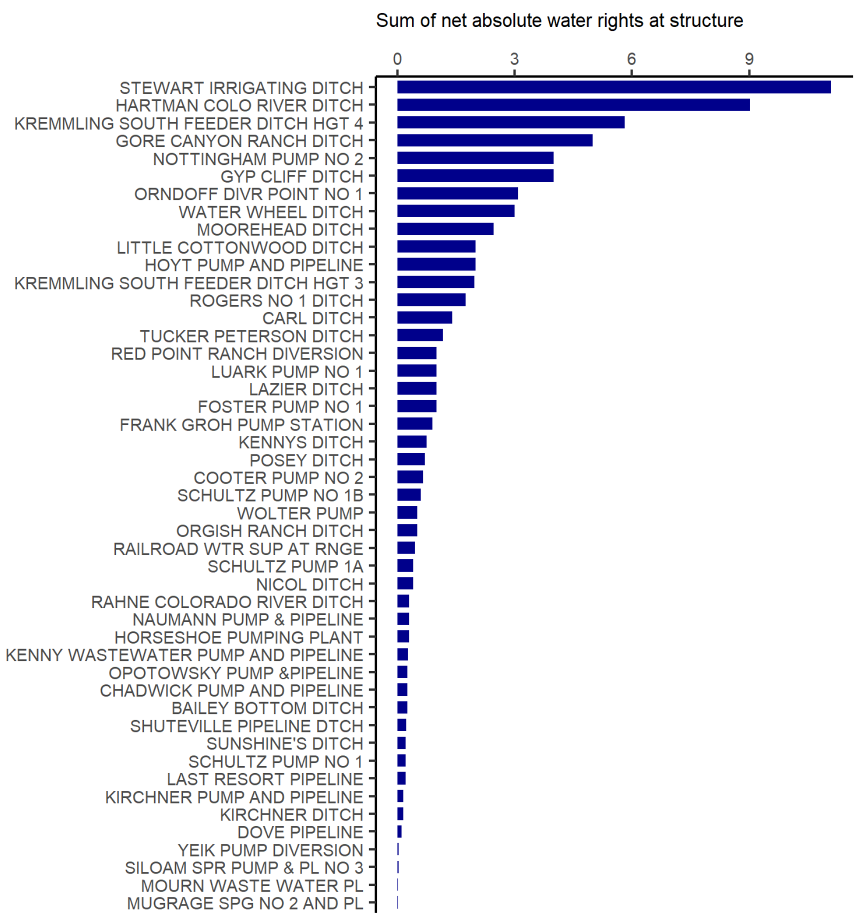

Figure 18. Aggregated net absolute rights at Colorado River-sourced surface structures in Segments 4-7. Each structure may be associated with multiple water rights. The total allocation of absolute rights for all structures included in this DWR database extract is 71 cfs.

4.3 Regulated Streamflows

Hydrologic modification via regulated flows from surface water diversions and reservoir operations may have a warming, cooling, buffering, or lagging impact on instream temperature regimes. Flow depletions can reduce thermal inertia in the stream channel and make a stream more sensitive to warming from solar irradiance. Flow augmentation may, conversely, boost thermal inertia, increasing the downstream distance before stream temperatures equilibrate with atmospheric conditions. Reservoir operations may increase downstream flows during late-summer baseflow periods. If water temperatures in these releases are cooler than downstream water temperatures, they may impart some reduction in the water temperatures of receiving waters. The temperature of released reservoir water is, in-turn, controlled by inflow water temperatures, impoundment surface area, reservoir residence time pen stock/spillway elevation, and other factors.

Northwest Colorado Council of Governments (NWCCOG) compared the 10-year average of all transmountain diversions from the Colorado River headwaters in 1993 to the annual flow of the Colorado River at Gore Canyon (removing the Blue River flow) and found approximately one-third of the annual flow is removed from the drainage by transmountain diversions at that location. Beeby et al. (2014) also compared annual flows at the Colorado River near Kremmling (09058000) to annual diversions at the Roberts, Adams, and Moffat transmountain diversions. That analysis found that 29% of the river’s native flow is removed from the watershed above Kremmling, on average, by these diversions.

Matthews and Richter (2007) created Indices of Hydrologic Alteration (IHA) to statistically characterize aspects of a stream’s flow regime relevant to ecological and physical river health. Beeby et al. (2014) used IHA to analyze hydrologic modification at the Colorado River near Kremmling (09058000). The authors used the 1904-1916 period to represent pre-modification hydrology and the 1963-2012 period to represent modern, altered hydrology (Table 3). Although localized diversions and the Grand Ditch were already impacting flows in the early period, their influence to annual flow regimes was considered relatively insignificant in comparison to the later impact of large reservoir operations and transmountain diversions. Average seasonal 30-day and 90-day minimum streamflows have increased, while maximum flows during snowmelt and/or flood periods have decreased. Maximum flows still typically occur during spring snowmelt and minimum flows occur in the late-fall and winter months.

Table 3. Metrics of hydrologic alteration calculated for observed streamflows (in CFS) from the Colorado River near Kremmling (09058000). The pre-alteration period was set to 1904-1916. The post-alteration period was set from 1963-2012.

Group	Metric	Pre-alteration	Post-alteration	Deviation	Percent change
Minimum flows	**1-day min**	300	391	91	30%
	3-day min	321	395	74	23%
	7-day min	338	416	78	23%
	30-day min	360	454	94	26%
	90-day min	379	510	131	35%
Maximum flows	**1-day max**	11,600	2980	-8620	-74%
	3-day max	11400	2777	-8623	-76%
	7-day max	10740	2516	-8224	-77%
	30-day max	7591	1909	-5682	-75%
	90-day max	4651	1558	-3093	-67%

Significant hydrologic alteration occurs on the W&S reaches during the spring runoff period between April and July when major reservoirs are filled to later provide augmentation water for transmountain diversions. Large transmountain diversions at the Moffat Tunnel on the Fraser River headwaters and the Grand River Ditch on the Colorado River headwaters combine with reservoir fill periods to shave off the peak magnitudes of snowmelt runoff, while the largest diversion, the Adams Tunnel, diverts significant flows (frequently in the range of 500-550 cfs daily) consistently from late summer through winter to the following spring. While these diversions have strongly and irreversibly altered hydrologic and temperature regimes in the Fraser River and Colorado River upstream of Kremmling, releases from Williams Fork, Wofford Mountain, and Green Mountain reservoirs after their respective fill periods compensate flows into the Wild and Scenic Reach beginning mid-summer most years for the upstream depletions and rebuild a somewhat more-normalized hydrograph through the W&S reach. Once combined flows of the Colorado River and local tributary inflows and flows from larger downstream tributaries like the Eagle River and Roaring Fork River are unable to supply senior Shoshone and Grand Valley water rights with sufficient water, reservoirs above the W&S segments supplement flows to meet those obligations (Figure 19). This generally occurs once runoff has subsided but may be earlier during exceptional low flow years. The net affect in the W&S reach is a reduction of high and mid-range flows during the rising, peak, and receding limbs of the seasonal hydrograph, and an artificial plateau of increased flows during the latter half of summer and fall growing seasons, July-October, before flows drop to minimum seasonal levels through the winter

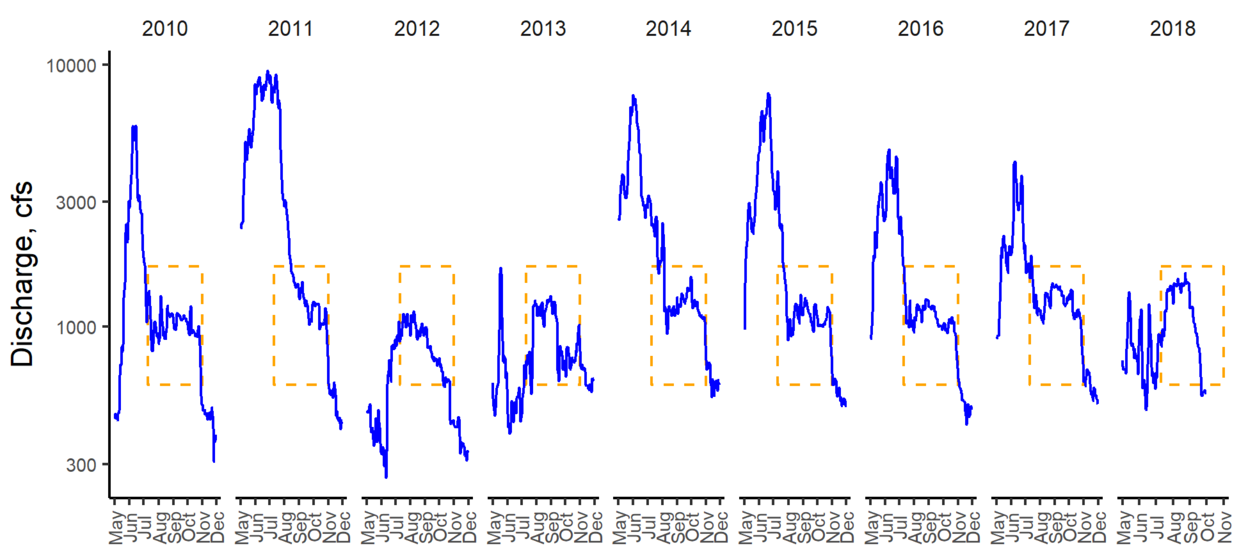

Figure 19. Observed streamflow patterns at the Colorado River near Kremmling (099058000) illustrating the influence of reservoir releases in late-summer. The orange dashed rectangles indicate the period between July and October in each year.

The environmental Resources Assessment and Management System (eRAMS) (Wibble et al., 2014) was used to stratify pre- and post-development flow duration curves. These stratified curves were used to evaluate the intra-seasonal impacts to flow regimes that occurred over the previous century (Figure 20). Pre-development flows were found to be higher than current flows for all exceedance percentiles in July, and the majority of flows in August. Only the very low flow observations in August remain similar today to the pre-development condition. Pre- and post-development regimes are fairly similar for September but begin to move apart by October and November. This indicates that current reservoir operations are only boosting baseflows above pre-development flows in the fall and into winter—a time period that may be too late to affect summer water temperature exceedances in the W&S segments.

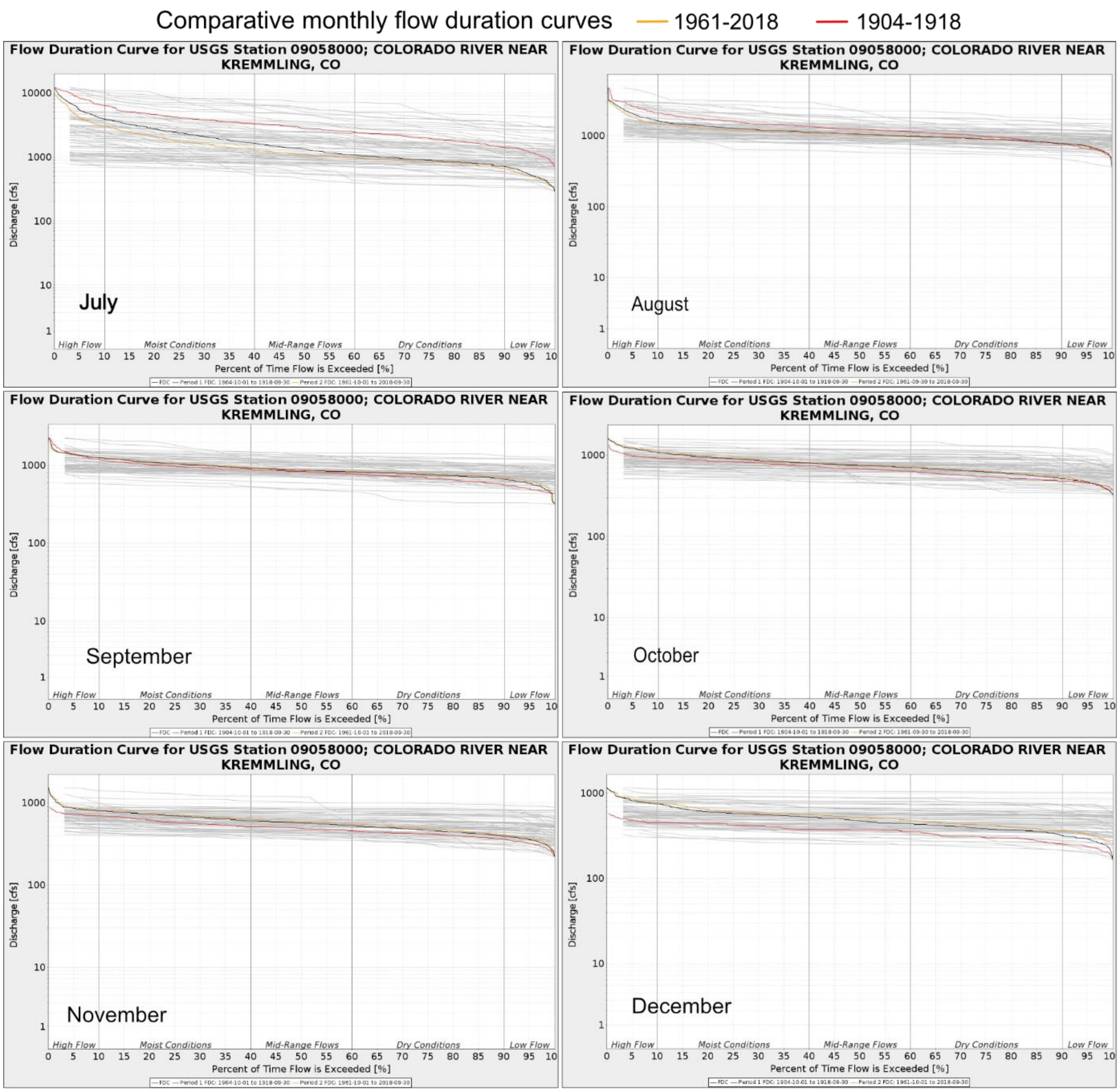

Figure 20. Flow duration curves for USGS 09058000 produced by the eRAMS seasonal flow analysis models.

A number of agreement overlays such as 15-mile Reach endangered fish water and others control the timing and delivery of water from upstream sources in Grand and Summit Counties to the Grand Valley via the W&S reaches. However, in practice the senior water calls downstream at Shoshone and Cameo typically provide the most dominant control across one summer season to the next. These water calls often occur in late July or August but vary widely from year to year. An analysis of the Grand Valley Project senior right (WDID 7200646) call history between 1988 and the present shows that call dates ranged from July 3 to October 3, with a median date of August 16 (

Figure 21). During low snowpack years (i.e. 2002, 2012, 2018) the call often comes on earlier. Spring temperatures, local planting/harvest conditions, late-summer monsoonal weather, and antecedent reservoir fill volumes may all drive the wide interannual timing in call dates.

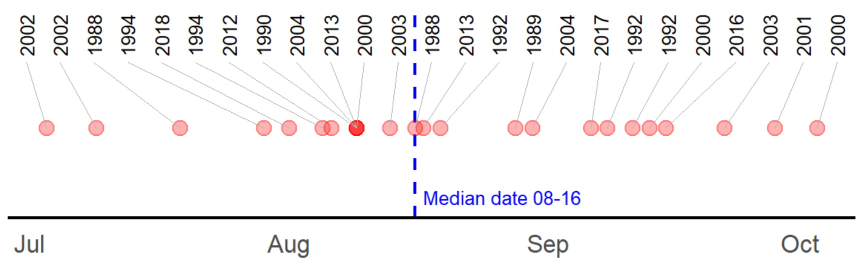

Figure 21. Call dates for senior Grand Valley water rights.

The net effect of water management above the W&S segments in most years is that summer flows are reduced and fall and winter flows are elevated above what would occur under a natural flow regime. The greatest risk and opportunity for reservoir operations to influence water temperatures in the W&S segments appears to lie in the period between runoff subsidence and the initiation of the downstream calls—generally early July to early August. Prior to this period, high stream flows, cool early summer weather, and a more-direct connection between localized surface snowmelt and stream runoff combine to keep streams and rivers cool. In the fall, ambient air temperatures and solar angles decline, exerting less of a warming influence. Although an artificial bench in the hydrograph is frequently observable in late summer, reservoir operations and transmountain diversion still appear overall to reduce natural flow volumes in the W&S segments during this midsummer period when they are most prone to water temperature excursions. Longitudinal temperature profiles do indicate that water releases from the Williams Fork and Green Mountain reservoirs can exert a cooling influence on mainstem Colorado reaches during some periods (Figure 11). Muddy Creek can provide both a warming or cooling influence at times depending on seasonal reservoir thermal stratification and release volume and timing from Wolford Mountain Reservoir, but its discharge contribution relative to the mainstem river and incoming Blue River flows tends to diminishes its overall influence at the start of W&S segment 4. A review of the data record for Muddy Creek (Appendix A, Site Reports, 09041400) reveals that temperature concerns occur predominantly in the spring and fall should seasons on Muddy Creek, coinciding with time periods when summer reservoir releases are curtailed and no longer providing a cooling influence downstream.

4.4 Point and non-point sources

Point source discharges such as municipal wastewater treatment facilities, industrial waste streams, or thermoelectric power generation may produce discharge water that is warmer than natural thermal regimes in headwaters streams. Because these discharges tend to be relative low volume, thermal impacts are typically only significant when they occur in small streams. Measurable impacts of discharges into larger volume rivers are not probable. A search of available online records hosted by CDHPE, NWCCOG, and municipal and county governments yielded information on several point sources within or upstream of the W&S segments. None were deemed of importance to temperature regimes in segments 4-7.

NWCCOG's 208 Regional Water Quality Plan and the Colorado Inventory and Assessment (Beeby, et al., 2016) both report on point source discharges in the region. Additional information is available via CDPHE's permit web portal.[6] Hot Sulphur Springs WWTF holds a general discharge permit for minor municipal facilities discharging 0.05 to 0.1 MGD, but this volume is very small relative to Colorado River flows. Kremmling WWTF is permitted for 300,000 gpd and averaged 132,500 gpd (0.21 cfs) discharge in 2018. The facility originally treated waste using a groundwater infiltration system but has since conducted modifications that utilize a series of ponds and aerobic denitrification technologies prior to discharging to the surface water of Muddy Creek just above the Colorado river confluence. Although WWTF effluent is frequently warmer than receiving headwaters streams, this treatment train tends to result in ambient-air temperature discharge and is very low in volume compared to stream flows. At 1/10th to 1/100th the volume of Muddy Creek during its base periods, the effluent stream volume should be of insufficient magnitude to strongly impact Colorado River mainstem temperatures. Overall, the volume and type of permitted point source discharges in the area appear insufficient to influence temperature patterns in the W&S segments (

Table 4).

Table 4. Permitted point-source discharges that may influence temperature on the W&S segments.

Location	Permit. No.	Type	Capacity
Hot Sulfur Springs	COG-588000	Lagoon system	0.14 MGD
Kremmling WWTF	CO004837	Aerated lagoon	0.3 MGD
Rancho Del Rio	Local/county, Eagle	ISDS	--
State Bridge	Local/county, Eagle	ISDS	--
Burns	Local/county, Eagle	ISDS	--
Dotsero mobile home park	Local/county, Eagle	Rotating biological contactor (groundwater discharge)	0.002 MGD
Two Rivers Village	Local/county, Eagle	--	0.15 MGD

[6] https://www.colorado.gov/pacific/cdphe/clean-water-active-permits

4.5 Upstream Thermal Boundary Conditions

It is beyond the scope of this work to provide an in-depth analysis of temperature conditions in the mainstem Colorado River between Windy Gap and Gore Canyon, where the Wild and Scenic reaches begin. Regulatory 305(b) Segment COUCU03_C (*Colorado River from 578 Road Bridge to Gore Canyon)* was 303(d)-listed in the 2018 cycle for temperature, aquatic life, and arsenic. The Listing Rationale may be obtained from the WQCD Environmental Data Unit if information on the specific sites and data used to make the listing determination is required.

Water temperature data for 14 sites on the mainstem Colorado River between Kremmling and Windy Gap was included as part of this data analysis to better understand the upstream boundary conditions for the W&S segments. Sites throughout the upstream reach registered exceedances during the analysis period of record. These sites include COR-blwWG, COR-SHRF, COR-abvHSS, COR-abvHSR, COR-blwByers, COR-LoneBuck, and COR-CR3. Below the Williams Fork, COR-Hwy9 near Kremmling also experienced exceedances but at a lesser frequency. After applying excursions to the monitoring record, only COR-LoneBuck, COR-CR3 (both above the Williams Fork), and COR-Hwy9 (just above the Blue River confluence, near Kremmling) still showed unexcused exceedances. Although exceedances in individual years were often excused by warming events for many of the other sites, the overall frequency of warming events occurrence (greater than 1 in 3 years) would still lead to a listing decision under current Regulation 31 guidance. Temperature issues occur throughout the reach including at sites near Kremmling but the majority of observed exceedances occur between Windy Gap and the Williams Fork confluence.

Release water from Williams Fork reservoir shows a cooling influence on the mainstem Colorado River (

Figure 22). Summer temperatures climb back to near to WQCD standards by the time the river reaches Kremmling. Muddy Creek water appears to exert a cooling influence on the Colorado during mid and late summer, and a warming influence during fall, as indicated by regular shoulder season exceedances at the USGS gauge site 09041400 and GCWIN sites near Highway 40. Blue River water entering on this segment typically produces either a cooling or neutral signal in the mainstem, depending on the season. In some years during July and August the Blue River appears to have little effect on mainstem temperatures, indicating that release water from Green Mountain Reservoir upstream has equilibrated to a similar temperature as the mainstem Colorado over the 15 miles between the dam and the confluence. Beeby et al. (2014) reported similar findings, linking elevated temperatures upstream of Windy Gap to reduced flows in the Fraser while noting a regular cooling influence from the Williams Fork and Blue River.

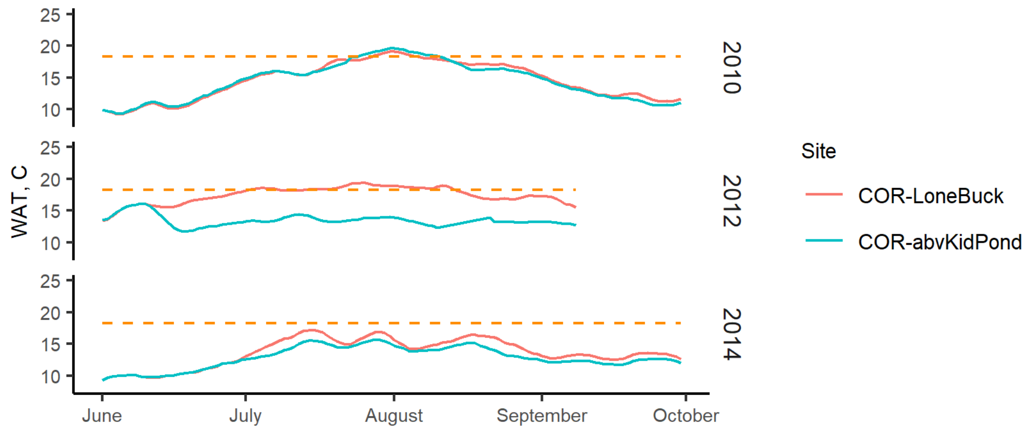

Figure 22. Comparative thermographs above and below Williams Fork River confluence during a typical hydrological year (2010), a dry year (2012), and a wet year (2014).

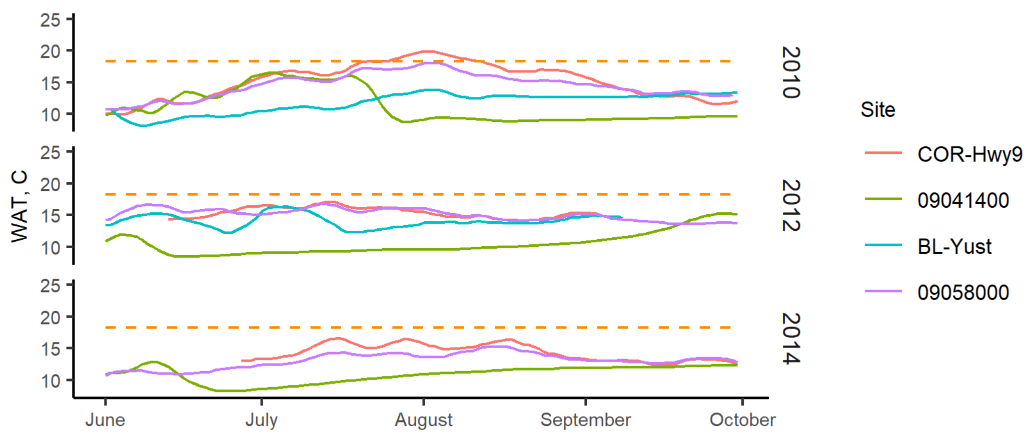

Figure 23. Comparative thermographs above and below the Blue River/Muddy Creek confluences during a typical hydrological year (2010), a dry year (2012), and a wet year (2014).

In related work, Hydros Consulting produced a dynamic temperature model for the Windy Gap Firming Project (WGFP) Environmental Impact Statement (EIS) that included the Colorado River between Windy Gap and the Williams Fork (Hydros Consulting, 2011). That model analyzed direct and indirect effects of increased pumping (and thus reduced flows) associated with the project. Although the variety and complexity of potential scenarios analyzed in that exercise is beyond this scope, the model in general identified effects (increased downstream temperatures due to active water management activities) that included up to 3 additional weeks over existing conditions of temperatures above WAT standards These increases were directly attributable to the WGFP project and indirectly to other projects' cumulative impacts, and were the worst in years with the most-unfavorable stream temperature conditions--increased water extraction combined with poor natural flows and hot summer air temperatures. Conceptually, those efforts support similar conclusions to this data review: at least some portion of temperature regime conditions in the W&S segments is driven by upstream river management activity.

Due to the highly-altered nature of stream flow on reaches above Gore Canyon and a lack of a historical water temperature record, definitive characterization of natural water temperature regimes in the W&S reaches for comparison to current conditions remains problematic. Approximating pre-development temperature regimes and simulating alternative scenarios will likely require application of more-complex models for the segments of interest. For these reasons, specific attribution and quantification of observed temperature patterns to either natural physical characteristics or anthropogenic impacts remains beyond the scope of this work. Warm stream conditions on this reach due to the combined influence of flow extraction and reservoir operation likely increase the seasonal frequency and spatial extent of water temperature exceedances on downstream reaches, but the relative amount of this contribution remains unquantified.

4.6 Geothermal influences

A number of thermal springs exist above, within, and below the W&S segments. In a 1965 technical report on Upper Colorado basin water resources, USGS reported on estimated discharges and chemical water quality of these springs (Iorns et al., 1965). Six thermal springs exist near the town of Hot Sulphur Springs. Total discharge has been reported at approximately 100 gpm (0.22 cfs) or less. The heat load in this low volume of discharge should not significantly influence temperature conditions even at very low flows. A comparative thermograph of sites upstream and downstream of Hot Sulphur Springs shows little effect across flow years (Figure 24).

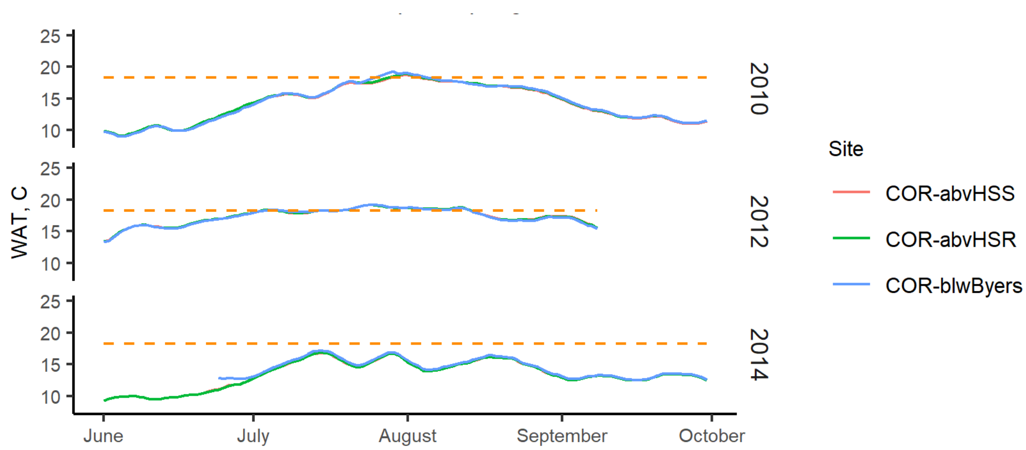

Figure 24. Comparative thermographs above and below Hot Sulphur Springs during a typical hydrological year (2010), a dry year (2012), and a wet year (2014).

USGS estimates the thermal springs in the Dotsero area to discharge about 1 cfs. Nine significant springs are recorded to discharge up to 5 cfs near Glenwood springs and more are believed to arise in the bed of the river itself. The majority of the known Glenwood Springs sites all occur below No Name, where the most exceedances are observed. A summer flow dilution factor of

100-1000x makes it unlikely that local spring discharges provide an observable temperature signature in the river. Development of a thermal mixing model for reaches of the Colorado River mainstem where geothermal springs are known to exist could provide more quantitative information on the impacts of those springs on water temperature patterns.

4.7 Channel Morphology

Some members of the W&S SG suggest that over-sized channels may be a contributing influence to stream temperatures in the region. In reaches above the W&S region, such as the Windy Gap area, permanently high levels of water extraction create a situation in which remaining flows fail to fill historic bankfull channel widths, decreasing typical seasonal values for hydraulic depth and wetted width. Shallow flow depths may increase a streams susceptibility to rapid warming. Although a comprehensive geomorphic study has not been performed on the WS reach, several lines of reasoning suggest that channel geometries in the W&S segments are unlikely to deviate significantly from pre-development conditions.

Stream channels adjust in width, depth, and slope in response to changes and interactions in hydrologic regime, sediment transport regime, and riparian vegetation composition. Local river systems like the Blue River, Eagle River, and the upper Colorado River in Grand County may have experienced an increased sediment load in the mid-nineteenth to early twentieth century due to extensive land use changes (e.g. railroads, clear cutting, mining, road development, agriculture and urban development, reservoir construction, etc.). Sediment loads have likely declined since that period due to stabilization in land use change rates and declines in extractive mining and forestry activities. Some Colorado West Slopes rivers seem to be trending towards more-uniform channel forms with less reach-scale and habitat-scale complexity than prior to western settlement. The sediment regime on the W&S segments was also permanently altered by the construction of upstream reservoirs, which likely have completely interrupted coarse sediment transport from major tributaries like the Blue River and Williams Fork. Colluvial hillslopes adjacent to the mainstem Colorado River and low-order tributary streams now serve as the primary contributors for both suspended load and bed load to the W&S segments. Finer sediment continues to enter the river as suspended load (wash load) and may accumulate during intra-annual periods of low flow throughout lower-energy stream reach types (pools, glides, and plane-bed reaches). Beeby et al. (2014) noted empirical evidence of a slightly increased fine-grain class sedimentation in the mainstem channel downstream of Catamount, concurrent with the shift to increasingly erodible surface geologies. Annual spring floods during May and June are generally able to transport the finer wash load downstream without significant channel geometry alteration in the confined canyon, even during moderate flow years. Some evidence of this transport is visible in the delta deposits at the upstream end of Shoshone Reservoir. Beeby et al. (2014) identified concerns that modern reductions in peak flow regimes due to reservoir and transmountain diversion operations may inhibit the frequency and magnitude of high flows necessary for bed load transport, flushing flows, and channel forming flows—aspects of the flow regime that are all vital to multiple aspects of ecosystem health including fisheries reproduction and riparian habitat replenishment.

Land use change such as agricultural conversation and increases in road network densities may contribute regionally significant increases of fine sediment to stream systems. However, the river already drains a region of highly-erosive soil and geology types. Beeby et al. (2014) produced sediment transport models indicating bed load in the project reach moves relatively infrequently during only the largest of modern-day flood flows. Further investigation to sediment transport dynamics is currently occurring during the 2019 runoff season by USGS researchers. Additional bed load-sized clasts may occur from tributary floods or colluvial processes (hillslope mass wasting, i.e. landslides, slumps, debris flows etc.) that reach the river channel. During heavy warm-season precipitation events, fine sediment plumes are regularly observed coloring the river below Radium. Road-covering mud and debris flows are a regular occurrence on county roads at the mouths of dry washes and arroyos, throughout the region. Little visible evidence exists that these depositional events contribute to reach-scale aggradation or other changes to channel geometry. It is also unlikely that the increased sediment load from the limited amount of agricultural activities in the area provides a significant increase to the already-high natural watershed background signal.

Channels can narrow and experience increased riparian vegetation establishment in rivers where reservoirs and water withdrawals reduced flow and sediment inputs. Beeby et al. (2014) noted no significant change in historical channel widths but did observe an increase in riparian vegetation establishment on islands and streambanks on reaches with unconfined floodplains near Radium area. Their analysis relied on interpretation of paired aerial photographs from 1938 and 2011. Fieldwork sponsored by the W&S Stakeholder Group and conducted by UGSS in 2019 may provide additional information regarding sediment regimes and geomorphic change.

4.8 Riparian Vegetation

Riparian shading can be a significant factor in stream temperature regimes depending on stream width and vegetation community composition. While canopy heights for mature cottonwood and ponderosa riparian forests may attain levels that provide significant shading at early and late day sun angles, these forest types do not comprise a dominant vegetation type in the W&S segments. Streambanks are more-frequently occupied by shrub communities and grasses. Beeby et al. (2014) noted average wetted channel widths of approximately 170 ft when the mainstem Colorado River is flowing at 1000 cfs. Riparian shading on wide channels like the Colorado River through the W&S segments is unlikely to provide a significant buffer against warming. The W&S segments traverse a mountainous region with highly dissected geography. Local topographic features create zones of hillslope and mountainside relief that blocks incoming solar radiation, providing a much stronger control on the water energy balance than riparian vegetation. Development of a stream channel energy balance model for representative reaches of the Colorado River mainstem would provide a means for testing the influence of different vegetative densities and heights on water temperatures.

4.9 Shoshone Reservoir

Water temperature exceedances are regular in the monitoring record from Dotsero above the Eagle River confluence. However, the frequency and magnitude of those exceedances increases significantly downstream at No Name. The shading imparted by the steep topography of Glenwood Canyon suggests this reach of river should not be experiencing large thermal gains, similar to the Gore Canyon to Radium reach. Other drivers may be responsible for the difference in observed exceedances. The channel between Dotsero and the top of Glenwood Canyon is relatively wide and shallow, potentially making this reach more susceptible to thermal gains from insolation. Shoshone Power Station also impounds the river in a shallow reservoir about half-way through Glenwood Canyon. Residence time increases and exposure of a larger surface area to the warming effects of long- and short-wave radiation may increase rates of warming in the river at this location. Development of a stream channel energy balance model for the reach of the Colorado River between Dotsero and No Name would provide a means for testing the influence of residence times and channel/reservoir top widths on water temperatures throughout the reach.

5 TEMPERATURE MODELING

The SG's collective interest in understanding the relationship between streamflow and water temperature on the W&S segments motivated the qualitative consideration of thermal influences presented in the previous section. A quantitative assessment of thermal influences will require development of complex modeling tools beyond the scope of this effort. However, opportunity existed for a cursory exploration of predictive relationships between air temperature, streamflow, and water temperature.

Non-linear logistical regression models are among the simplest tools that investigators use to evaluate the influence of air temperature, streamflow, riparian shading, channel geometry, and other watershed characteristics on water temperature. They require relatively little data for their development and parameterization. The data they do require is readily available for many streams. This assessment employed the model presented by Mohseni et al. (1998) for predicting weekly average stream temperature (T^s). This is referred to as the *logR1* model in this report, and represents a water temperature model based on air temperature with no variable streamflow component.

$$T_i^S = a + \frac{b - a}{1 + \exp(c \cdot (d - T_i^A))}$$

Where *a* is the minimum annual water temperature, *b* is the maximum annual water temperature, T^A is weekly average air temperature, and *c* and *d* are parameters representing the slope of a logistic function and the temperature of that function at the inflection point, respectively. An extension of the *logR1* model as proposed by Piotrowski and Napiorkowski (2019) was also employed.

$$T_i^S = a + \frac{b - a}{1 + \exp(c \cdot (d - T_i^{AW}))} + \frac{e}{Q_i^W}$$

Where T^{AW} is weighted average of recent lag values of air temperature, *e* is a parameter to be fit by the model, and Q^W is the weighted average of recent lag values of discharge. This model is referred to as the *NlogR1* model in this report, representing a model that relies on both air temperature and streamflow inputs. Weighted averages of air temperature were computed as follows:

$$T_i^{AW} = \sum_{j=0}^{lag} w_j \cdot T_{i-j}^{A}$$

Where w_j is the weight applied to the observed air temperature value at j^{th} time step away from the air temperature at time step i. Weights were applied as an arithmetic decay from zero to lag, the number of lag days. Weighted discharge values were estimated in the same manner. Both models were coded in the R statistical computing environment and applied to data sets from the Colorado River near Kremmling (09058000), the Colorado River at Catamount (09060799), and the Colorado River above Glenwood Springs (09071750) (

Table 5). Values for a and b were estimated directly from the observed data from each site. Values for c, d, e, and lag were estimated using a differential evolution algorithm in the DEoptim R library using the Nash Sutcliffe Efficiency objective function (Table 6). Overall model fit was evaluated by comparing the distance between predicted values of water temperature to observed values using a suite of Goodness-of-Fit (GOF) measures (

Table 7,

Table 8, Figure 25).

Table 5. Data sets used to complete temperature modeling exercise.

Temp. Station ID	Description	Met Station ID	Stream Gauge ID
09058000	CO River below Kremmling	54664	09058000
09060799	CO River at Catamount	54664	09060799
09071750	CO River above Glenwood	53359	09070500

Table 6. Fitted parameter values for the logRI and NlogR1 models at each of the three sites where models were developed.

	09058000		09060799		09071750	
Parameter	**logR1**	**NlogR1**	**logR1**	**NlogR1**	**logR1**	**NlogR1**
a	0.1	0.1	0	0	0	0
b	22.6	22.6	22.8	22.8	22.8	22.8
c	0.1	0.1	0.1	0.1	0.1	0.1
d	9.7	10.3	8.4	8.3	11.8	13.1
e	-	-1.2	-	-1.2	-	2.4
lag	-	5	-	6	-	18

Table 7. Various Goodness-of-Fit measures used to evaluate the reliability of each parameterized model.

GOF Measure	Description
ME	Mean Error
MAE	Mean Absolute Error
MSE	Mean Squared Error
RMSE	Root Mean Square Error
NRMSE %	Normalized Root Mean Square Error (-100% <= nrms <= 100%)
PBIAS %	Percent Bias
RSR	Ratio of RMSE to the Standard Deviation of the Observations (0 <= RSR <= +Inf)
rSD	Ratio of Standard Deviations, rSD = sd(sim) / sd(obs)
NSE	Nash-Sutcliffe Efficiency (-Inf <= NSE <= 1)
mNSE	Modified Nash-Sutcliffe Efficiency
rNSE	Relative Nash-Sutcliffe Efficiency
d	Index of Agreement (0 <= d <= 1)
md	Modified Index of Agreement
rd	Relative Index of Agreement
cp	Persistence Index (0 <= PI <= 1)
r	Pearson Correlation coefficient (-1 <= r <= 1)
R2	Coefficient of Determination (0 <= R2 <= 1).
bR2	R2 multiplied by the coefficient of the regression line between sim and obs (0 <= bR2 <= 1)
KGE	Kling-Gupta efficiency between sim and obs (0 <= KGE <= 1)
VE	Volumetric efficiency between sim and obs (-Inf <= VE <= 1)

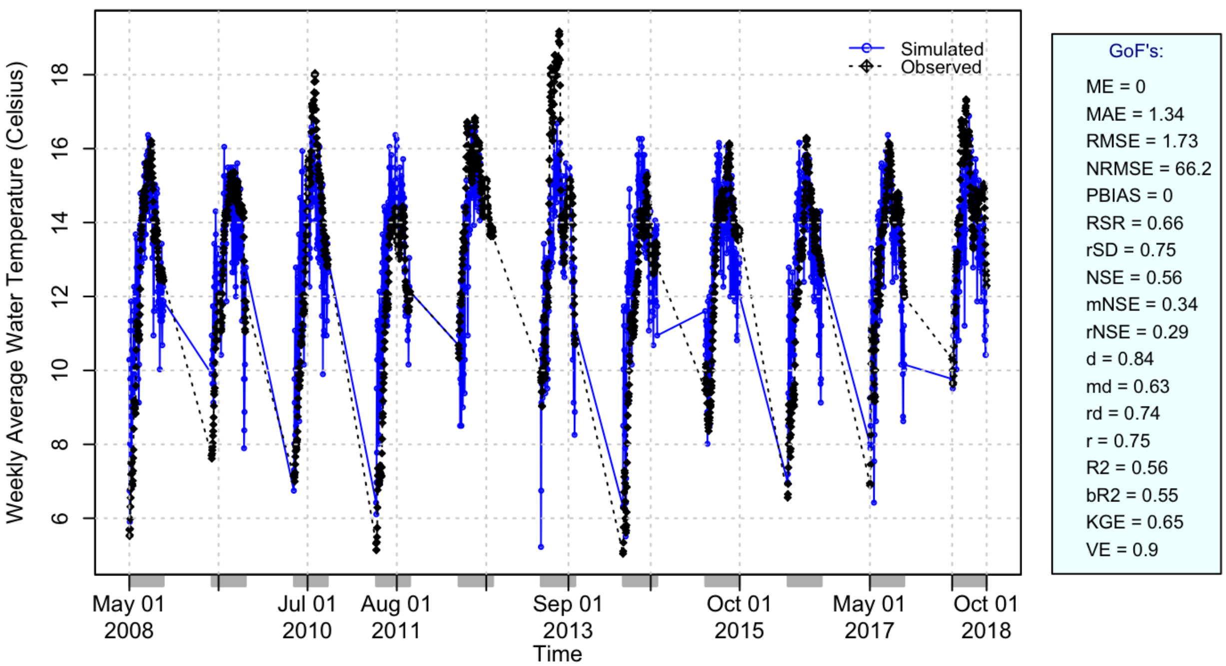

Figure 25. Simulated and observed water temperatures produced by the logR1 model for the Colorado River near Kremmling (09058000).

Table 8. GOF results for parameterized logR1 and NlogR1 models from each site were models were developed.

GOF Measure	09058000		09060799		09071750	
	logR1	NlogR1	logR1	NlogR1	logR1	NlogR1
ME	0	-0.01	-0.01	-0.04	-0.04	-0.09
MAE	1.34	1.14	0.79	0.93	1.94	1.24

MSE	2.98	2.17	0.98	1.47	5.48	2.41
RMSE	1.73	1.47	0.99	1.21	2.34	1.55
NRMSE %	66.2	57.1	32.3	39	63.5	42.2
PBIAS %	0	0	-0.1	-0.3	-0.3	-0.7
RSR	0.66	0.57	0.32	0.39	0.63	0.42
rSD	0.75	0.82	0.94	0.92	0.78	0.91
NSE	0.56	0.67	0.9	0.85	0.6	0.82
mNSE	0.34	0.43	0.7	0.65	0.4	0.61
rNSE	0.29	0.44	0.88	0.78	0.43	0.75
d	0.84	0.89	0.97	0.96	0.86	0.95
md	0.63	0.69	0.85	0.82	0.65	0.8
rd	0.74	0.82	0.97	0.94	0.8	0.93
cp	-13.28	-9.5	-8.54	-13.6	-40.6	-21.35
r	0.75	0.82	0.95	0.92	0.77	0.91
R2	0.56	0.67	0.9	0.85	0.6	0.82
bR2	0.55	0.67	0.89	0.84	0.58	0.81
KGE	0.65	0.75	0.92	0.89	0.68	0.87
VE	0.9	0.91	0.94	0.93	0.86	0.91

Fitted models exhibited mean absolute prediction errors as low as 0.79 ºC near Catamount to as high as 1.94 ºC above Glenwood Springs (

Table 8). Model fits for the Colorado River at Catamount were generally better, but that may be a result of the relatively short 2-year data set available for evaluation. Model fit for the Colorado River near Kremmling and above Glenwood Springs showed some interesting consistent patterns and errors. At both sites, inclusion of streamflow as a prediction parameter improved model fit, indicating that air temperature alone is not the sole primary driver of instream conditions in the W&S segments. Inclusion of streamflow did not appear to improve model fit at Catamount. This may also be a result of the short period of record at Catamount or it may reflect a greater sensitivity to variable streamflow at the two sites that bookend the W&S segments where inflows from large tributaries and/or reservoir operations play a significant role in controlling water temperatures.

Water temperature predictions by the *logR1* and *NlogR1* models at both Colorado River near Kremmling and above Glenwood Springs were generally too high in 2011 and in 2013 they were too low (Figure 25). This might be explained by the exceptionally high flows in 2011, followed by two years of low flows in 2012 and 2013. It is important to note that the inclusion of discharge in the *NlogR1* model assumes an inverse linear effect on water temperature (i.e. the impact of an additional cfs of water is consistent across year types and times of year). The effect of exceptionally large flows that occurred in 2011 may be better approximated by a non-linear function. Predictions in 2012 are satisfactory. Reservoirs were full at the beginning of this year and likely released water to downstream reaches in a typical fashion, albeit earlier than in most years. Reservoir levels in 2013 were much lower than in the previous year. The lower fill volumes may have been accompanied by different thermal stratification characteristics and higher outflow temperatures. This effect, if real, cannot be well predicted by the model. If the SG does require a more accurate tool for interpreting historical controls on water temperature and for predicting future conditions under different management scenarios, a more complex and comprehensive modeling effort will likely be required.

6 NEXT STEPS

6.1 Filling Data Gaps

Temporal and spatial coverage of monitoring stations on segments 4-7 varies strongly by year. The most consistent data records occur at the USGS sites book-ending the reaches: Colorado River Near Kremmling (09058000) and Colorado River above Glenwood Springs (09071750). The BLM's Pumphouse site produced a decade of data but not all summer months are available in several years of the record. Temperature records at Pumphouse and Radium appear nearly identical for concurrent seasons, indicating little heat gain occurs on this reach. Datasets for intermediate locations (i.e. State Bridge, Catamount, Red Dirt, and Dotsero) exhibit short periods of record. These short records inhibit detailed analyses on the extent of tributary influences and thermal gain in this 50-mile section of river.

The limited data record at Dotsero, a lack of bracketing at the Eagle River confluence, and a lack of bracketing at Shoshone Reservoir also limits the ways that temperature dynamics can be explored on Segment 7. Establishment (or re-establishment) of water temperature sensors/loggers in these locations may benefit further understanding of the lowest W&S segment (Table 9). Other temperature influences like the role of groundwater returns or the differential effects of releases from reservoirs in Grand County and Summit County on temperature patterns in the W&S segment could be better-quantified with additional study or model development.

Table 9. Potential sites for monitoring network expansion and associated motivating factors.

Potential Monitoring Location	Spatial Data Gap	Model Parameterization	Significant Tributary	Comments
Mouth of Blue River, Downstream of Green Mountain Dam		x	x	Two years of pre-existing data, but no recent data. Provides an important input to understanding source water contribution influences
Colorado River at State Bridge	x			Consider discontinuing Radium due to its high similarity to Pumphouse and re-establishing a monitoring station a State Bridge
Mouth of Red Dirt Creek	x	x		Approximate mid-distance between Catamount and Dotsero. Poor spatial coverage.
Colorado River above Eagle River	x	x		Brackets Eagle River and the wider valley reach from Red Dirt to Dotsero
Mouth of Eagle River		x	x	Major tributary influence during July and August
Colorado River below Eagle River	x	x		Brackets Eagle River and above Shoshone Reservoir
Colorado River Below Shoshone Reservoir	x			Brackets Shoshone reservoir

6.2 Considering Additional Approaches

Both natural warming mechanisms and impacts from hydrologic modification and reduced summer flows appear to drive temperature conditions on the W&S segments. Separating the effects of upstream water management from natural conditions was beyond the scope of this assessment and may require alternative analyses or more complex predictive modelling efforts. Mechanistic models such as USGS's SNTEMP may provide opportunities for greater understanding and separation of human and natural effects on water temperature. Modeling tools can also be useful for supporting future resource management decision making intended to protect the ORVs on the W&S segments.

State stream water temperature standards are informed by the extensive biological literature database established by WQCC and CPW for the suite of freshwater species present in Colorado streams However, considering the W&S segments in a purely empirical context separate from the regulatory overlay. A wild (naturally reproducing) fishery of both introduced salmonid and native Colorado basin species continues to persist in many reaches despite temperature regime conditions that regularly exceed the hypothetical thresholds for cold water species. In downstream reaches where salmonids are still present but species dominance shifts towards increased suckers and other native species, Beeby et al. (2014) suggests that shifts in geology and habitat-level changes (i.e. a shift to a more featureless river bottom with long plane bed or glide sections as opposed to more-complex physical habitat with frequent riffle-run sequences above State Bridge) may provide an important driver on fishery community structure. The basic issue then becomes the apparent contradiction between a successful and persistent cold-water fishery despite the occurrence of theoretically detrimental temperature conditions. This situation conceptually bastions the idea that the W&S segments may be predisposed to warmer conditions than the regulatory standards would suggest and that these somewhat-warmer temperature patterns may be amplified by upstream water management. Outputs from mechanistic modelling may help inform a discussion about whether current regulatory overlays remain the most appropriate basis for the water temperature Resource Guide.

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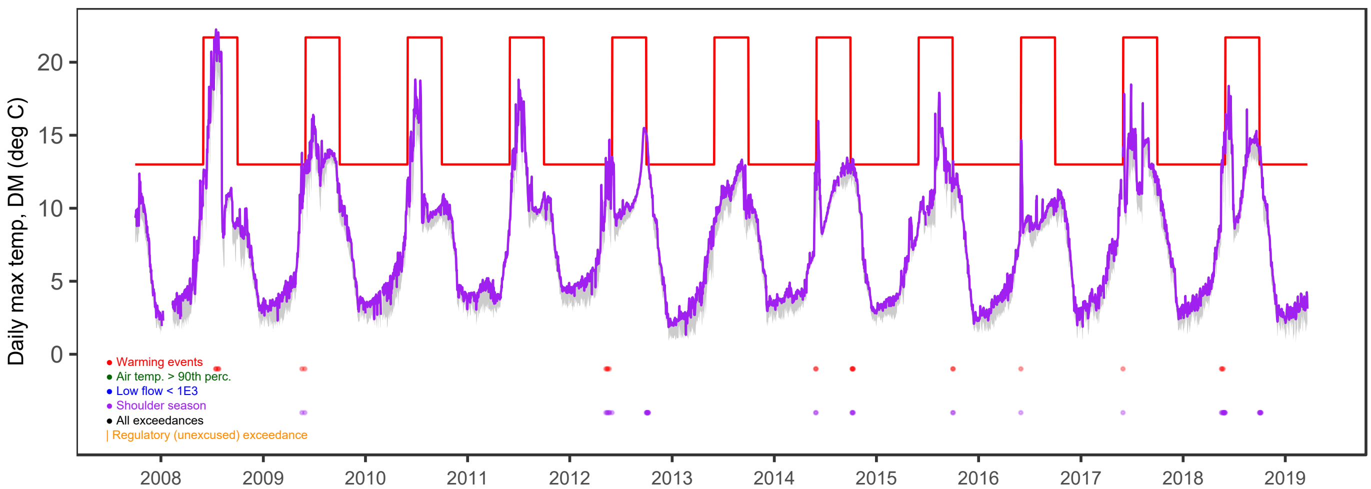
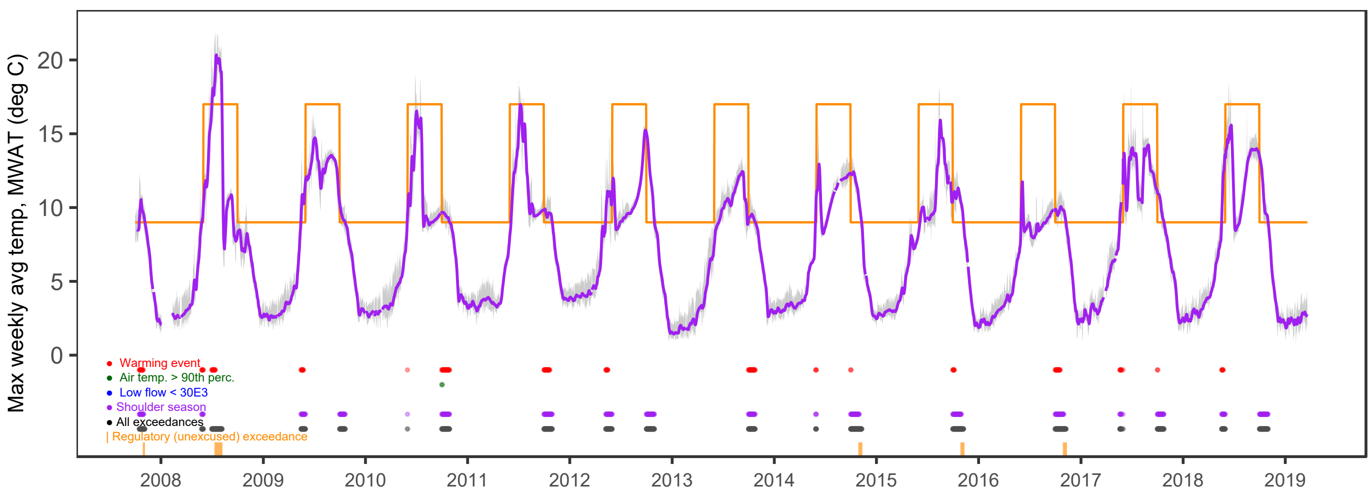
APPENDIX A: Individual Site Reports

Table of Contents

Temperature Summary: 09041400
MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO
Standards tier: CS1, Wild and Scenic study reach number: NA

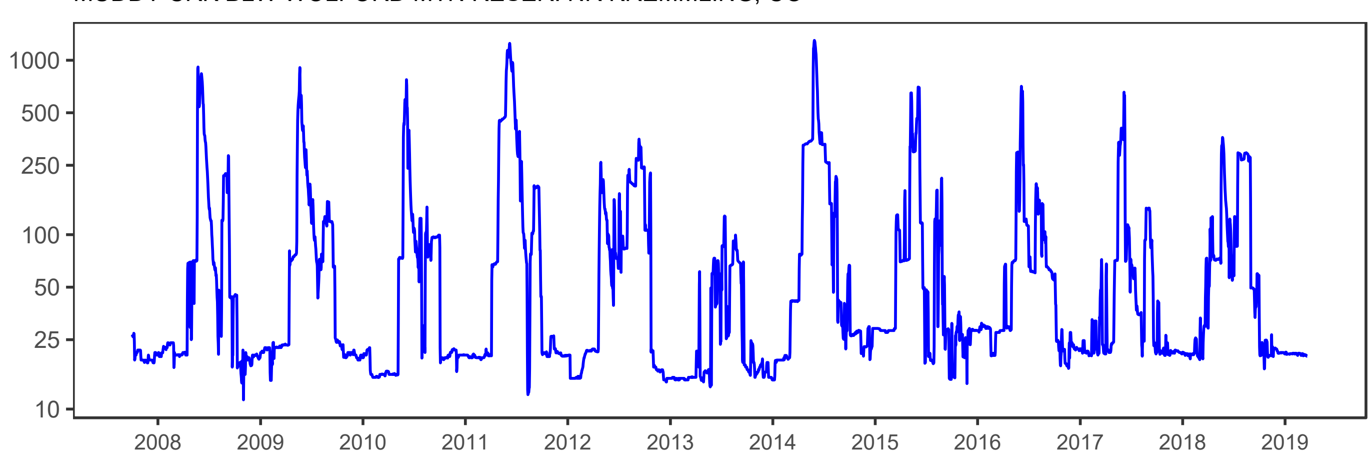


DM summary: Years in record: 13, total exceedances: 46, unexcused exceedances: 0



WAT summary: Years in record: 13, total exceedances: 430, unexcused exceedances: 11

Discharge (cfs) at gauge 09041400
MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO



MWAT regulatory exceed summaries for 09041400
MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2007	0	0	0	0	0	0	0	0	0	0	1	0	1
2008	0	0	0	0	0	0	3	1	0	0	0	0	4
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	2	0	2
2015	0	0	0	0	0	0	0	0	0	0	2	0	2
2016	0	0	0	0	0	0	0	0	0	0	2	0	2
2017	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for 09041400
MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO

Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2016-11-08	9.03	9	winter-2016	28.42	FALSE	FALSE	FALSE	FALSE	TRUE
2016-11-01	9.78	9	winter-2016	25.57	FALSE	FALSE	FALSE	FALSE	TRUE
2015-11-08	9.03	9	winter-2015	63.07	FALSE	FALSE	FALSE	FALSE	TRUE
2015-11-01	10.22	9	winter-2015	58.44	FALSE	FALSE	FALSE	FALSE	TRUE
2014-11-08	9.18	9	winter-2014	96.62	FALSE	FALSE	FALSE	FALSE	TRUE
2014-11-01	10.27	9	winter-2014	92.15	FALSE	FALSE	FALSE	FALSE	TRUE
2008-08-04	19.20	17	summer-2008	74.35	FALSE	FALSE	FALSE	FALSE	TRUE
2008-07-28	20.06	17	summer-2008	57.38	FALSE	FALSE	FALSE	FALSE	TRUE
2008-07-21	19.99	17	summer-2008	36.59	FALSE	FALSE	FALSE	FALSE	TRUE
2008-07-14	19.43	17	summer-2008	14.68	FALSE	FALSE	FALSE	FALSE	TRUE
2007-11-01	9.47	9	winter-2007	14.89	FALSE	FALSE	FALSE	FALSE	TRUE

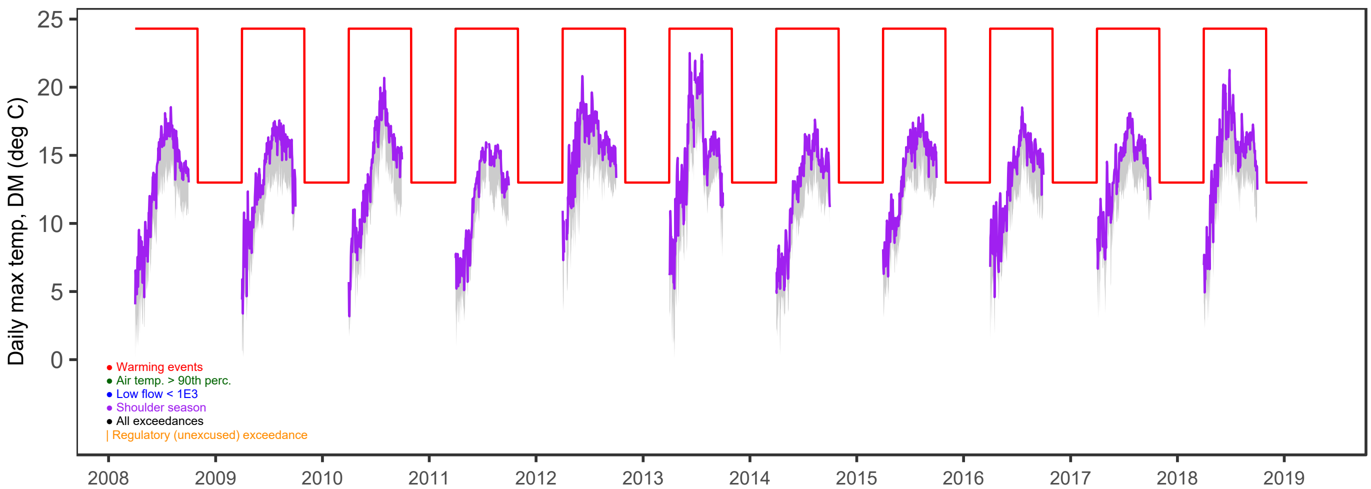
Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

Regulatory status summary 09041400

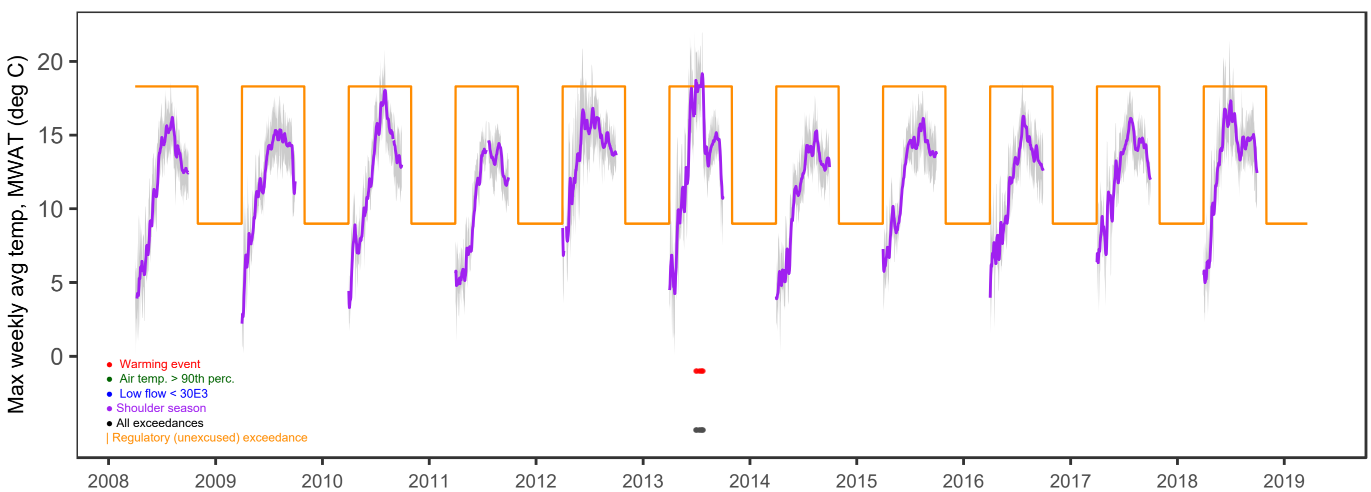
MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO

Site	09041400
POR_yrs	13
DM_exceed_total	46
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	430
WAT_unexcused_exceed_total	11
WAT_unexc_exceed_freq	0.38
WAT_unexc_exceed_recur_ratio	1 in 2.6
WAT_unexc_exceed_in_last_3_yrs	TRUE

Temperature Summary: 09058000
COLORADO RIVER NEAR KREMMLING, CO
Standards tier: CS2, Wild and Scenic study reach number: 4

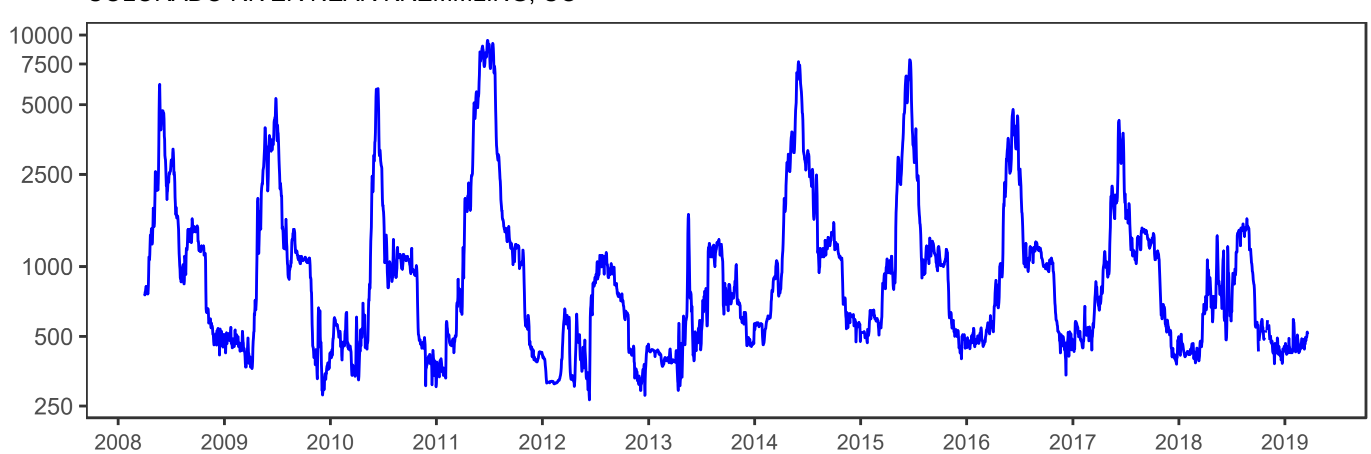


DM summary: Years in record: 12, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 12, total exceedances: 17, unexcused exceedances: 0

Discharge (cfs) at gauge 09058000
COLORADO RIVER NEAR KREMMLING, CO



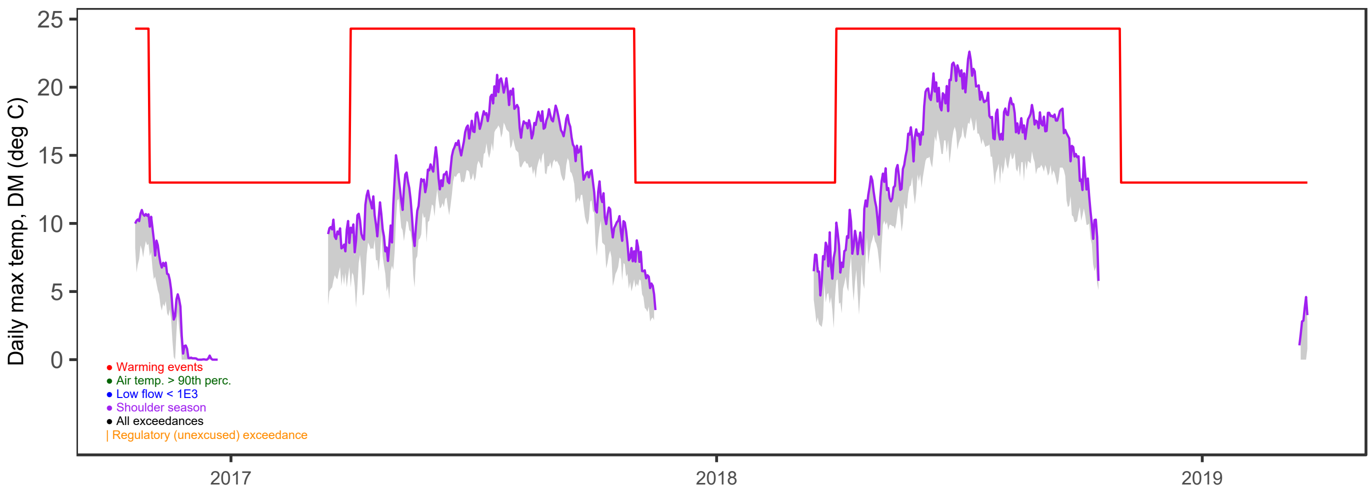
Regulatory status summary 09058000
COLORADO RIVER NEAR KREMMLING, CO

Site	09058000
POR_yrs	12
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	17
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

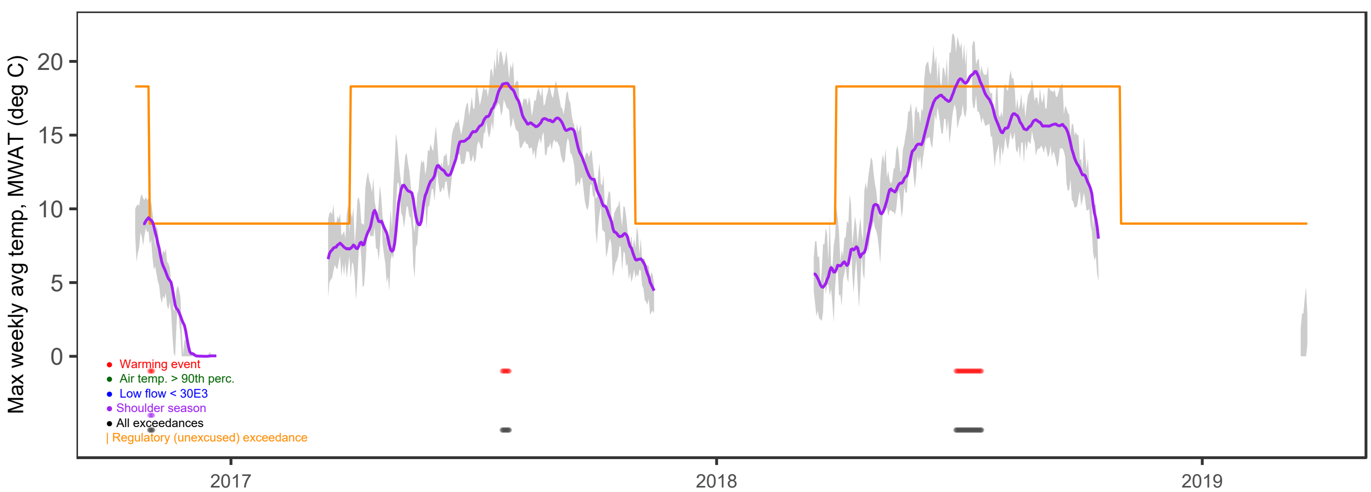
Temperature Summary: 09060799

COLORADO RIVER AT CATAMOUNT BRIDGE, CO

Standards tier: CS2, Wild and Scenic study reach number: 6



DM summary: Years in record: 4, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 4, total exceedances: 29, unexcused exceedances: 0

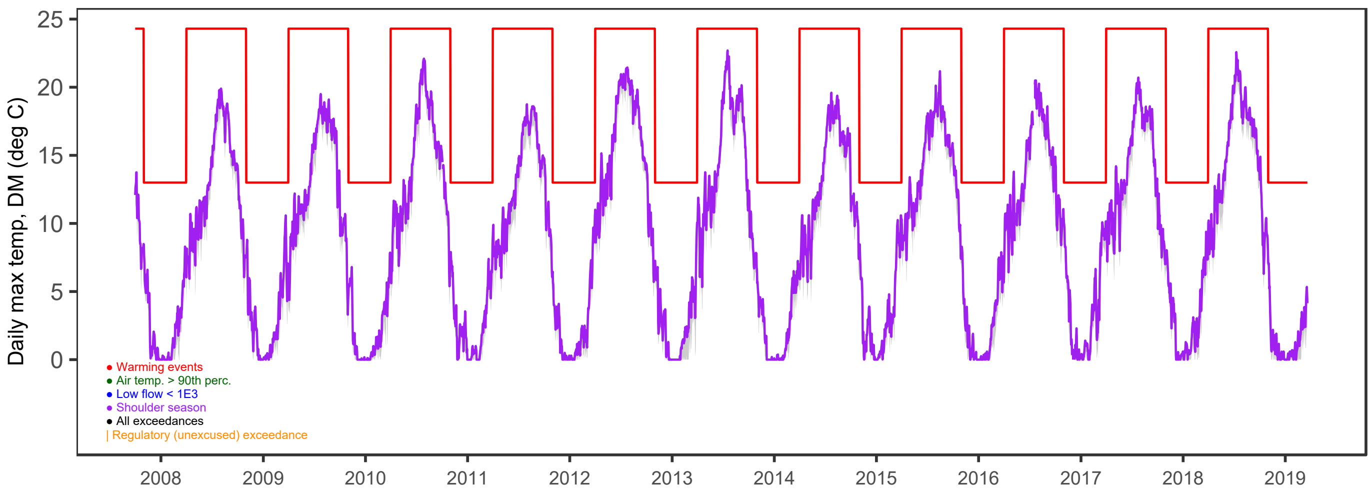
Discharge (cfs) at gauge 09058000

COLORADO RIVER AT CATAMOUNT BRIDGE, CO

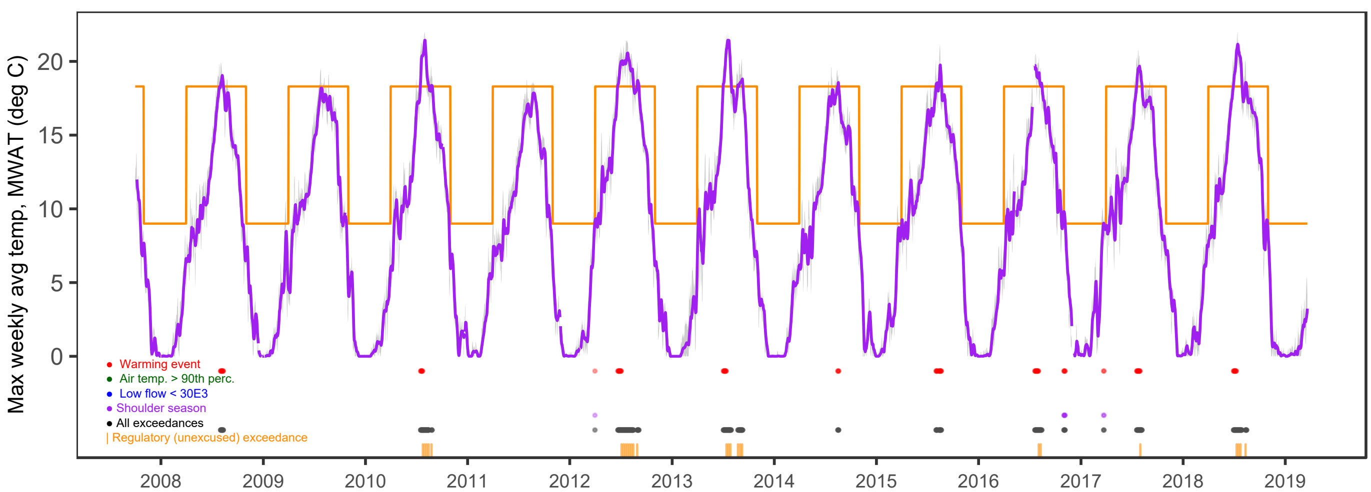
Regulatory status summary 09060799
COLORADO RIVER AT CATAMOUNT BRIDGE, CO

Site	09060799
POR_yrs	4
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	29
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: 09071750
COLORADO RIVER ABOVE GLENWOOD SPRINGS, CO
Standards tier: CS2, Wild and Scenic study reach number: 7

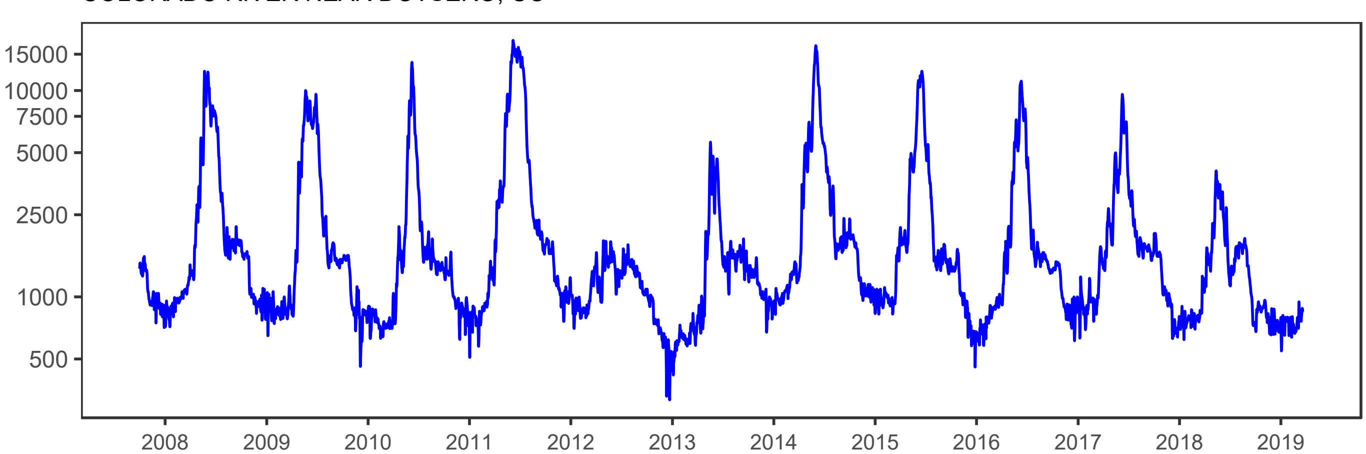


DM summary: Years in record: 13, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 13, total exceedances: 264, unexcused exceedances: 26

Discharge (cfs) at gauge 09070500
COLORADO RIVER NEAR DOTSERO, CO



MWAT regulatory exceed summaries for 09071750
COLORADO RIVER ABOVE GLENWOOD SPRINGS, CO

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	1	4	0	0	0	0	5
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	4	4	0	0	0	0	8
2013	0	0	0	0	0	0	3	1	2	0	0	0	6
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	2	0	0	0	0	2
2017	0	0	0	0	0	0	0	1	0	0	0	0	1
2018	0	0	0	0	0	0	3	1	0	0	0	0	4
2019	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for 09071750
COLORADO RIVER ABOVE GLENWOOD SPRINGS, CO

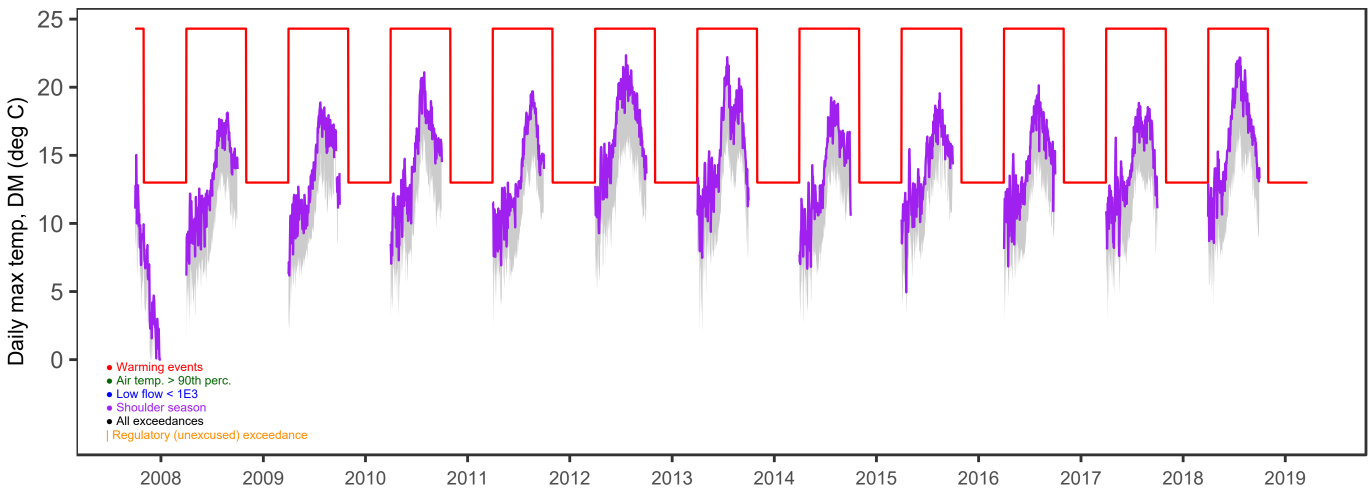
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2018-08-12	18.53	18.3	summer-2018	53.01	FALSE	FALSE	FALSE	FALSE	TRUE
2018-07-25	20.24	18.3	summer-2018	47.29	FALSE	FALSE	FALSE	FALSE	TRUE
2018-07-18	20.73	18.3	summer-2018	32.40	FALSE	FALSE	FALSE	FALSE	TRUE
2018-07-11	20.75	18.3	summer-2018	13.74	FALSE	FALSE	FALSE	FALSE	TRUE
2017-08-01	19.32	18.3	summer-2017	13.72	FALSE	FALSE	FALSE	FALSE	TRUE
2016-08-10	18.38	18.3	summer-2016	16.70	FALSE	FALSE	FALSE	FALSE	TRUE
2016-08-03	19.19	18.3	summer-2016	14.05	FALSE	FALSE	FALSE	FALSE	TRUE
2013-09-08	18.79	18.3	summer-2013	57.53	FALSE	FALSE	FALSE	FALSE	TRUE
2013-09-01	18.57	18.3	summer-2013	55.05	FALSE	FALSE	FALSE	FALSE	TRUE
2013-08-24	18.41	18.3	summer-2013	54.04	FALSE	FALSE	FALSE	FALSE	TRUE
2013-07-28	19.78	18.3	summer-2013	52.16	FALSE	FALSE	FALSE	FALSE	TRUE
2013-07-21	21.41	18.3	summer-2013	34.79	FALSE	FALSE	FALSE	FALSE	TRUE
2013-07-14	20.83	18.3	summer-2013	14.20	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-29	18.42	18.3	summer-2012	79.19	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-15	18.58	18.3	summer-2012	79.03	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-08	19.34	18.3	summer-2012	72.60	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-01	20.05	18.3	summer-2012	63.85	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-25	20.56	18.3	summer-2012	49.96	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-18	19.82	18.3	summer-2012	36.58	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-11	19.90	18.3	summer-2012	25.05	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-04	20.01	18.3	summer-2012	13.65	FALSE	FALSE	FALSE	FALSE	TRUE
2010-08-25	18.38	18.3	summer-2010	51.13	FALSE	FALSE	FALSE	FALSE	TRUE
2010-08-15	18.40	18.3	summer-2010	51.04	FALSE	FALSE	FALSE	FALSE	TRUE
2010-08-08	19.41	18.3	summer-2010	48.45	FALSE	FALSE	FALSE	FALSE	TRUE
2010-08-01	21.44	18.3	summer-2010	33.17	FALSE	FALSE	FALSE	FALSE	TRUE
2010-07-25	20.37	18.3	summer-2010	14.81	FALSE	FALSE	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

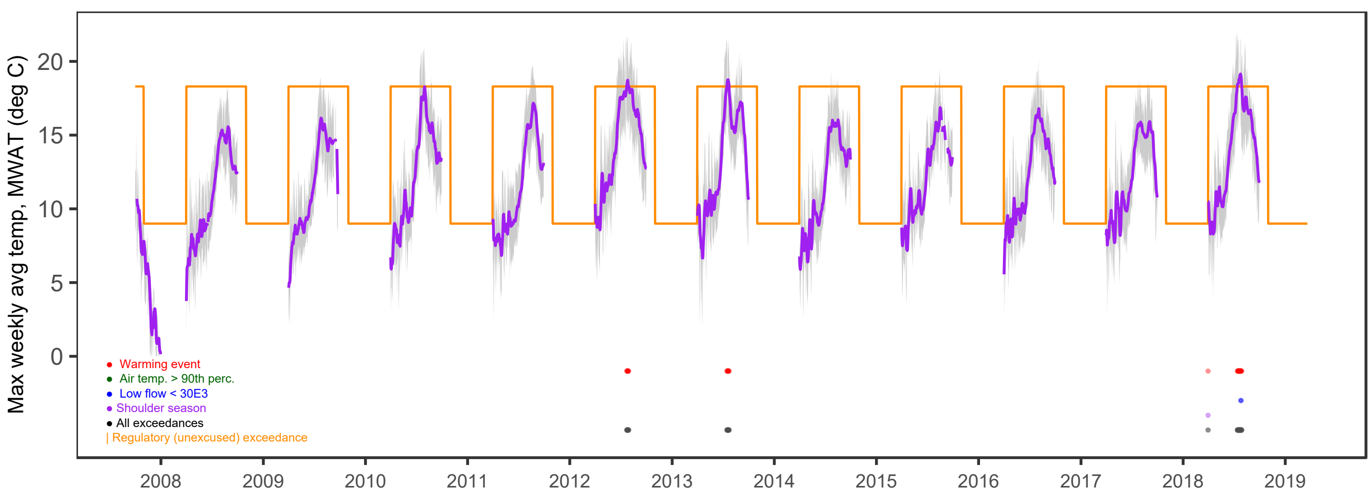
Regulatory status summary 09071750
COLORADO RIVER ABOVE GLENWOOD SPRINGS, CO

Site	09071750
POR_yrs	13
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	264
WAT_unexcused_exceed_total	26
WAT_unexc_exceed_freq	0.46
WAT_unexc_exceed_recur_ratio	1 in 2.2
WAT_unexc_exceed_in_last_3_yrs	TRUE

Temperature Summary: 09085000
ROARING FORK RIVER AT GLENWOOD SPRINGS, CO.
Standards tier: CS2, Wild and Scenic study reach number: NA



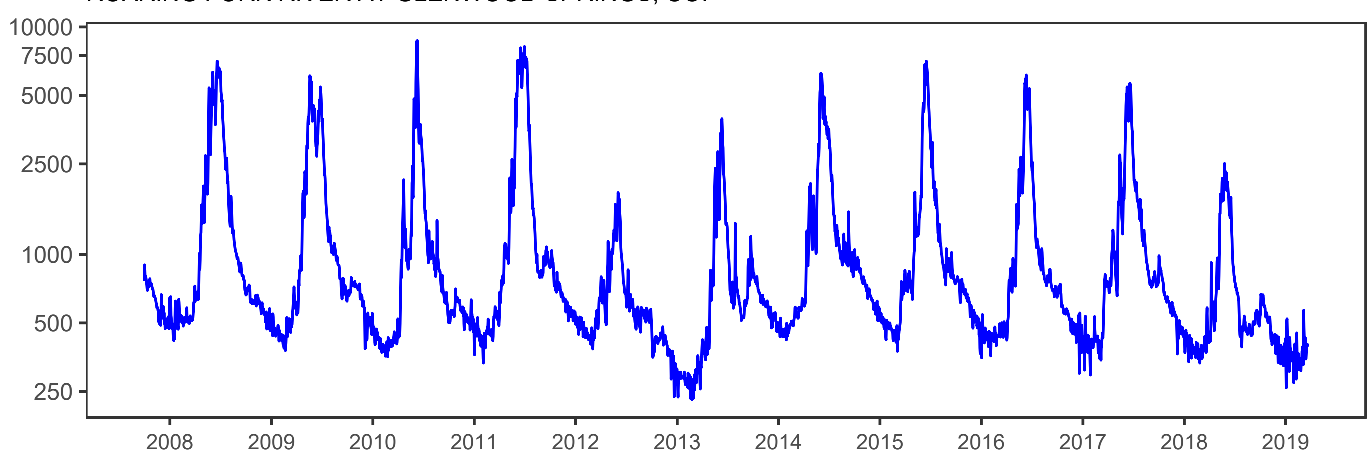
DM summary: Years in record: 13, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 13, total exceedances: 32, unexcused exceedances: 0

Discharge (cfs) at gauge 09085000

ROARING FORK RIVER AT GLENWOOD SPRINGS, CO.



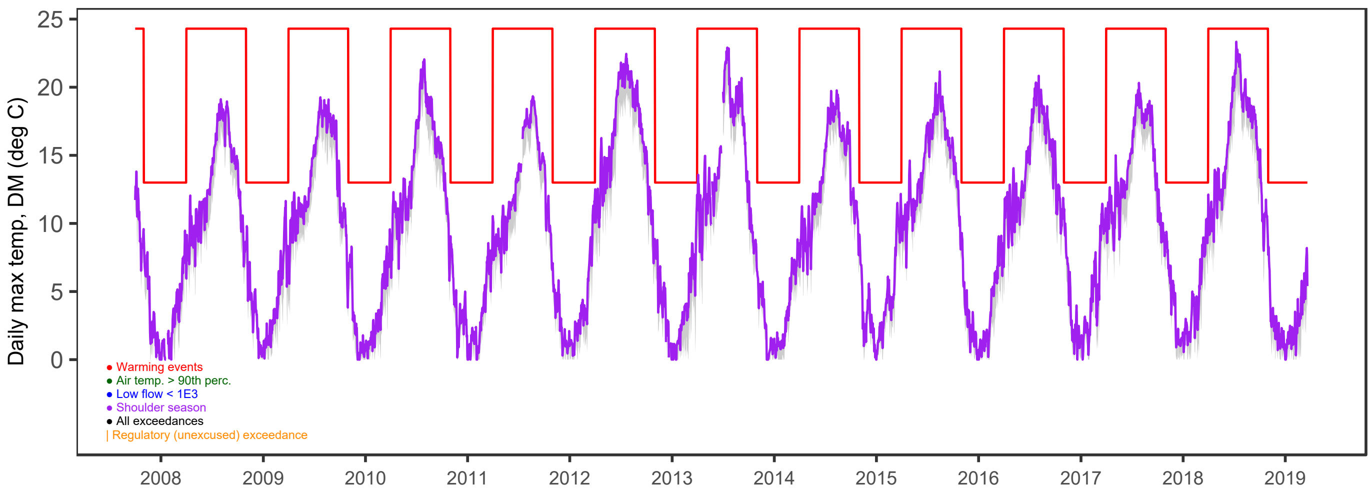
Regulatory status summary 09085000
ROARING FORK RIVER AT GLENWOOD SPRINGS, CO.

Site	09085000
POR_yrs	13
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	32
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

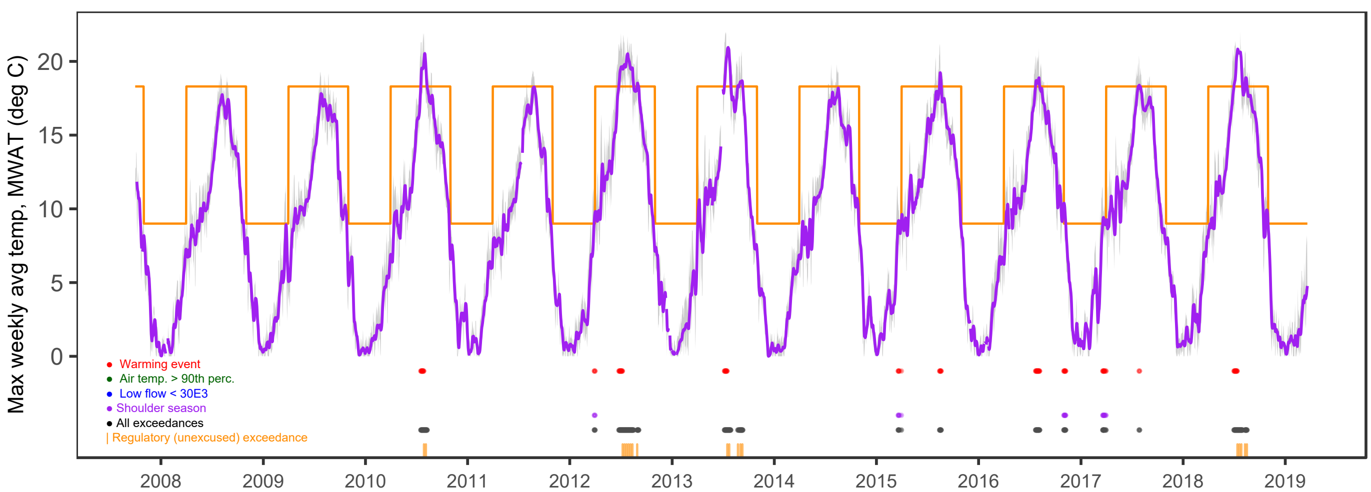
Temperature Summary: 09085150

COLORADO R ABV SOUTH CANYON CR NR GLENWOOD SPGS CO

Standards tier: CS2, Wild and Scenic study reach number: NA



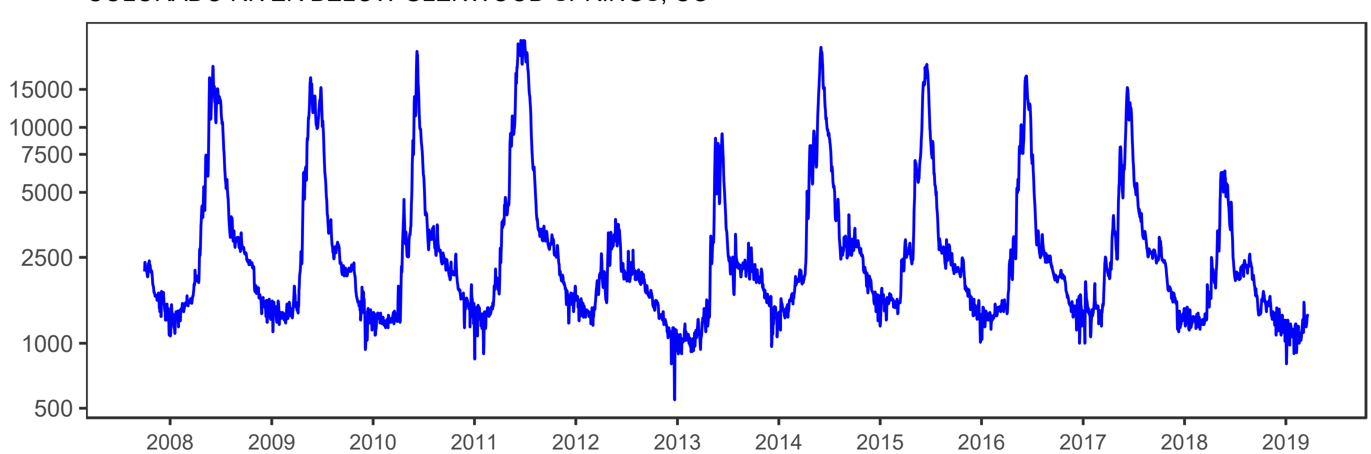
DM summary: Years in record: 13, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 13, total exceedances: 207, unexcused exceedances: 19

Discharge (cfs) at gauge 09085100

COLORADO RIVER BELOW GLENWOOD SPRINGS, CO



MWAT regulatory exceed summaries for 09085150
COLORADO R ABV SOUTH CANYON CR NR GLENWOOD SPGS CO

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	1	1	0	0	0	0	2
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	4	3	0	0	0	0	7
2013	0	0	0	0	0	0	2	1	2	0	0	0	5
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	3	2	0	0	0	0	5
2019	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which
are not excused by a warming event or other excursion type.

MWAT exceedance dates for 09085150
COLORADO R ABV SOUTH CANYON CR NR GLENWOOD SPGS CO

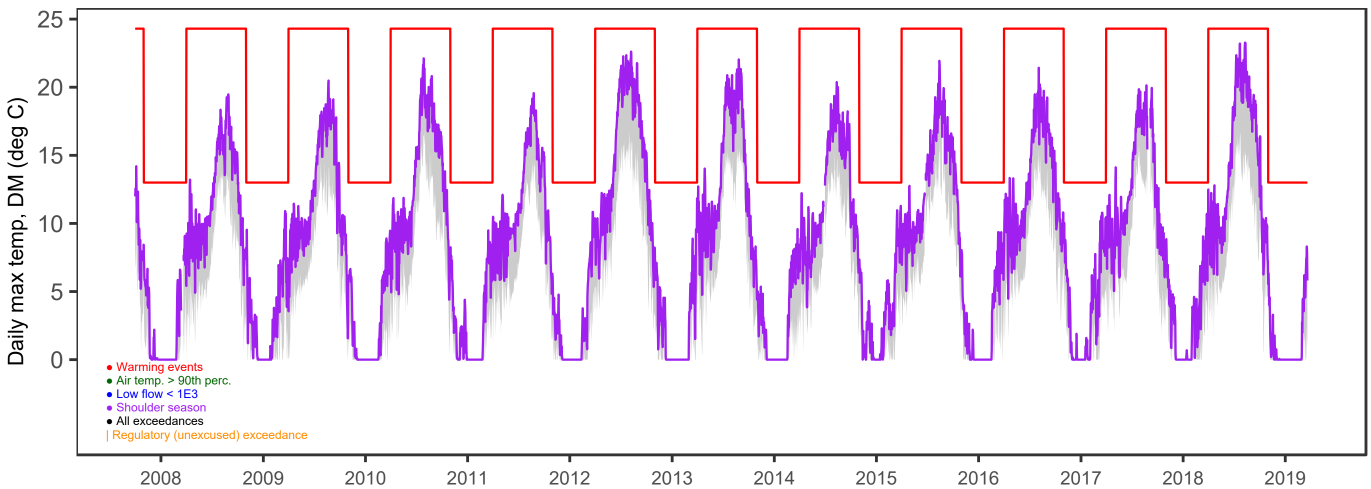
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2018-08-17	18.45	18.3	summer-2018	52.07	FALSE	FALSE	FALSE	FALSE	TRUE
2018-08-10	18.31	18.3	summer-2018	48.84	FALSE	FALSE	FALSE	FALSE	TRUE
2018-07-28	20.01	18.3	summer-2018	46.28	FALSE	FALSE	FALSE	FALSE	TRUE
2018-07-21	20.55	18.3	summer-2018	31.15	FALSE	FALSE	FALSE	FALSE	TRUE
2018-07-14	20.71	18.3	summer-2018	14.48	FALSE	FALSE	FALSE	FALSE	TRUE
2013-09-09	18.64	18.3	summer-2013	42.23	FALSE	FALSE	FALSE	FALSE	TRUE
2013-09-02	18.63	18.3	summer-2013	39.87	FALSE	FALSE	FALSE	FALSE	TRUE
2013-08-24	18.36	18.3	summer-2013	38.65	FALSE	FALSE	FALSE	FALSE	TRUE
2013-07-24	20.47	18.3	summer-2013	32.50	FALSE	FALSE	FALSE	FALSE	TRUE
2013-07-17	20.69	18.3	summer-2013	14.90	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-29	18.36	18.3	summer-2012	70.12	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-12	19.54	18.3	summer-2012	67.94	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-05	19.52	18.3	summer-2012	59.54	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-29	20.17	18.3	summer-2012	48.83	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-22	20.07	18.3	summer-2012	34.36	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-15	19.79	18.3	summer-2012	24.04	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-08	19.59	18.3	summer-2012	14.60	FALSE	FALSE	FALSE	FALSE	TRUE
2010-08-05	19.58	18.3	summer-2010	27.34	FALSE	FALSE	FALSE	FALSE	TRUE
2010-07-29	20.06	18.3	summer-2010	13.94	FALSE	FALSE	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

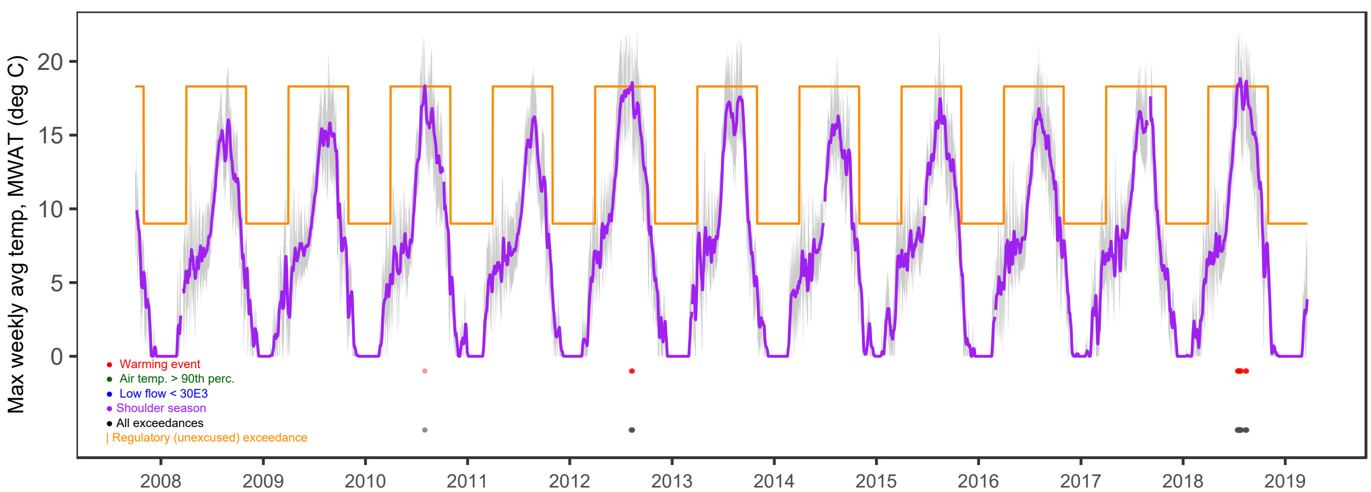
Regulatory status summary 09085150
COLORADO R ABV SOUTH CANYON CR NR GLENWOOD SPGS CO

Site	09085150
POR_yrs	13
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	207
WAT_unexcused_exceed_total	19
WAT_unexc_exceed_freq	0.31
WAT_unexc_exceed_recur_ratio	1 in 3.2
WAT_unexc_exceed_in_last_3_yrs	TRUE

Temperature Summary: 394220106431500
EAGLE RIVER BELOW MILK CREEK NEAR WOLCOTT, CO
Standards tier: CS2, Wild and Scenic study reach number: NA

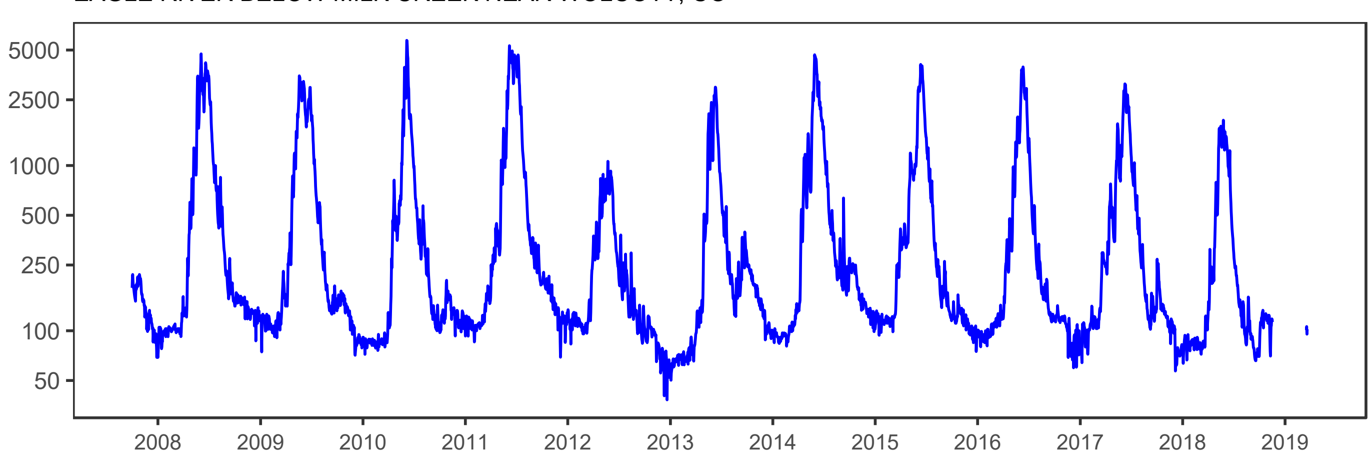


DM summary: Years in record: 13, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 13, total exceedances: 25, unexcused exceedances: 0

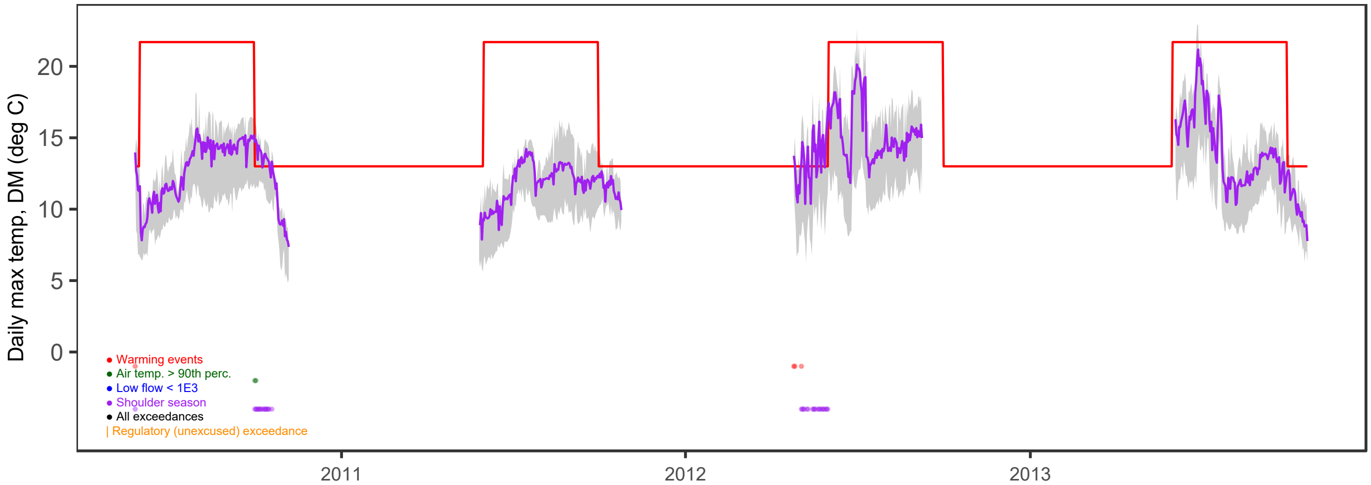
Discharge (cfs) at gauge 394220106431500
EAGLE RIVER BELOW MILK CREEK NEAR WOLCOTT, CO



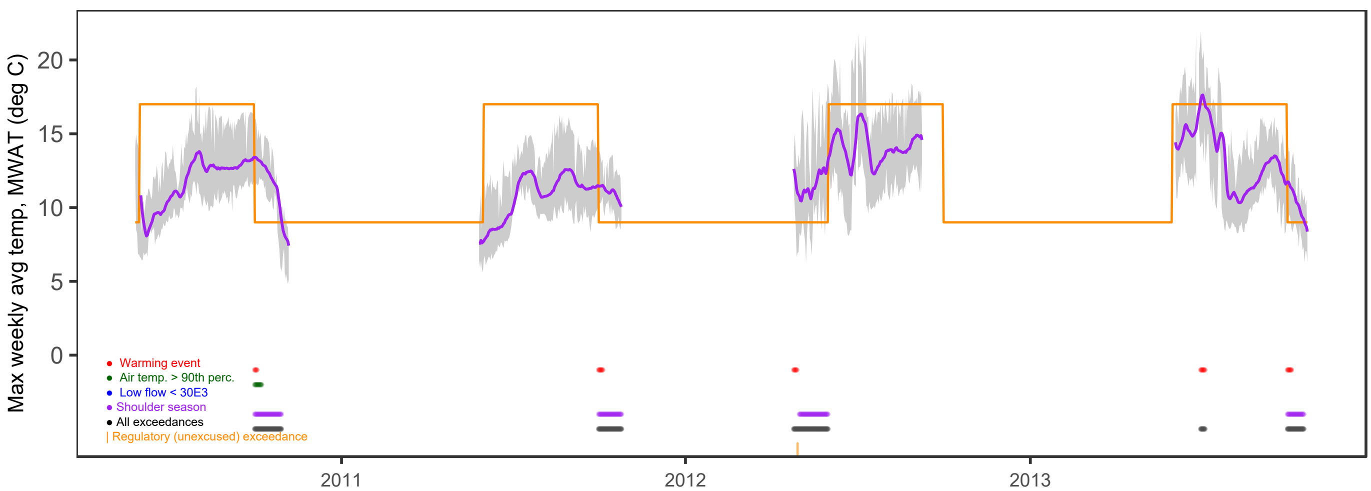
Regulatory status summary 394220106431500
EAGLE RIVER BELOW MILK CREEK NEAR WOLCOTT, CO

Site	394220106431500
POR_yrs	13
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	25
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: BL-Yust
Blue River at Yust Ranch 100 feet downstream of Trough Road Bridge
Standards tier: CS1, Wild and Scenic study reach number: NA

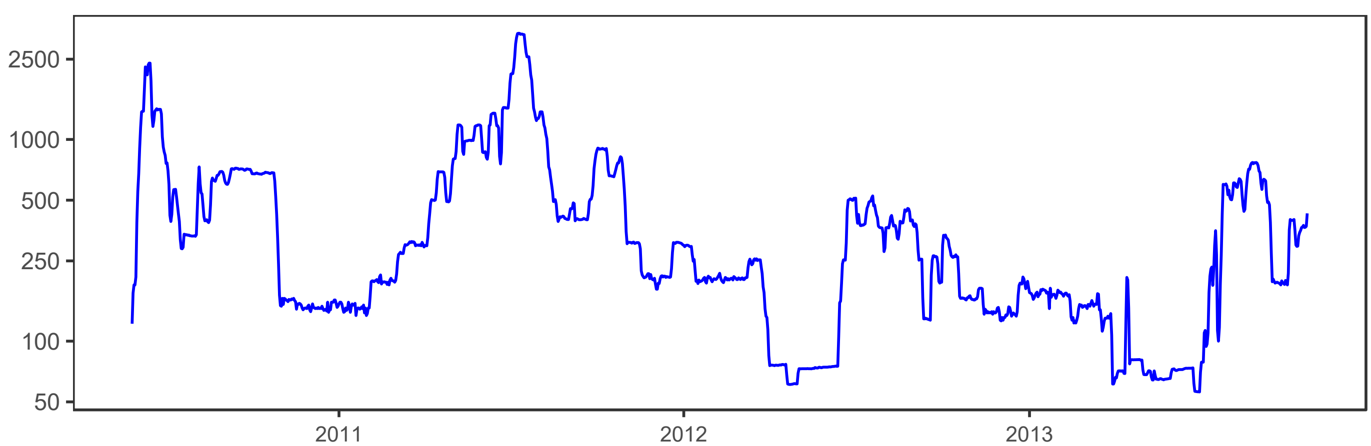


DM summary: Years in record: 4, total exceedances: 38, unexcused exceedances: 0



WAT summary: Years in record: 4, total exceedances: 114, unexcused exceedances: 1

Discharge (cfs) at gauge 09057500
BLUE RIVER BELOW GREEN MOUNTAIN RESERVOIR, CO.



MWAT regulatory exceed summaries for BL-Yust
Blue River at Yust Ranch 100 feet downstream of Trough Road Bridge

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	1	0	0	0	0	0	0	0	0	1
2013	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for BL-Yust
Blue River at Yust Ranch 100 feet downstream of Trough Road Bridge

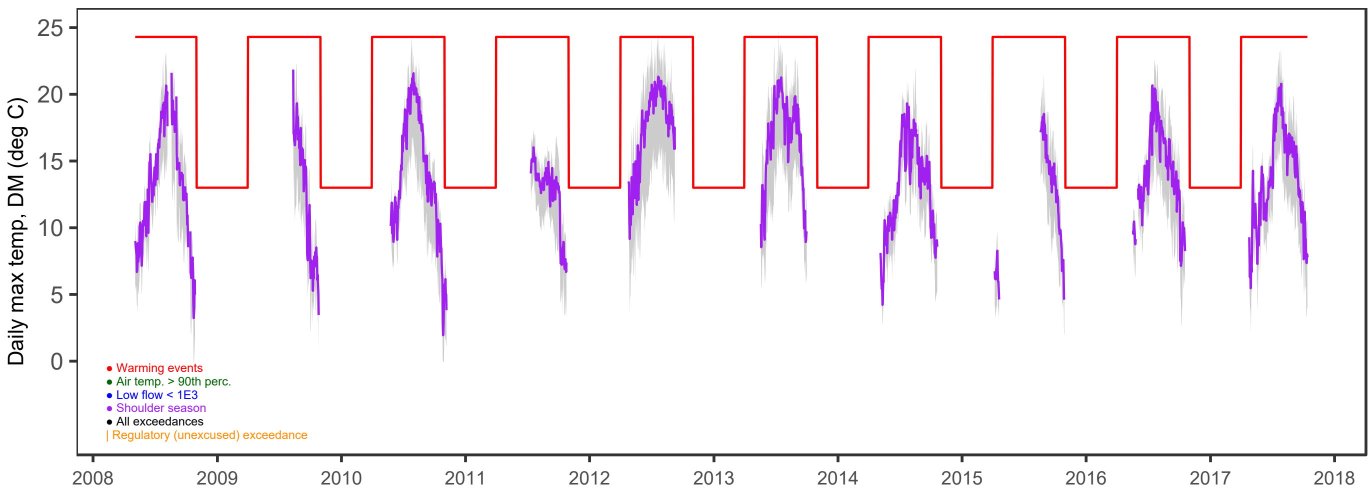
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2012-04-29	10.97	9	winter-2012	13.95	FALSE	FALSE	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

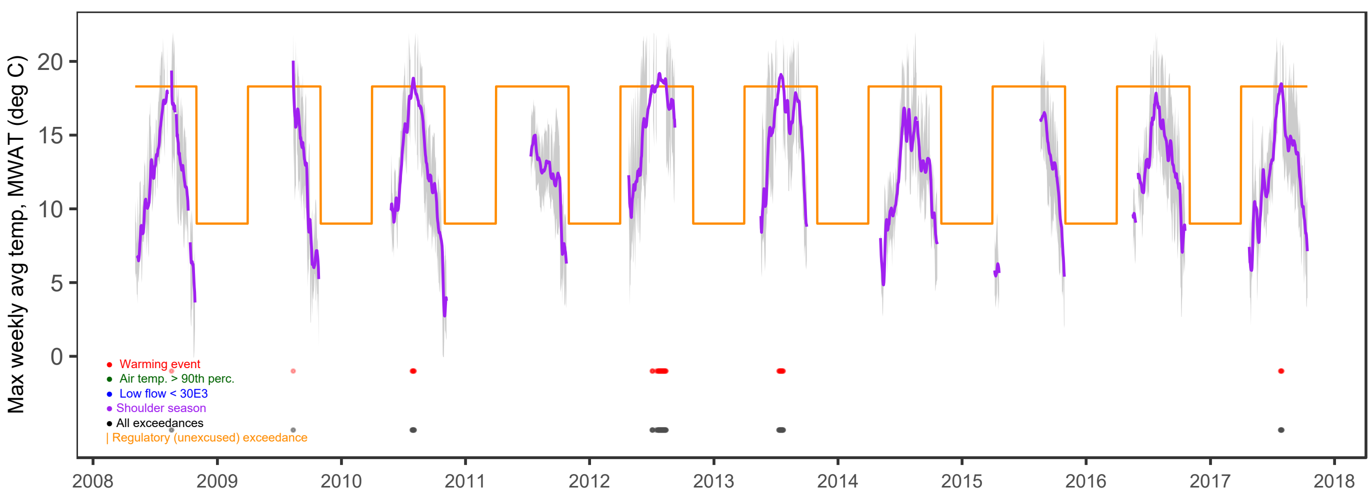
Regulatory status summary BL-Yust
Blue River at Yust Ranch 100 feet downstream of Trough Road Bridge

Site	BL-Yust
POR_yrs	4
DM_exceed_total	38
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	114
WAT_unexcused_exceed_total	1
WAT_unexc_exceed_freq	0.25
WAT_unexc_exceed_recur_ratio	1 in 4
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-abvHSR
Colorado River upstream of Hot Sulphur Springs Resort
Standards tier: CS2, Wild and Scenic study reach number: NA



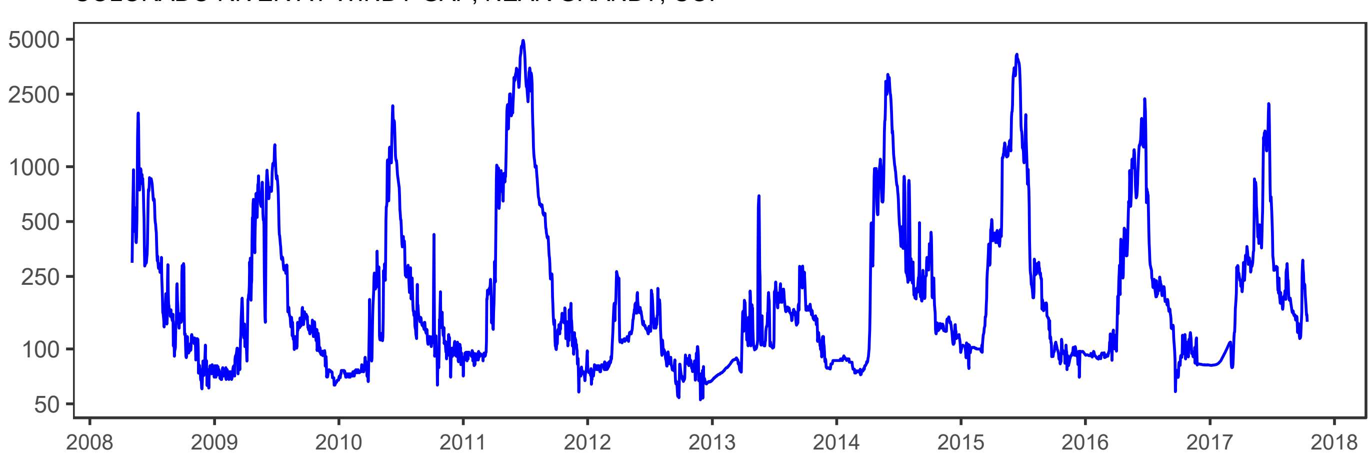
DM summary: Years in record: 10, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 10, total exceedances: 58, unexcused exceedances: 0

Discharge (cfs) at gauge 09034250

COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



Regulatory status summary COR-abvHSR

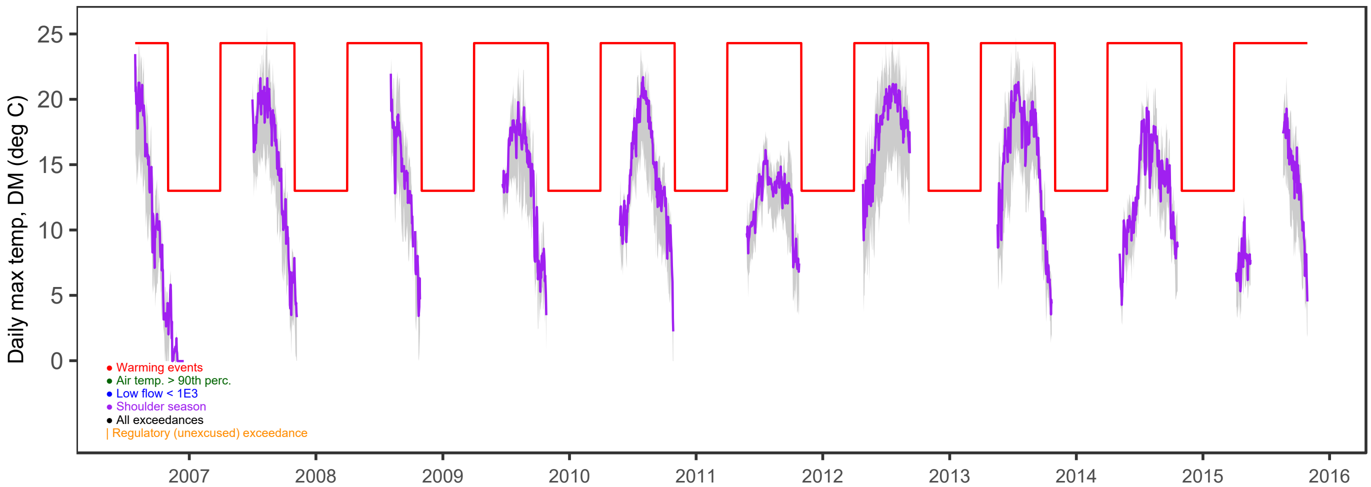
Colorado River upstream of Hot Sulphur Springs Resort

Site	COR-abvHSR
POR_yrs	10
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	58
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

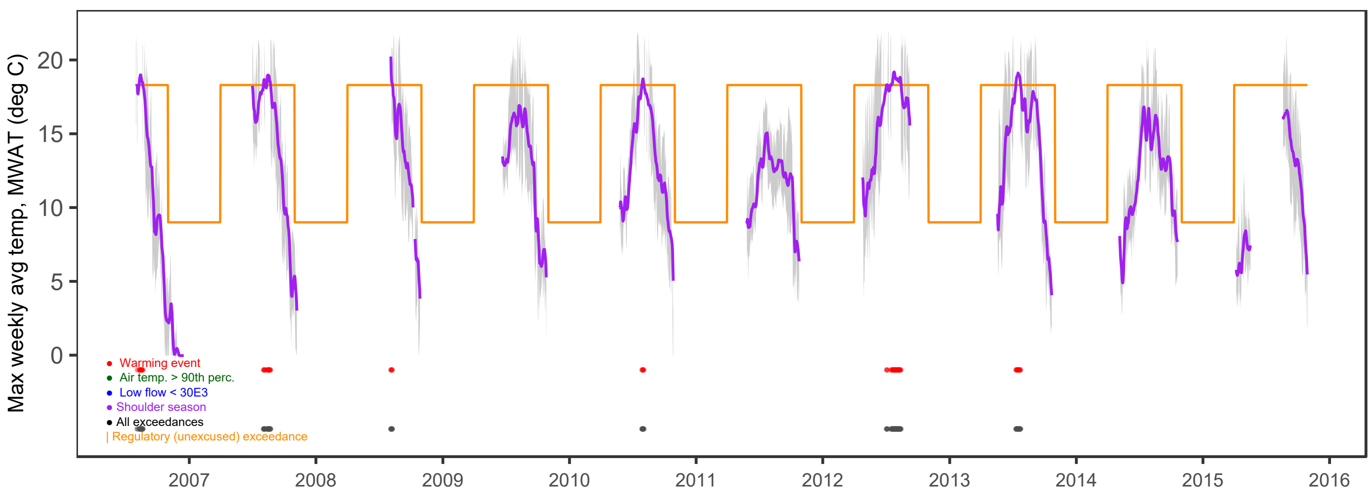
Temperature Summary: COR-abvHSS

Colorado River upstream of Hot Sulphur Springs Water Treatment Plant

Standards tier: CS2, Wild and Scenic study reach number: NA



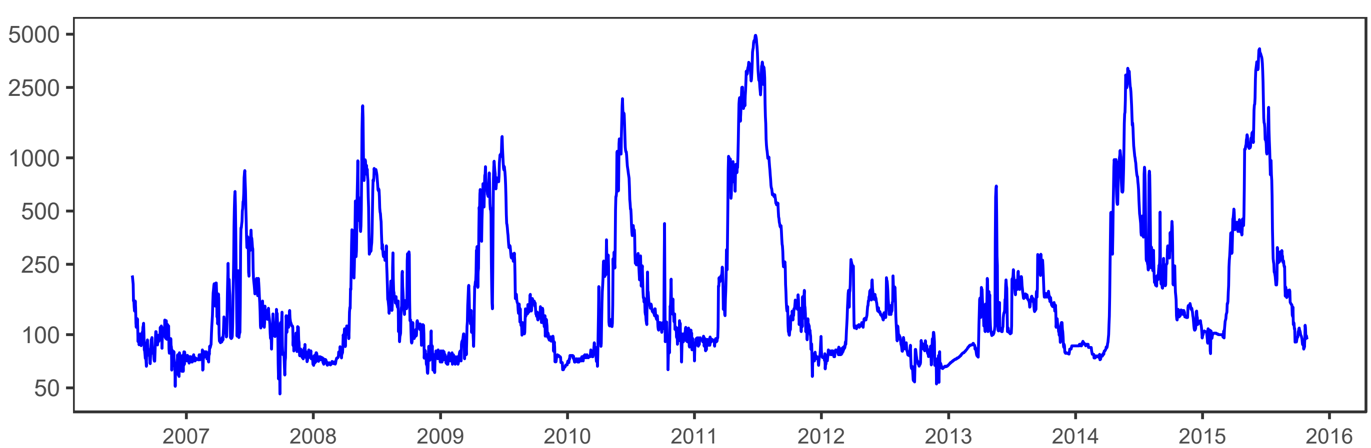
DM summary: Years in record: 10, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 10, total exceedances: 84, unexcused exceedances: 0

Discharge (cfs) at gauge 09034250

COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



Regulatory status summary COR-abvHSS

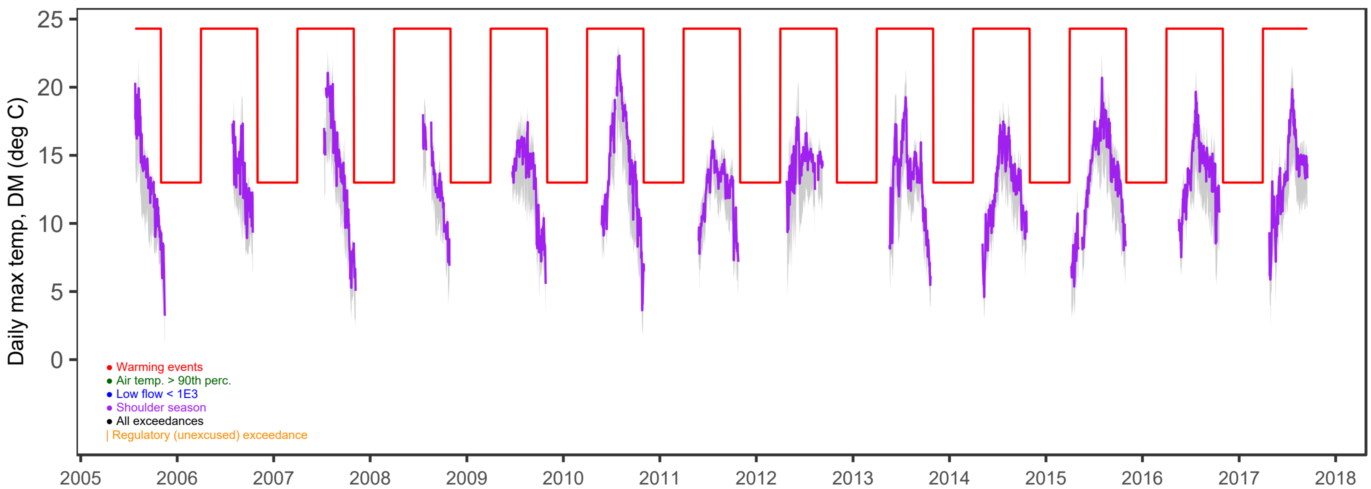
Colorado River upstream of Hot Sulphur Springs Water Treatment Plant

Site	COR-abvHSS
POR_yrs	10
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	84
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

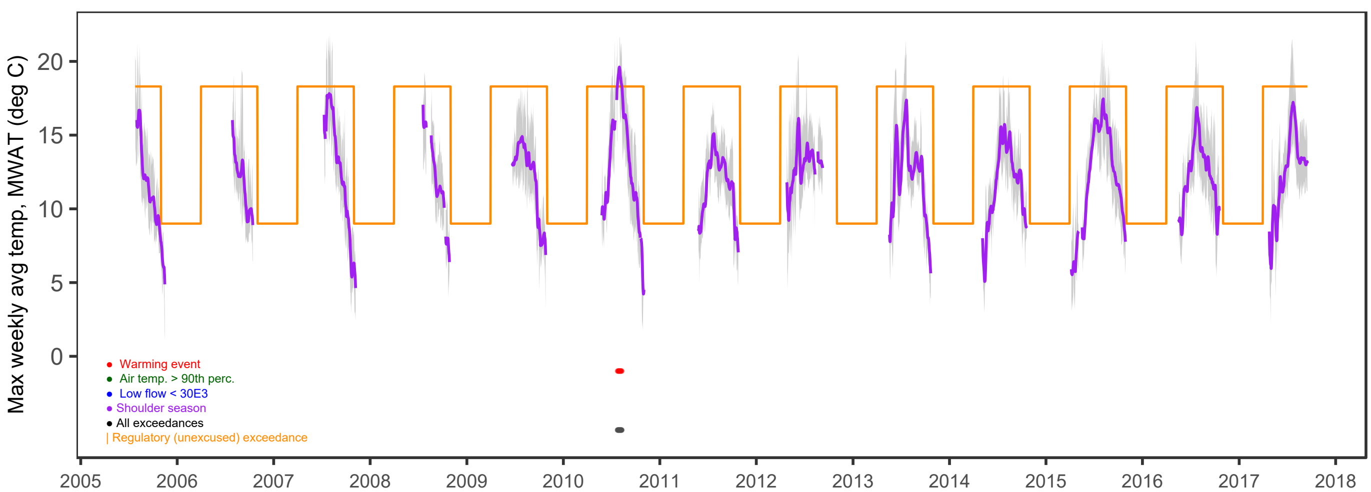
Temperature Summary: COR-abvKidPond

Colorado River upstream of Kids Fishing Pond downstream of Parshall CO

Standards tier: CS2, Wild and Scenic study reach number: NA



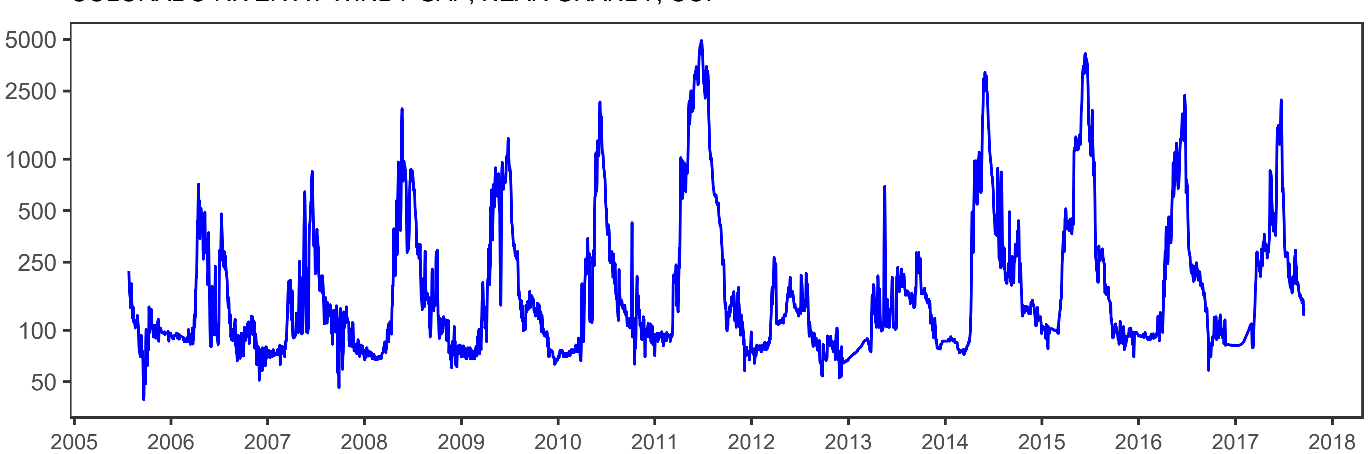
DM summary: Years in record: 13, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 13, total exceedances: 17, unexcused exceedances: 0

Discharge (cfs) at gauge 09034250

COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.

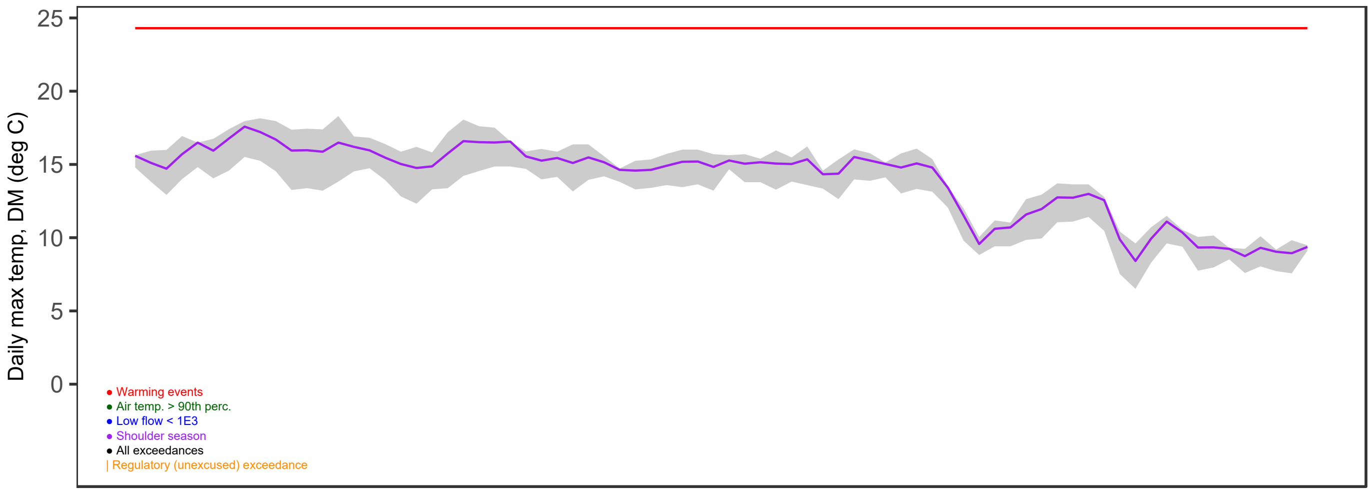


Regulatory status summary COR-abvKidPond

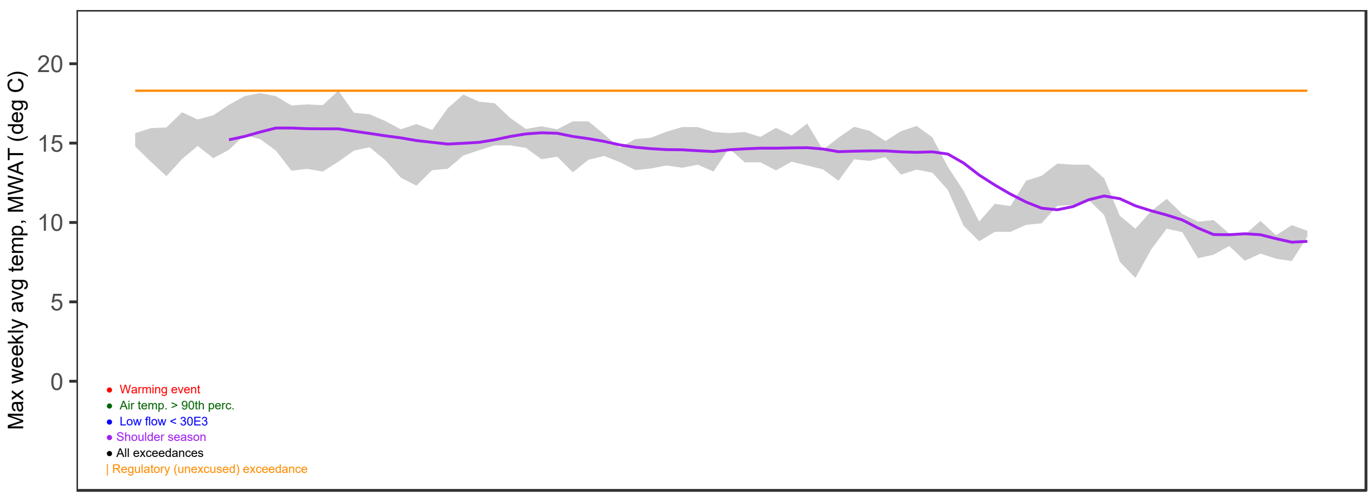
Colorado River upstream of Kids Fishing Pond downstream of Parshall CO

Site	COR-abvKidPond
POR_yrs	13
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	17
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-abvStateBridge
Colorado River upstream of State Bridge
Standards tier: CS2, Wild and Scenic study reach number: 5

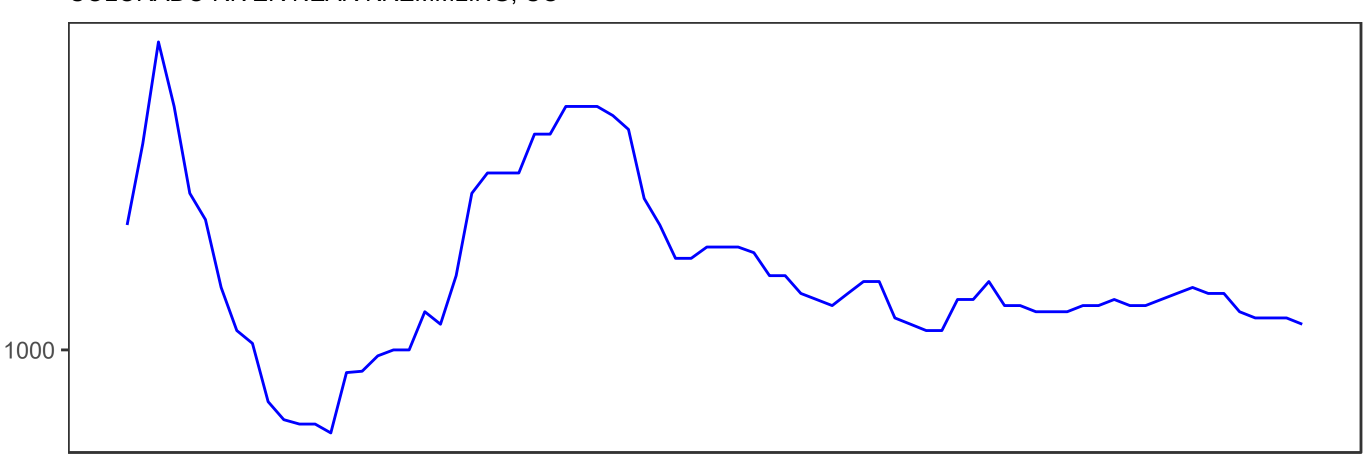


DM summary: Years in record: 1, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 1, total exceedances: 0, unexcused exceedances: 0

Discharge (cfs) at gauge 09058000
COLORADO RIVER NEAR KREMMLING, CO



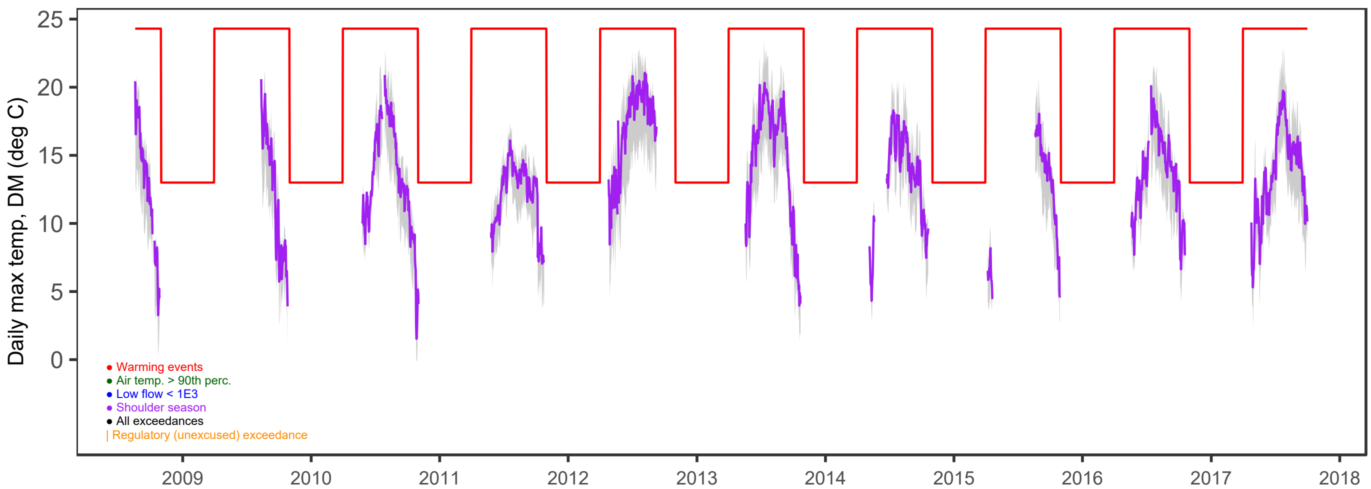
Regulatory status summary COR-abvStateBridge
Colorado River upstream of State Bridge

Site	COR-abvStateBridge
POR_yrs	1
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	0
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

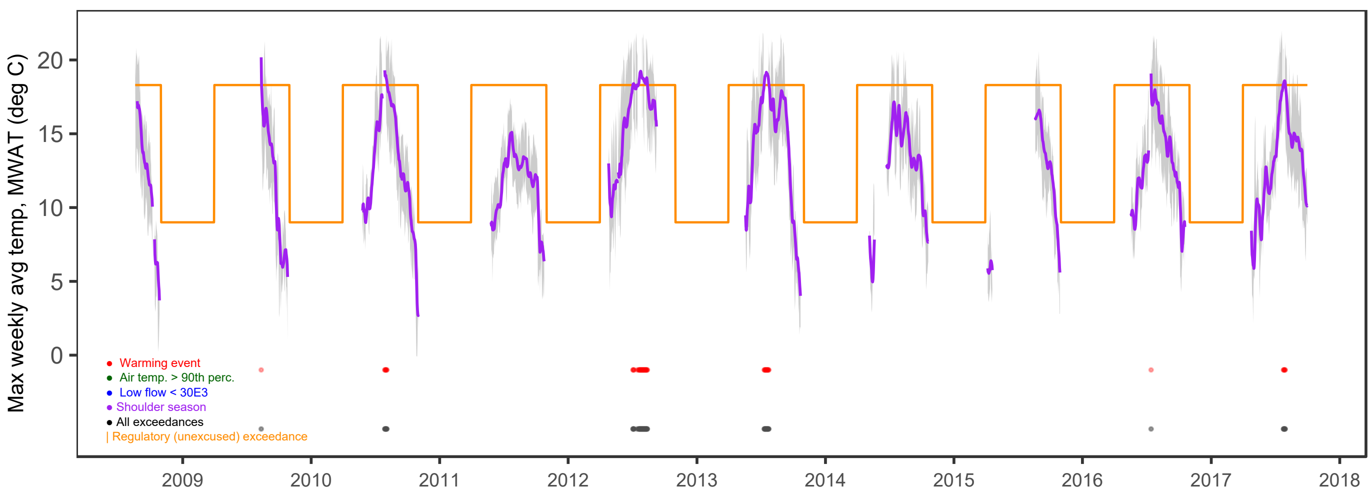
Temperature Summary: COR-blwByers

Colorado River downstream of Byers Canyon

Standards tier: CS2, Wild and Scenic study reach number: NA



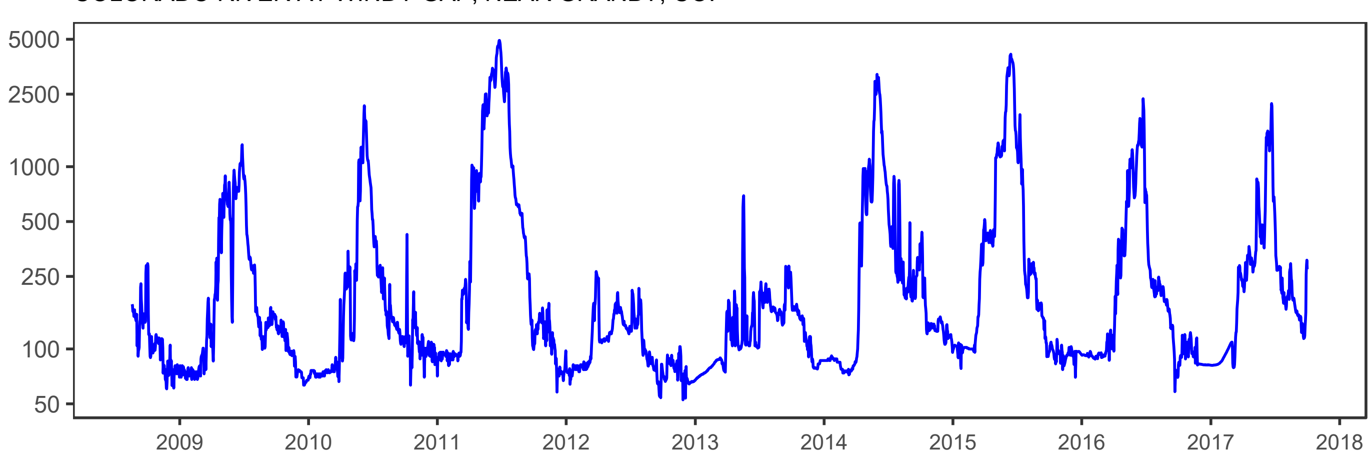
DM summary: Years in record: 10, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 10, total exceedances: 60, unexcused exceedances: 0

Discharge (cfs) at gauge 09034250

COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.

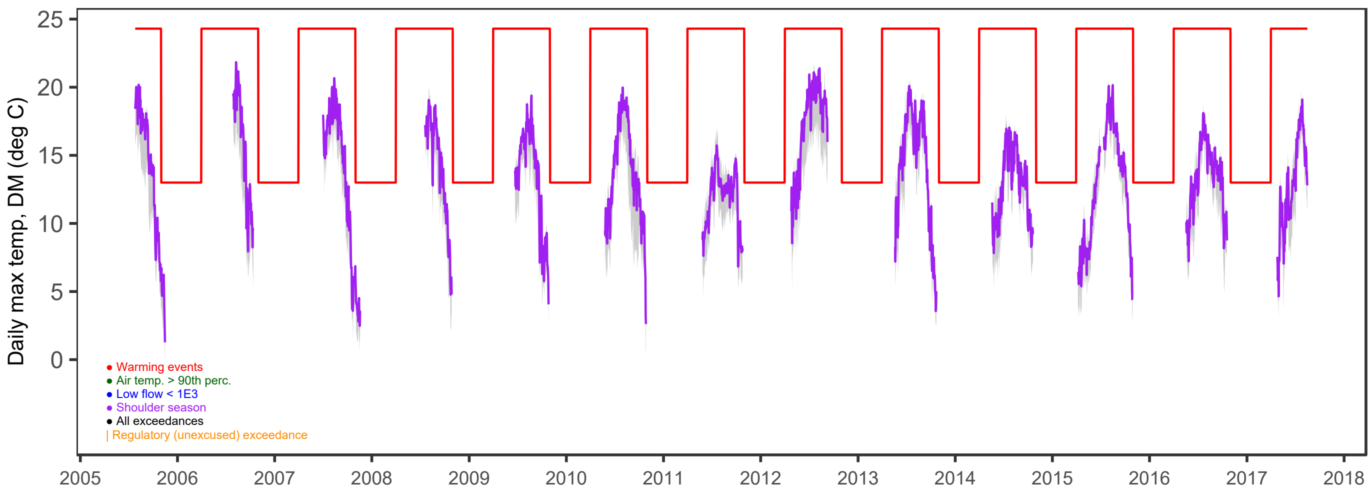


Regulatory status summary COR-blwByers

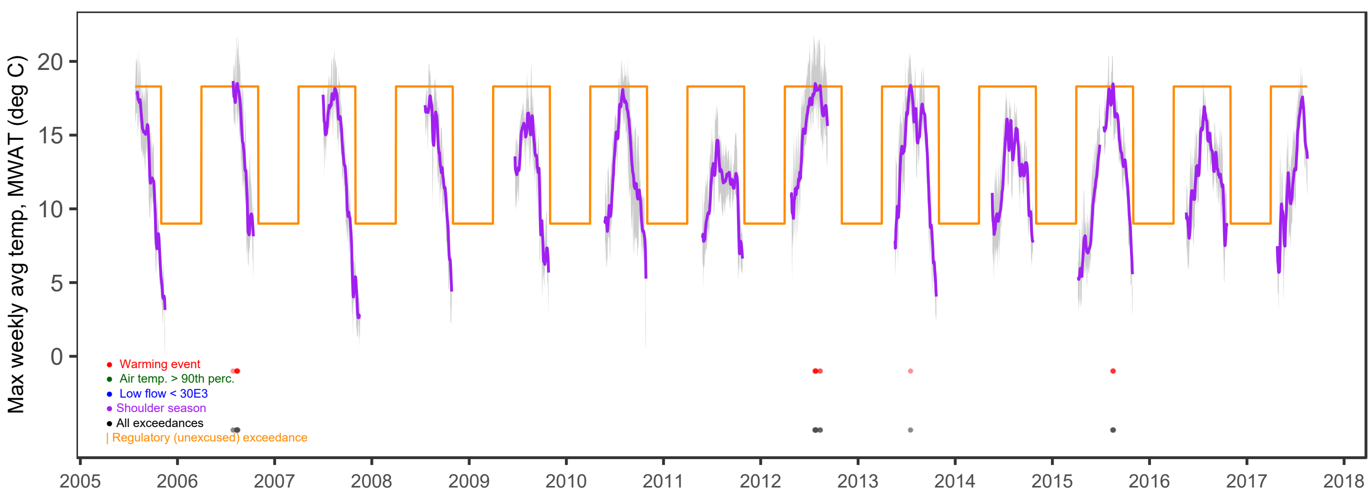
Colorado River downstream of Byers Canyon

Site	COR-blwByers
POR_yrs	10
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	60
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-blwWG
Colorado River downstream of Windy Gap at Hitching Post
Standards tier: CS2, Wild and Scenic study reach number: NA

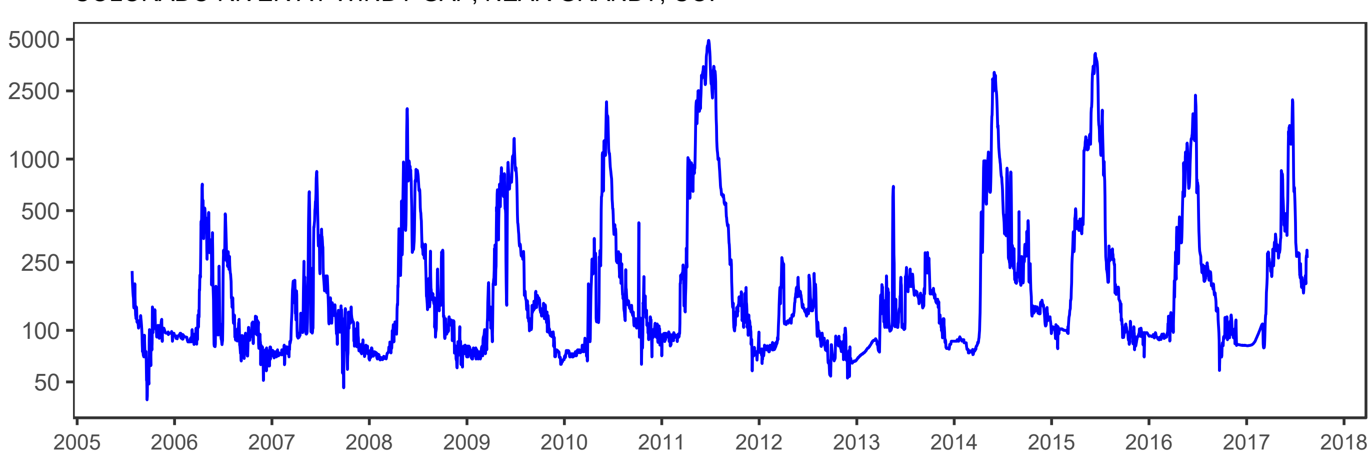


DM summary: Years in record: 13, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 13, total exceedances: 17, unexcused exceedances: 0

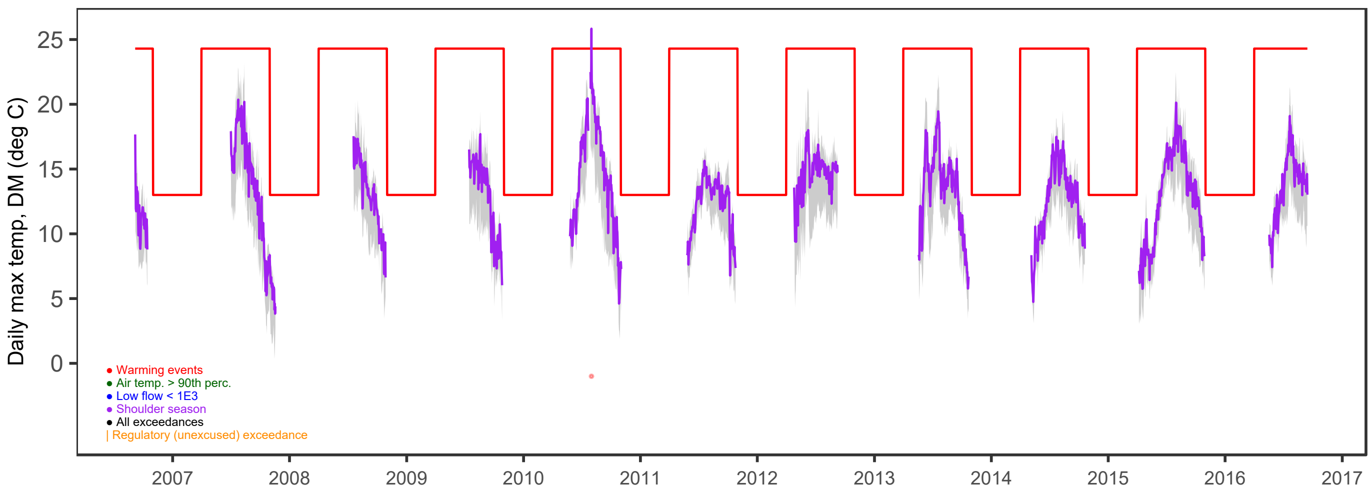
Discharge (cfs) at gauge 09034250
COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



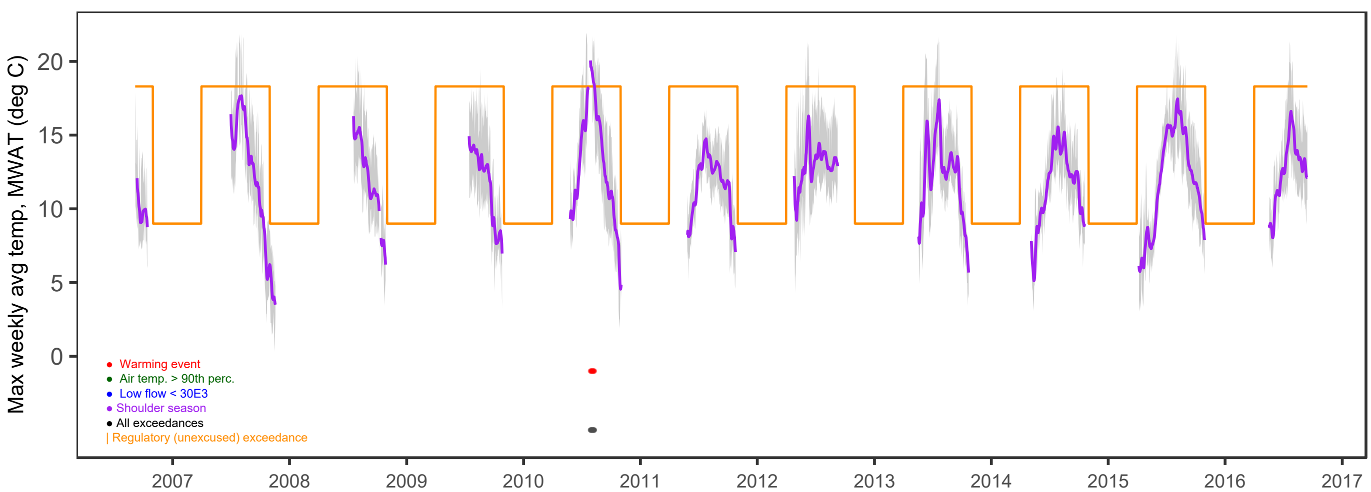
Regulatory status summary COR-blwWG
Colorado River downstream of Windy Gap at Hitching Post

Site	COR-blwWG
POR_yrs	13
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	17
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-ConRitschard
Colorado River at public fishing access east of Con Ritschard Ranch
Standards tier: CS2, Wild and Scenic study reach number: NA

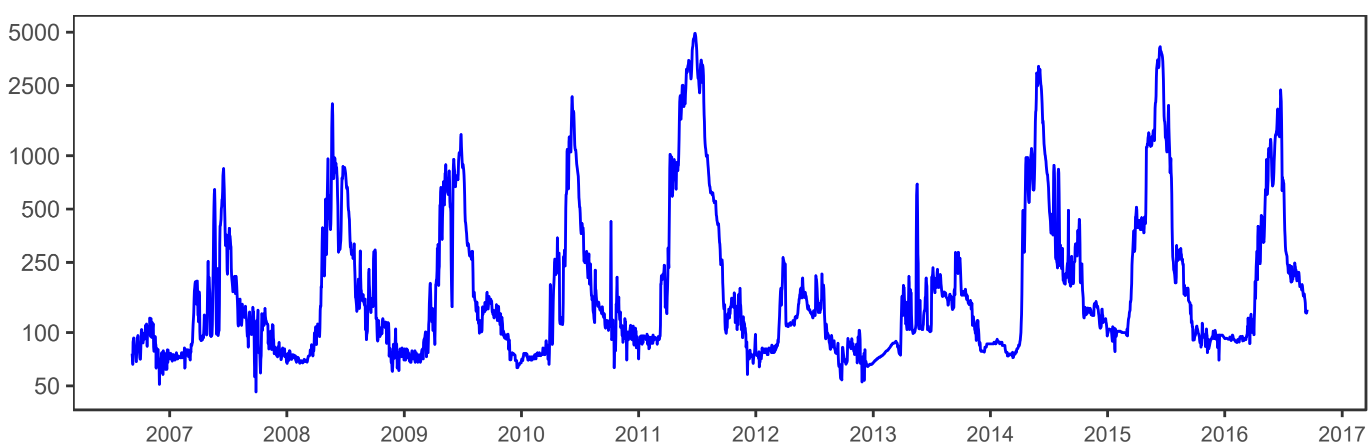


DM summary: Years in record: 11, total exceedances: 1, unexcused exceedances: 0



WAT summary: Years in record: 11, total exceedances: 13, unexcused exceedances: 0

Discharge (cfs) at gauge 09034250
COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



Regulatory status summary COR-ConRitschard

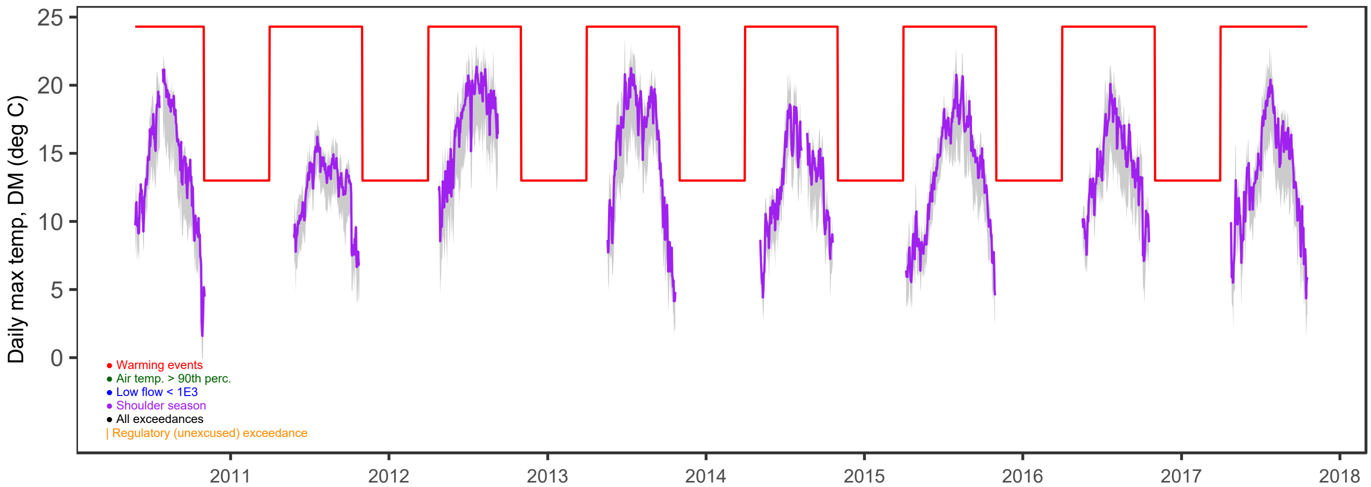
Colorado River at public fishing access east of Con Ritschard Ranch

Site	COR-ConRitschard
POR_yrs	11
DM_exceed_total	1
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	13
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

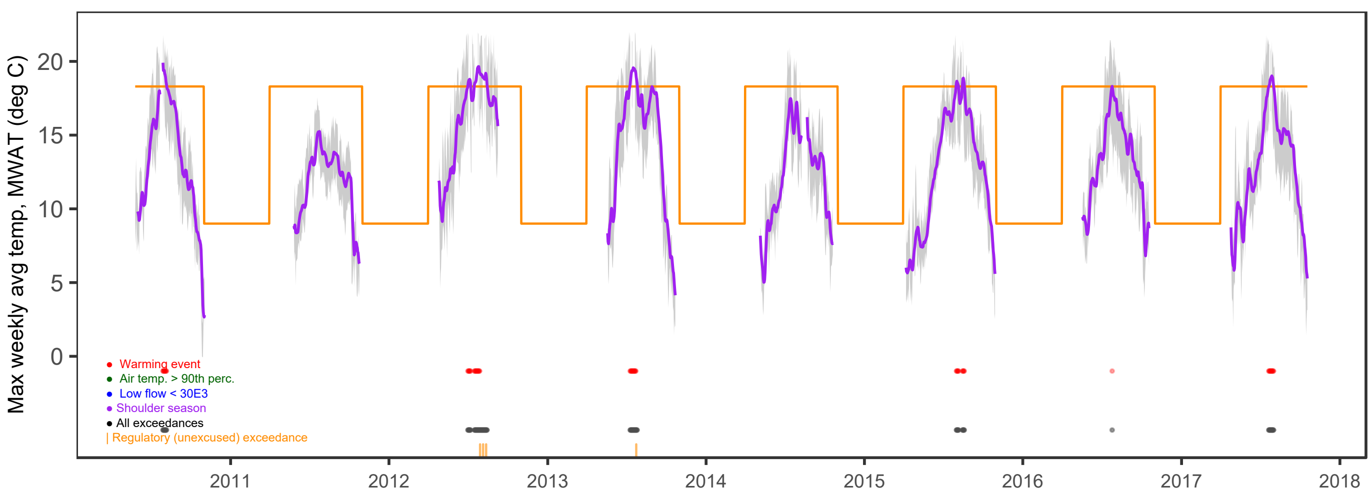
Temperature Summary: COR-CR3

Colorado River at CR3 bridge at Bar Lazy J Ranch

Standards tier: CS2, Wild and Scenic study reach number: NA



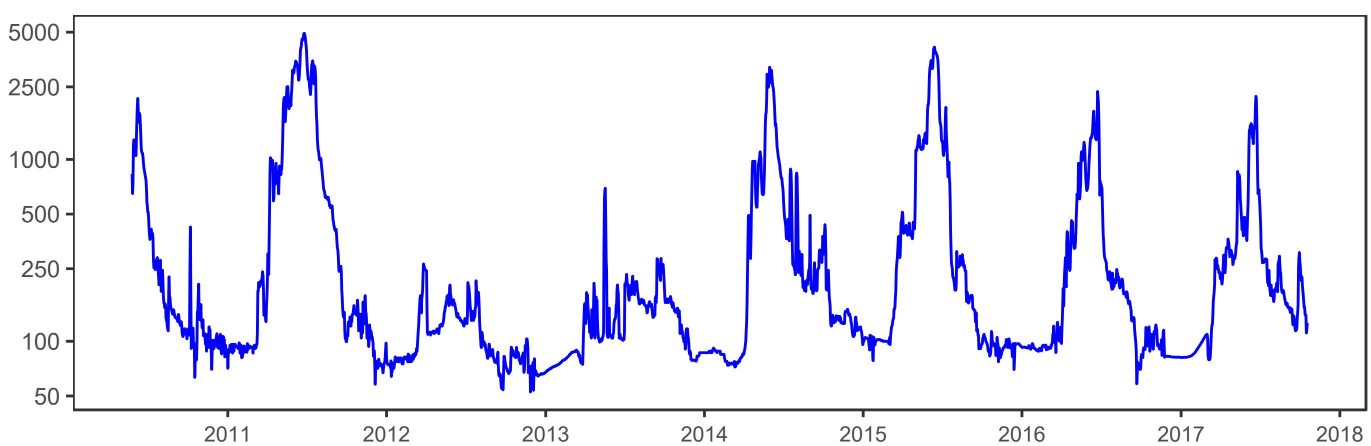
DM summary: Years in record: 8, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 8, total exceedances: 87, unexcused exceedances: 4

Discharge (cfs) at gauge 09034250

COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



MWAT regulatory exceed summaries for COR-CR3
Colorado River at CR3 bridge at Bar Lazy J Ranch

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	1	2	0	0	0	0	3
2013	0	0	0	0	0	0	1	0	0	0	0	0	1
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for COR-CR3
Colorado River at CR3 bridge at Bar Lazy J Ranch

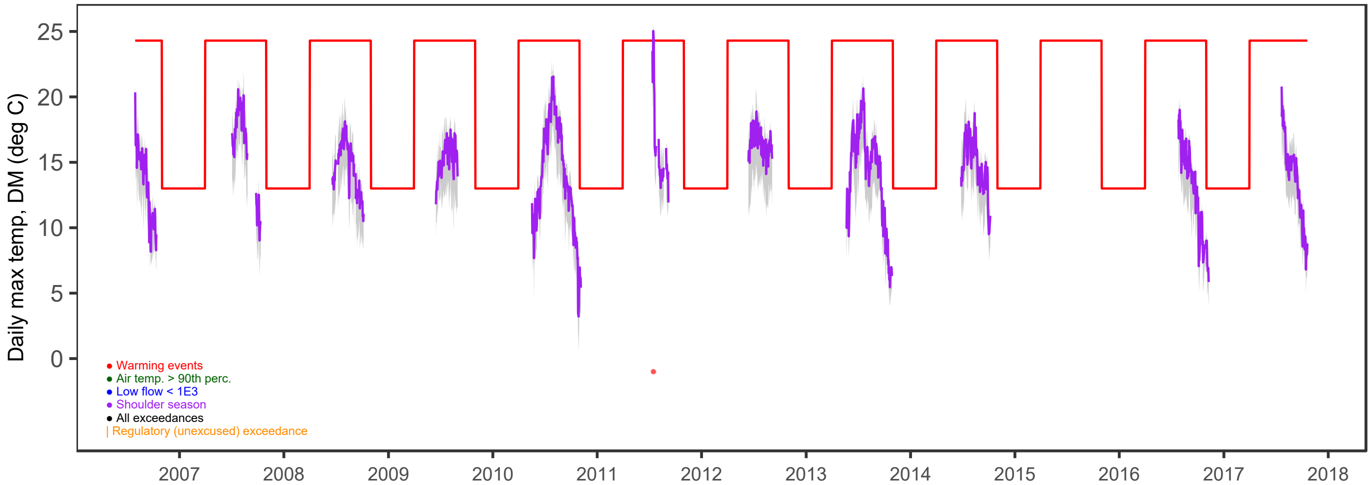
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2013-07-24	18.92	18.3	summer-2013	14.10	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-12	19.09	18.3	summer-2012	23.53	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-05	18.92	18.3	summer-2012	18.94	FALSE	FALSE	FALSE	FALSE	TRUE
2012-07-29	19.21	18.3	summer-2012	13.77	FALSE	FALSE	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

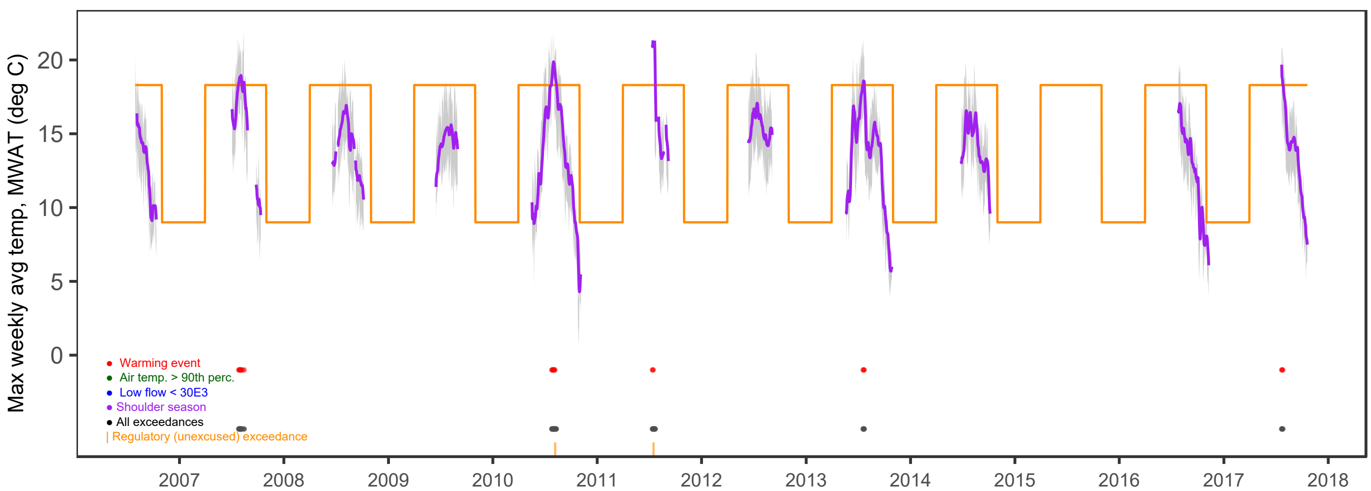
Regulatory status summary COR-CR3
Colorado River at CR3 bridge at Bar Lazy J Ranch

Site	COR-CR3
POR_yrs	8
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	87
WAT_unexcused_exceed_total	4
WAT_unexc_exceed_freq	0.25
WAT_unexc_exceed_recur_ratio	1 in 4
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-Hwy9
Colorado River upstream of Hwy 9 bridge in Kremmling CO
Standards tier: CS2, Wild and Scenic study reach number: NA

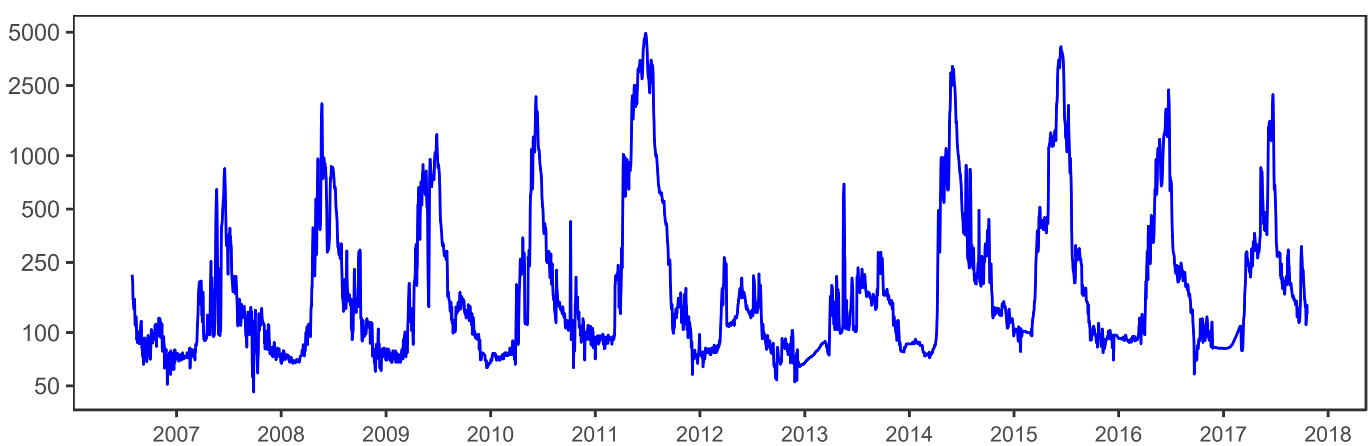


DM summary: Years in record: 12, total exceedances: 2, unexcused exceedances: 0



WAT summary: Years in record: 12, total exceedances: 52, unexcused exceedances: 2

Discharge (cfs) at gauge 09034250
COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



MWAT regulatory exceed summaries for COR-Hwy9
Colorado River upstream of Hwy 9 bridge in Kremmling CO

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2006	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	1	0	0	0	0	1
2011	0	0	0	0	0	0	1	0	0	0	0	0	1
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for COR-Hwy9
Colorado River upstream of Hwy 9 bridge in Kremmling CO

Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2011-07-17	22.54	18.3	summer-2011	16.33	FALSE	NA	FALSE	FALSE	TRUE
2010-08-07	18.99	18.3	summer-2010	13.70	FALSE	FALSE	FALSE	FALSE	TRUE

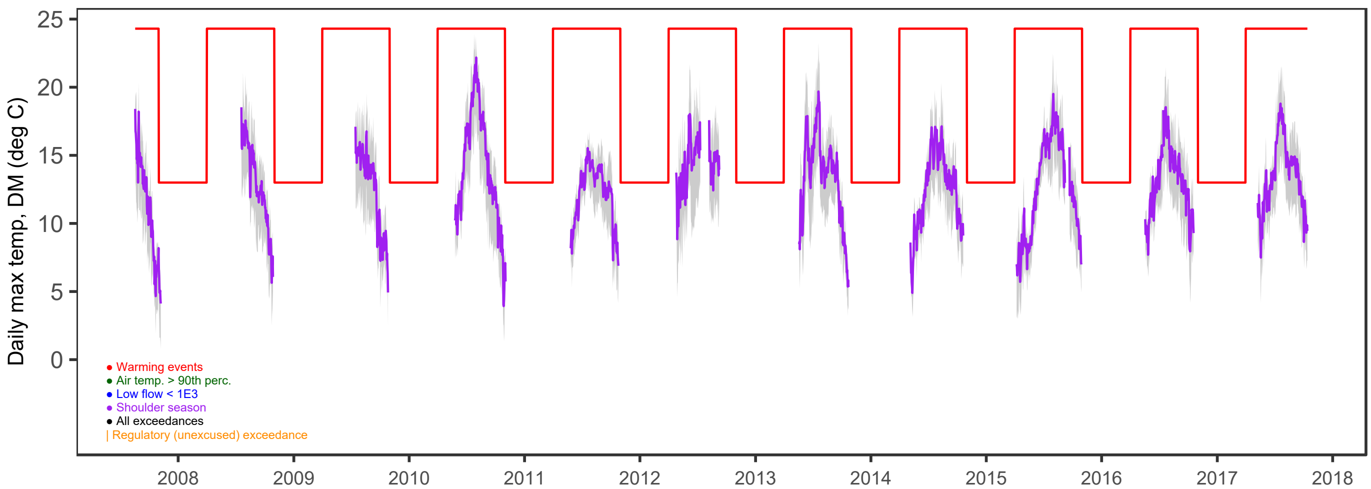
Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

Regulatory status summary COR-Hwy9

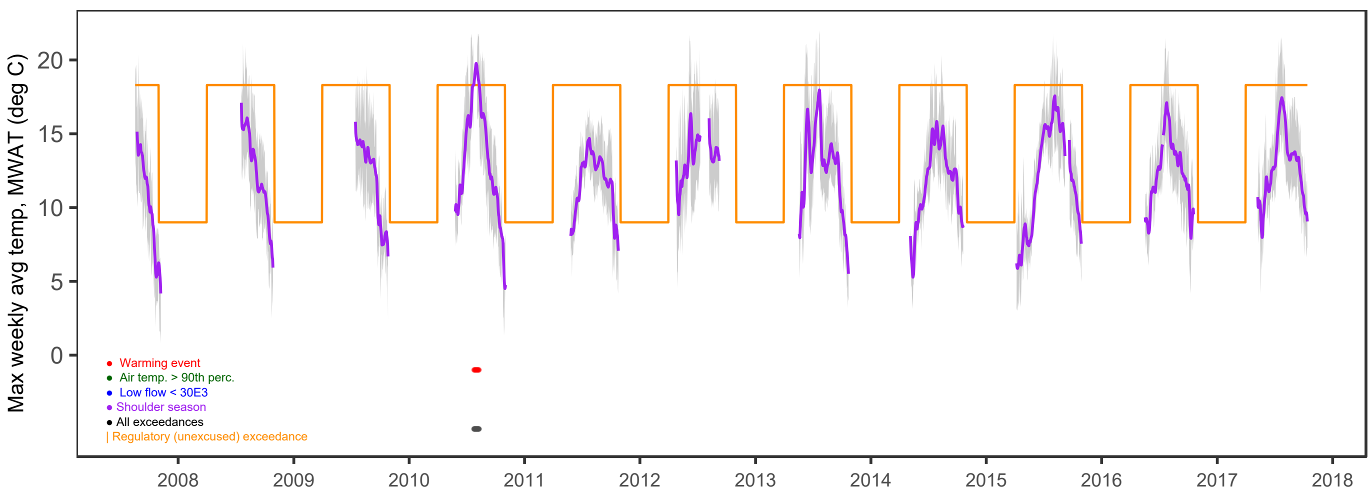
Colorado River upstream of Hwy 9 bridge in Kremmling CO

Site	COR-Hwy9
POR_yrs	12
DM_exceed_total	2
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	52
WAT_unexcused_exceed_total	2
WAT_unexc_exceed_freq	0.17
WAT_unexc_exceed_recur_ratio	1 in 6
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-KBDitch
Colorado River at CR39 bridge upstream of KB Ditch
Standards tier: CS2, Wild and Scenic study reach number: NA

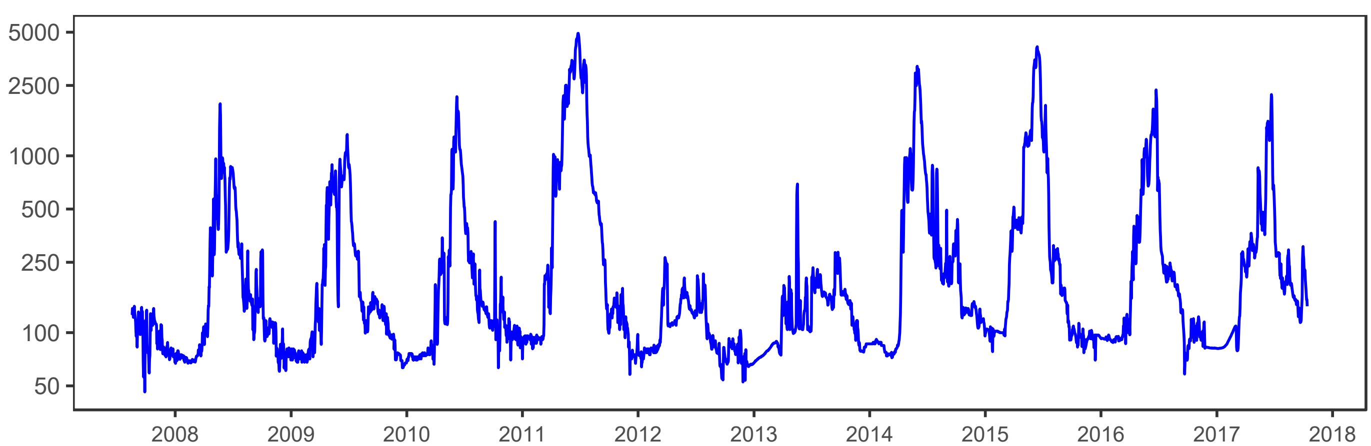


DM summary: Years in record: 11, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 11, total exceedances: 17, unexcused exceedances: 0

Discharge (cfs) at gauge 09034250
COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



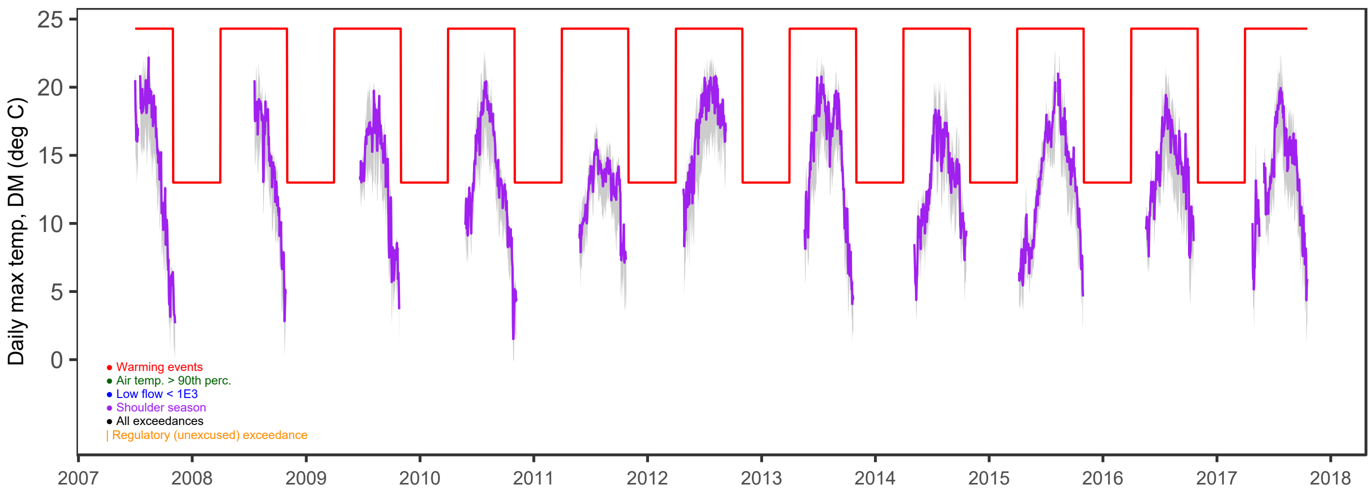
Regulatory status summary COR-KBDitch
Colorado River at CR39 bridge upstream of KB Ditch

Site	COR-KBDitch
POR_yrs	11
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	17
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

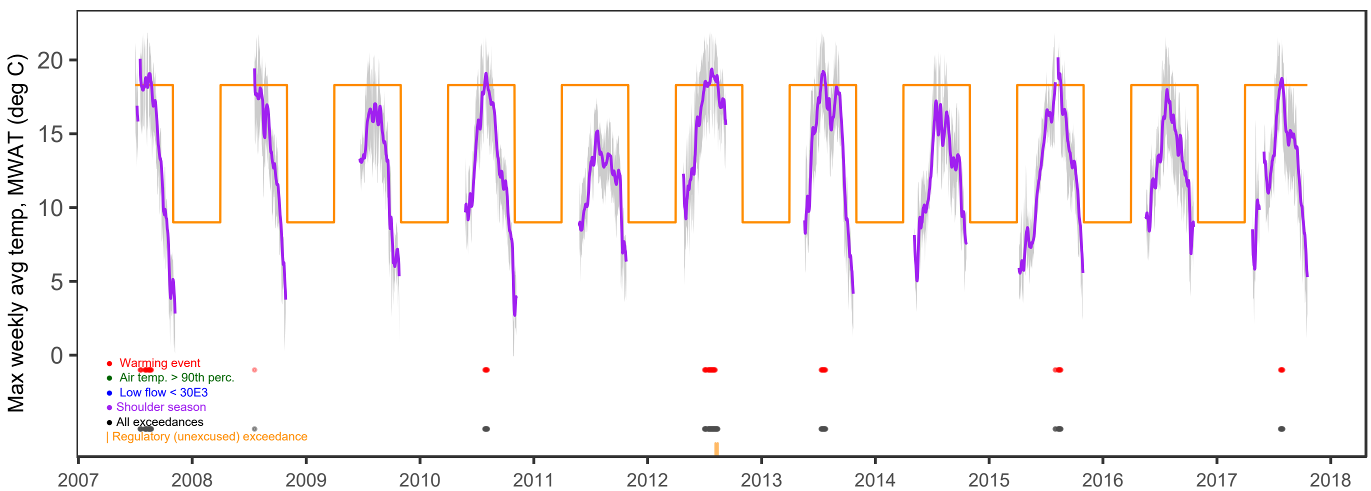
Temperature Summary: COR-LoneBuck

Colorado River at Lone Buck downstream of CPW Office

Standards tier: CS2, Wild and Scenic study reach number: NA



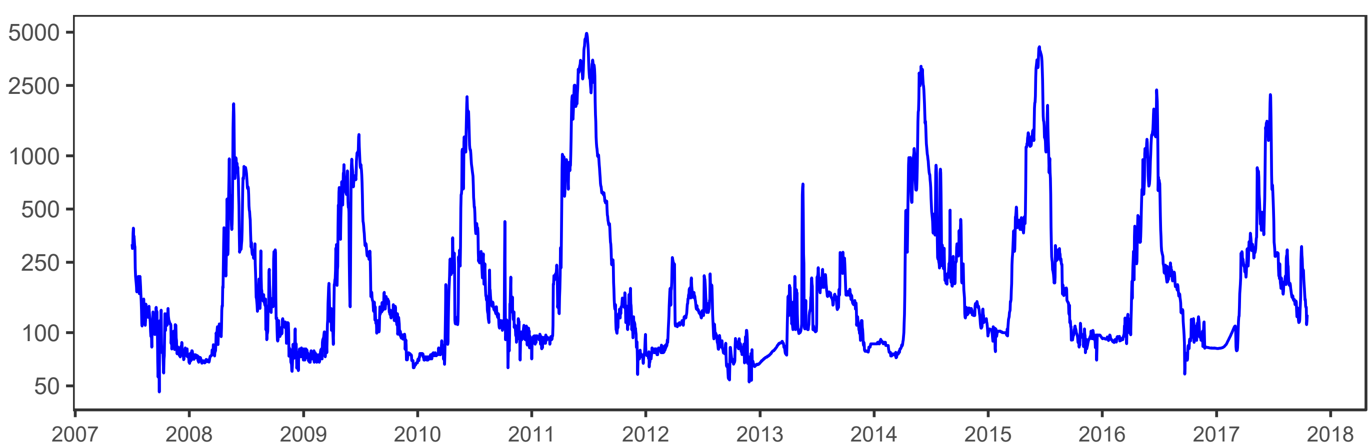
DM summary: Years in record: 11, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 11, total exceedances: 106, unexcused exceedances: 2

Discharge (cfs) at gauge 09034250

COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



MWAT regulatory exceed summaries for COR-LoneBuck
Colorado River at Lone Buck downstream of CPW Office

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	2	0	0	0	0	2
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for COR-LoneBuck
Colorado River at Lone Buck downstream of CPW Office

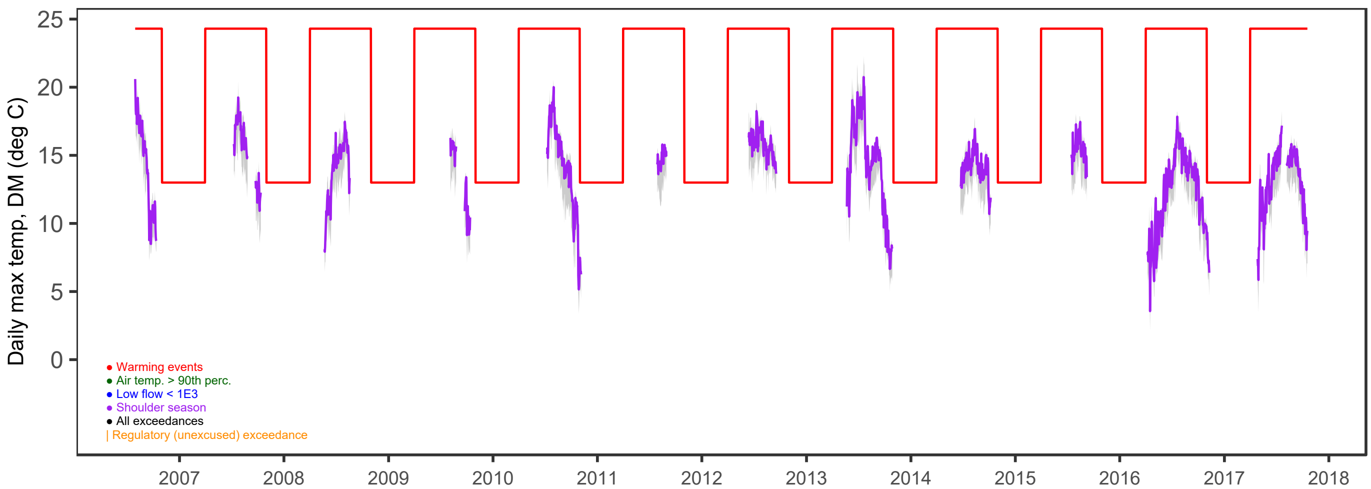
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2012-08-13	18.61	18.3	summer-2012	16.34	FALSE	FALSE	FALSE	FALSE	TRUE
2012-08-06	18.61	18.3	summer-2012	13.55	FALSE	FALSE	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

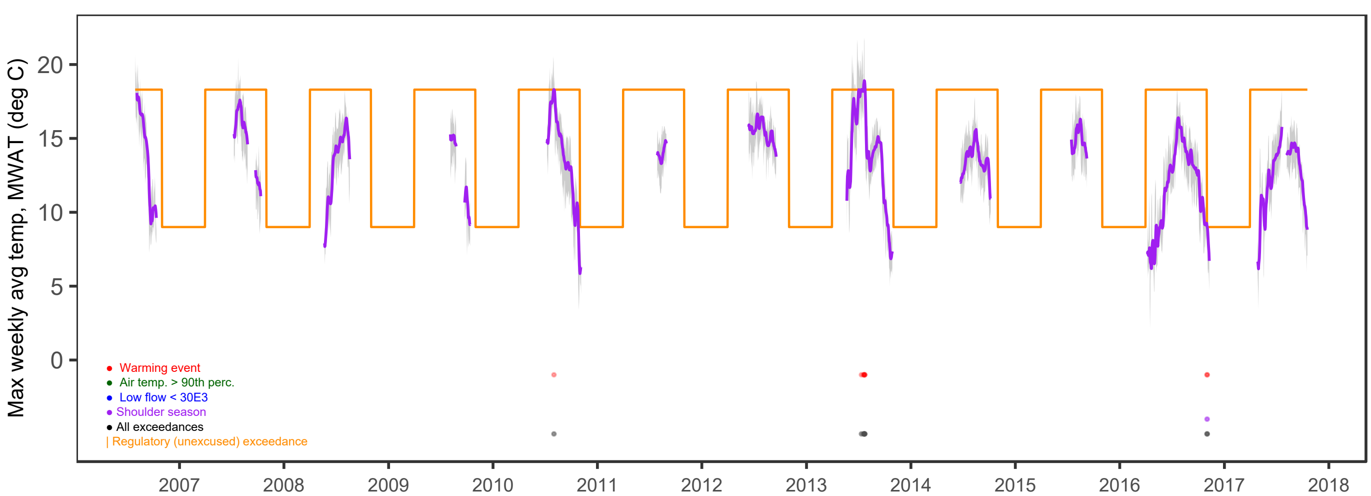
Regulatory status summary COR-LoneBuck
Colorado River at Lone Buck downstream of CPW Office

Site	COR-LoneBuck
POR_yrs	11
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	106
WAT_unexcused_exceed_total	2
WAT_unexc_exceed_freq	0.09
WAT_unexc_exceed_recur_ratio	1 in 11
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-Pumphouse
Colorado River downstream of Gore Canyon and upstream of Pumphouse
Standards tier: CS2, Wild and Scenic study reach number: 5



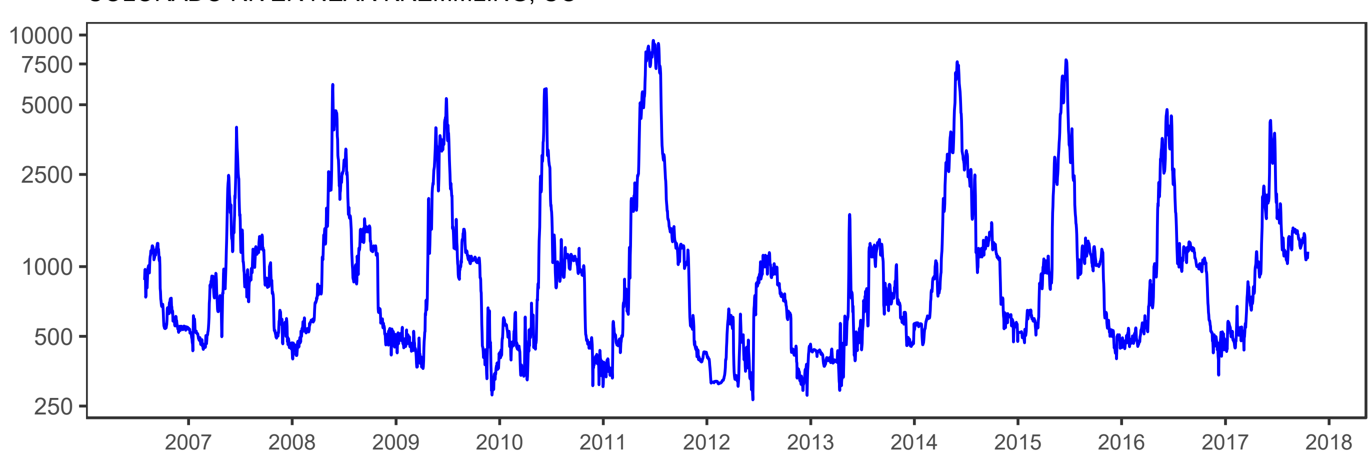
DM summary: Years in record: 12, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 12, total exceedances: 9, unexcused exceedances: 0

Discharge (cfs) at gauge 09058000

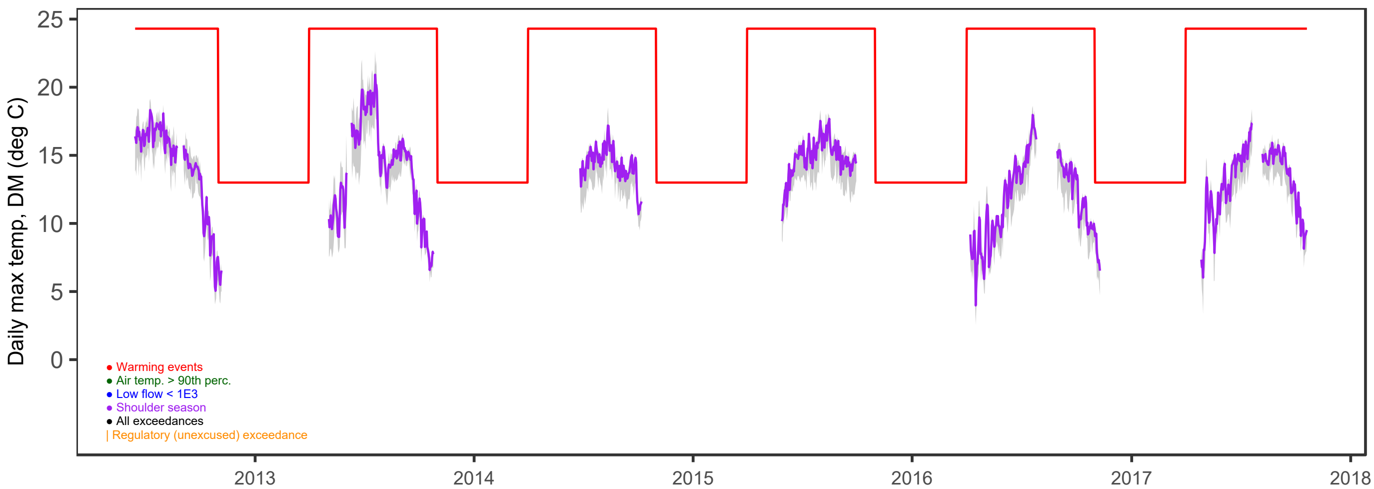
COLORADO RIVER NEAR KREMMLING, CO



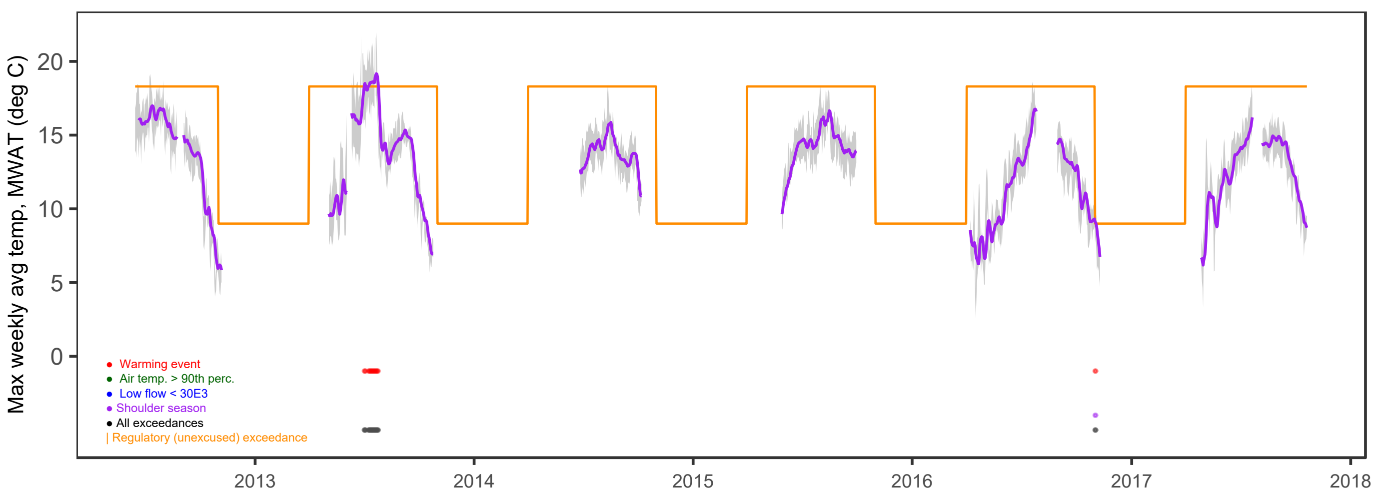
Regulatory status summary COR-Pumphouse
Colorado River downstream of Gore Canyon and upstream of Pumphouse

Site	COR-Pumphouse
POR_yrs	12
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	9
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-Rad
Colorado River at Radium
Standards tier: CS2, Wild and Scenic study reach number: 5

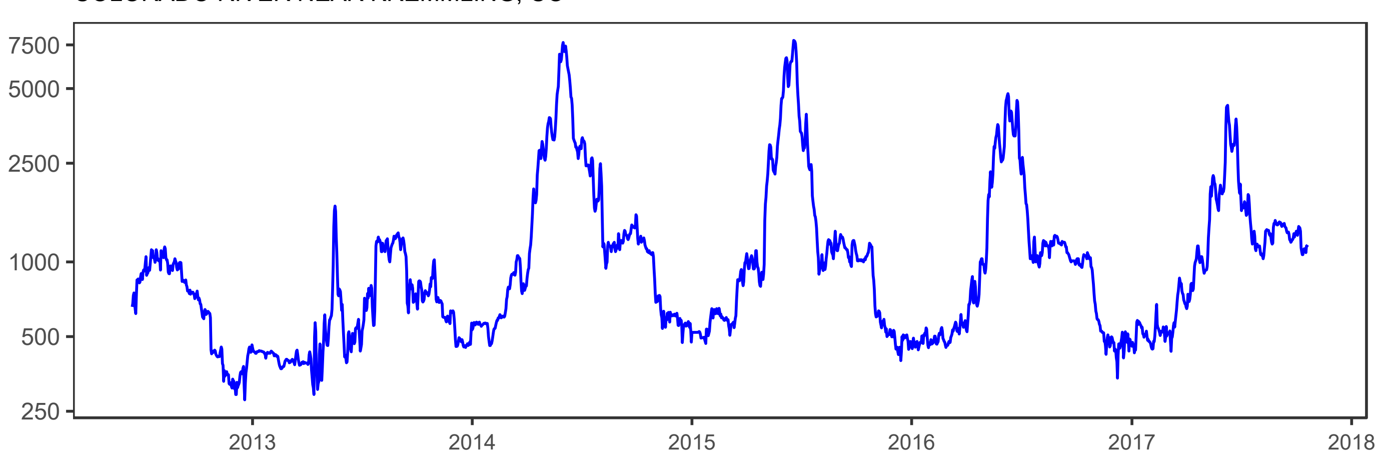


DM summary: Years in record: 6, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 6, total exceedances: 22, unexcused exceedances: 0

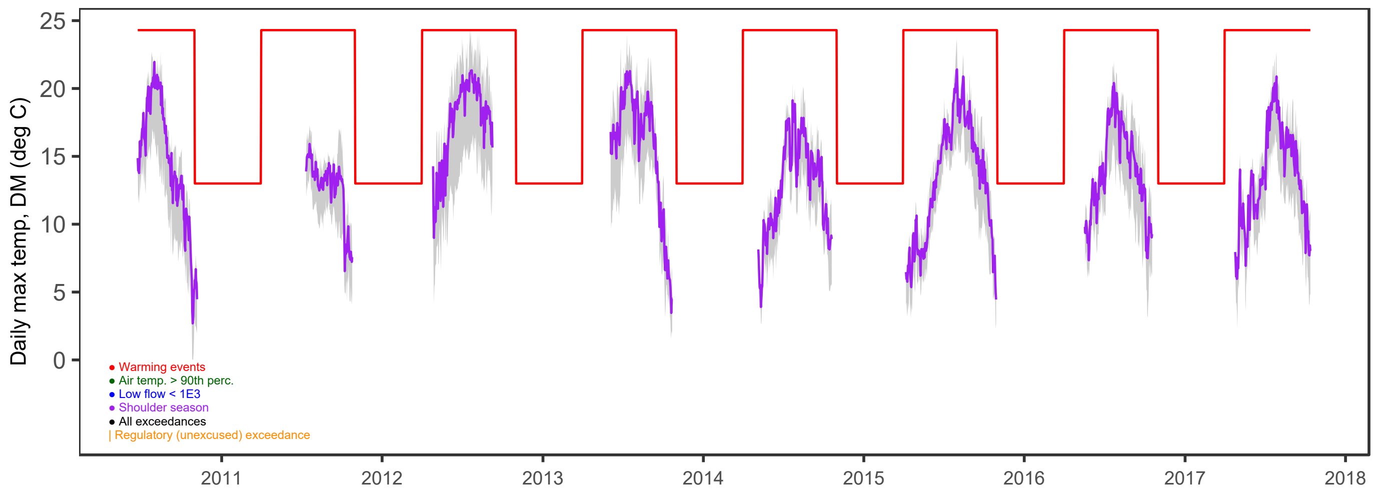
Discharge (cfs) at gauge 09058000
COLORADO RIVER NEAR KREMMLING, CO



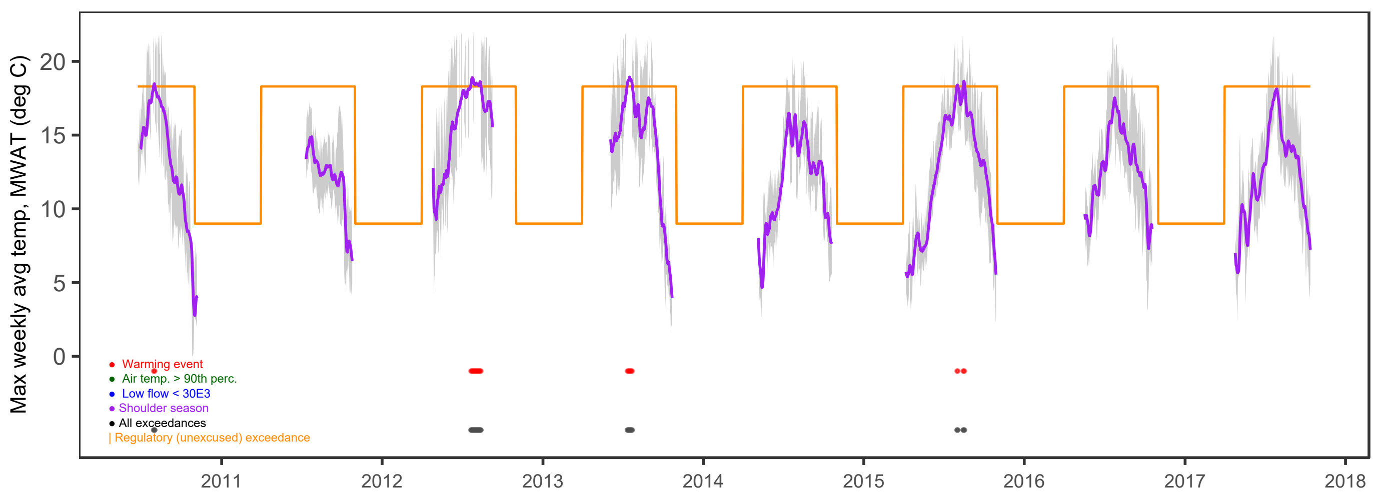
Regulatory status summary COR-Rad
Colorado River at Radium

Site	COR-Rad
POR_yrs	6
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	22
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: COR-SHRF
Colorado River at Sheriff Ranch at Silver Doctor Cabin before Hot Sulphur Springs CO
Standards tier: CS2, Wild and Scenic study reach number: NA



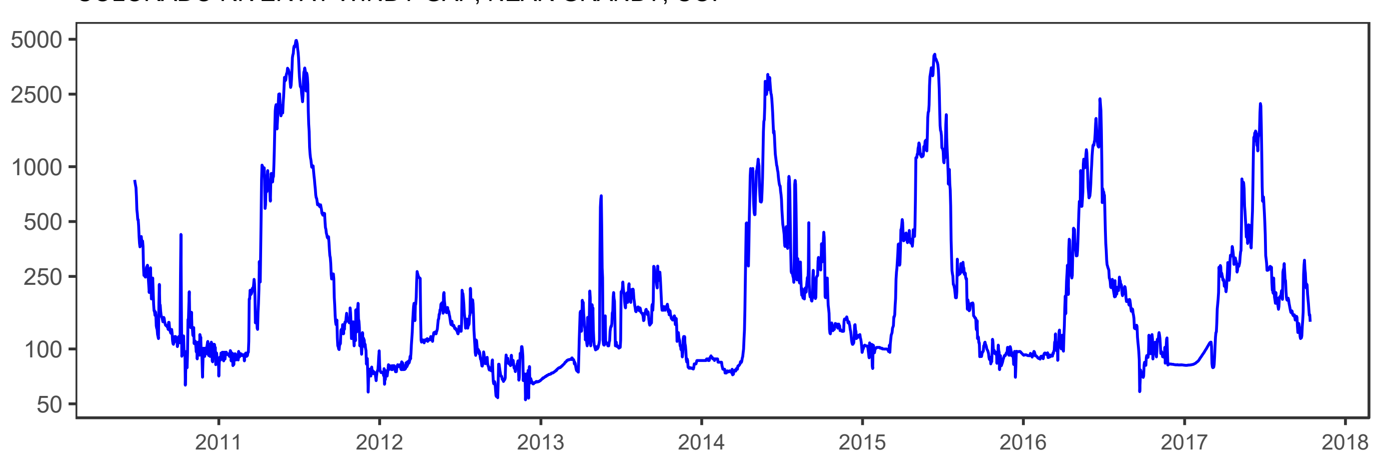
DM summary: Years in record: 8, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 8, total exceedances: 47, unexcused exceedances: 0

Discharge (cfs) at gauge 09034250

COLORADO RIVER AT WINDY GAP, NEAR GRANBY, CO.



Regulatory status summary COR-SHRF

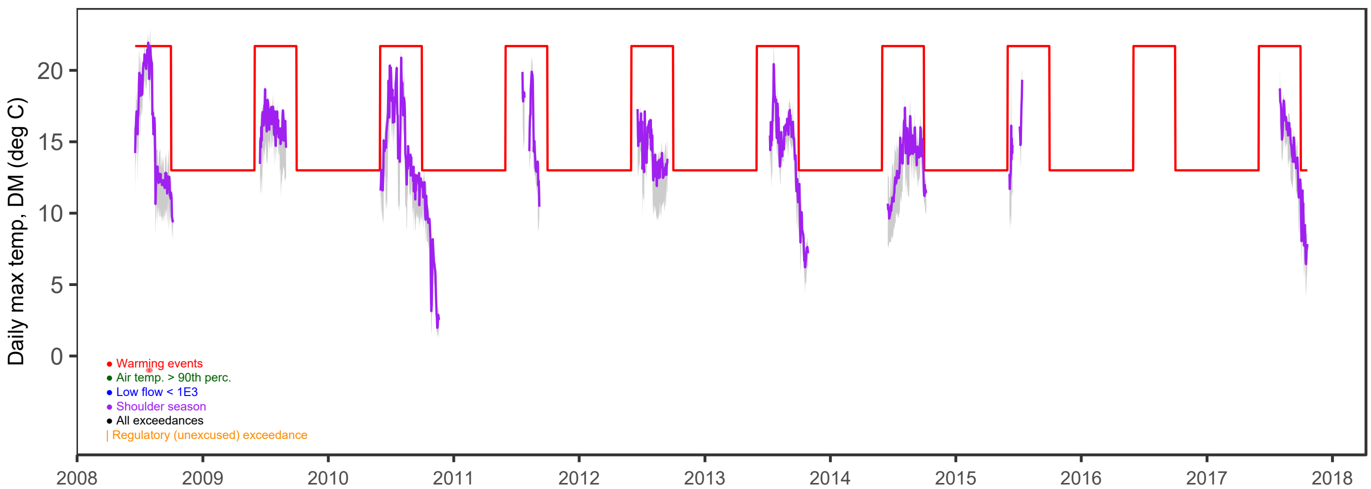
Colorado River at Sheriff Ranch at Silver Doctor Cabin before Hot Sulphur Springs CO

Site	COR-SHRF
POR_yrs	8
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	47
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

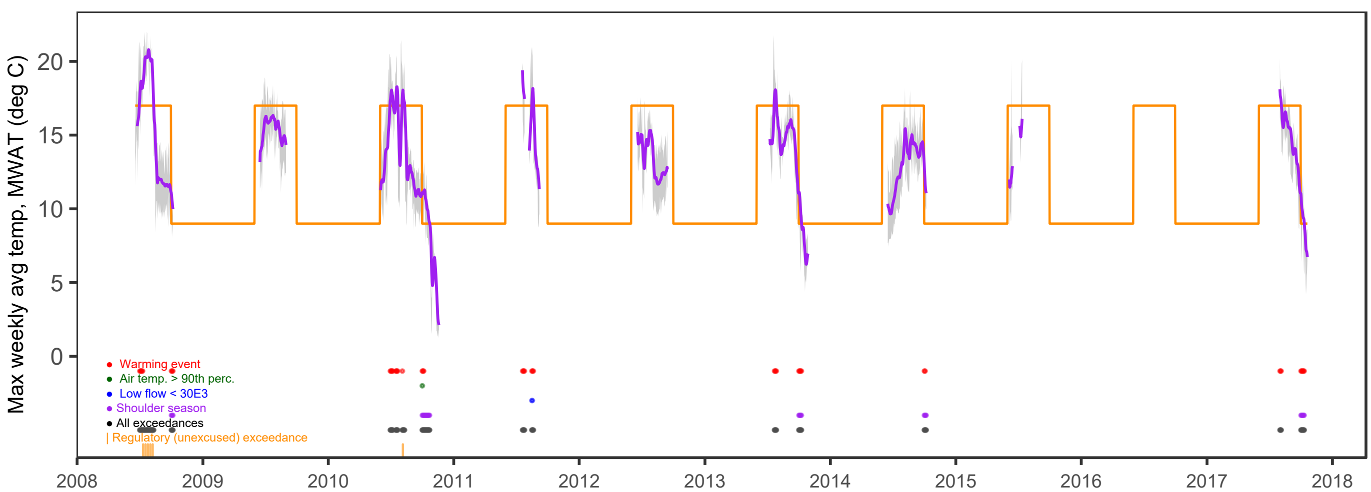
Temperature Summary: MC-blwHwy40

Muddy Creek downstream of Hwy 40 bridge

Standards tier: CS1, Wild and Scenic study reach number: NA



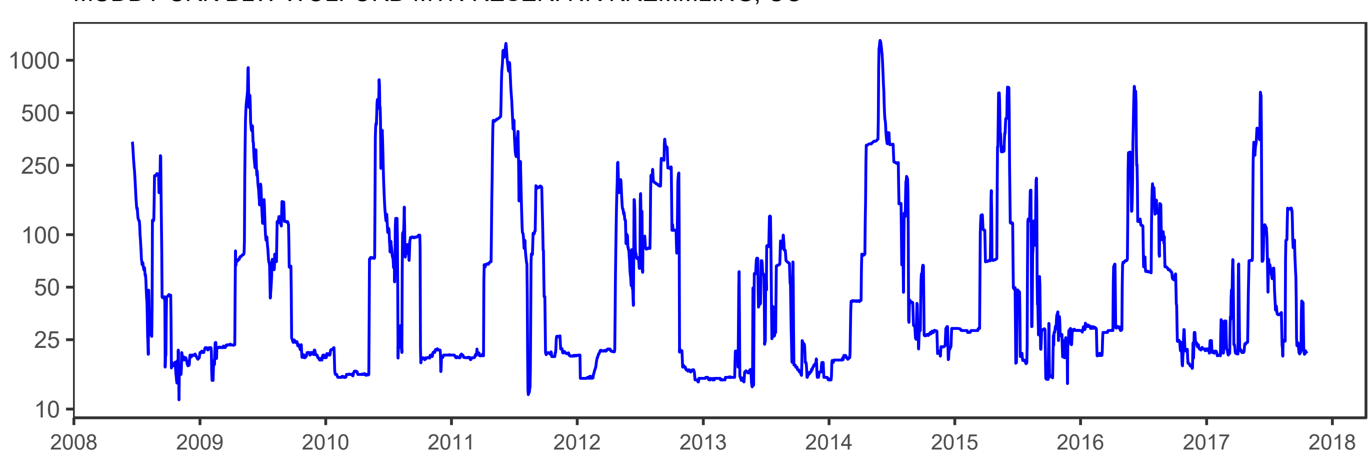
DM summary: Years in record: 10, total exceedances: 2, unexcused exceedances: 0



WAT summary: Years in record: 10, total exceedances: 147, unexcused exceedances: 6

Discharge (cfs) at gauge 09041400

MUDDY CRK BLW WOLFORD MTN RESER. NR KREMMLING, CO



MWAT regulatory exceed summaries for MC-blwHwy40
Muddy Creek downstream of Hwy 40 bridge

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2008	0	0	0	0	0	0	3	2	0	0	0	0	5
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	1	0	0	0	0	1
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for MC-blwHwy40
Muddy Creek downstream of Hwy 40 bridge

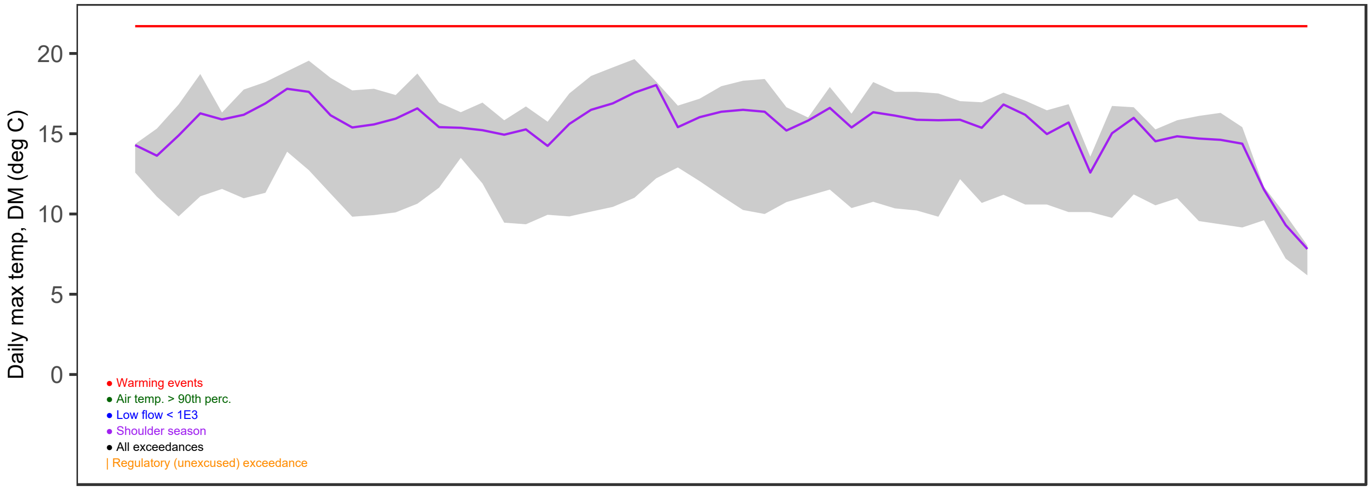
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2010-08-06	18.06	17	summer-2010	14.45	FALSE	FALSE	FALSE	FALSE	TRUE
2008-08-08	18.99	17	summer-2008	99.74	FALSE	FALSE	FALSE	FALSE	TRUE
2008-08-01	20.22	17	summer-2008	79.78	FALSE	NA	FALSE	FALSE	TRUE
2008-07-25	20.47	17	summer-2008	55.28	FALSE	FALSE	FALSE	FALSE	TRUE
2008-07-18	20.32	17	summer-2008	32.06	FALSE	FALSE	FALSE	FALSE	TRUE
2008-07-11	18.47	17	summer-2008	13.72	FALSE	FALSE	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

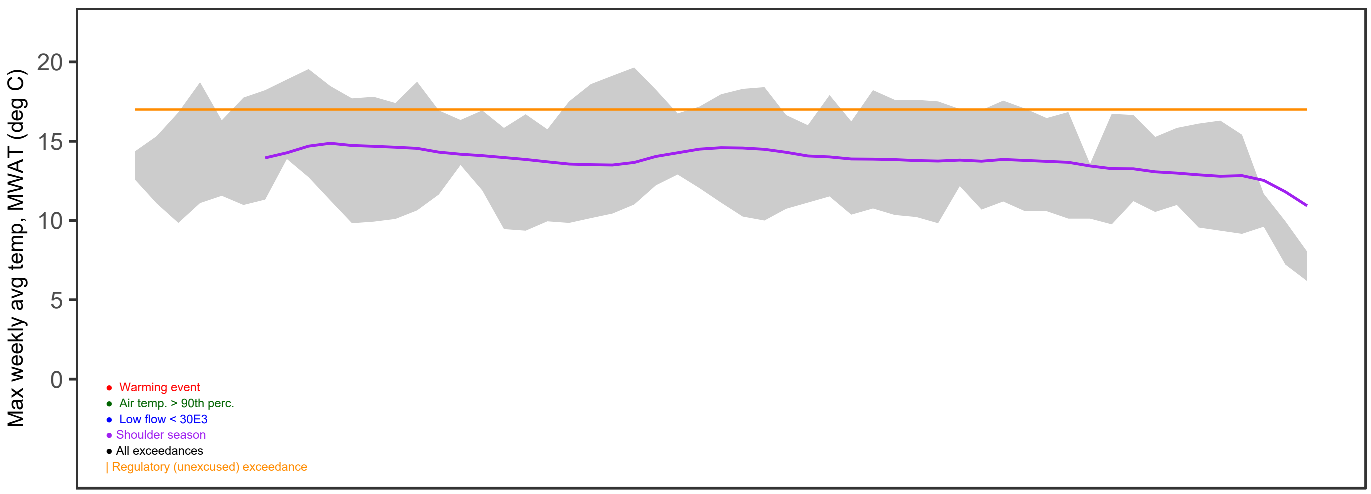
Regulatory status summary MC-blwHwy40
Muddy Creek downstream of Hwy 40 bridge

Site	MC-blwHwy40
POR_yrs	10
DM_exceed_total	2
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	147
WAT_unexcused_exceed_total	6
WAT_unexc_exceed_freq	0.2
WAT_unexc_exceed_recur_ratio	1 in 5
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: Piney-abvCOR
Piney River upstream of Colorado River confluence
Standards tier: CS1, Wild and Scenic study reach number: NA

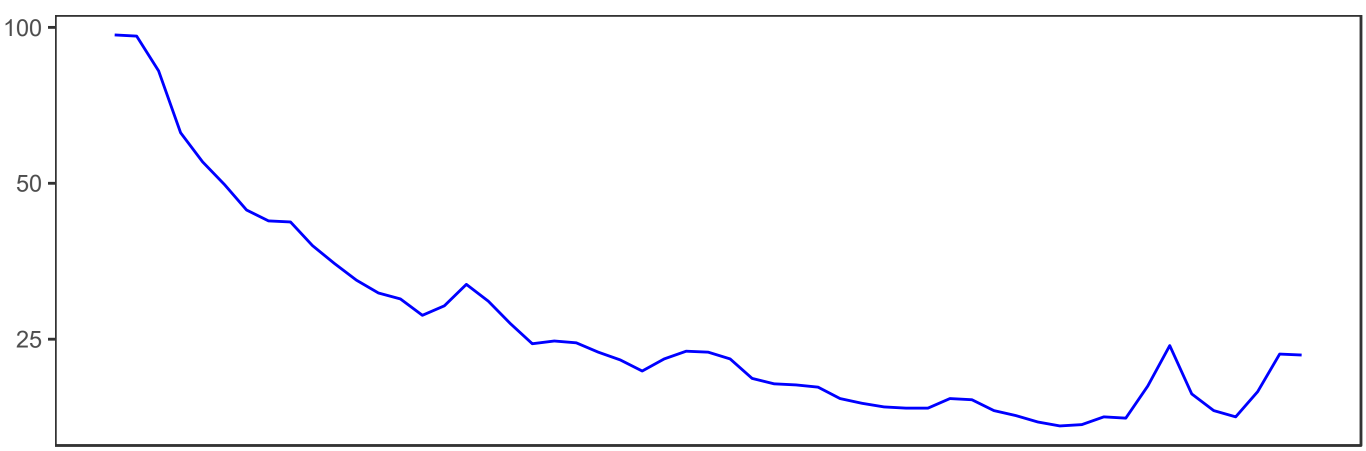


DM summary: Years in record: 1, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 1, total exceedances: 0, unexcused exceedances: 0

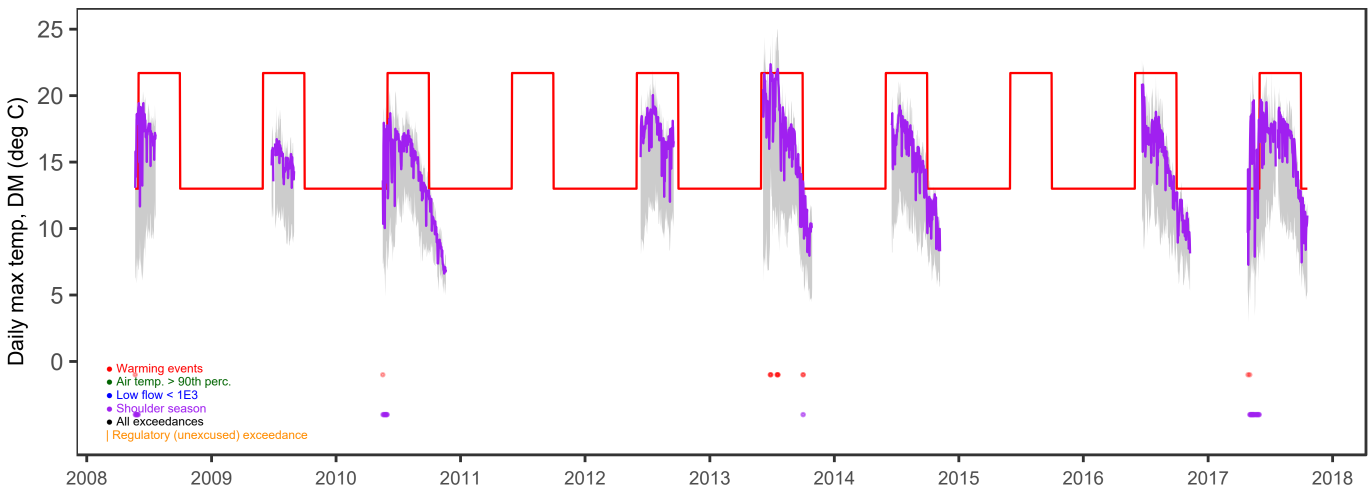
Discharge (cfs) at gauge 09059500
PINEY RIVER NEAR STATE BRIDGE, CO



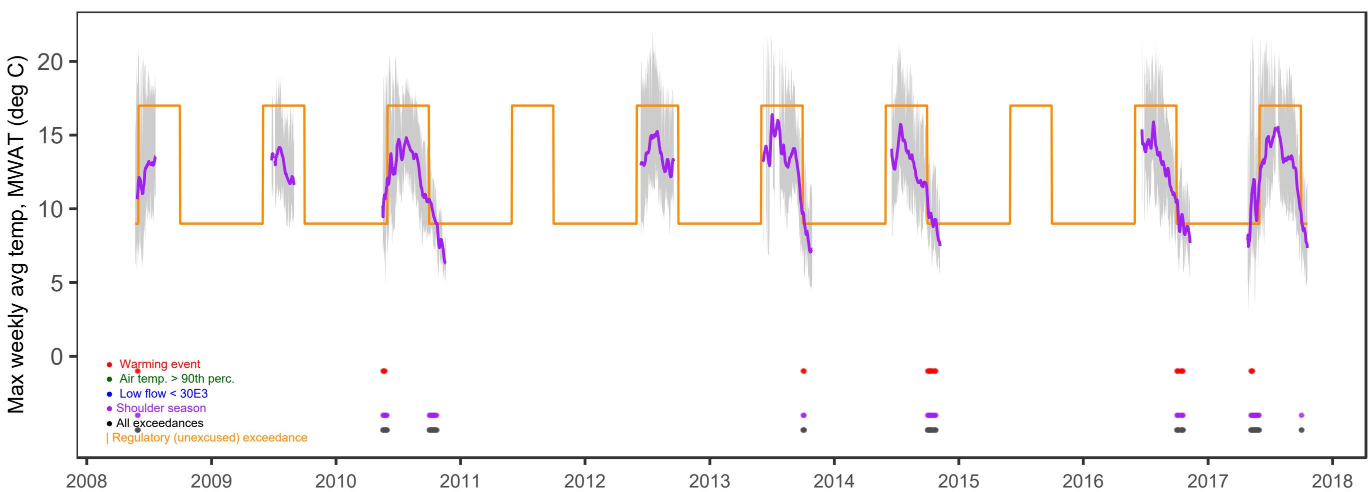
Regulatory status summary Piney-abvCOR
Piney River upstream of Colorado River confluence

Site	Piney-abvCOR
POR_yrs	1
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	0
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: REE-Upper
Reeder Creek, upper
Standards tier: CS1, Wild and Scenic study reach number: NA



DM summary: Years in record: 10, total exceedances: 57, unexcused exceedances: 0



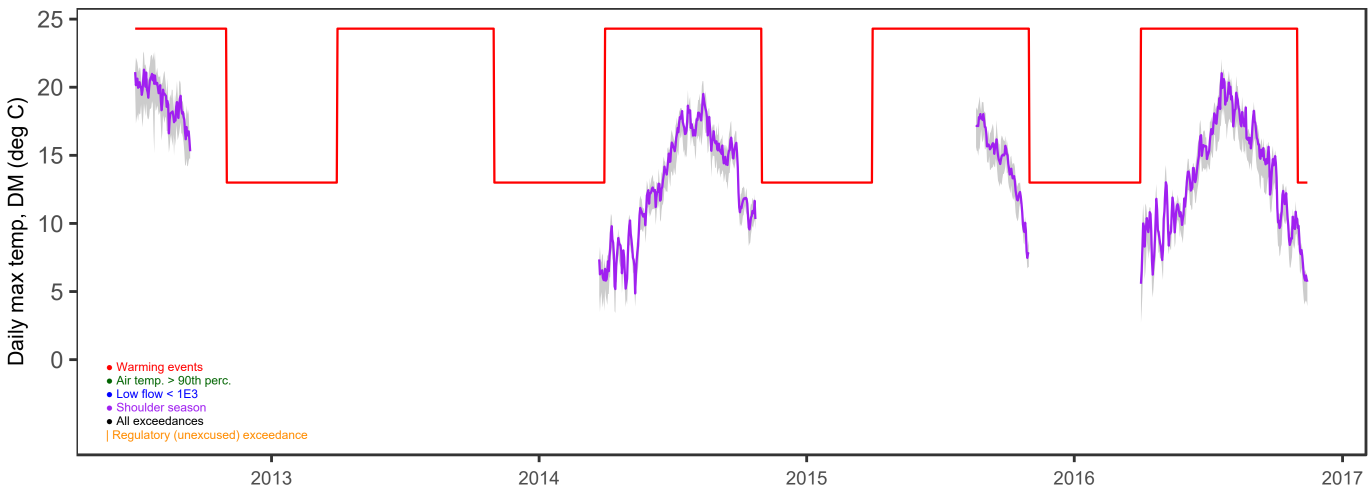
WAT summary: Years in record: 10, total exceedances: 113, unexcused exceedances: 0

No associated gauge data for this site

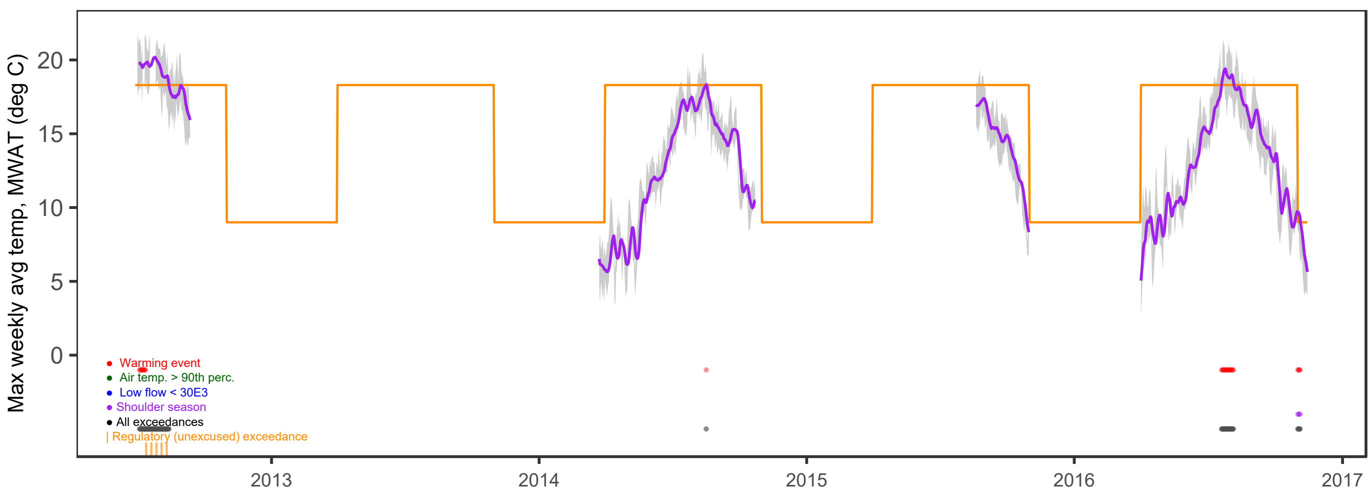
Regulatory status summary REE-Upper
Reeder Creek, upper

Site	REE-Upper
POR_yrs	10
DM_exceed_total	57
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	113
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: UPCO-DOT
Upper Colorado River upstream of Dotsero
Standards tier: CS2, Wild and Scenic study reach number: 6

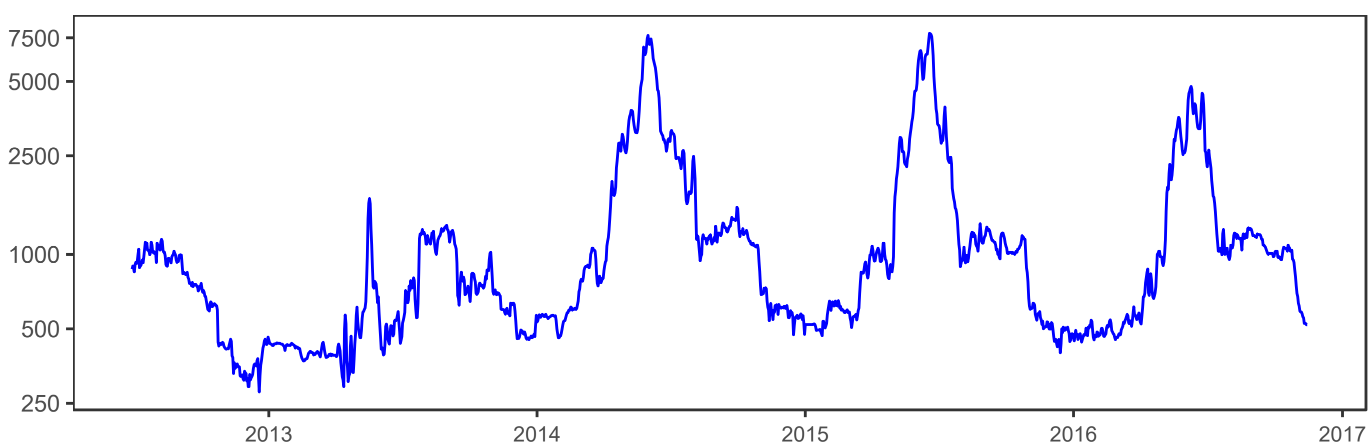


DM summary: Years in record: 5, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 5, total exceedances: 63, unexcused exceedances: 5

Discharge (cfs) at gauge 09058000
COLORADO RIVER NEAR KREMMLING, CO



MWAT regulatory exceed summaries for UPCO-DOT
Upper Colorado River upstream of Dotsero

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2012	0	0	0	0	0	0	3	2	0	0	0	0	5
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which
are not excused by a warming event or other excursion type.

MWAT exceedance dates for UPCO-DOT
Upper Colorado River upstream of Dotsero

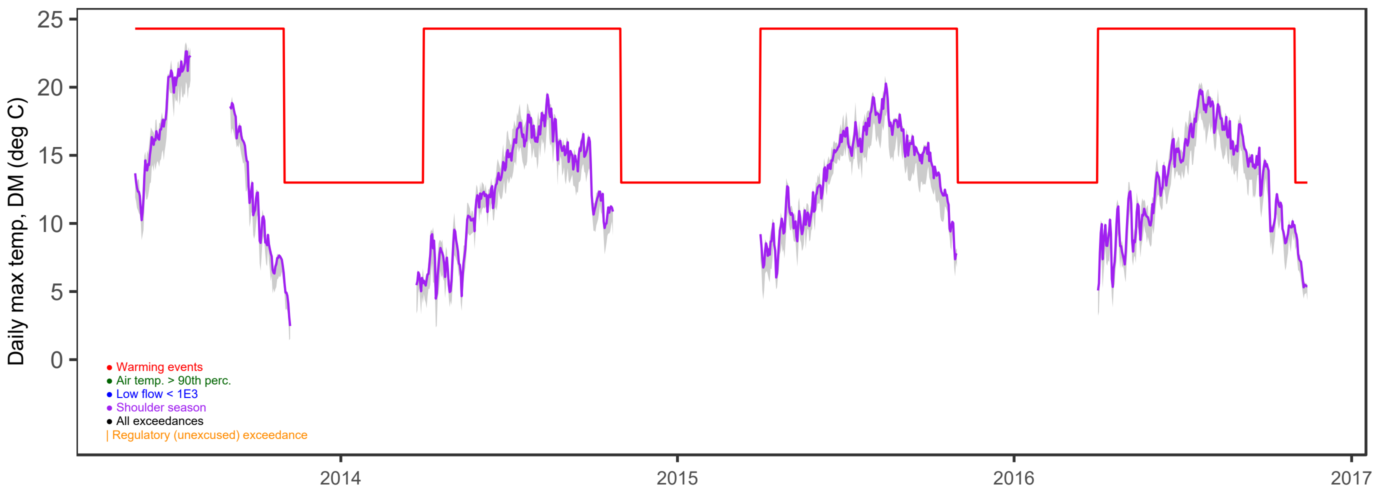
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2012-08-11	18.90	18.3	summer-2012	49.15	FALSE	NA	FALSE	FALSE	TRUE
2012-08-04	19.15	18.3	summer-2012	45.17	FALSE	NA	FALSE	FALSE	TRUE
2012-07-28	20.03	18.3	summer-2012	35.94	FALSE	NA	FALSE	FALSE	TRUE
2012-07-21	19.67	18.3	summer-2012	23.60	FALSE	NA	FALSE	FALSE	TRUE
2012-07-14	19.80	18.3	summer-2012	13.86	FALSE	NA	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

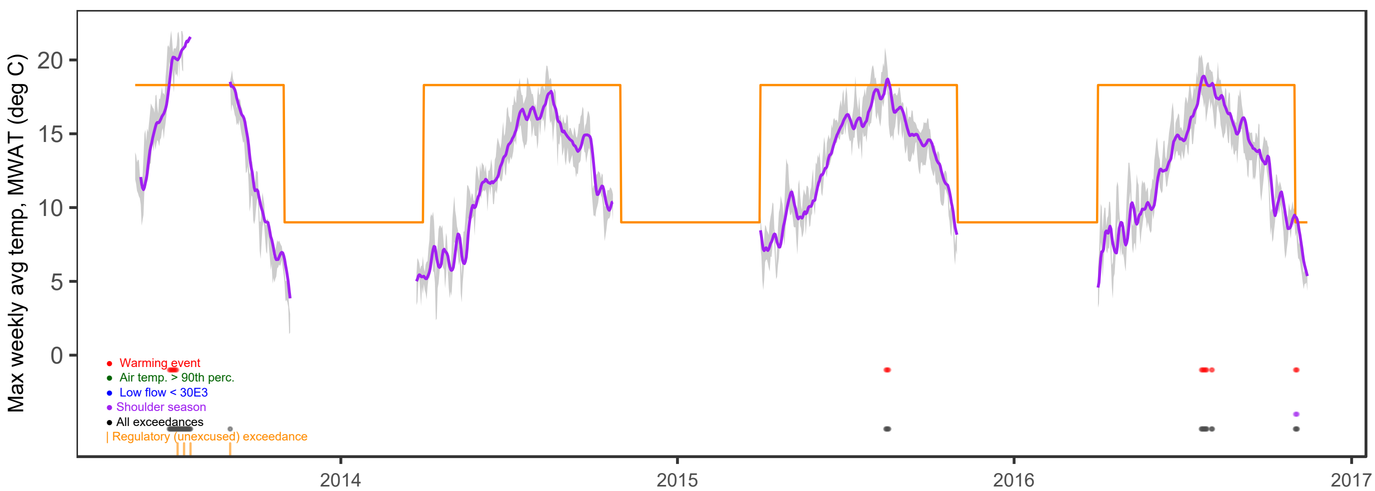
Regulatory status summary UPCO-DOT
Upper Colorado River upstream of Dotsero

Site	UPCO-DOT
POR_yrs	5
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	63
WAT_unexcused_exceed_total	5
WAT_unexc_exceed_freq	0.2
WAT_unexc_exceed_recur_ratio	1 in 5
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: UPCO-RD
Upper Colorado River downstream of Red Dirt Creek
Standards tier: CS2, Wild and Scenic study reach number: 6



DM summary: Years in record: 4, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 4, total exceedances: 41, unexcused exceedances: 4

Discharge (cfs) at gauge 09058000
COLORADO RIVER NEAR KREMMLING, CO

MWAT regulatory exceed summaries for UPCO-RD
Upper Colorado River downstream of Red Dirt Creek

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual_total
2013	0	0	0	0	0	0	3	0	1	0	0	0	4
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0

Regulatory exceedances are those exceedances of the standard which are not excused by a warming event or other excursion type.

MWAT exceedance dates for UPCO-RD

Upper Colorado River downstream of Red Dirt Creek

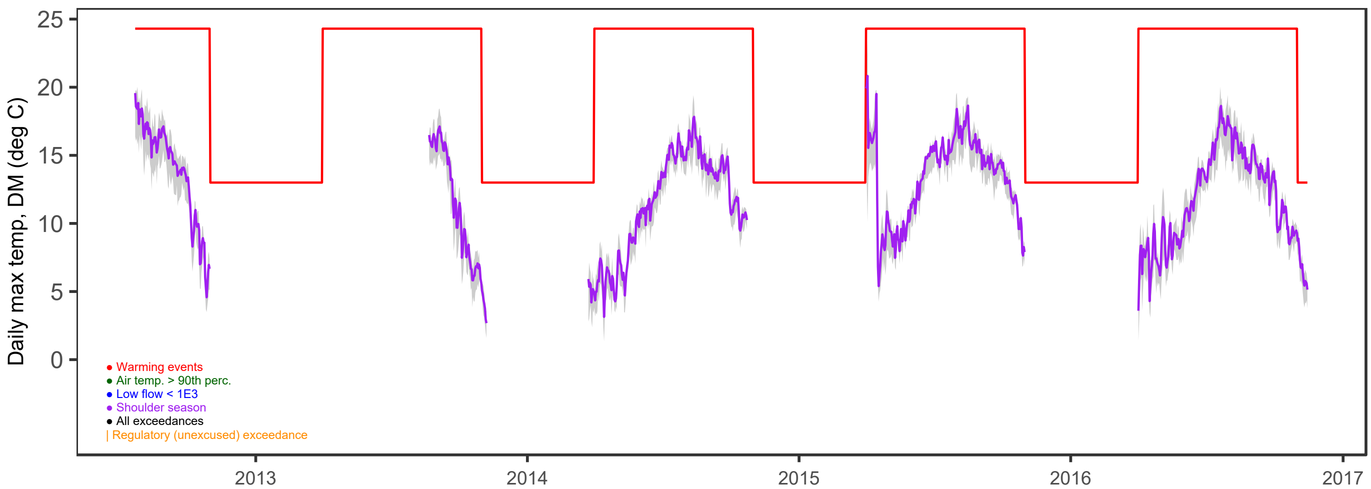
Date	WAT	Std.	Season-Yr	WE Cumultn.	WE Exc.	Air Excurs.	Low Flow Excur.	Shoulder	WAT Exceed Unexcused
2013-09-03	18.52	18.3	summer-2013	51.01	FALSE	NA	FALSE	FALSE	TRUE
2013-07-22	21.56	18.3	summer-2013	50.79	FALSE	NA	FALSE	FALSE	TRUE
2013-07-15	20.85	18.3	summer-2013	29.96	FALSE	NA	FALSE	FALSE	TRUE
2013-07-08	20.00	18.3	summer-2013	14.47	FALSE	NA	FALSE	FALSE	TRUE

Warming Event Cumulation is the running total of degree days on the regulatory exceedance date. Regulatory exceedances occur if no other excursion types can be applied in addition to the Warming Event criteria.

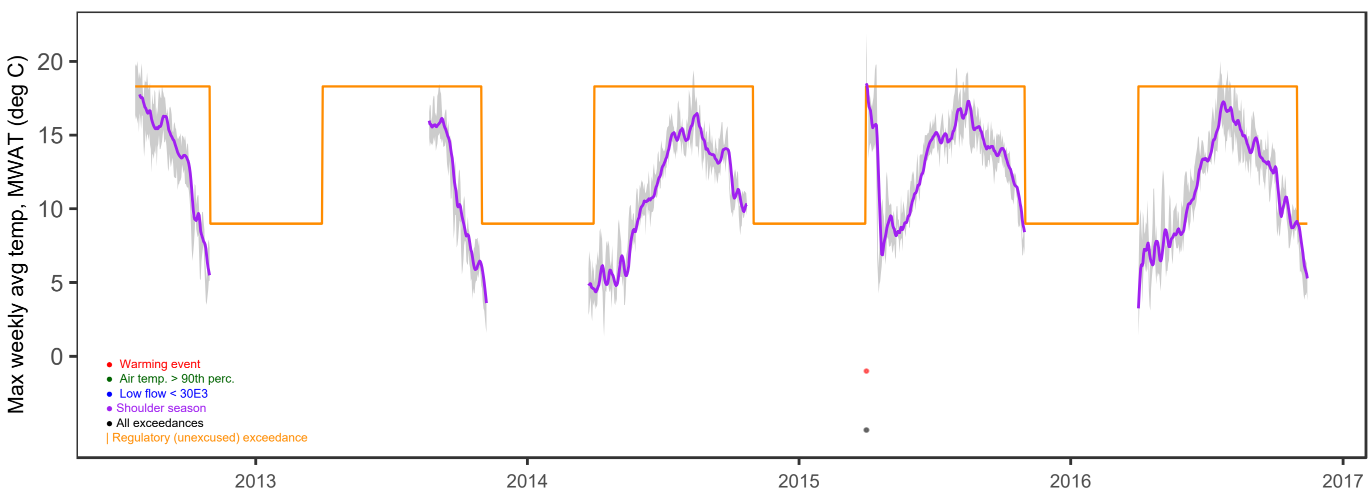
Regulatory status summary UPCO-RD
Upper Colorado River downstream of Red Dirt Creek

Site	UPCO-RD
POR_yrs	4
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	41
WAT_unexcused_exceed_total	4
WAT_unexc_exceed_freq	0.25
WAT_unexc_exceed_recur_ratio	1 in 4
WAT_unexc_exceed_in_last_3_yrs	FALSE

Temperature Summary: UPCO-SB
Upper Colorado River upstream of State Bridge
Standards tier: CS2, Wild and Scenic study reach number: 6

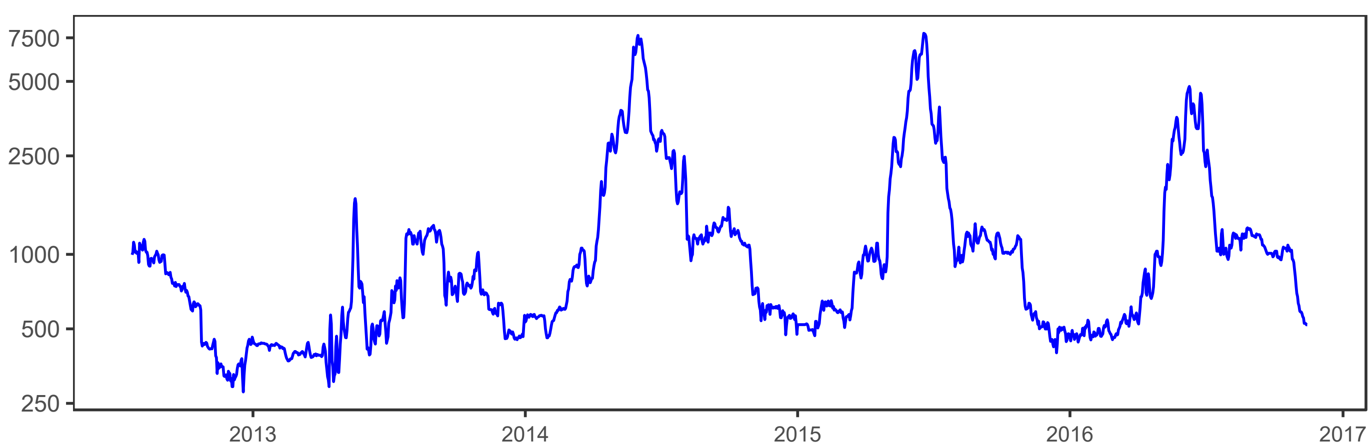


DM summary: Years in record: 5, total exceedances: 0, unexcused exceedances: 0



WAT summary: Years in record: 5, total exceedances: 2, unexcused exceedances: 0

Discharge (cfs) at gauge 09058000
COLORADO RIVER NEAR KREMMLING, CO



Regulatory status summary UPCO-SB
Upper Colorado River upstream of State Bridge

Site	UPCO-SB
POR_yrs	5
DM_exceed_total	0
DM_unexcused_exceed_total	0
DM_unexc_exceed_freq	0
DM_unexc_exceed_recur_ratio	0
DM_unexc_exceed_in_last_3_yrs	NA
WAT_exceed_total	2
WAT_unexcused_exceed_total	0
WAT_unexc_exceed_freq	0
WAT_unexc_exceed_recur_ratio	0
WAT_unexc_exceed_in_last_3_yrs	FALSE

Click below to access:

APPENDIX B: Compiled Data Record