# ANNUAL SHASTA RIVER TMDL MONITORING REPORT 2022

PPREPARED AND SUBMITTED BY

Ethan Brown and Zach Crow

Shasta Valley Resource Conservation District

December 2023

SHASTA VALLEY
RESOURCE CONSERVATION DISTRICT

**(This page left blank intentionally)**

# CONTENTS

List of Figures ........ 4
List of Tables ........ 4
INTRODUCTION ........ 5
Tempreature TMDL ........ 5
Dissolved Oxygen TMDL ........ 6
Monitoring Locations ........ 6
METHODS ........ 9
Dissolved oxygen Sampling ........ 9
Temperature Sampling ........ 9
RESULTS AND DISCUSSION ........ 10
Meteorological Conditions ........ 10
Shasta River Flow ........ 13
Temperature Results ........ 15
Longitudinal Analysis ........ 16
Reach 1 ........ 18
Reach 2 ........ 19
Reach 3 ........ 20
Reach 4 ........ 21
Reach 5 ........ 22
Reach 6 ........ 23
Dissolved Oxygen Results ........ 24
Reach 1 ........ 28
Reach 2 ........ 29
Reach 3 ........ 31
Reach 4 ........ 33
Reach 5 ........ 35
Reach 6 ........ 38
Summary of Management Actions ........ 39
Impact on Water Quality ........ 40
CONCLUSIONS ........ 40
REFERENCES ........ 42
ACKNOWLEDGEMENTS ........ 43
APPENDIX ........ 44

# LIST OF FIGURES

Figure 1. Map of 2022 temperature, DO, flow, meteorological and CDEC monitoring locations. ............... 8
Figure 2. 2022 Meteorological data from site 105SRMWTHR. ................................................................ 13
Figure 3. WY 2022 continuous Shasta River discharge and SWRCB minimum instream flow criteria. ...... 15
Figure 4. Longitudinal MWMT data for long term Shasta River temperature sites, 2017-2022. ............... 17
Figure 5. Longitudinal MWAT data for long term Shasta River temperature sites 2017-2022. ................. 17
Figure 6. Longitudinal Absolute Max temps for long term Shasta River temperature sites 2017-2022. ... 18
Figure 7. 2022 7-DAD Maximum temperatures at Reach 1 (Shasta River and Yreka Creek sites). ............ 19
Figure 8. 2022 7-DAD Maximum temperatures for Reach 2, Shasta River. ............................................... 20
Figure 9. 2022 7-DAD Max temperatures for Shasta River, Reach 3. ........................................................ 21
Figure 10. 2022 7-DAD Max temperatures for Shasta River, Reach 4. ...................................................... 22
Figure 11. 2022 7-DAD Max temperatures at Parks Creek Reach 5. All sites are on Parks Creek. ............. 23
Figure 12. 2022 7-DAD Max temperatures at monitoring locations in the Shasta River at Reach 6. ......... 24
Figure 13. 2022 daily minimum DO at all Shasta River sites. ..................................................................... 25
Figure 14. 2022 daily minimum DO at all Parks Creek sites. ....................................................................... 26
Figure 15. 2022 daily maximum temperature and daily minimum at 105SRL1DO, Shasta River ............... 28
Figure 16. 2022 daily maximum temperature and daily minimum DO at 105SRTM01DO, Shasta River ... 29
Figure 17. 2022 daily maximum temperature and daily minimum DO at 105SRA1DO, Shasta River ........ 30
Figure 18. 2022 daily maximum temperature and daily minimum DO at 105SRM1DO, Shasta River ....... 31
Figure 19. 2022 daily maximum temperature and daily minimum DO at 105SRS1DO, Shasta River ........ 32
Figure 20. 2022 daily maximum temperature and daily minimum DO at 105SRT1DO, Shasta River ........ 33
Figure 21. 2022 daily maximum temperature and daily minimum DO at 105SRV1DO, Shasta River ........ 34
Figure 22. 2022 daily maximum temperature and daily minimum DO at 105SRN1DO, Shasta River ........ 35
Figure 23. 2022 daily maximum temperature and daily minimum DO at 105SRP1DO, Parks Creek ......... 36
Figure 24. 2022 daily maximum temperature and daily minimum DO at 105PCFPDO, Parks Creek ......... 37
Figure 25. 2022 daily maximum temperature and daily minimum DO at 105PCB1DO, Parks Creek ......... 38
Figure 26. 2022 daily maximum temperature and daily minimum DO at 105SRU1DO, Shasta River ........ 39

# LIST OF TABLES

Table 1. Reach, Site ID, river mile, equipment, and measured metrics during the 2022 irrigation season. 7
Table 2. MWMT for different life stages of coho salmon (reproduced from Carter 2005). ....................... 10
Table 3. Regional snow depth and water content for the month of April of 2022, 2021, and 2020. ........ 11
Table 4 . Meteorological totals for SVRCD cooperated CIMIS and weather stations. ............................... 12
Table 5. Shasta River emergency min flow requirement for SRY, 2022 effective 8/30/21 to 7/28/22 ...... 14
Table 6. Shasta River emergency min flow requirement for SRY, 2022 effective 7/29/22 to 7/30/23 ...... 14
Table 7. 2022 Shasta River annual discharge and irrigation season discharge totals. .............................. 14
Table 8. 2022 Shasta River MWMT, MWAT, absolute max temp, and percent of days exceeded 18°C. ... 16
Table 9. Percentage of days monitored where DO levels fell below 6 mg/L. ............................................ 27

# INTRODUCTION

The North Coast Regional Water Quality Control Board (NCRWQCB) lists the Shasta River in the Shasta Total Max Daily Load (TMDL) for high temperature and low dissolved oxygen (DO). The NCRWQCB identifies agricultural activities (livestock impacts, impoundments, and diversions) as sources contributing to these impairments (NCRWQCB 2007). Surface water diversions from the Shasta River and tailwater, or excess irrigation return flows, to the river system degrade water quality and impact the *beneficial uses*, which include: 1) cold freshwater habitat (COLD) that supports migration, spawning and rearing (MIGR, SPWN) of salmonids including Chinook, steelhead and state and federally ESA-listed coho (RARE), 2) drinking water (MUN), 3) recreation (REC-1 & 2), 4) agricultural supply (AGR) and 5) groundwater recharge (GWR) (NCRWQCB 2007).

Under the protocols established in the Monitoring Plan, Quality Assurance Project Plan (QAPP) and Project Assessment and Evaluation Plan (PAEP) approved by the State Water Resource Control Board (SWRCB), the Shasta Valley Resource Conservation District (SVRCD) is monitoring water quality on the Shasta River and its tributaries. The goals of this monitoring effort are to assess progress in meeting TMDLs (temperature and DO) by monitoring Shasta River water quality and to identify locations where the restoration or alteration of riparian habitat, land management actions, and land management practices would likely improve water quality in the Shasta River and its tributaries.

This report summarizes and discusses meteorological data and the impact on the Shasta River watershed, as well as temperature and DO monitoring data at 26 sites (twelve sites measured DO and temperature) on the Shasta River and tributaries Parks Creek and Yreka Creek. Access to monitoring locations was acquired from private landowners through landowner agreements.

## TEMPREATURE TMDL

The Shasta River TMDL temperature load allocation sources are riparian vegetation (shade), tailwater return flows, and surface water flow. The temperature water quality compliance scenario, as modeled by the NCRWQCB, included increased riparian shade to represent site potential riparian conditions on a river-reach scale, modified temperature regime of tailwater return flows such that return flows do not cause heating of the receiving water, Big Springs Creek temperatures reduced by 4°C from baseline, Parks Creek temperatures reduced by 2°C from baseline, and fifty percent (50%) increase in Shasta River flows downstream of the Big Springs Creek confluence, an increase of 45 $ft^3$/second (cfs) (NCRWQCB, 2006).

Juvenile salmonids are known or suspected to rear in the following reaches of the Shasta River: Grenada Irrigation District pumps to Highway A-12, near Breceda Lane, and in the Shasta River canyon at a side channel known as “Salmon Heaven”. Based on this information, the following locations are considered temperature compliance locations, as they are at or near the downstream end of these critical summer rearing locations (NCRWQCB, 2006). The name and River Mile (RM) are:

- “Salmon Heaven”, RM 5.6
- Montague-Grenada Road, RM 15.5
- Highway A-12, RM 24.1

For the modeled water quality compliance scenario, reductions in maximum water temperatures compared to the August baseline water temperatures at RM 5.6, RM 15.5, and RM 24.1 are 4.82°C, 4.92°C, and 4.71°C, respectively. The 5-day average daily maximum temperatures for the compliance scenario at RM 5.6, RM 15.5, and RM 24.1 are 18.9°C, 17.5°C, and 16.7°C, respectively (NCRWQCB, 2006).

For a full analysis and description of the load allocations, model conditions, calibration data, and modeled scenario outputs, please refer to the 2006 *Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads*.

## DISSOLVED OXYGEN TMDL

The dissolved oxygen water quality compliance scenario was developed using a process that separately evaluated components identified in the dissolved oxygen source and linkage analysis that affect dissolved oxygen concentrations in the Shasta River. They include photosynthetic and respiration rates, sediment oxygen demand rates, dissolved oxygen and nitrogenous oxygen demand concentrations of Lake Shastina outflow, key tributaries, and tailwater return flows, riparian shade, and Shasta River flow. The water quality compliance scenario consists of the baseline condition with key modifications including, reduced photosynthetic and respiration rates, reduced sediment oxygen demand (SOD) behind minor impoundments, reduced nitrogenous oxygen demand (NBOD input concentrations, modified dissolved oxygen concentrations at key locations, increased riparian shade (represented as decreased percent transmittance on a river reach scale), and increased Shasta River flow.  and appears to result in attainment of the Basin Plan biostimulatory substances objective, as nutrient load reductions result in attainment of dissolved oxygen objective and non-nuisance level growth of aquatic plants, (NCRWQCB, 2006).

For a full analysis and description of the load allocations, model conditions, calibration data, and modeled scenario outputs, please refer to the 2006 *Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads*.

## MONITORING LOCATIONS

Temperature and DO were measured from April 1st through October 1st, 2022 at 26 locations on the Shasta River and its tributaries (Table 1). Table 1 lists sites in order from upstream to downstream. The study area spans approximately 40 river miles from Dwinnell Reservoir to the mouth of the Shasta River at its confluence with the Klamath River (Figure 1). Many of the monitoring locations coincide with the Shasta River temperature and DO compliance points.

**TABLE 1. REACH, SITE ID, RIVER MILE, EQUIPMENT, AND MEASURED METRICS DURING THE 2022 IRRIGATION SEASON.**

| Reach | Reach Description | Site ID | River Mile | Equipment | Measurement |
|---|---|---|---|---|---|
| 6 | Dwinnell Reservoir Outlet to Parks Creek | 105SRHVRPOD | 39.1 | TidbiTs® | Temperature |
| | | 105SRHVSPL | 38.1 | TidbiTs® | Temperature |
| | | 105SRHVRALC | 37.9 | TidbiTs® | Temperature |
| | | 105SRU1DO | 37.9 | Onset DO Logger | DO/Temperature |
| | | 105SRHVDSSPG | 37.8 | TidbiTs® | Temperature |
| | | 105SRU0IT | 37.7 | TidbiTs® | Temperature |
| | | 105SR7163DS | 36.9 | TidbiTs® | Temperature |
| | | 105SRHIGF | 36.6 | TidbiTs® | Temperature |
| 5 | Parks Creek to Big Springs Creek | 105SRP1DO* | SR 33.9; PC 0.04** | InSitu AquaTroll | DO/Temperature |
| | | 105PCFPDO* | SR 33.9; PC 7.3** | Onset DO Logger | DO/Temperature |
| | | 105PCAFPT* | SR 33.9; PC 9.3** | TidbiTs® | Temperature |
| | | 105PCBMDT* | SR 33.9; PC 10.9** | TidbiTs® | Temperature |
| | | 105PCB1DO* | SR 33.9; PC 11.7** | Onset DO Logger | DO/Temperature |
| 4 | Big Springs Creek to Willow Creek | 105SRN1DO | 30.9 | D-Opto | DO/Temperature |
| | | 105SRV1DO | 26.0 | D-Opto | DO/Temperature |
| | | 105SRV4AT | 25.2 | TidbiTs® | Temperature |
| | | 105SRV4BT | 24.3 | TidbiTs® | Temperature |
| 3 | Willow Creek to Little Shasta River | 105SRT1DO | 23.0 | D-Opto | DO/Temperature |
| | | 105SRS1DO | 16.7 | D-Opto | DO/Temperature |
| 2 | Little Shasta River to Yreka Creek | 105SRM1DO | 14.6 | D-Opto | DO/Temperature |
| | | 105SR400T | 12.3 | TidbiTs® | Temperature |
| | | 105SRA1DO | 11.8 | Onset DO Logger | DO/Temperature |
| | | 105SRA01T | 10.2 | TidbiTs® | Temperature |
| 1 | Yreka Creek to Shasta River Mouth | 105YCA01T* | SR 7.3; YC 0.6** | TidbiTs® | Temperature |
| | | 105SRTM01DO | 5.3 | D-Opto | DO/Temperature |
| | | 105SRL1DO | 0.6 | Onset DO Logger | DO/Temperature |

* Site was located on tributary to Shasta River

** River miles are provided both for where the tributary meets the mainstem as well as tributary river mile for the monitoring site.

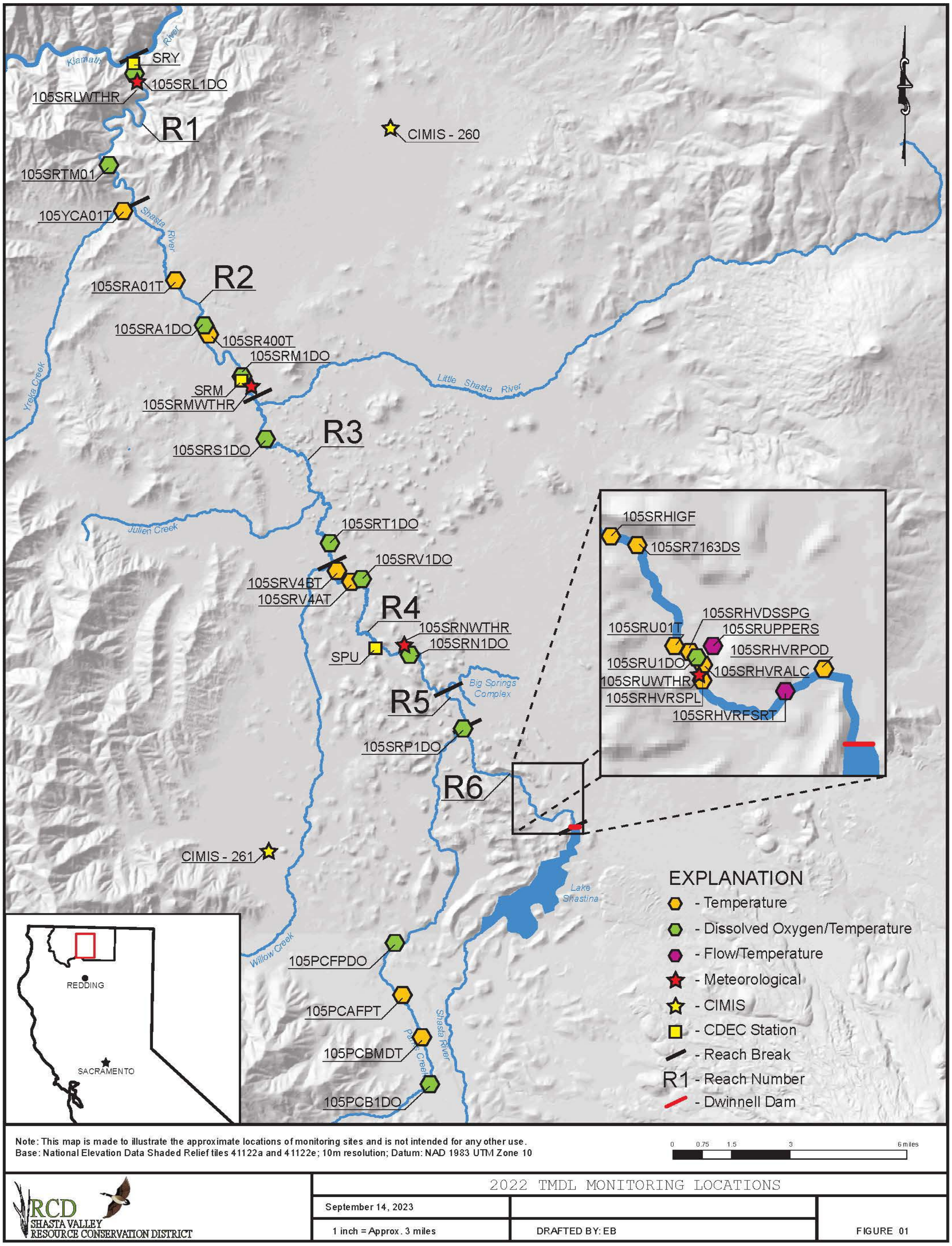


**Figure 1. Map of 2022 temperature, DO, flow, meteorological and CDEC monitoring locations.**

# METHODS

## DISSOLVED OXYGEN SAMPLING

Dissolved Oxygen (DO) and temperature were measured at twelve sites (Table 1; Figure 1) using a combination of ZebraTech D-Opto Loggers, InSitu AquaTroll 600, and Onset HOBO U26 Dissolved Oxygen Loggers. All three sensor types use optical fluorescence sensing elements to measure DO in liquids. These DO loggers were housed in custom made canisters designed to suspend the logger above sediment in the benthic zone, and to maintain a stationary position in the river in high flow.

Where possible, DO loggers were placed in runs or pool tail-outs and within the thalweg or deepest part of the cross-section. D-opto loggers were downloaded, cleaned of bio-fouling and re-calibrated per manufacturer specifications every three weeks. Intervals of more than three weeks may have increased the risk of optical lens bio-fouling that may have caused the logger to record inaccurate measurements. AquaTroll 600 and HOBO U26 loggers were calibrated immediately prior to deployment and initialization of the RDO Cap, which expires seven months after initialization. HOBO U26 loggers were downloaded and cleaned of bio-fouling every three weeks. Independent measurements of DO and temperature were made at the monitoring locations each time the sensors were downloaded.

## TEMPERATURE SAMPLING

Temperature loggers were deployed at 14 sites (Table 1; Figure 1) in sets of two (paired for quality control) and housed in custom made canisters to protect them from direct sunlight. Where possible, temperature loggers were placed in runs or pool tail-outs and within the thalweg or deepest part of the channel cross-section.

In 2022, temperatures were recorded at 15-minute intervals (D-Opto loggers, U26 loggers, AquaTroll 600, and Onset Tidbits) at temperature monitoring locations as identified in Table 1 and on Figure 1. The 7-day average daily maximums (7-DAD Max) were calculated as the 7-day running average of daily maximum temperatures. Dates reported correspond with the middle date of this running average.

In addition to the 7-DAD Maximum temperature graphs are an analysis of the Maximum Weekly Average Temperatures (MWAT) and Maximum Weekly Maximum Temperatures (MWMT) for each site. The use of MWAT values was first proposed by the National Academy of Sciences (NAS) in 1972 as a long-term standard for preventing chronic sub-lethal effects for a variety of fish species. However, the MWAT is not calculated consistently by all researchers and agencies. The MWAT, as reported by Carter (2005), is the highest single value of the seven-day moving average temperature. Likewise, the MWMT is the highest seasonal or yearly value of the daily maximum temperatures over a running seven-day consecutive period. This methodology for calculating MWAT and MWMT was followed in this report and calculated for the entire irrigation season. The absolute maximum is calculated as the highest daily maximum temperature for the entire irrigation season.

The objective of the MWAT index is to provide an upper temperature standard that is protective of juvenile salmonids during the summer rearing period. The MWAT is a common measure of chronic (i.e. sub-lethal) exposure, the absolute maximum is a measure of acute (i.e. lethal) exposure, and the MWMT is a common measure of both chronic and acute effects (Carter 2005). The MWMT describes the maximum temperatures in a stream, but the value is not overly influenced by the maximum temperature of a single day. Table 2 describes the MWMT for the Shasta River during various life stages of coho salmon (Carter 2005). Refer to Carter (2005) for additional information regarding temperature effects on various life stages of Chinook and steelhead salmonids.

**TABLE 2. MWMT FOR DIFFERENT LIFE STAGES OF COHO SALMON (REPRODUCED FROM CARTER 2005).**

| Coho Life Cycle | | | | | | |
|---|---|---|---|---|---|---|
| | **Adult Migration** | **Spawning** | **Egg Incubation** | **Fry Emergence** | **Juvenile Rearing** | **Juvenile Out-migration** |
| **Coho Periodicity** | Sept 15 – Jan 31 | Nov 1 – Jan 31 | Nov 1 – Mar 31 | Feb 1 – Apr 15 | Jan 1 – Dec 31 | Feb 15 – July 15 |
| **MWMT Criterion (°C)** | 20 | 13 | 13 | 13 | 18 | 18 |

In addition to water temperature and dissolved oxygen sampling, meteorological and discharge data were collected and used to inform and evaluate water temperature and dissolved oxygen sampling. ambient air temperature, precipitation, and solar radiation data were retrieved from four field meteorological stations, located along the Shasta River between Dwinnell Reservoir and the Klamath River, to inform water temperature and DO results in this study.

# RESULTS AND DISCUSSION

## METEOROLOGICAL CONDITIONS

Meteorological data is measured at several locations throughout the Shasta River watershed. Regional snowpack and snow water content are measured annually as part of the Department of Water Resources Statewide Monitoring Network, which partners with more than 50 state, federal, and private agencies. The cooperating agencies take snow and water content measurements in January, February, and March. The USFS continues to collect monthly data for April and May. Results from each monthly survey at a given site are tabulated and form an average of a region's annual snowpack and water content, which gives forecasters and resource managers the ability to make important management decisions. These data are also compared against a running historical average for the site for the given month. Regional data are summarized annually by the US Forest Service Shasta-Trinity National Forest and presented in Table 3. For the last several years, the region has received significantly less water in the upper watershed.

**TABLE 3. REGIONAL SNOW DEPTH AND WATER CONTENT FOR THE MONTH OF APRIL OF 2022, 2021, AND 2020.**

| Course | Elevation (ft. asl) | 2022 Snow (in) | 2022 Water (in) | 2021 Snow (in) | 2021 Water (in) | 2020 Snow (in) | 2020 Water (in) | Historic Avg Snow (in) | Historic Avg Water (in) |
|---|---|---|---|---|---|---|---|---|---|
| Horse Camp | 7900 | 30 | 13 | 68.5 | 26.5 | 69.0 | 22.5 | 117.44 | 52.5 |
| Sand Flat | 6800 | 9.5 | 4 | 63.5 | 26.5 | 57.0 | 24.0 | 97.84 | 40.72 |
| North Fork | 6900 | 0 | 0 | 42.5 | 22.0 | 26.0 | 7.0 | 59.26 | 24.06 |
| Grey Rocks | 6200 | 23.5 | 10.5 | 73.0 | 52.5 | 57.0 | 21.5 | 104.33 | 45.71 |
| Sweetwater | 5850 | 5.5 | 2.5 | 44.5 | 10.5 | 13.5 | 5.0 | 37.11 | 13.53 |
| Parks Creek | 6700 | 22 | 10 | 66.5 | 25.5 | 37.0 | 14.0 | 86.57 | 34.49 |
| Deadfall Lakes | 7200 | 19.5 | 8.4 | 55.0 | 22.0 | 45.0 | 15.5 | 73.87 | 31.57 |
| **Average of Courses Sampled (in)** | | **16** | **6.9** | **59.1** | **26.5** | **43.5** | **15.6** | **81.5** | **34.3** |
| **Percent of Historic Average** | | **19%** | **20%** | **72%** | **76%** | **53%** | **45%** | | |

Note: Sites within Shasta River watershed are highlighted in light blue

In 2019, the SVRCD utilized SWCG Prop 1 funds through the DWR Sustainable Groundwater Planning (SGWP) grant program to implement two Hydrologic Data Acquisition System (HyDAS) stations in the upper Shasta River watershed. The stations are located on the north flank of Mt. Shasta, and the Goosenest. These stations provide snow depth and snow water content in real time. However, these stations do not have established snow courses and their small sample size prevents a comparison to an historical site average.

The SVRCD also utilized SGWP Prop 1 funds in 2019 to implement two California Irrigation Management Information System (CIMIS) stations. CIMIS stations collect and utilize meteorological data to provide accurate estimates of Evapotranspiration (ET) for a reference crop like alfalfa or grass. Through 2021, the SVRCD staff maintained the CIMIS station on a monthly basis. In addition to co-operating the CIMIS stations, the SVRCD cooperated and maintained four meteorological stations donated by the NCRWQCB. These stations are located within the riparian corridor of the Shasta River between Dwinnell Reservoir and the confluence with the Klamath River. These four stations are not used to estimate ET and are primarily used to record accurate air temperature and precipitation measurements adjacent to the Shasta River. Where available, annual precipitation and ET totals from the CIMIS stations, and precipitation totals from the NCRWQCB meteorological stations are presented for 2022 and the 2022 irrigation season in Table 4.

**TABLE 4 . METEOROLOGICAL TOTALS FOR SVRCD COOPERATED CIMIS AND WEATHER STATIONS.**

| Station ID | Station Name or Reach | Elevation (ft. asl)* | 2022 Total Precip (in) | 2022 Total ET (in) | 4/1/22 - 9/30/22 Total Precip (in) | 4/1/22 - 9/30/22 Total ET (in) |
|---|---|---|---|---|---|---|
| 105SRLWTHR | Reach 1 | 2050 | n/a | n/a | 3.51 | n/a |
| 260 | Montague | 2265 | 6.88 | 49.95 | 2.55 | 38.57 |
| 105SRMWTHR | Reach 2 | 2465 | 7.19 | n/a | 2.36 | n/a |
| 105SRNWTHR | Reach 4 | 2555 | n/a | n/a | 10.15 | n/a |
| 105SRUWTHR | Reach 6 | 2665 | n/a | n/a | n/a | n/a |
| 261 | Gazelle | 2745 | 4.81 | 49.17 | 3.14 | 37.71 |

*WGS-84 Datum

Note: CIMIS Stations are highlighted in light blue

Ambient air temperatures recorded at the CIMIS and NCRWQCB meteorological stations were examined to assist with analysis of seasonal and inter-annual river temperature and dissolved oxygen trends. As air temperatures increase into the summer, water temperatures in the Shasta River generally increase while dissolved oxygen levels decrease. An exception to this trend is in the upper Shasta River and Big Springs Creek where extensive macrophyte growth during mid and late summer minimizes increases in water temperature (Jeffres et al. 2009), although it is not clear if this exception is dependent on a normal water year. Additionally, tailwater returns to the river via overland flows are greatly affected by air and ground surface temperatures, and can subsequently have an impact on instream temperature and dissolved oxygen demands.

Temperature, rainfall, and solar radiation data from site 105SRMWTHR is shown in Figure 2. Site 105SRMWTHR is centrally located within the Shasta River watershed (see Figure 1). Meteorological data display warm-dry weather during the summer season and cooler temperatures and increased precipitation during the winter months, typical of a Mediterranean climate. Incursions in the maximum daily solar radiation occur during the winter months when cloud cover is heavy and prevalent. During the summer months the peaks in the maximum daily solar radiation are coincident with decreases in daily maximum air temperatures. Precipitation data values for each day have been summed and multiplied by 100 for graphical purposes. Precipitation events at this site coincide with reductions in maximum daily air temperature and relative peaks in daily solar radiation values.

On September 2, 2022 the Mill Fire ignited near the City of Weed, CA burning 3,935 acres, destroying 118 structures, and damaging 26 more. The fire also caused two fatalities of residents near the point of ignition just south of Highway 97. The fire was fully contained on September 13, 2022.

On September 2, 2022 the Mountain Fire ignited near the town of Gazelle, CA burning 13,440 acres, destroying 4 structures. The fire burned intensely north of Gazelle Callahan Road in both the Shasta and Scott River Watersheds. The fire was fully contained on September 11, 2022.

Air and water temperatures within the Shasta River Watershed were also impacted by smoke associated with the McKinney Fire (60,138 acres) and Yeti Fire (7,886 acres), in Siskiyou County, CA. Both fires ignited on July 29, 2022 and burned into early September.

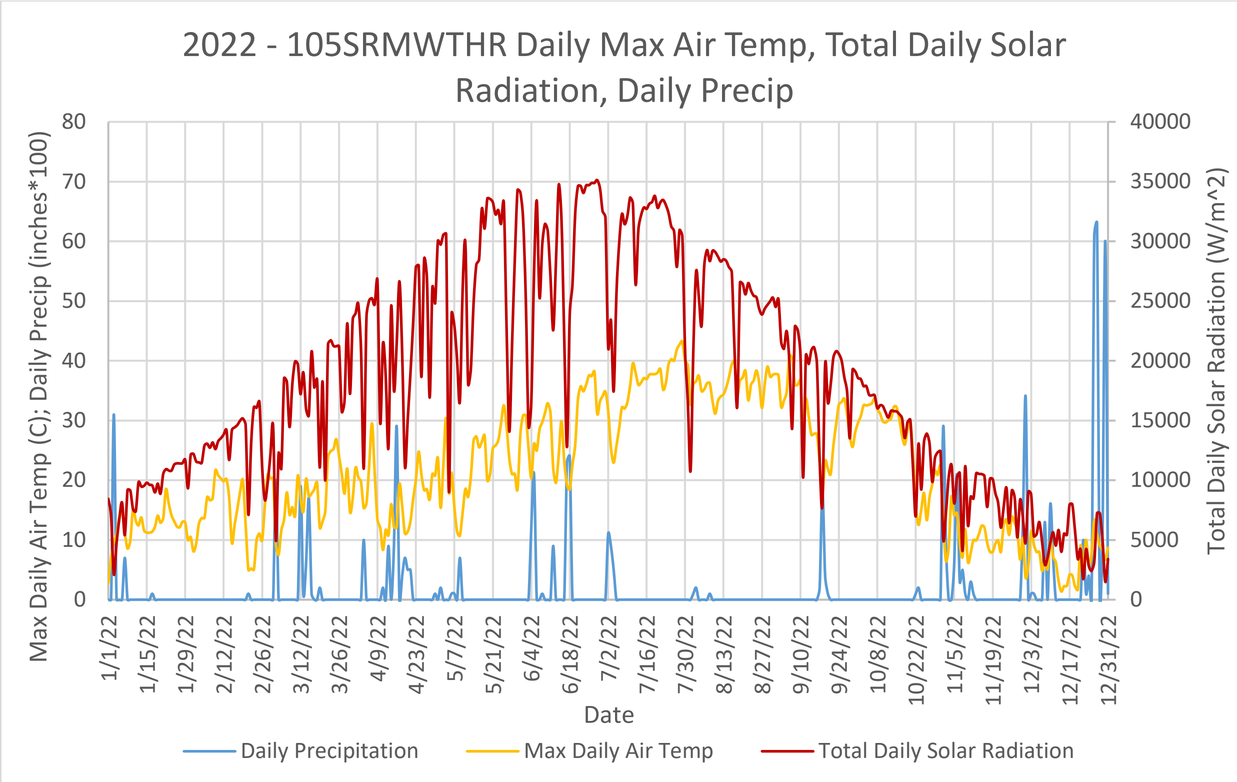


**FIGURE 2. 2022 METEOROLOGICAL DATA FROM SITE 105SRMWTHR.**

## SHASTA RIVER FLOW

Publicly available flow data recorded at fifteen-minute intervals at US Geologic Survey rated stream gauge sites near the cities of Montague and Yreka, and Department of Water Resources rated stream gauge downstream of Big Springs Creek (see Figure 1) are shown in Figure 3. 2022 continuous Shasta River discharge and SWRCB minimum instream flow criteria. Figure 3 and displays discharge of the Shasta River in cubic feet per second. Due to persistent drought conditions within the region, on May 10, 2021 California Governor Gavin Newsome declared a drought emergency for 41 counties, including Siskiyou County. Despite voluntary reductions in water use by stakeholders within the Shasta Valley, on August 17, 2021 the State Water Board adopted an emergency regulation which became effective on August 30, 2021. On June 21, 2022 the State Water Board readopted emergency instream flow requirements with modified flow levels which became effective on July 29, 2022. This emergency legislation establishes emergency drought minimum flows in the Shasta River watershed as measured at the Shasta River gauge near Yreka. The corresponding monthly emergency flow volume is shown in Figure 3as a red line, and given in Table 5. In order to meet the emergency drought minimum flow volumes set forth in the legislation, certain water rights are being curtailed by the State Water Board.

**TABLE 5. SHASTA RIVER EMERGENCY MIN FLOW REQUIREMENT FOR SRY, 2022 EFFECTIVE 8/30/21 TO 7/28/22**

| Shasta River Emergency Drought Minimum Flow Requirements | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| 135 | 135 | 135 | 70 | 50 | 50 | 50 | 50 | 50 | 125 | 150 | 150 |

**TABLE 6. SHASTA RIVER EMERGENCY MIN FLOW REQUIREMENT FOR SRY, 2022 EFFECTIVE 7/29/22 TO 7/30/23**

| | | Shasta River Emergency Drought Minimum Flow Requirements | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | FEB | MAR<br>1-24 | MAR<br>25-31 | APR | MAY | JUN | JUL | AUG | SEP<br>1-15 | SEP<br>16-30 | OCT | NOV | DEC |
| ~~135~~<br><u>125</u> | ~~135~~<br><u>125</u> | ~~135~~<br><u>125</u> | <u>105</u> | 70 | 50 | 50 | 50 | 50 | 50 | 75 | ~~125~~<br><u>105</u> | ~~150~~<br><u>125</u> | ~~150~~<br><u>125</u> |

Note: Values are in cubic feet per second and measured at the Shasta River Gauge near Yreka. Values with strikethroughs are 2021 emergency flow targets. 2022 emergency flow targets are underlined below.

Typically, between the months of October through March, the SRY gauge consistently records greater discharge than the SRM gauge. Between the months of April through September, this relationship inverts and the SRM gauge consistently reports higher flows than the SRY gauge. Though summers are warm and dry, significant reductions in flow volumes at both SRM and SRY gauges occur on April 1 coinciding with the onset irrigation season and surface water diversion. Flow volumes typically increase significantly on October 1, coinciding with the end of irrigation season and the return of cooler days and increased precipitation. However, in 2022 flow volumes were slow to rebound. Flow volumes both in and outside of irrigation season are markedly lower than in previous years, and emergency flow targets were difficult to meet even after irrigation ceased. This is likely due to the compounding effects of continued drought and limited water supplies in the upper watershed.

According to USGS data, flows at SRY reached an annual low of 12.2 cfs on August 24, 2022, and an annual high of 241 cfs on December 27, 2022. The annual low occurred between August 17, and August 25, 2022 during a period when diversion occurred in violation of the emergency flow requirement. Total discharge measured at the Shasta River gauges near Montague, Yreka, and downstream of Big Springs Creek is presented in Table 6.

**TABLE 7. 2022 SHASTA RIVER ANNUAL DISCHARGE AND IRRIGATION SEASON DISCHARGE TOTALS.**

| Gauge | Total Discharge 10/1/21 – 9/30/22 | Total Discharge 4/1/22 – 9/30/22 | Total Emergency Minimum Discharge 10/1/21 – 9/30/22 | Total Emergency Minimum Discharge 4/1/22 – 9/30/22 |
|---|---|---|---|---|
| SPU | 67,157 af | 28,287 af | n/a | n/a |
| SRM | 68,846 af | 20,957 af | n/a | n/a |
| SRY | 72,194 af | 20,174 af | 70,000 af | 20,078 af |

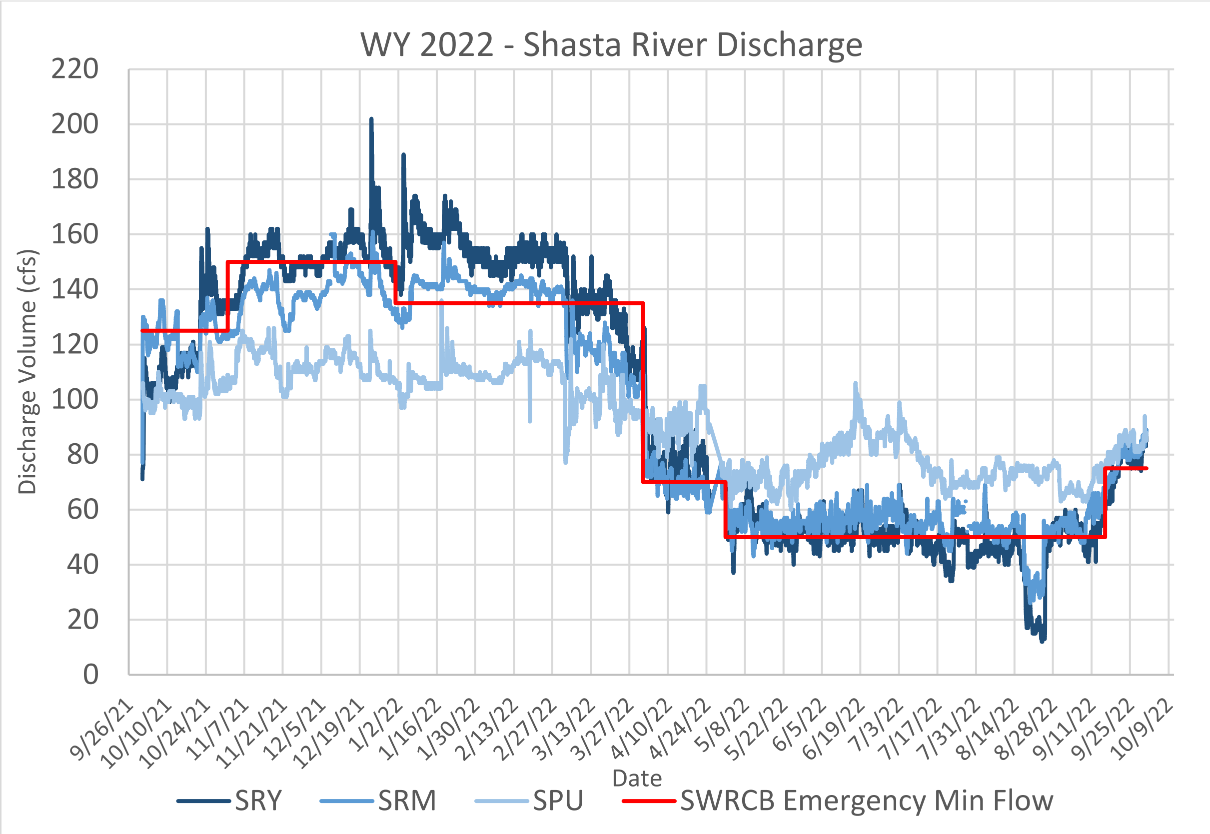


**Figure 3. WY 2022 continuous Shasta River discharge and SWRCB minimum instream flow criteria.**

## TEMPERATURE RESULTS

Temperature was measured at 26 sites on the Shasta River and its tributaries in 2022. Temperatures in the Shasta River and its tributaries fluctuate daily and are moderate in comparison to air temperatures due to the high specific heat capacity of water.

Table 7 summarizes 2022 MWMT, MWAT, Absolute Maximum temperatures recorded over the course of the period monitored at each site in the Shasta River, Parks Creek, and Yreka Creek. A percentage has been calculated for each site corresponding to the number of days where the site exceeded the juvenile coho criterion of 18°C. All reach 5 sites are located on Parks Creek. Site ID105YCA01T in Reach 1 is located on Yreka Creek. The general trend of 7-DAD Max temperatures among all sites measured is a continuous rise that appears to correlate with seasonal warming, and late season decreases that correlate with cooling air temperatures and decreased solar radiation from shorter days, regional wildfires, and/or increased instream vegetation. All sites saw a peak in 7-DAD Max temperatures during the month of July, before the onset of shorter days and the smoke from regional and local fires.

**TABLE 8. 2022 SHASTA RIVER MWMT, MWAT, ABSOLUTE MAX TEMP, AND PERCENT OF DAYS EXCEEDED 18°C.**

| Site ID | Reach | MWMT (°C) | MWAT (°C) | Abs. Max Temp (°C) | % Days Exceeded 18°C |
|---|---|---|---|---|---|
| 105SRHVRPOD | 6 | 21.91 | 19.32 | 22.46 | 66 |
| 105SRHVRSPL | 6 | 24.12 | 20.14 | 25.52 | 58 |
| 105SRHVRALC | 6 | 17.88 | 16.74 | 18.17 | 0 |
| 105SRU1DO | 6 | 24.13 | 20.05 | 27.70 | 78 |
| 105SRHVDSSPG | 6 | 24.08 | 20.24 | 25.48 | 70 |
| 105SRU0IT | 6 | 24.16 | 20.53 | 25.50 | 69 |
| 105SR7163DS | 6 | 24.80 | 22.26 | 26.03 | 73 |
| 105SRHIGF | 6 | 25.35 | 22.58 | 26.40 | 73 |
| 105PCB1DO | 5 | 22.98 | 21.25 | 23.41 | 75 |
| 105PCBMDT | 5 | 23.64 | 19.42 | 24.53 | 58 |
| 105PCAFPT | 5 | 25.86 | 22.77 | 27.18 | 68 |
| 105PCFPDO | 5 | 29.05 | 24.40 | 30.55 | 83 |
| 105SRP1DO | 5 | 26.30 | 21.97 | 27.22 | 84 |
| 105SRN1DO | 4 | 22.14 | 18.44 | 22.77 | 67 |
| 105SRV1DO | 4 | 20.65 | 19.69 | 21.39 | 50 |
| 105SRV4AT | 4 | 21.53 | 20.40 | 22.34 | 49 |
| 105SRV4BT | 4 | 21.96 | 20.62 | 22.70 | 46 |
| 105SRT1DO | 3 | 22.91 | 20.93 | 23.86 | 42 |
| 105SRS1DO | 3 | 25.34 | 22.72 | 26.14 | 69 |
| 105SRM1DO | 2 | 24.82 | 23.09 | 25.53 | 67 |
| 105SR400T* | 2 | 22.62 | 21.54 | 22.96 | 66 |
| 105SRA1DO | 2 | 25.40 | 23.79 | 26.89 | 67 |
| 105SRA01T | 2 | 26.25 | 24.10 | 27.80 | 67 |
| 105YCA01T | 1 | 21.98 | 20.57 | 22.75 | 44 |
| 105SRTM01DO | 1 | 26.74 | 24.66 | 28.07 | 69 |
| 105SRL1DO | 1 | 27.24 | 25.13 | 28.54 | 61 |

*MWMT, MWAT, and Absolute Max Temperature for 2022 at 105SR400T is artificially low due to sensor burial in late July when temperatures were highest. Burial attenuates diurnal fluctuation and daily maximum temperatures are not accurately accounted for.

## LONGITUDINAL ANALYSIS

Longitudinal MWMT data from 2017 to 2022 is shown below. In 2022, 105SR400T was frequently buried in soft sediment and did not accurately record the highest water temperatures achieved during late July and early August. In 2021, 105SRN1DO was not monitored, and data is not reported for that year. Additionally, in 2019, the data from points 105SRTM01DO and 105SRS1DO is not available.

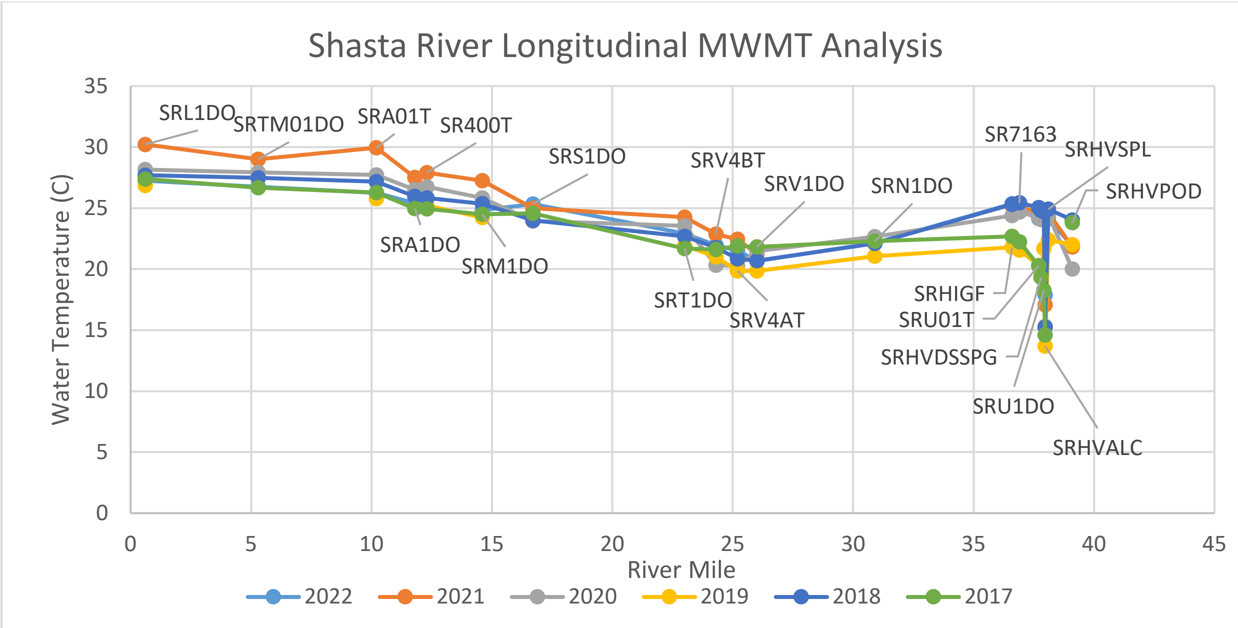


**FIGURE 4. LONGITUDINAL MWMT DATA FOR LONG TERM SHASTA RIVER TEMPERATURE SITES, 2017-2022.**

Longitudinal MWAT data from 2017 to 2022 is listed below. In 2022, 105SR400T was frequently buried in soft sediment and did not accurately record the highest water temperatures achieved during late July and early August. In 2021, 105SRN1DO was not monitored, so that data point is not included. Additionally, in 2019, the data from points 105SRTM01DO and 105SRS1DO is not available.

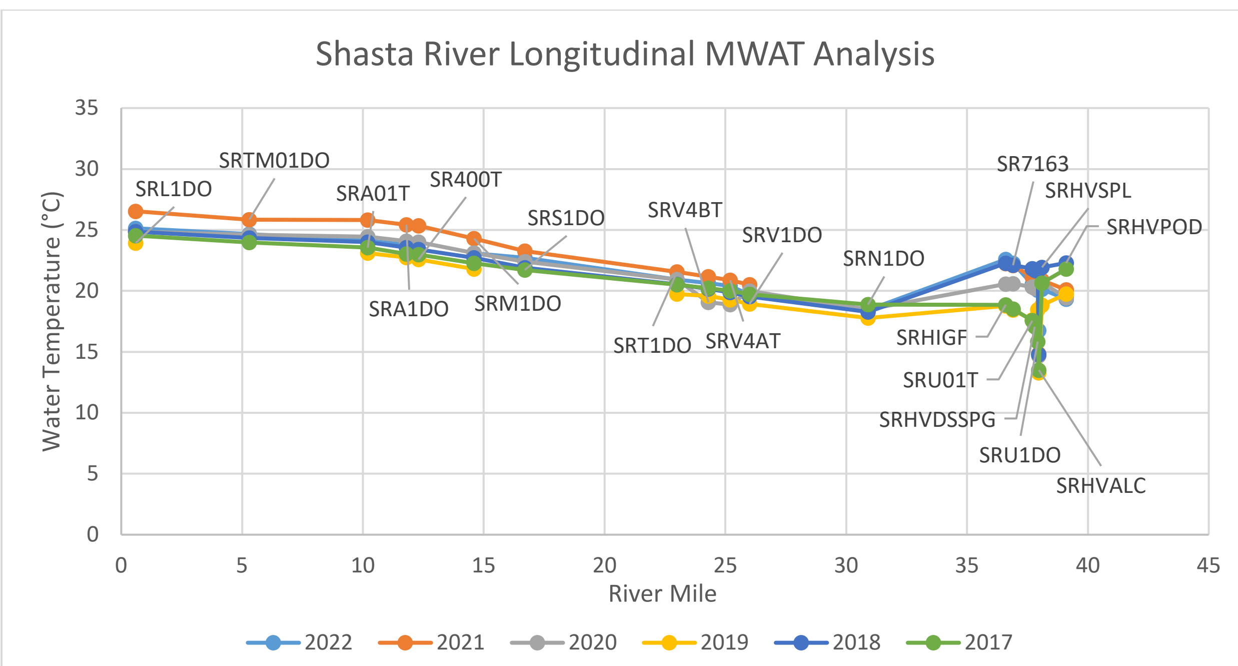


**FIGURE 5. LONGITUDINAL MWAT DATA FOR LONG TERM SHASTA RIVER TEMPERATURE SITES 2017-2022.**

Longitudinal Max Temp Data from back to 2017 is listed below. In 2022, 105SR400T was frequently buried in soft sediment and did not accurately record the highest water temperatures achieved during late July and early August. In 2021, 105SRN1DO was not monitored, so that data point is not included. Additionally, in 2019, the data from points 105SRTM01DO and 105SRS1DO is not available.

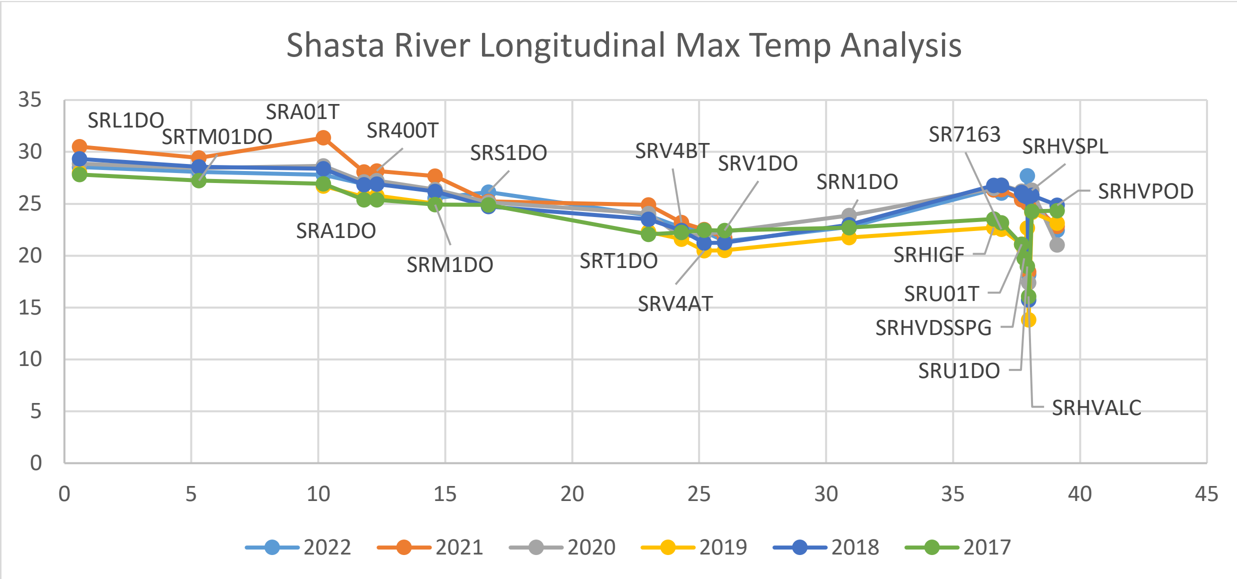


**FIGURE 6. LONGITUDINAL ABSOLUTE MAX TEMPS FOR LONG TERM SHASTA RIVER TEMPERATURE SITES 2017-2022.**

## REACH 1

Figure 7 displays MWMT criterion for juvenile coho salmon rearing and 7-DAD Max water temperatures at a site within the tributary Yreka Creek (105YCA01T) and sites downstream of the confluence of Yreka Creek within Shasta River Reach 1. 7-DAD Maximum temperatures at Yreka Creek are consistently cooler than all other sites within Reach 1 throughout the monitored period. The temperature gap between Yreka Creek and the Shasta River in Reach 1 widens substantially from mid-May through mid-August when Reach 1 7-DAD Maximum temperatures reach their maximums. Despite the cool water input from Yreka Creek, its flows are minimal, ranging from 1-4 cfs during the summer. 7-DAD Maximum temperatures throughout Reach 1 are generally consistent with each other, increasing only slightly in the downstream direction.

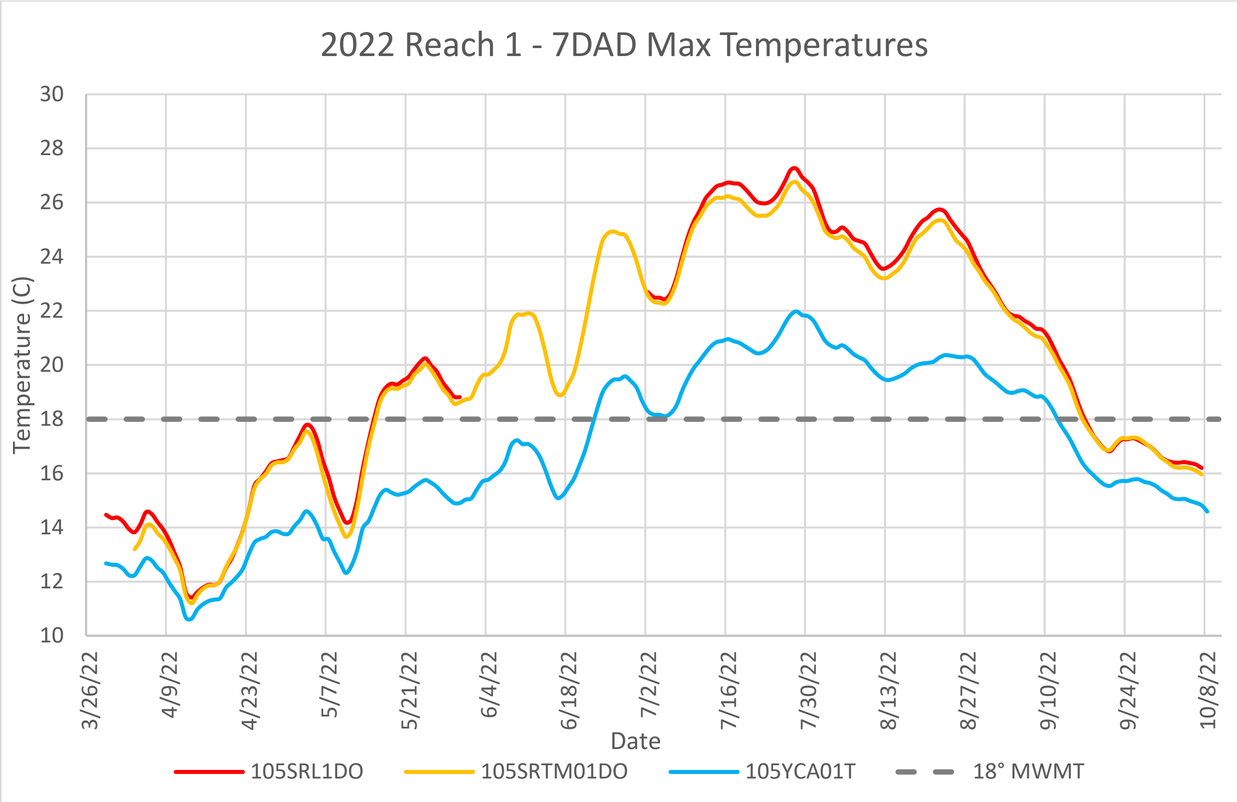


**FIGURE 7. 2022 7-DAD MAXIMUM TEMPERATURES AT REACH 1 (SHASTA RIVER AND YREKA CREEK SITES).**

## REACH 2

Figure 8 displays MWMT criterion for juvenile coho salmon rearing and 7-DAD Maximum water temperatures at sites within Shasta River Reach 2. These sites are located downstream of the USGS operated weir near Montague. Site 105SR400T is located on very soft sediment and increased summer flows continued to mobilize and deposit sediments, burying the sensor. Consequently, diurnal fluctuations were attenuated when the sensor was buried, and maximum daily temperatures were not accurately recorded. Aside from 105SR400T. Aside from 105SR400T, 7-DAD Maximum temperatures decrease slightly at all sites within Reach 2 until early June. After this inflection point, 7-DAD Maximum temperatures increase in the downstream direction.

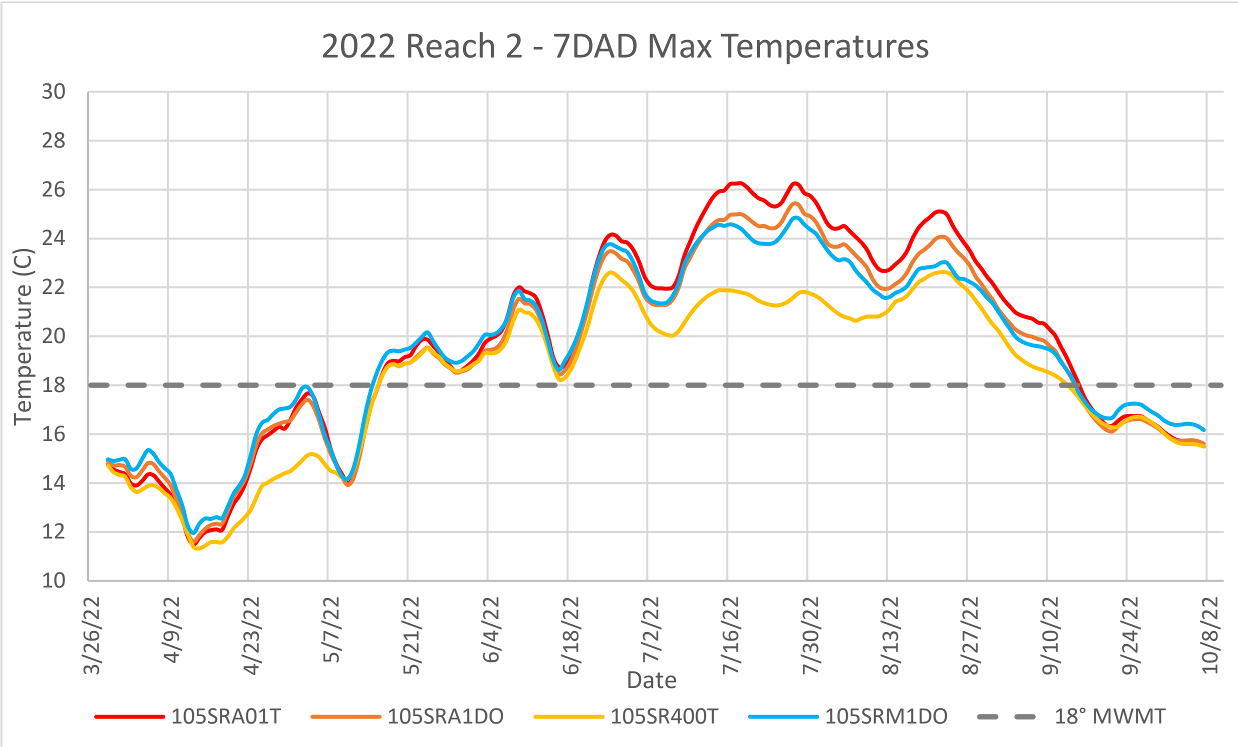


**FIGURE 8. 2022 7-DAD MAXIMUM TEMPERATURES FOR REACH 2, SHASTA RIVER.**

## REACH 3

Figure 9 displays MWMT criterion for juvenile coho salmon rearing and 7-DAD Maximum water temperatures at sites within Shasta River Reach 3. 7-DAD Maximum temperatures increased in the downstream direction.

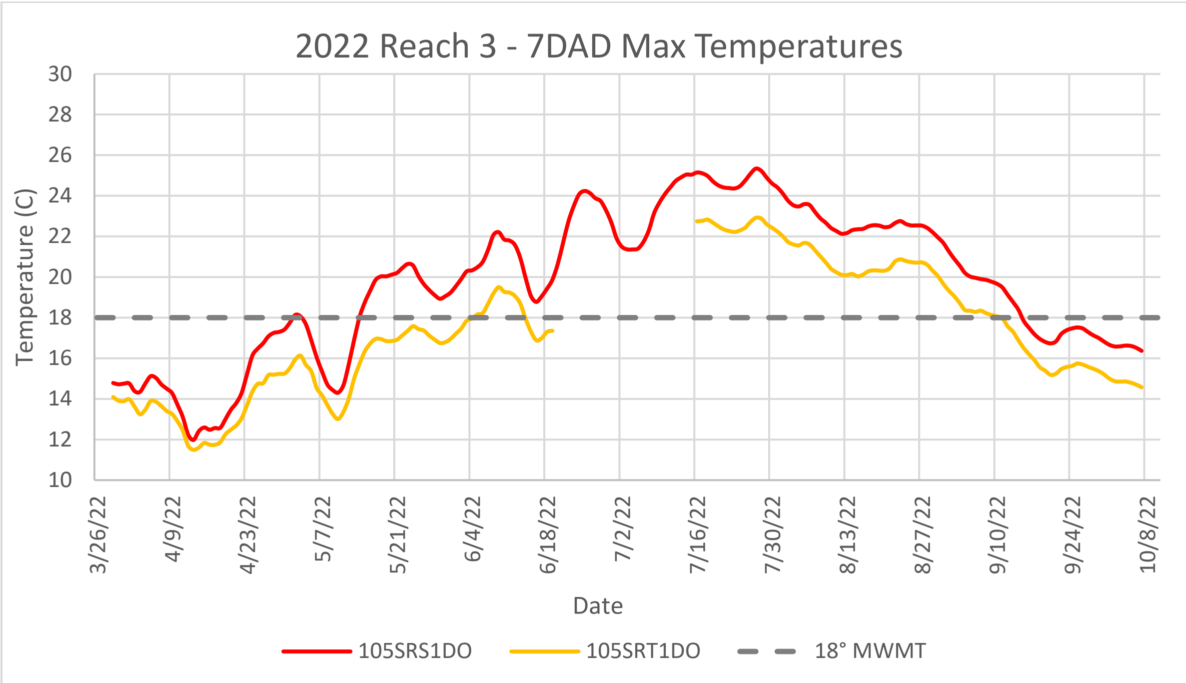


**FIGURE 9. 2022 7-DAD MAX TEMPERATURES FOR SHASTA RIVER, REACH 3.**

## REACH 4

Figure 10 displays MWMT criterion for juvenile coho salmon rearing and 7-DAD Maximum water temperatures at sites within Shasta River Reach 4. These sites are located downstream of the Big Springs Creek confluence, which adds a large volume (52 cfs average during July and August) of cold water to the Shasta River (Nichols et al. 2010). Consequently, 7-DAD Maximum water temperatures within this reach are attenuated by this large cold water input. Uniquely, 7-DAD Maximum water temperatures exhibit a downstream cooling trend from the beginning of irrigation season until approximately early July where an inflection occurs and the most downstream site (105SRV4BT) is warmer than the most upstream site (105SRN1DO), or closest to the confluence with Big Springs Creek, within the reach. However, the most upstream site (105SRN1DO) is always warmer than the second most upstream site (105SRV1DO).

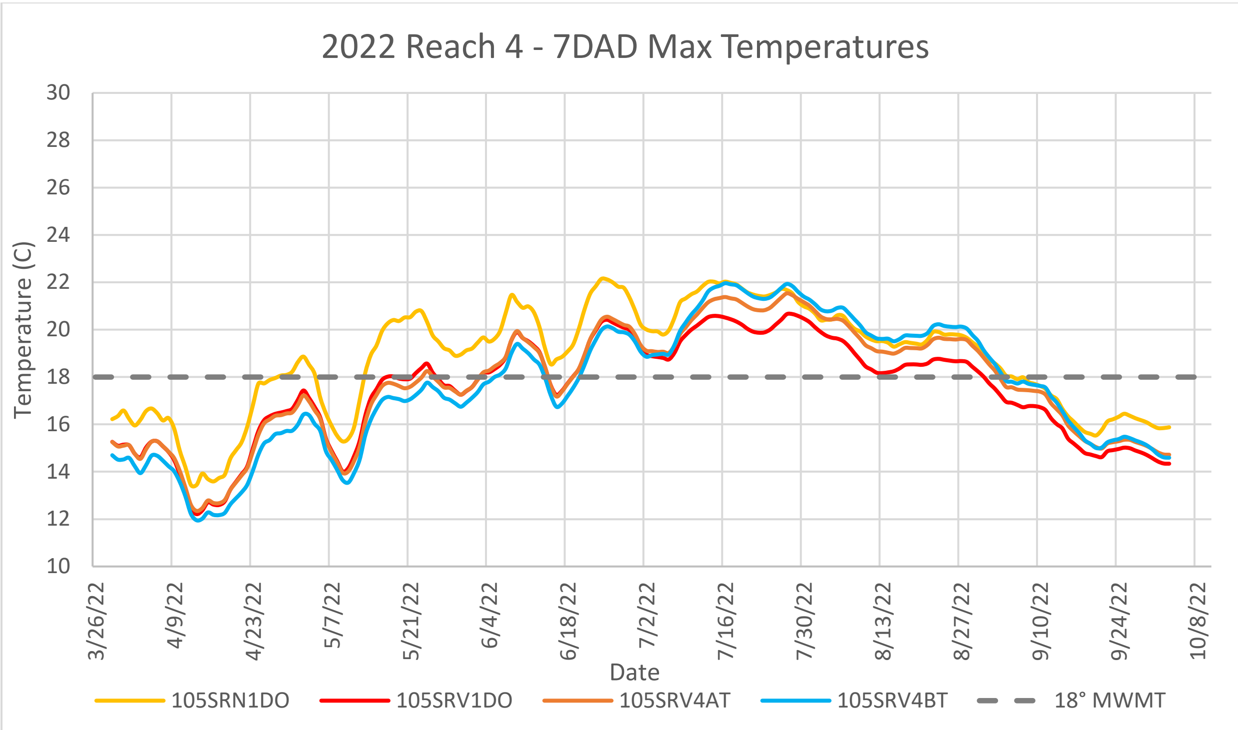


**Figure 10. 2022 7-DAD Max temperatures for Shasta River, Reach 4.**

## Reach 5

Figure 11 displays MWMT criterion for juvenile coho salmon rearing and 7-DAD Maximum water temperatures at sites within Shasta River Reach 5. The Shasta River is supplemented by flows from Parks Creek, and Hole in the Ground Creek in Reach 5. All sites within this reach are located on Parks Creek. Coho salmon utilize Parks Creek for migration, spawning and juvenile rearing (Chesney et al. 2009). Recent projects on Parks Creek, including the SVRCD's completion of the Parks Creek Fish Passage Project at the Interstate-5 bridge and Parks Creek Riparian Improvement Project which excluded livestock from the riparian area by constructing fencing and off channel stockwatering systems, are expected to improve water quality, habitat, and the mobility of aquatic species. Monitoring sites on Parks Creek span nearly twelve river-miles. Data at 105SRP1DO is missing between August 5 and September 2 due to sensor failure. 7-DAD Maximum temperatures generally track consistent with one another throughout the monitored period. However, temperatures decrease in the downstream direction between 105PCBDO and 105PCBMDT until early to mid-July at which point temperatures are similar until early September when temperatures at 105PCBMDT drop again. Temperatures between 105PCFPDO and 105SRP1DO increase in the downstream direction until early June at which point temperatures appear to decrease in the downstream direction. There is significant distance and cold groundwater or spring water inputs between 105PCFPDO and 105SRP1DO.

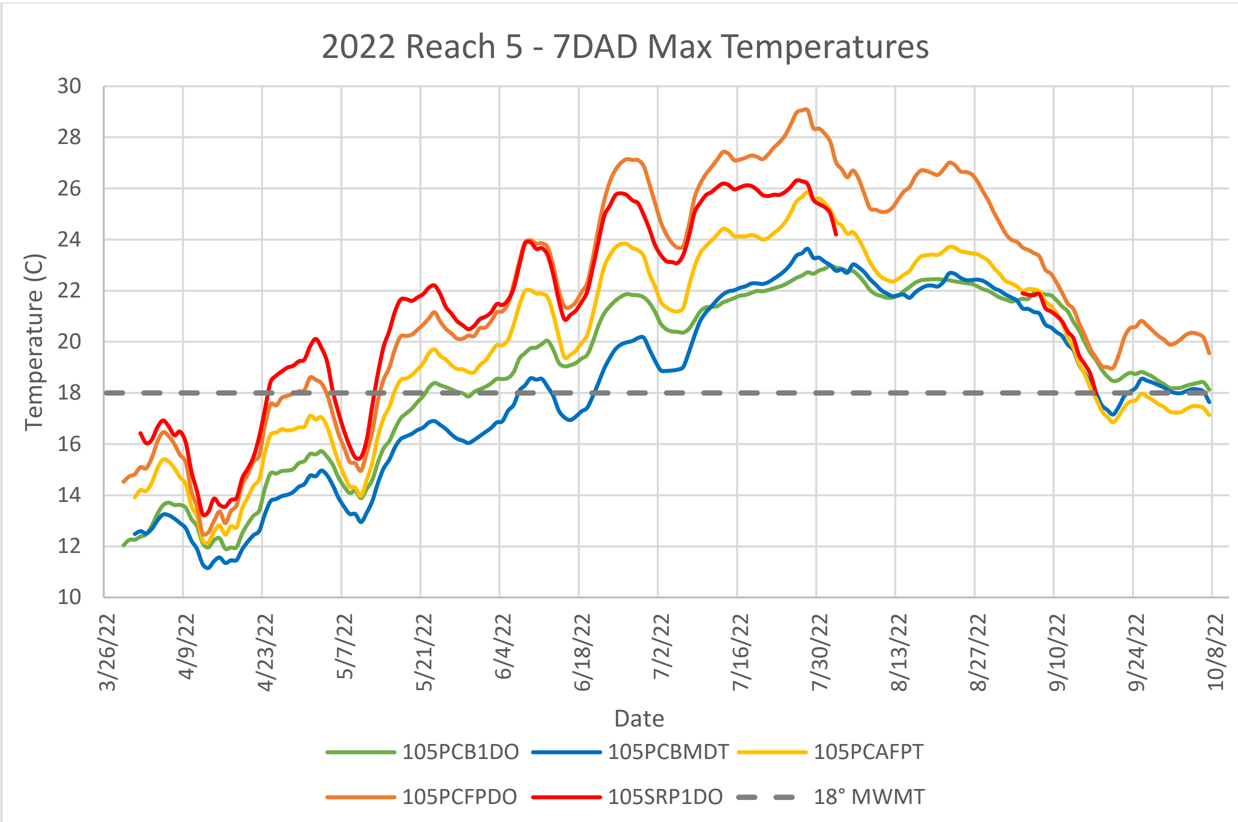


**FIGURE 11. 2022 7-DAD MAX TEMPERATURES AT PARKS CREEK REACH 5. ALL SITES ARE ON PARKS CREEK.**

## REACH 6

Figure 12 displays MWMT criterion for juvenile coho salmon rearing and 7-DAD Maximum water temperatures at sites within Shasta River Reach 6. This reach experienced a reduction in natural cold-water inputs as a result of drought conditions. Temperatures at most sites exceeded the MWMT juvenile coho criterion of 18 °C by late-April and consistently remained above it from early-May until early-September. 7-DAD Maximum temperatures generally increased in the downstream direction in this reach, with the exception of 105SRHVRALC which is located adjacent to a cold spring and likely records subsurface cold-water inputs to the Shasta River. Notably, the most upstream site in this reach, 105SRHVRPOD is cooler than the downstream sites, except for 105SRHVRALC, for most of the period monitored.

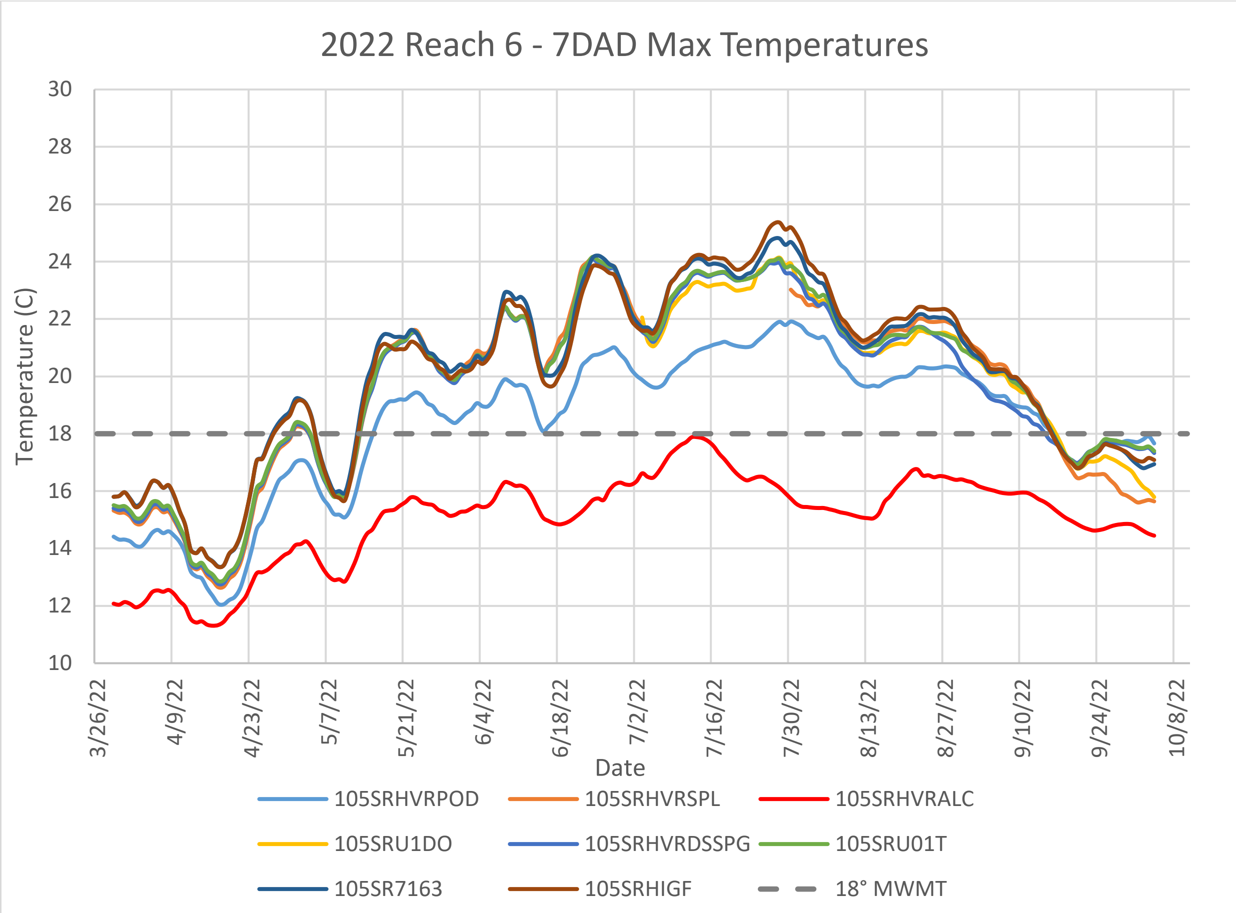


**FIGURE 12. 2022 7-DAD MAX TEMPERATURES AT MONITORING LOCATIONS IN THE SHASTA RIVER AT REACH 6.**

## DISSOLVED OXYGEN RESULTS

Dissolved oxygen (DO) levels in surface waters are not constant, but change throughout the day as oxygen is added (by photosynthesis and reaeration) and removed (by carbonaceous and nitrogenous deoxygenation, sediment oxygen demand, and respiration) from the water. Salmonids such as coho and Chinook salmon are particularly sensitive to low DO concentrations as DO regulates metabolic activity in these and many fish species (Fry 1971). The 2015 North Coast Water Quality Control Plan states that the minimum dissolved oxygen concentration in the Shasta River should not fall below 6 mg/L.

Diurnal DO fluctuations were recorded at twelve monitoring sites on the Shasta River and its tributaries. The lowest DO concentrations during a 24-hour period were between 23:00 and 7:00 when respiration occurs without photosynthesis, while the highest concentrations of DO were between 12:00 and 15:00 when peak photosynthesis occurs.

Figure 13 and Figure 14 display 2022 daily minimum dissolved oxygen measurements at all sites on the Shasta River and Parks Creek, respectively. The general trend among all Shasta River sites measured was a continuous reduction in the daily minimum DO from early April through late July due to seasonal warming and reduced flow volumes and velocities. The general trend among all Parks Creek sites measured was a slight increase in daily minimum DO from the beginning of the period of record through the end of April. The slight increase is likely from increased flows from spring runoff, and is followed by a steep reduction in the daily minimum DO level from the end of April through late July and August due to seasonal warming and reduced flow volumes and velocities, General trends for all Shasta River and Parks Creek sites are characterized by increasing DO levels from late July and August through early October due to cooling temperatures, decreased solar radiation from regional wild fires and increased production of instream vegetation (e.g., macrophytes).

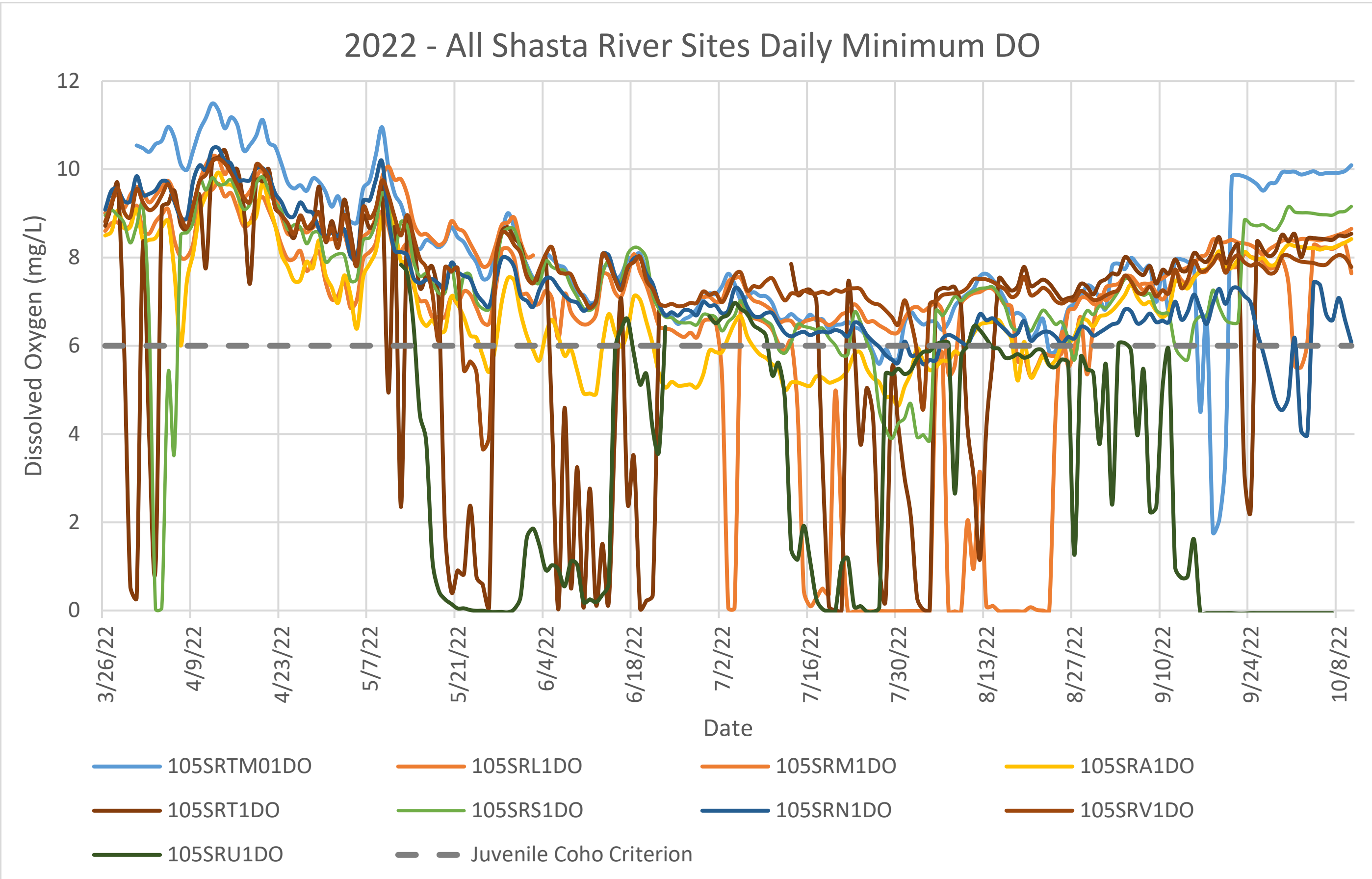


**FIGURE 13. 2022 DAILY MINIMUM DO AT ALL SHASTA RIVER SITES.**

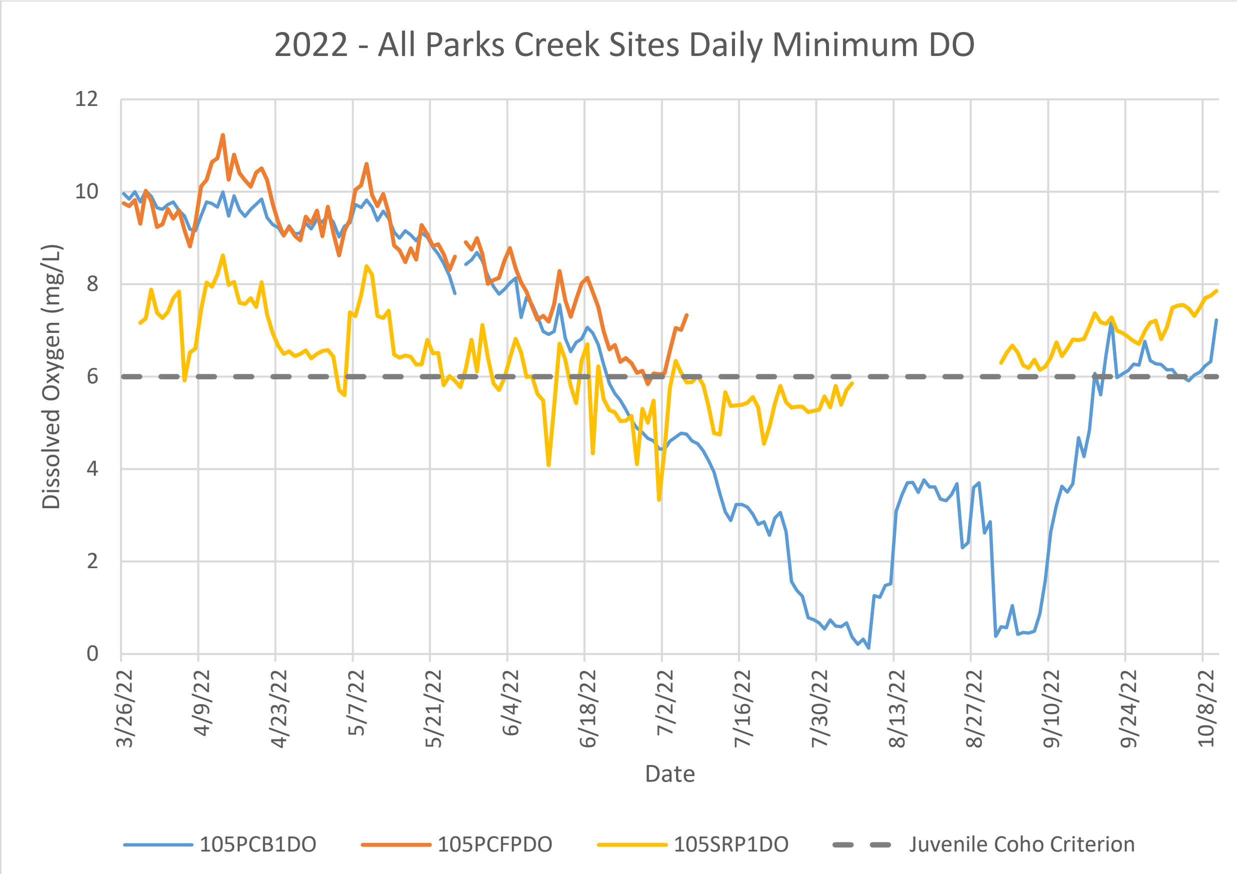


**FIGURE 14. 2022 DAILY MINIMUM DO AT ALL PARKS CREEK SITES.**

Table 8 displays the percentage of days that each site fell below the juvenile coho criterion (6 mg/L) during the 2022 irrigation season. Upstream sites on the Shasta River (105SRU1DO) and Parks Creek (105PCB1DO, 105SRP1DO) experienced a high percentage of days below the juvenile coho DO criterion. Middle River site (105SRA1DO) also experienced a significant percentage of days below the juvenile coho criterion. Persistent drivers of dissolved oxygen demand within the Shasta River Watershed are all exacerbated by drought conditions.

**TABLE 9. PERCENTAGE OF DAYS MONITORED WHERE DO LEVELS FELL BELOW 6 MG/L.**

| Reach | DO Monitoring Site | Percentage of Days DO Fell Below Juvenile Coho Criterion * | Days Site Occupied | Days of Quality Data |
|---|---|---|---|---|
| 1 | 105SRL1DO | 6.4 | 183 | 157 |
| | 105SRTM01DO | 6.0 | 183 | 183 |
| 2 | 105SRA1DO | 34.4 | 183 | 183 |
| | 105SRM1DO | 27.9 | 183 | 183 |
| 3 | 105SRS1DO | 12 | 183 | 183 |
| | 105SRT1DO | 32.5 | 183 | 163 |
| 4 | 105SRV1DO | 3.8 | 183 | 183 |
| | 105SRN1DO | 7.7 | 183 | 183 |
| 5 | 105SRP1DO | 38.2 | 183 | 157 |
| | 105PCFPDO | 1.0** | 97 | 96 |
| | 105PCB1DO | 49.7 | 183 | 183 |
| 6 | 105SRU1DO | 82.4ᵻ | 183 | 136 |

*Percentage is calculated from the total number of days the minimum fell below 6mg/L and days of quality data at a site

**Due to many days of missing data during August, the percentage is artificially low at this site

ᵻDO levels at this site are heavily impacted by a nearby groundwater spring inflow, which is typically oxygen depleted and the percentage at this site is not representative of this reach.

## Reach 1

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRL1DO is shown in Figure 15. DO and temperature equipment were deployed for 199 days, between March 26 and October 10, 2021. The Missing DO data between June 2 and June 29, 2022 was caused by D-Opto sensor failure DO sensor was replaced with Onset HOBO U26. DO levels fell below the juvenile coho criterion of 6 mg/L in 10 of the 157 days for which quality DO data was recorded during the 2022 irrigation season.

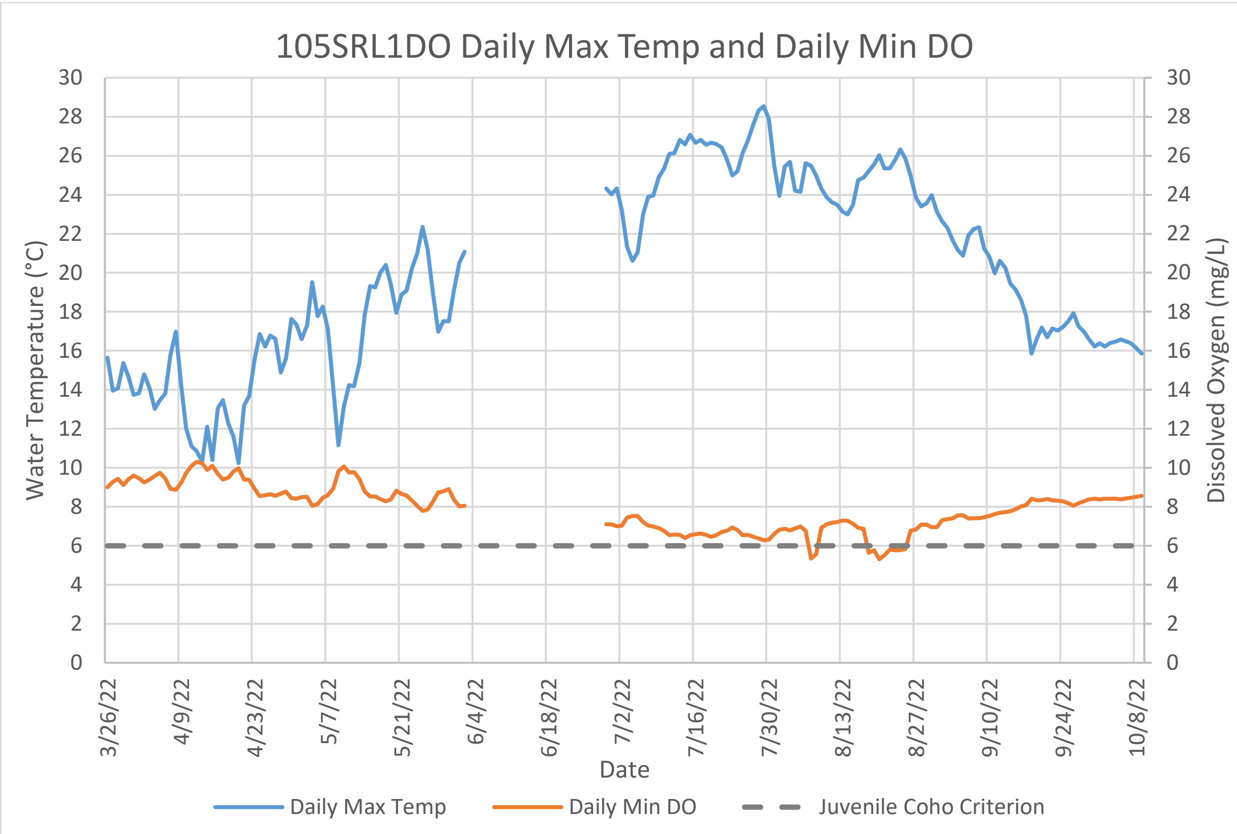


**Figure 15. 2022 daily maximum temperature and daily minimum at 105SRL1DO, Shasta River**

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRTM01DO is shown in Figure 16. DO and temperature equipment were deployed for 194 days, between March 31 and October 10, 2022. DO levels fell below the juvenile coho criterion of 6 mg/L in 11 of the 183 days for which quality DO data was recorded during the 2022 irrigation season.

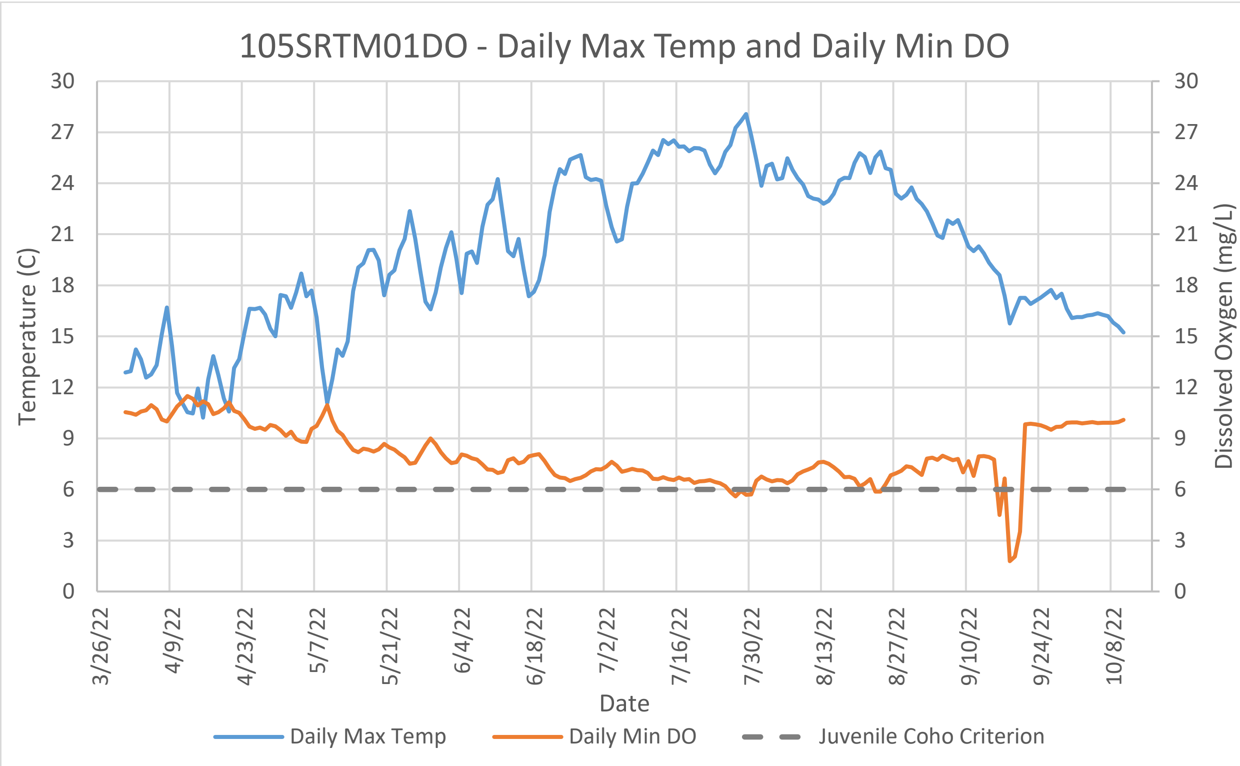


**FIGURE 16. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRTM01DO, SHASTA RIVER**

## REACH 2

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRA1DO is shown in Figure 17. DO and temperature equipment were deployed for 199 days, between March 26 and October 10, 2021. DO fell below the juvenile coho criterion of 6 mg/L in 63 of the 183 for which quality DO data was recorded during the 2022 irrigation season.

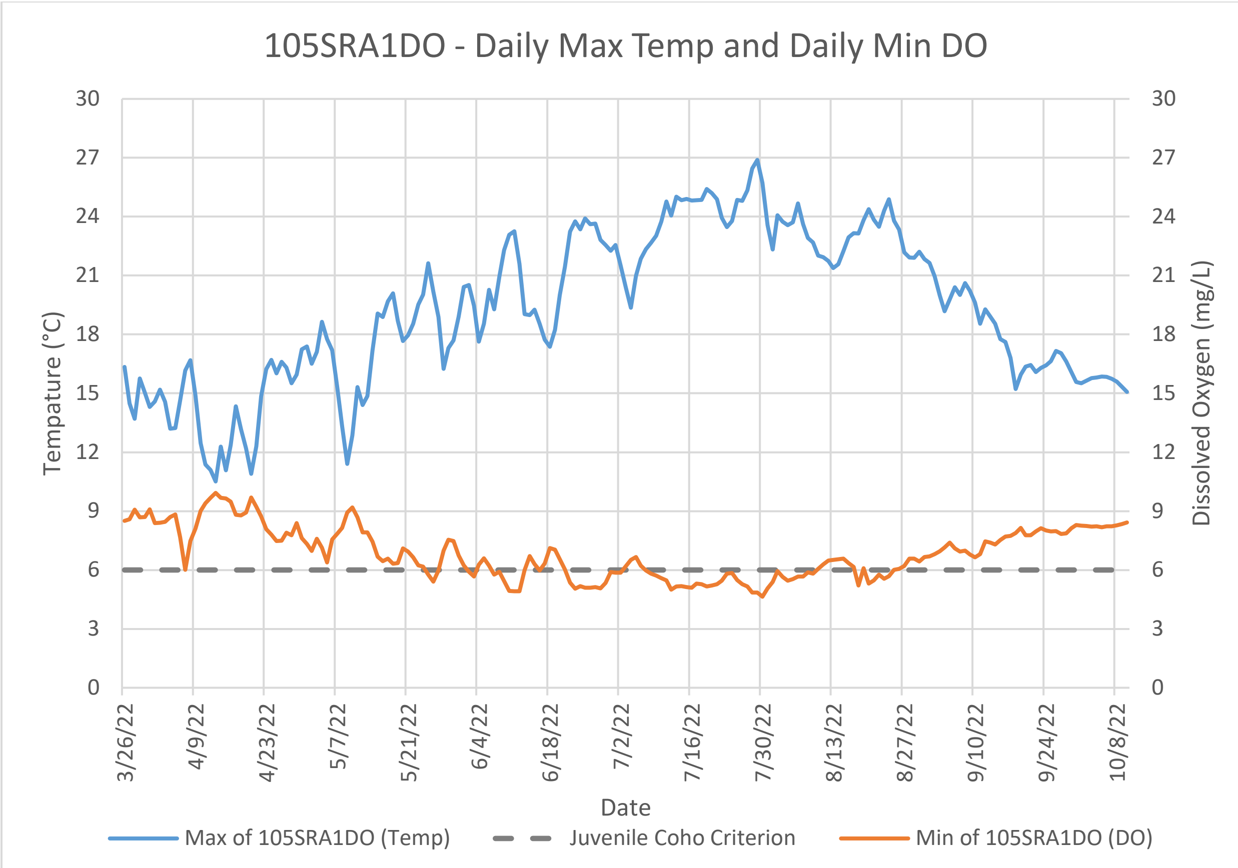


**FIGURE 17. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRA1DO, SHASTA RIVER**

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRM1DO is shown in Figure 18. DO and temperature equipment were deployed for 199 days between March 26 and October 10, 2021. DO fell below the juvenile coho criterion of 6mg/L in 51 of the 183 days for which quality DO data was recorded during the 2022 irrigation season.

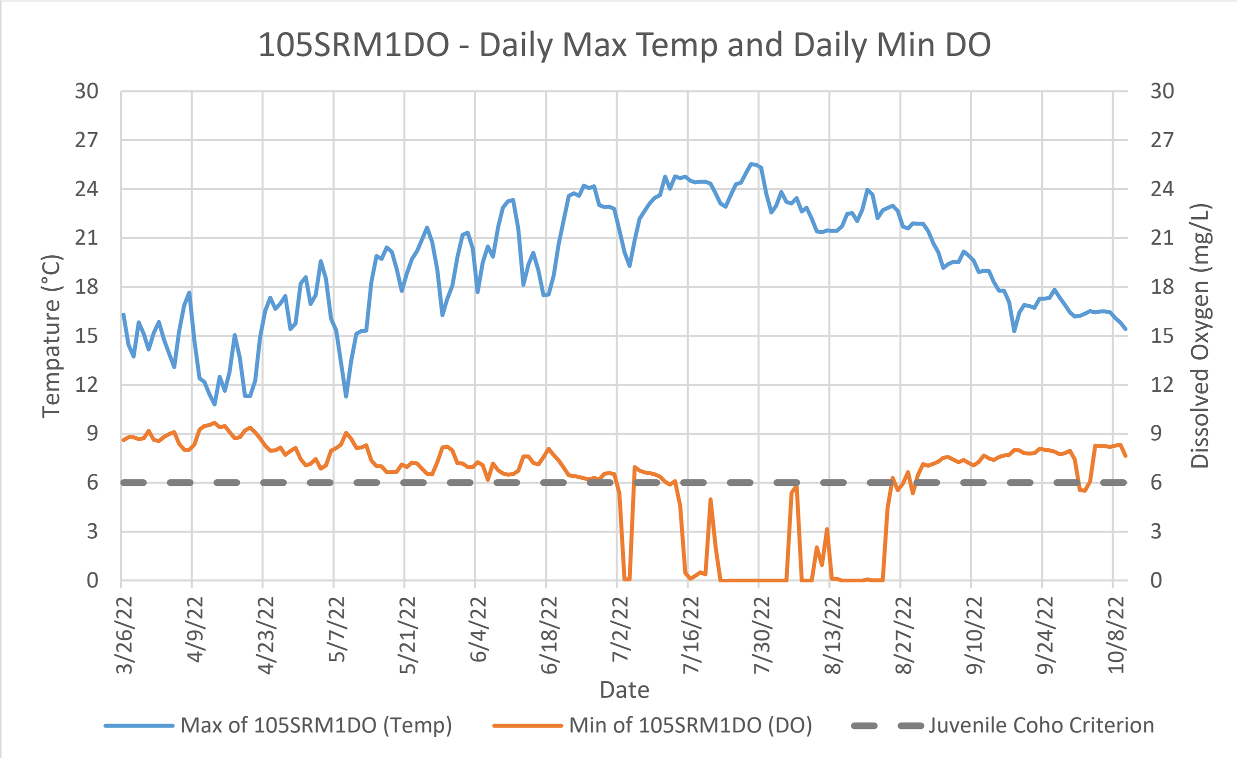


**FIGURE 18. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRM1DO, SHASTA RIVER**

## REACH 3

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRS1DO is shown in Figure 19. DO and temperature equipment were deployed for 199 days between March 26 and October 10, 2022. DO fell below the juvenile coho criterion of 6 mg/L in 22 of the 183 days for which quality DO data was recorded during the 2022 irrigation season.

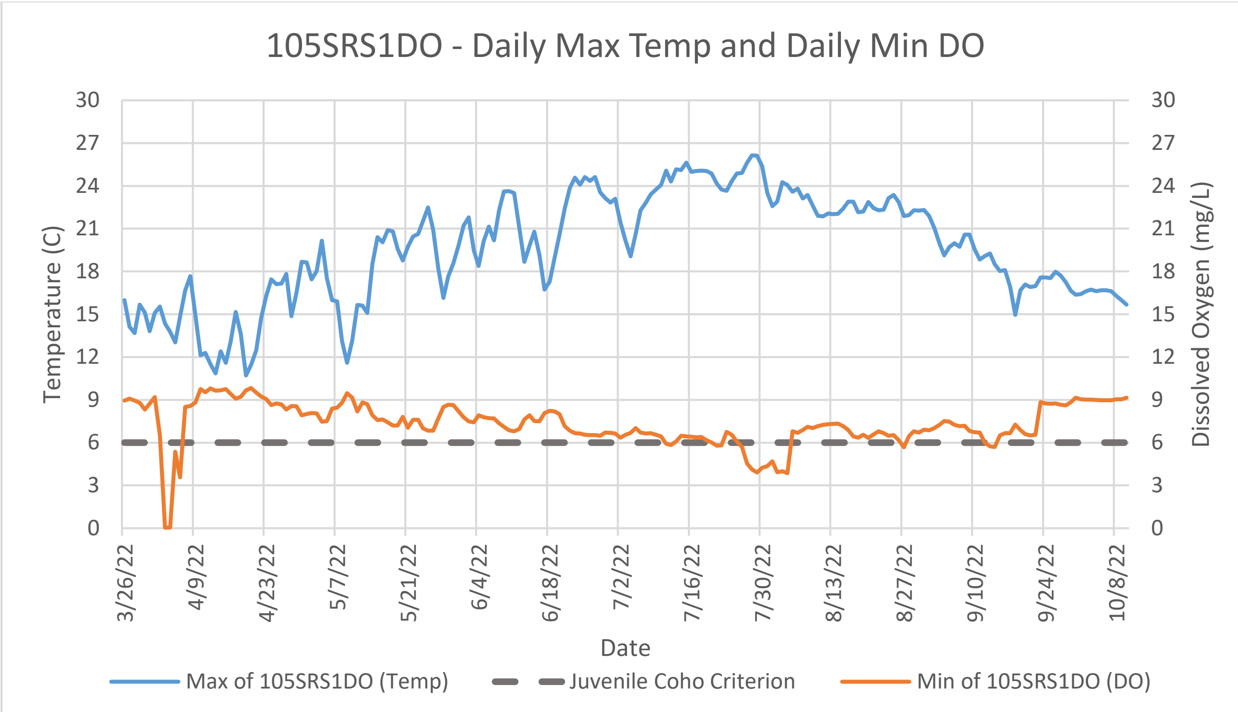


**FIGURE 19. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRS1DO, SHASTA RIVER**

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRT1DO shown in Figure 20. DO and temperature equipment were deployed for 199 days between March 26 and October 10, 2022. DO and temperature data are missing from June 20 to July 15 due to sensor malfunction. DO fell below the juvenile coho criterion of 6mg/L in 53 of the 163 days for which quality DO data was recorded during the 2022 irrigation season.

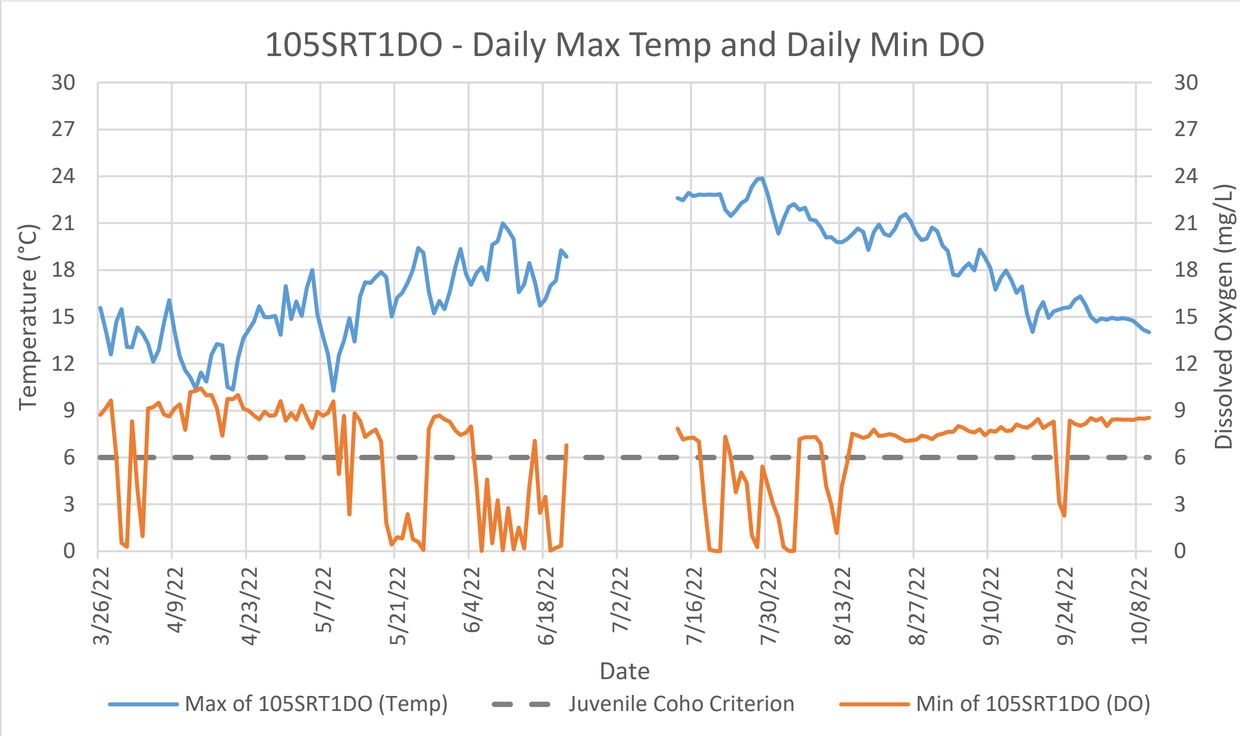


**FIGURE 20. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRT1DO, SHASTA RIVER**

## REACH 4

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRV1DO are shown in Figure 21. DO and temperature equipment were deployed for 199 days between March 26 and October 10, 2022. DO levels fell below the juvenile coho criterion of 6 mg/L in 7 of the 183 days for which quality DO data was recorded during the 2022 irrigation season.

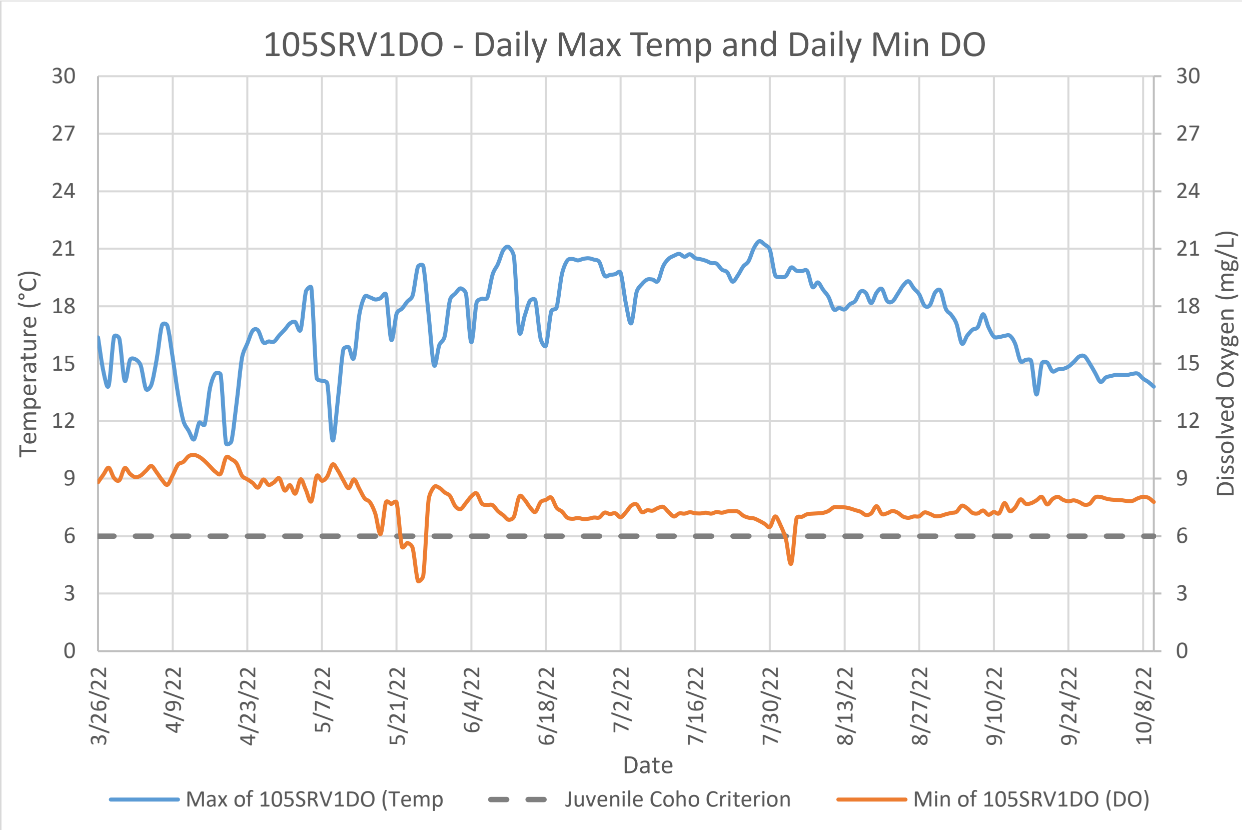


**FIGURE 21. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRV1DO, SHASTA RIVER**

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRN1DO are shown in Figure 22. DO and temperature equipment were deployed for 199 days between March 26 and October 10, 2022. DO levels fell below the juvenile coho criterion of 6 mg/L in 14 of the 183 days for which quality DO data was recorded during the 2022 irrigation season.

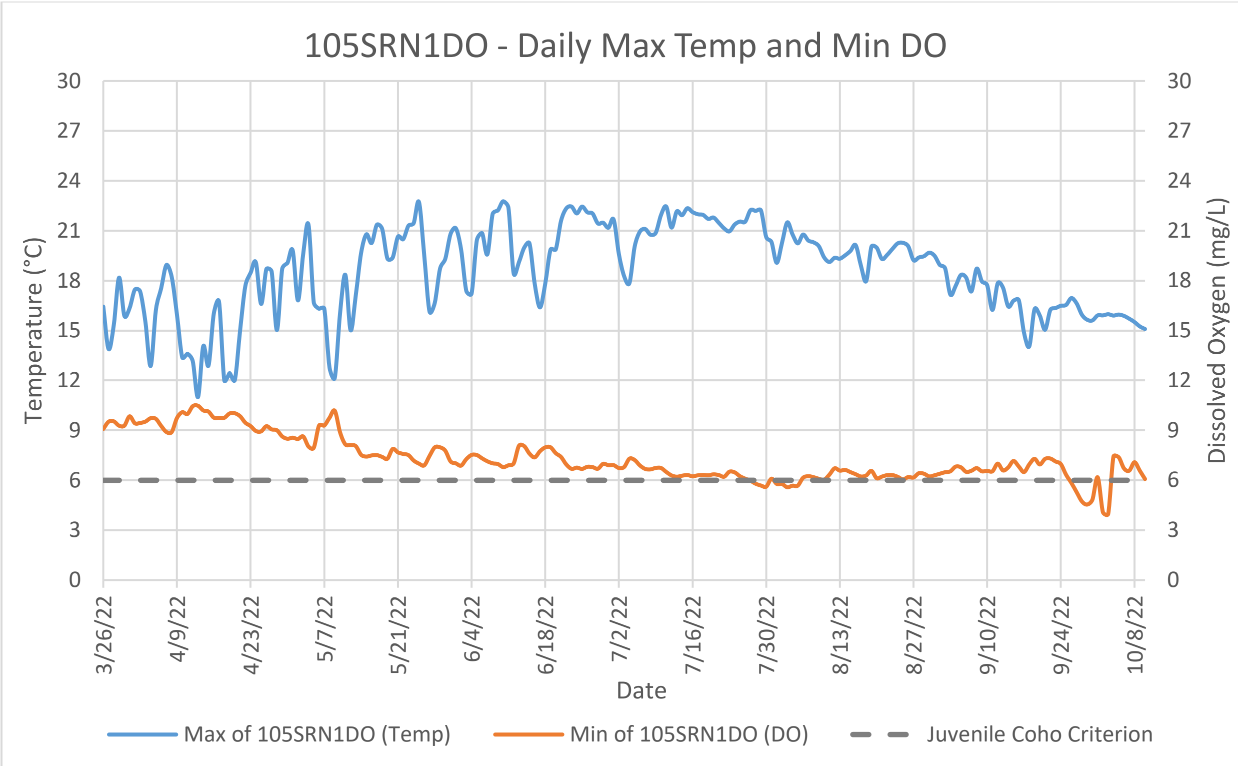


**FIGURE 22. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRN1DO, SHASTA RIVER**

## REACH 5

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRP1DO are shown in Figure 23. DO and temperature data were deployed for 196 days from March 29 to October 10, 2022. DO data is missing from August 5 to September 2 due to sensor failure. DO levels fell below the juvenile coho criterion of 6 mg/L in 60 of the 157 days for which quality DO data was recorded during the 2022 irrigation season.

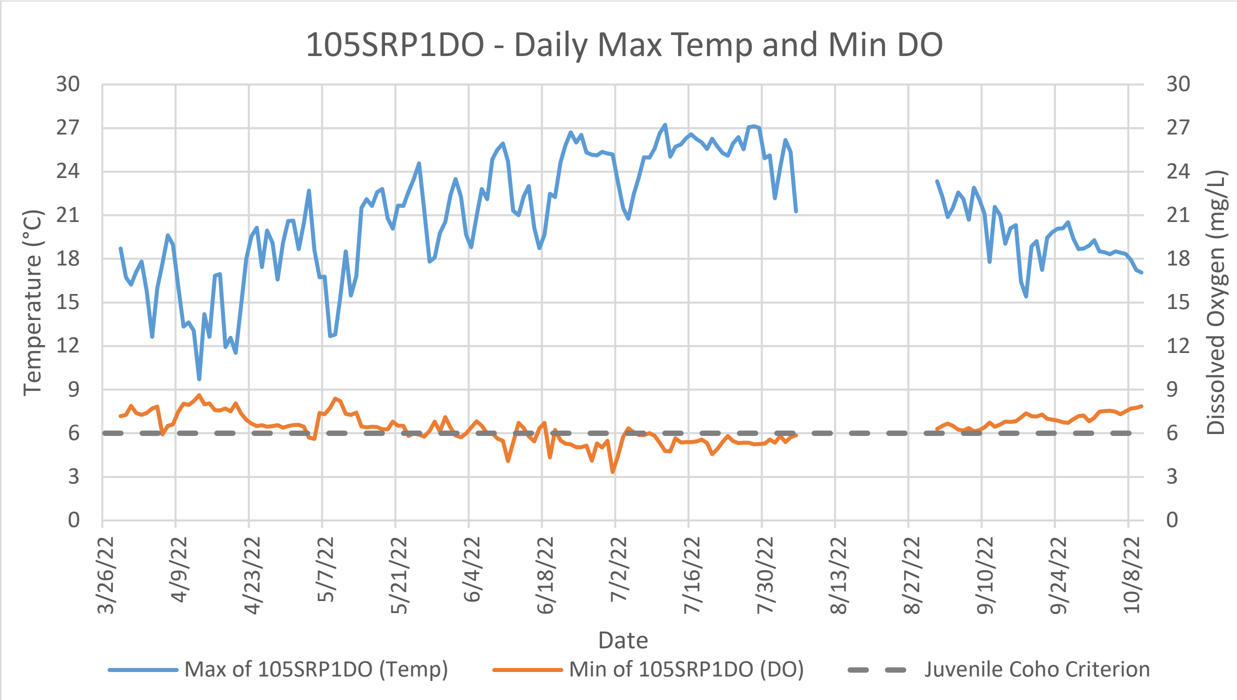


**FIGURE 23. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRP1DO, PARKS CREEK**

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105PCFPDO are shown in Figure 24. DO and temperature equipment were deployed for 103 days from March 26 to July 6, 2022. On May 26, data was not collected due to sensor malfunction. The D-Opto Logger sensor completely failed after July 6, and was not replaced due to budget constraints. Temperature for the remainder of the monitoring period was collected from Onset HOBO U20 Pressure Transducer co-located at the site, also maintained by the SVRCD. DO levels fell below the juvenile coho criterion of 6 mg/L in 1 of the 96 days for which quality DO data was recorded during the 2022 irrigation season.

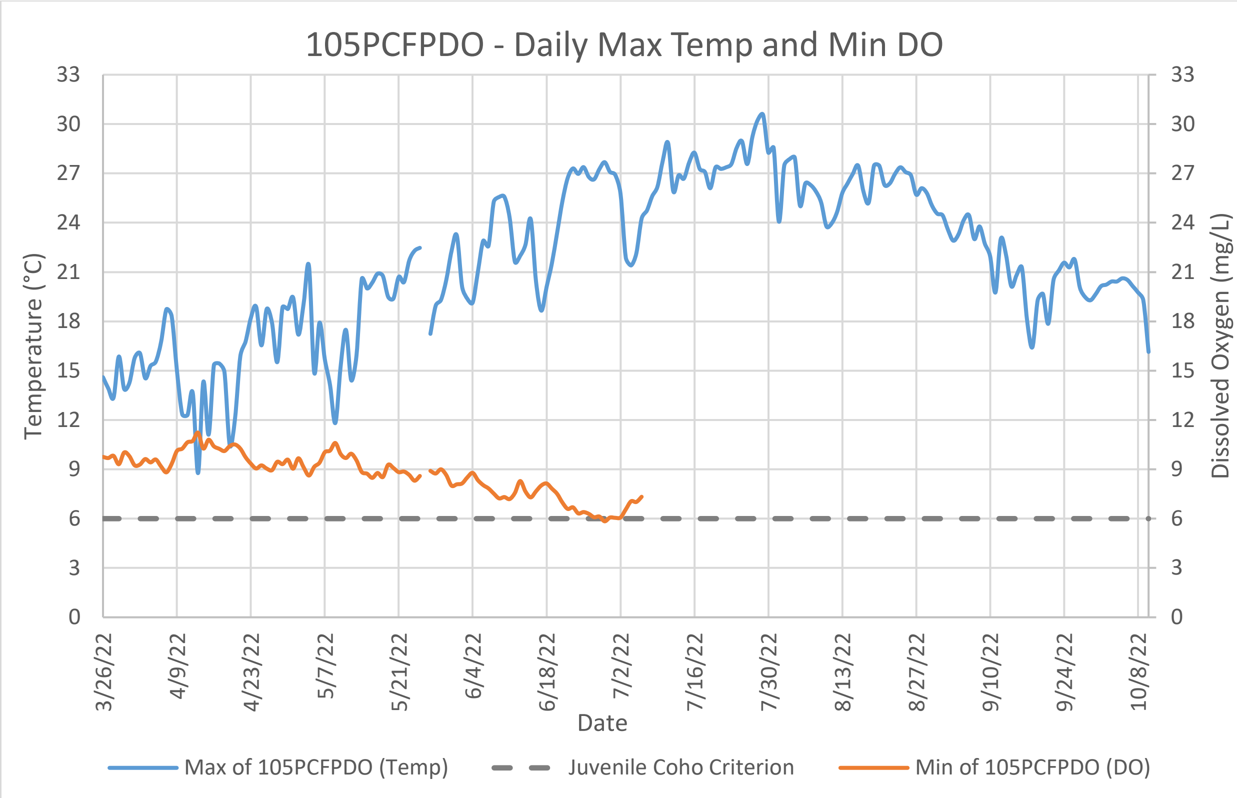


**FIGURE 24. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105PCFPDO, PARKS CREEK**

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105PCB1DO is shown in Figure 25. DO and temperature equipment was deployed for 199 days from March 26 to October 10, 2022. The missing DO data on May 25 and May 27 is due to sensor malfunction. Large gravels to cobbles make up the substrate at this reach and channel morphology becomes isolated pools in the latter part of the summer, with limited flow percolating through the large rocky substrate. There is limited macrophyte growth in the late summer, which when present, can be a source of DO. DO fell below the juvenile coho criterion of 6 mg/L in 91 of the 183 days for which quality DO data was recorded during the 2022 irrigation season.

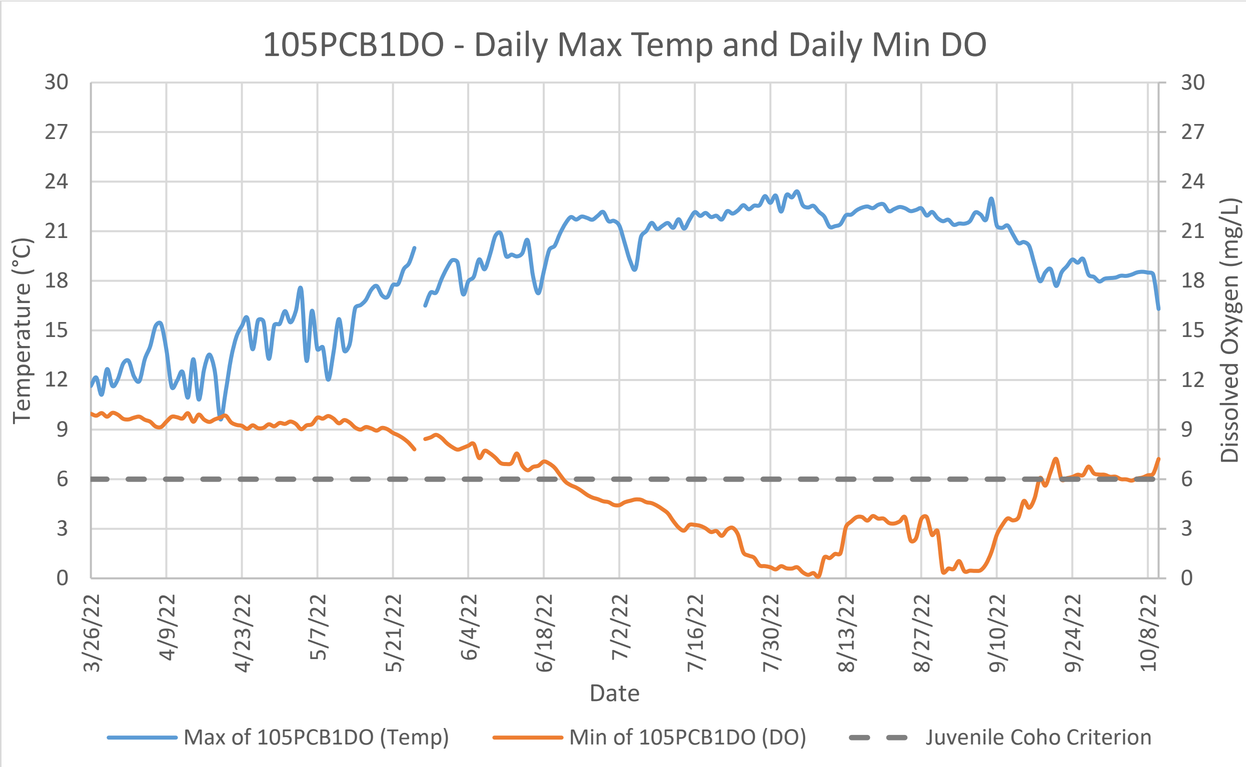


**FIGURE 25. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105PCB1DO, PARKS CREEK**

## REACH 6

Daily maximum temperature, daily minimum DO, and the juvenile coho DO criterion for site 105SRU1DO are shown in Figure 26. DO and temperature equipment were deployed for 149 days from May 12 to October 7, 2022. DO data between March 26 and May 12, 2022 are missing due to D-Opto sensor malfunction and sensor was replaced with a different D-Opto sensor. Data between June 23 and June 29, 2022 is missing due to sensor malfunction and sensor was replaced with Onset Hobo U26 sensor. Data appear bimodal with significant segments of time recording near 0 mg/L or 6 mg/L. Data from previous years show similarly high frequencies of crashes and are thought to be related to the close proximity to groundwater inflows, which is typically have very low DO concentrations. This site also experiences more frequent and intense biofouling due to drought and a downstream beaver dam which has limited flow volumes and velocities leading to an abundance of macrophyte growth. DO levels fell below the juvenile coho criterion of 6 mg/L in 112 of the 136 days for which quality DO data was recorded during the 2022 irrigation season.

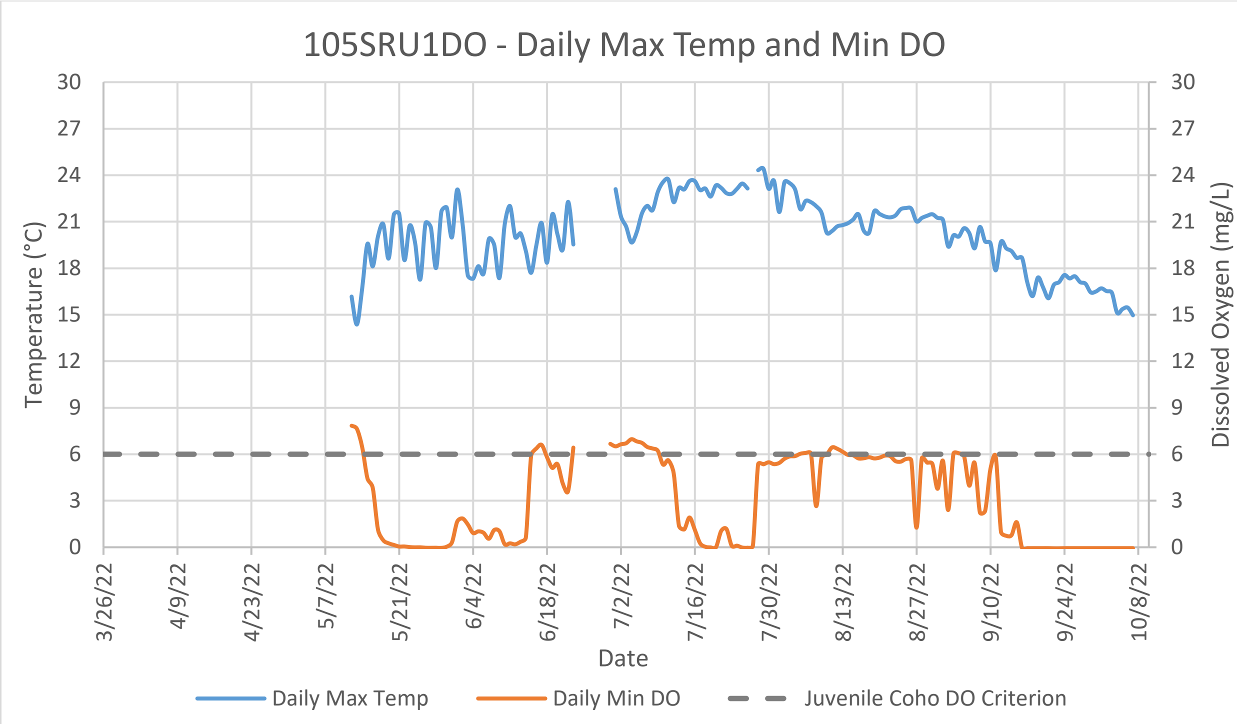


**FIGURE 26. 2022 DAILY MAXIMUM TEMPERATURE AND DAILY MINIMUM DO AT 105SRU1DO, SHASTA RIVER**

## SUMMARY OF MANAGEMENT ACTIONS

The Governor's emergency drought declaration for Siskiyou County brought minimum instream flow requirements for the Shasta River. Marking the first full year of emergency instream required flows, 2022 saw nearly twice the volume of water move through the mainstem of the Shasta River during the irrigation season as in previous years, particularly between Big Springs Creek and the confluence with the Klamath River. Using the water rights established in the Shasta River Decree as a guide when local collaboration did not achieve the required flows, curtailment of diversions from the Shasta River were enforced until the minimum required flow target was met, as measured at the Shasta River gauge near Yreka.

While curtailments on diversions were enforced in order of seniority of water right, the remainder of ranches that were not curtailed irrigated using reduced diversion amounts. Nearly all cow calf operations were forced to reduce herd sizes.

The ongoing drought, emergency minimum instream flow requirements and dam removal present major changes to the Shasta River watershed management. These large-scale management changes make evaluation of progress of individual projects and changes to ranch management particularly challenging, but the multi-year longitudinal analysis of MWMT, MWAT, and Absolute Max temperatures is helpful in understanding year to year trends. A multi-year analysis between any two consecutive water quality monitoring sites in the proximity of known habitat restoration, water conservation, or changes to on-farm management projects is needed to fully assess efficacy of related actions. Looking at relative changes between two consecutive points on the river eliminates differences resulting from air temperatures, which are known to be the predominant driver of instream temperatures. Additionally, increased spatial resolution of water temperature and dissolved oxygen data, as well as spatial, temporal, and quantity of cold groundwater and spring water inputs would be helpful to better understand specific actions or changes in management within a given reach.

### IMPACT ON WATER QUALITY

Water temperatures coinciding with increased flow volumes during the 2022 irrigation season generally corroborate the RMS model assumptions in the 2006 *Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads*. Specifically, the 50% flow increase model scenario and the water quality compliance model scenario were broadly reproduced through the enforced diversion curtailment of BSID and diverters downstream of Big Springs Creek. Increased flow in an open channel increases stage which can have an insulating effect on water temperatures and increase habitat connectivity. The magnitude of this impact is variable and is highly dependent on channel morphology. Greater flow volume has a more pronounced effect on flow velocity. Because ambient air temperature is the single greatest driver of changes to surface water temperatures in the Shasta River, increased velocity has the effect of moving water more quickly through the system, increasing negative advection of heat, thereby attenuating maximum water temperatures. Despite this, water temperatures in the Shasta River still exceeded TMDL and MWMT objectives during the 2022 irrigation season at all monitoring sites that were not directly measuring spring inflows.

Increased flow volumes attenuate the magnitude of diurnal fluctuation of dissolved oxygen levels within the Shasta River by diluting the impact oxygen demand and oxygen production has on a given volume of water.

## CONCLUSIONS

The compounding effects of ongoing drought, significant reaches lacking continuous riparian shade, and warm tailwater inputs continue to impact water temperatures in the Shasta River. Water temperatures and DO levels exceeded TMDL and MWMT objectives during the 2022 irrigation season at all monitoring sites that were not directly measuring spring inflows.

While comparisons and multi-year analysis of data have been made and presented, direct comparisons to the modeled water quality compliance scenario are difficult for the following reasons:

- Actual meteorological conditions during August do not necessarily match those of the model calibration for baseline and subsequent modeled scenarios.
- we cannot directly measure both the maximum daily temperature and the expected reduction based on any changes to management.
- the SVRCD analyzes data using 7-DAD maximum temperatures, where as the model creates outputs for 5-DAD maximum temperatures.
- and, the SVRCD has recorded temperature and DO at RM 5.6 in the mainstem location, not at the TMDL compliance point, which is in the approximately 2,000-foot-long side channel.

Additional coordination with NCRWQCB staff is needed to ensure monitoring parameters, locations, and data processing methods allow for comparison to modeled TMDL goals and compliance scenarios.

Further, additional coordination with other entities involved in preparing integrated hydrologic models for the Shasta River Watershed would be beneficial. These include the Siskiyou County Flood Control and Water Conservation District and their agents as well as the State Water Resources Control Board and the California Department of Fish and Wildlife.

Continued efforts to identify high quality water within the watershed while also improving infrastructure and on farm practices to leverage and increase the impact of improved water quality remain the SVRCDs top priority.

The SVRCD looks forward to working with agencies and stakeholders to support them in adapting to broader changes to resource management within our district.

# REFERENCES


United States Geological Survey. 2022. Shasta River Flow datasets. Datasets accessed 2023-07-23 at https://waterdata.usgs.gov/ca/nwis/

Carter, K. 2005. The Effects of Temperature on Steelhead Trout, Coho Salmon, and Chinook Salmon Biology and Function by Life Stage: Implications for Klamath Basin TMDLs. California Regional Water Quality Control Board North Coast Region. 26pp.

Chesney, W. R., Adams, C. C., Crombie, W. B., Langendorf, H. D., Stenhouse, S. A., & Kirkby, K. M. (2009). Shasta River juvenile coho habitat and migration study. *Prepared for US Bureau of Reclamation, Klamath Area Office by California Department of Fish and Game*.

Fry, F. E. J. 1971. The effect of environmental factors on the physiology of fish. W. S. Hoar and D. J. Randall, editors. Fish physiology. Volume 6. Academic Press, New York.

Jeffres, C. A., R.A. Dahlgren, M.L. Deas, J.D. Kiernan, A.M. King, R.A. Lusardi, J.M. Mount, P.B. Moyle, A.L. Nichols, S.E. Null, S.K. Tanaka, A.D. Willis. 2009. Baseline Assessment of Physical and Biological Conditions Within Waterways on Big Springs Ranch, Siskiyou County, California. Report prepared for: California State Water Resources Control Board.

Nichols, A.L., C.A Jeffres, A.D. Willis, N.J. Corline, A.M. King, R.A. Lusardi, M.L. Deas, J.F. Mount, and P.B. Moyle. 2010. Longitudinal Baseline Assessment of Salmonid Habitat Characteristics of the Shasta River, March to September, 2008. Report prepared for: United States Bureau of Reclamation, Klamath Basin Area Office.

North Coast Regional Water Quality Control Board. 2007. Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. Water Quality Control Plan for the North Coast Region. http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/shasta_river/060707/finalshastatmdlactionplan.pdf

North Coast Regional Water Quality Control Board. 2006. Staff Report for the Action Plan for the Shasta River Watershed Temperature and Dissolved Oxygen Total Maximum Daily Loads. Ch. 6-7. https://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/shasta_river/060707/staff_report.pdf

# ACKNOWLEDGEMENTS

*Funding for this report has been provided in full or in part through an Agreement (Agreement No. 21-053-110 ) between the State Water Boards Resource Control Boards in the amount of $113,000.00 and an Agreement (Agreement No. D1913111) with the State Water Resources Control Board and the U.S. Environmental Protection Agency under the Federal Nonpoint Source Pollution Control Program (Clean Water Act Section 319) in the amount of $679,953.00. The total Agreement amounts represent compensation for multiple documents and written reports. The contents of these documents and reports do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of the trade names or commercial products constitute endorsement or recommendation for use (Gov. Code 7550, 40 CFR 31.20).*

*The SVRCD would like to give sincere thanks to all the landowners who provided access to the Shasta River and its tributaries through their properties. The data gathered year after year serves as an invaluable tool to help inform the watershed and provide the basis for solutions that benefit all of its stakeholders. Our appreciation for their ongoing cooperation and participation cannot be overstated.*

*Cover Photo: Parks Creek, 2022*

# APPENDIX

## Public Data Access

California Irrigation Management Information System (CIMIS)

- Station 260 – Montague
- Station 261 – Gazelle

https://cimis.water.ca.gov/

California Data Exchange Center (CDEC)

- Hydrologic Data Acquisition System (HyDAS)
  - Station SVG – Goosenest
    - https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=SVG
  - Station SVB – Bolam
    - https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=SVB

California Data Exchange Center (CDEC)

- Shasta River Discharge and Stage
  - Station SRM – Near Montague
    - https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=SRM
  - Station SRY – Near Yreka
    - https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=SRY
  - Station SPU – Near Big Springs Creek
    - https://cdec.water.ca.gov/dynamicapp/selectQuery?Stations=SPU