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The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2010

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Key words: Trinity River, Lewiston Dam, flow, water temperature

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2010

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Abstract —Water temperatures were monitored on the Trinity and lower Klamath rivers from April to October 2010 to evaluate the influence of a Normal water year schedule from Lewistown Dam on downstream water temperature objectives specified in the Trinity River Record of Decision. The North Coast Region Basin Plan temperature objective of 15.6 °C at Douglas City was exceeded by up to 0.2 °C for 7 days between August 3 and September 14. The temperature objective of 13.3 °C at the North Fork Trinity River was also exceeded by up to 1.1 °C for 7 days between October 1 and October 11. Warm air temperatures and release water temperatures are assumed to be the causative factors for failing to meet the objective 100% of the time.

During the spring and early summer, the water temperature regime of the lower Trinity River at Weitchpec was within the "Optimal" thermal regime for salmonid smolts from mid-April to June 25. A small increase in water temperatures followed from June 25 to June 29 that resulted in water temperatures exceeding the targeted "Optimal" temperature regime for this water year by a maximum of 0.5 ˚C. Following this excursion into the "Marginal" regime, water temperatures at Weitchpec decreased to the "Optimal" regime for a period of about 5 days before again increasing to 19 ˚C, or 2.0 ˚C above the "Optimal" threshold. Reasons for the excursions above the "Optimal" regime during late June and early July are believed to be caused by warming air temperatures. Another factor that likely played a role in exceeding the "Optimal target includes the reduction in flow from Lewiston Dam that occurred in late June and early July (See Figure 3), as opposed to the original flow schedule for a Normal water year type where a 2000 cfs release would extend until July 9th.

Despite not meeting the targets during these times, the prescribed flow did result in increased temperature reductions of the Klamath River, indicating that Lewiston Dam releases initially helped in moderating water temperatures during a time when water temperatures of the Klamath River were increasing. A peak difference of 1.4 °C was recorded on July 09, a time when water

temperatures of both rivers were beginning to increase. The differential resulted in a temperature reduction of 1.4 °C below the confluence.

INTRODUCTION

The Trinity River Restoration Program (TRRP) was reauthorized with the signing of the Record of Decision (ROD) of the Final Trinity River Mainstem Fishery Restoration Environmental Impact Statement in December of 2000 (USDOI 2000). Since this time, the TRRP has moved in earnest towards the over-arching goal of restoring the natural production of salmon and steelhead below Lewiston Dam. An important component of the TRRP is the application of an Adaptive Environmental Assessment and Management (AEAM) program. As part of this program, monitoring is used to evaluate progress towards achieving restoration objectives, and improved understanding of the river response to various management actions (e.g. dam releases or gravel augmentation). In support of the AEAM program, this report assesses the influences that Lewiston Dam releases had on the downstream thermal environment, and in particular whether or not the water temperature objectives as identified in the ROD were achieved (Table 1).

This report presents the temperature monitoring information collected for WY2010 and is the ninth consecutive year for which a report of this type has been written for the TRRP. Reports describing the thermal regimes for the years 2002 to 2009 (Zedonis 2003, Zedonis 2004, Zedonis 2005, Zedonis and Turner 2006, and Zedonis and Turner 2007, Zedonis and Turner 2008, Zedonis 2009, and Scheiff, T. and P. Zedonis, 2010) are available in electronic format from the TRRP or the Arcata Fish and Wildlife Office of the U.S. Fish and Wildlife Service (http://www.fws.gov/arcata/fisheries).

STUDY AREA

The Trinity River, located in northwest California, is the largest tributary to the Klamath River (Figure 1). This tributary is regulated by Trinity and Lewiston Dams constructed in the early 1960s. Trinity Dam created Trinity Reservoir that can store up to 2.45 million acre-feet of water. Located immediately below Trinity Dam, Lewiston Dam forms Lewiston Reservoir, which serves as a re-regulating reservoir for flow to the Trinity River

and diversion to the Sacramento River Basin. From Lewiston Dam, the Trinity River flows for approximately 180 river kilometers (rkm) before joining the Klamath River at Weitchpec, CA. From Weitchpec, the Klamath River flows for 70 rkm before entering the Pacific Ocean.

METHODS

The influence of Lewiston Dam releases on downstream water temperature was assessed using water temperature data collected by telemetered stations, operated by the U.S. Geological Survey (USGS), the California Department of Water Resources, and from probes deployed by the Arcata Fish and Wildlife Office (AFWO), U.S. Bureau of Reclamation (BOR), and the Yurok Tribe's Environmental Program (YTEP) (Table 2). Data from telemetered stations were downloaded from the California Data Exchange Center (CDEC) website available at http://cdec.water.ca.gov. Data obtained from the CDEC site are labeled "preliminary and subject to revision", meaning the accuracy of the data is unknown. To correct for possible errors, we conducted graphic evaluations to identify erroneous data points that were later deleted. These data have been used in prior years (2004 thru 2009) following discovery that resultant data were generally accurate when compared to independent certified thermistors (Zedonis 2003).

AFWO used temperature probes manufactured by Onset Computer Corporation® to collect hourly water temperature data from April to October. Prior to and after deployment, each probe was subjected to a performance test to verify it was recording within the manufacturer's accuracy specification of ± 0.2 degrees Celsius (˚C). A copy of the AFWO protocol is available upon request. In all tests, the instruments proved to be accurate and reliable.

Factors known to influence water temperatures in river systems, namely flow and air temperature, were also considered in the evaluation on how dam releases influenced water temperatures in space or time. Air temperature data were also obtained from the CDEC. These data were also labeled "preliminary and subject to revision" and were reviewed and corrected using the same standards established for water temperature downloads. Estimates of river flow at several sites on the Trinity River (Lewiston –rkm 178.2; and

Hoopa – rkm 20.0) and Klamath River (Iron Gate - rkm 305.5; Orleans - rkm 95.1; and Klamath - rkm 13.0) were obtained from the USGS website (http://water.usgs.gov). Efforts were made to use "final" flow data from USGS, but this was largely dependent on the timing of its release and the timing of completion of this report. In some cases, we may have used data labeled "provisional and subject to change."

RESULTS AND DISCUSSION

Hydrology

Six hundred and fifty-six thousand acre-feet (TAF) of water was released from Lewiston Dam to the Trinity River in FY2010. This total was slightly greater than the prescribed flow of 647 TAF to support a flow prescription for a Normal water year (Figure 2). Gage error and the precision in which released flow can be controlled through Lewiston Dam are likely reasons for the small discrepancy in total flow.

Contributions of flow from Lewiston Dam to the lower Trinity River and Klamath River varied through the year (Figure 2; also see Appendix A for daily information). During the early part of April the contributions of flow from Lewiston Dam to the lower river gauges were quite small (e.g. 1 to 2 %) due to low base flows (e.g. 300 cubic feet per second (cfs)) and the larger contributions of flow from the abundant tributaries located above downstream gauges. In contrast, by late April and early May, peak spring flow releases from Lewiston Dam resulted in a substantially greater contribution of flow to the lower Trinity River as well as the lower Klamath River. In the most extreme case, Lewiston Dam releases comprised up to 20% of total flow at the Klamath gauge in early May (see Appendix A).

Spring flow from Lewiston Dam generally followed a Normal water year schedule as prescribed in the ROD (Figure 3). Notable differences included a faster transition to a greater peak flow (6,840 cfs) approximately 1 week earlier than originally prescribed, an earlier ramp down from 2000 cfs to 450 cfs in early July, and higher than ROD-prescribed flows for the remainder of July. These altered flows occurred to support ongoing geomorphological and aquatic habitat evaluations by the TRRP (J. Polos, Pers. Comm.).

In early August the flow schedule ramped down to a summer base flow of 450 cfs. Lewiston Dam releases remained at the 450 cfs base flow through the end of the water year.

Water Temperatures of the Mainstem Trinity River

Lewiston Gauge (rkm 178.2)

From April to mid-October, water temperatures of Lewiston Dam releases remained between 8.0 ˚C and 11.8 ˚C (Figure 4). The warmest release temperatures occurred between early July and mid-September, coinciding with typical warming trends and times of decreasing discharge from Lewiston Reservoir. Reduced flows to the river (and thus through Lewiston Reservoir) resulted in increased hydraulic residence time of water in the reservoir that warmed before release to the Trinity River. A good example of this situation is illustrated in Figure 4 where flows from Trinity Reservoir were reduced in mid-September (indicating longer residence time in Lewiston) and the release temperature to the Trinity River increased by approximately 1.0 ˚C. In contrast, some of the coldest release temperatures occurred during times of high flow (and thus short hydraulic residence time), most notably from early to late May (Figure 4).

Douglas City Gauge (rkm 148.5)

From April to mid-October water temperatures at Douglas City gauge ranged between 8.5 ˚C and 15.8 ˚C (Figure 5). Average daily water temperature at this site peaked on August 6 at 15.8 ˚C. Water temperatures at this site also exhibited an inverse relationship of flow from Lewiston Dam, most notably during high flow periods from late April to late May.

Water temperatures exceeded the Regional Water Quality Control Board temperature objective (North Coast Regional Water Quality Control Board, 1994) at this location for a total of 5 days from August 4 through August 8. A maximum exceedence of 0.2 ˚C over the 15.6˚C objective occurred on August 6.

Reasons for exceeding the objective are likely several-fold. First, the average temperatures of water released from Lewiston Dam at this time were greater than 11.0 ˚C, which is approximately 1.0 ˚C warmer than what is typically needed to meet the objective

in most weather conditions (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999). This increase in water temperature was likely due to an increase in air temperature, and warmer releases from Lewiston dam that resulted from increased hydraulic residence time in Lewiston Reservoir (see Figure 4) and reduced flow from Lewiston Reservoir (Figure 5). From August 15 to September 30 the water temperature objectives for this location were met.

Trinity above the North Fork Trinity (rkm 117.6)

Average daily water temperatures of the Trinity River above the North Fork Trinity were warmer in comparison to the upstream Douglas City site, but followed a similar trend (Figure 6). Similar to the Douglas City site, water temperatures above the North Fork Trinity showed an inverse relationship with flow. Average daily temperatures peaked at 18.5 ˚C on August 7.

Water temperatures exceeded the Regional Water Quality Control Board temperature objectives (North Coast Regional Water Quality Control Board, 1994) at this location for two multiday periods for a total of 7 days between October 1 and 11th (Figure 6). A maximum exceedence of 1.1 ˚C over the 13.3 ˚C objective (Table 1) occurred on October 3. Examination of the average daily air temperature suggest it was a factor in not meeting the objective inspite of release temperatures from Lewiston Dam being close to the recommended value of 10.0 ˚C (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999). *Above Big French Creek to Weitchpec (rkm 94.2 to 0.1)*

Water temperatures in this region were also influenced by Lewiston Dam releases, although to a lesser degree than in previous years due to the large accretion of flow from tributaries this year The peak daily average temperatures were less than 23.0˚C at Weitchpec and less than 20 ˚C at rkm 94 (Figure 7). Review of average daily water temperatures from previous years suggest that water temperatures typically peak between 24 and 25˚ C (Zedonis 2003, Zedonis 2004, Zedonis 2005, Zedonis and Turner 2006, and Zedonis and Turner 2007, Zedonis and Turner 2008, Zedonis 2009, and Scheiff, T. and P. Zedonis, 2010).

The spring-time temperatures at Weitchpec fell within the "Optimal" smolt temperature (OST) regime for smolts from mid-April to June 25 (Figure 8). A small increase in water temperatures followed from June 25 to June 29 where water temperatures were 0.5 ˚C above the Optimal and fell into the "Marginal" smolt temperature regime. Following this excursion into the "Marginal" regime, water temperatures at Weitchpec decreased to the "Optimal" regime for a period of about 5 days before again increasing to 19 ˚C, or 2.0 ˚C above the "Optimal" threshold. As is illustrated in Figure 9, periods of exceeding the "Optimal" temperature regime in late June and early July can be at least partially attributed to the warming air temperatures. Another factor that likely played a role in exceeding the "Optimal target includes the reduction in flow from Lewiston Dam that occurred in early late June and early July (See Figure 3), as opposed to the original flow schedule for a Normal water year type where a 2000 cfs release would extend until July 9 (TRFE 1999).

Water Temperatures of the Klamath River above and below the Trinity River Confluence

From mid-April to mid-October, the average daily water temperatures at Weitchpec on the Trinity were variable compared to the Klamath River above the confluence with the Trinity River at rkm 70.2 (Figure 10, See Appendix A for daily information). From April 15 to June 24, water temperatures of the Klamath River at rkm 70.2 were on average 0.3 °C colder than the Trinity River entering the Klamath River even though the peak releases of 6,840 cfs from Lewiston Dam occurred within this time period. From June 27 to July 31, this relationship changed and on average the Trinity River was approximately 0.9 °C colder than the Klamath River. The peak difference in temperature occurred on July 9 when the Trinity River was 1.4 °C colder than the Klamath River (Figure 10). This difference correspondingly altered the thermal regime of the mainstem Klamath River downstream of its confluence with the Trinity River. About 1.5 km downstream of the confluence (i.e. rkm 68.7), water temperatures of the river were reduced by the same amount of 1.4°C. A similar but less pronounced influence was observed in the lower Klamath River at Terwer (rkm 13.0), where water temperatures were reduced by only 0.4°C. We believe this less pronounced influence is likely an influence of the cooler coastal meteorology and tributary accretion within this area. From August 4 through the

end of the water year, Trinity temperatures remained slightly cooler than the Klamath by an average of 0.3 °C (see Appendix A).

ACKNOWLEDGEMENTS

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PERSONAL COMMUNICATIONS

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Table 1. Water temperature objectives for the Trinity River, California.

Source	Target Area	Dates	Temperature Objective[1]
Basin Plan for the North Coast Region (Regional Water Quality Control Board, 1994)	• Lewiston to Douglas City (rkm 178.2 to 148.5)	All Years • July 1 to September 14	≤ 15.6
	• Lewiston to Douglas City (rkm 178.2 to 148.5)	• September 15 to September 30	≤ 13.3
	• Lewiston to the Confluence of the North Fork Trinity River Confluence (rkm 178.2 to 117.6)	• October 1 to December 31	≤ 13.3
Spring-Time Objectives of the Record of Decision for the Trinity River EIS/EIR (USDOI 2000 and USFWS et.al., 2000)	• Lewiston to Weitchpec (rkm 178.2 to 0.1)	Normal and Wetter Water Years: • April 22 to May 22 • May 23 to June 4 • June 5 to July 9 Dry and Critically Dry Water Years: • April 22 to May 22 • May 23 to June 4 • June 5 to June 15	 ≤ 13.0 ≤ 15.0 ≤ 17.0 ≤ 15.0 ≤ 17.0 ≤ 20.0

[1] = Average daily water temperature in degrees Centigrade

Table 2. Water temperature monitoring sites of the Trinity River (TR) and the Klamath River (KR) below Weitchpec, 2010. Note: Not all data identified in this table are presented in the report but are available upon request.

Water Temperature Monitoring Sites			
Mainstem Trinity River			
Site Name (abbreviation)	**Location (rkm)**	**Data Source**	**Operator**
TR @ Lewiston Gauge (LWS)	178.2	California Data Exchange Center (CDEC)	(U.S. Geological Survey /and U.S. Bureau of Reclamation)
TR above Rush Ck (TRRC1)	173.0	FWS	Fish and Wildlife Service (FWS)
TR@ Limkiln Gulch Gauge (TLK)	158.7	CDEC	USGS
TR @ Douglas City Gauge (TRDC2)	148.5	CDEC	USGS
TR above Canyon Ck (TRCN1)	127.4	FWS	FWS
TR abv N.F. Trinity R. (NFH)	117.6	CDEC	USGS
TR abv Big French Creek (TRBF1)	94.2	FWS	FWS
TR @ Burnt Ran. Trans Sta (TRBR1)	76.4	FWS	FWS
TR abv S. Fork Trinity R. (TRSF1)	50.6	FWS	FWS
TR @ Willow Creek Trap (TRWC1)	34.1	FWS	FWS
TR @ Hoopa Gauge (HPA)	20.0	CDEC	USGS/Dept. Of Water Resources
TR @ Weitchpec (TRWE1)	0.1	FWS/YTEP/USBR	FWS/YTEP/USBR
Mainstem Klamath River			
KR at Weitchpec (KRWE1) [b]	70.2	YTEP	Yurok Tribe
KR below Weitchpec (KBW3)	68.7	YTEP/FWS	FWS/Yurok Tribe
KR above Terwer (KRTG2) [a]	13.0	YTEP/FWS	FWS/Yurok Tribe
Trinity River Tributary Sites			
Canyon Ck (CNTR1)	127.3 + 0.1	FWS	FWS
N. F. Trinity R (NFTR1)	116.7 + 0.1	FWS	FWS
Big French Ck (BFTR1)	94.1 + 0.1	FWS	FWS
S. F. Trinity R (SFTR1)	50.5 + 0.1	FWS	FWS

'a = Data is available from multiple sources
'b = This site is located immediately above the confluence of the Trinity River and refers to the distance from the Klamath River mouth.
'

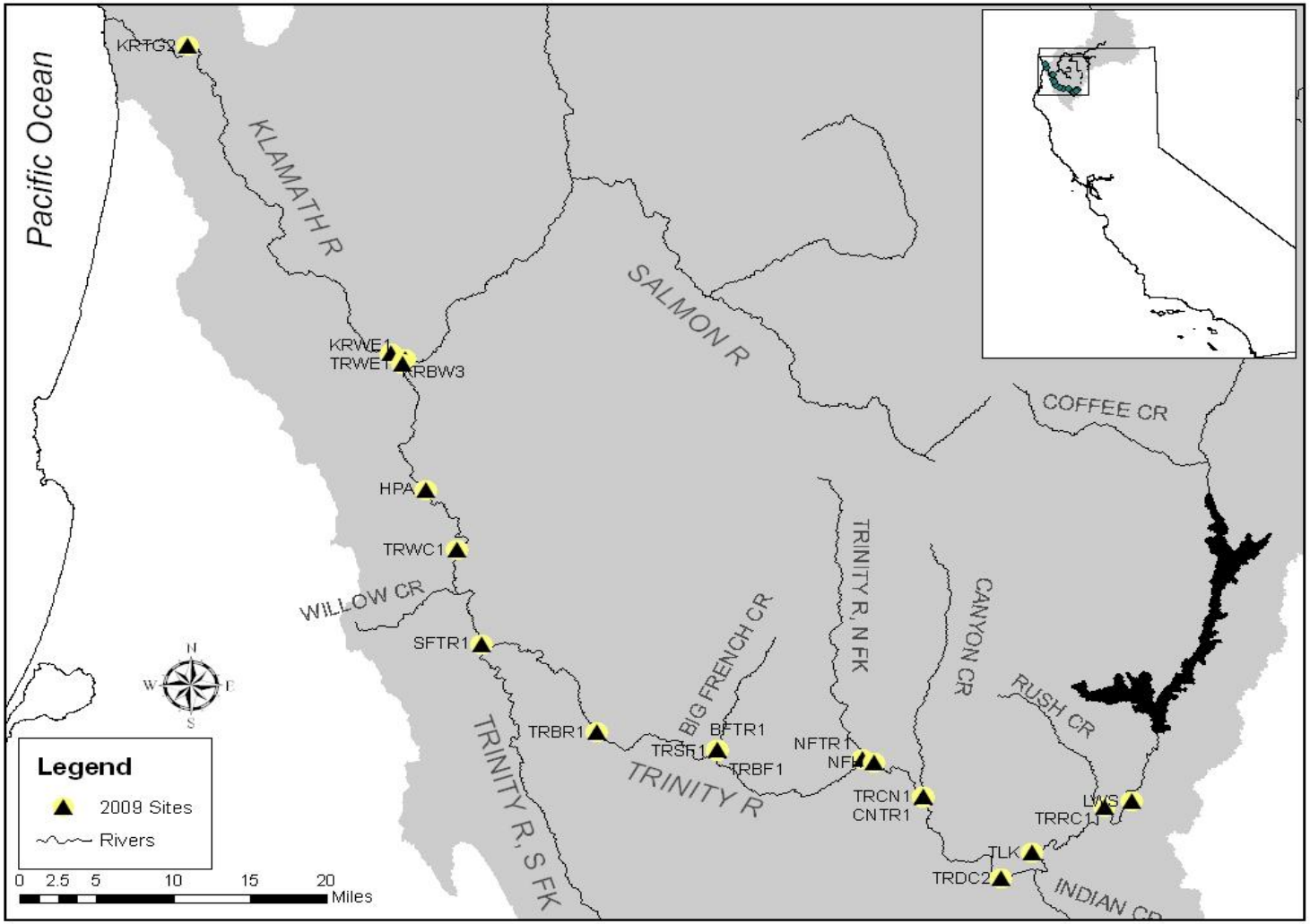

Figure 1. Location of water temperature monitoring sites of the Trinity River and lower Klamath River in 2010. See Table 2 for site information.

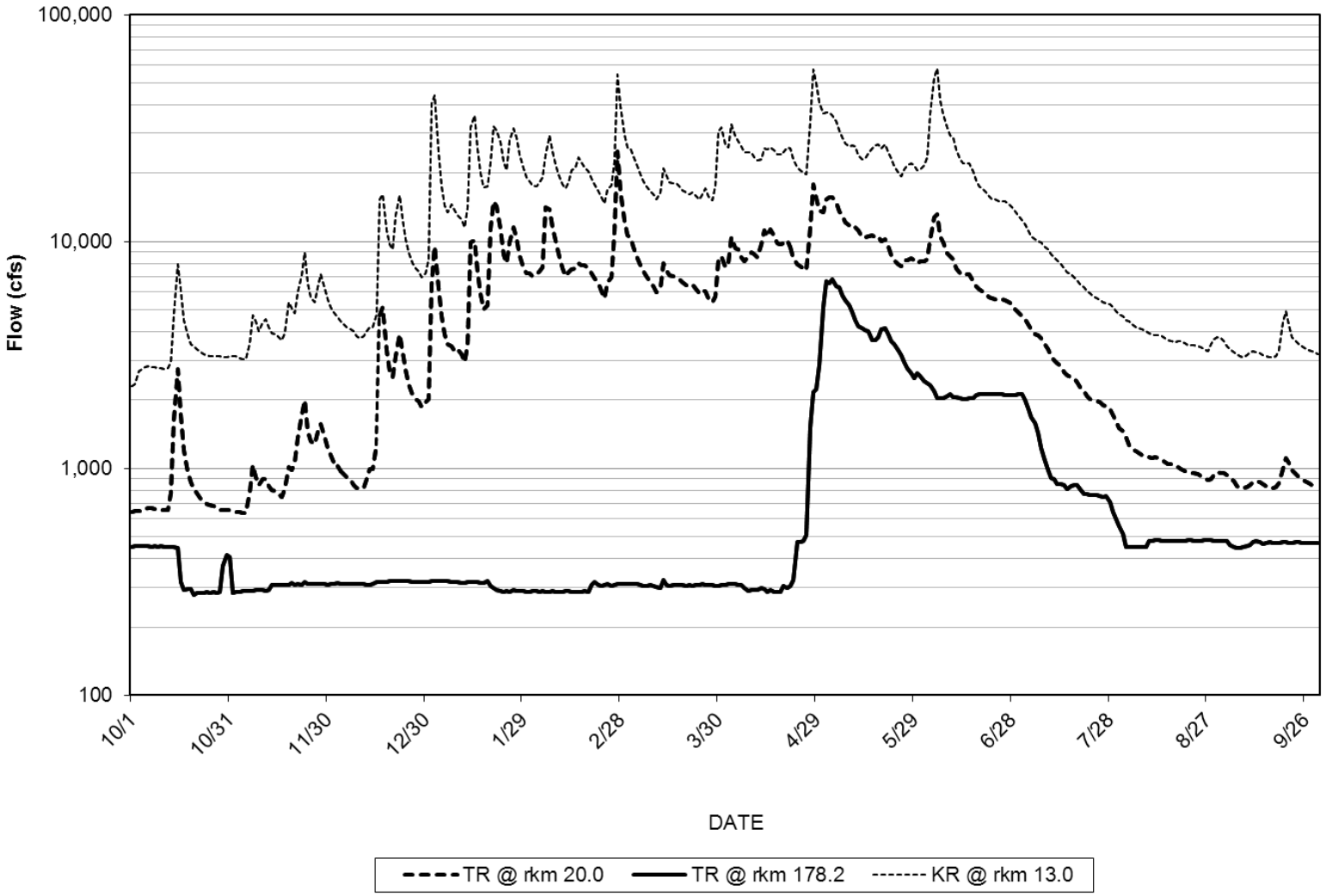

Figure 2. Average daily flow of the Trinity River (TR) at Lewiston gauge (rkm 178.2) and Hoopa gauge (rkm 20.0), and the Klamath River (KR) at the Terwer Gauge (rkm 13.0), 2010. US Geological Survey gauge data, preliminary and subject to revision.

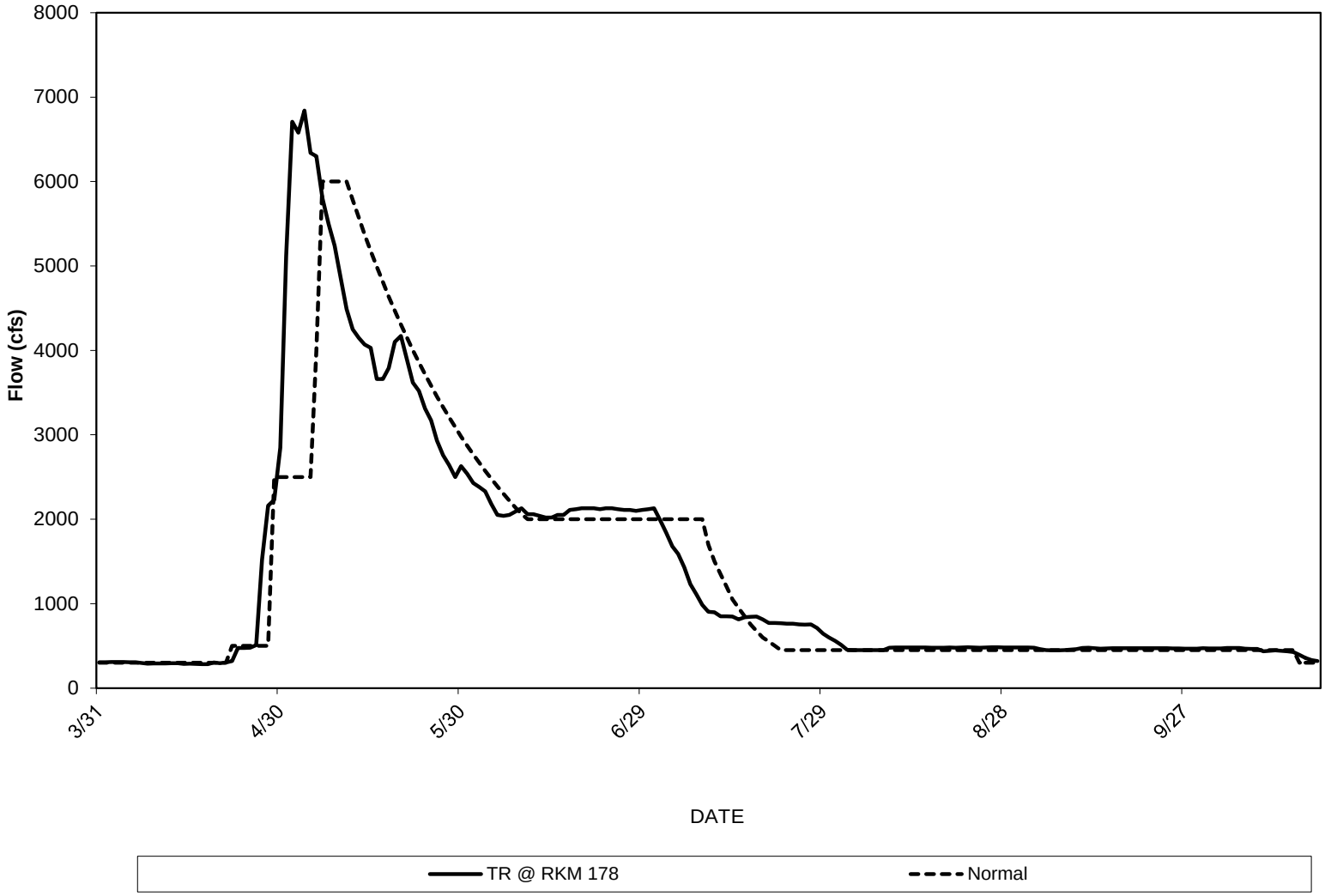

Figure 3. Spring and early summer flow releases from Lewiston Dam (rkm 178.2) on the Trinity River (TR) in 2010 compared to the flow schedule for a Normal hydrologic water year identified in the Record of Decision (USDOI 2000).

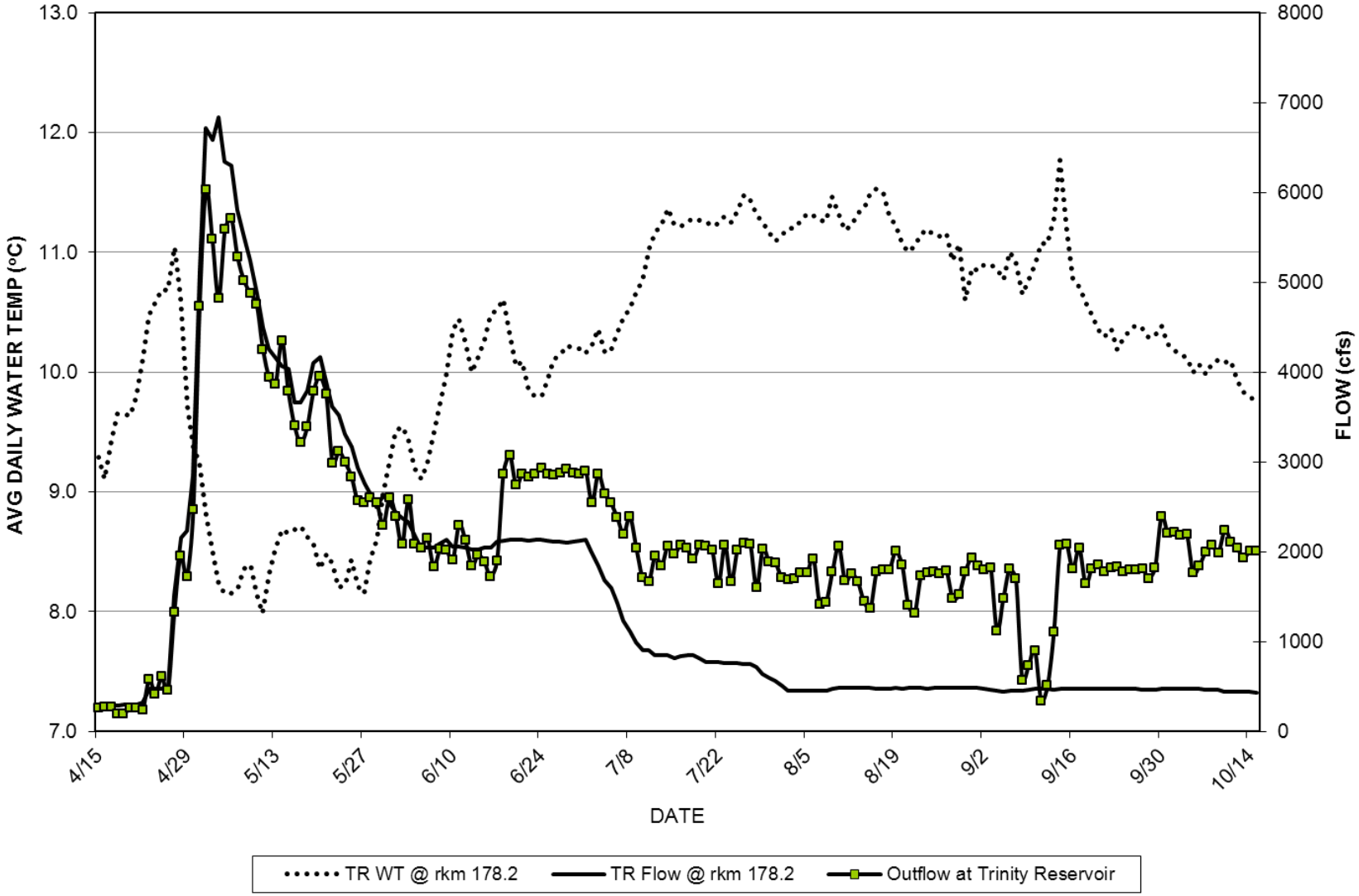

Figure 4. Water temperature (WT) and flow of the Trinity River (TR) at Lewiston (rkm 178.2) and Trinity Reservoir outflow in 2010. Trinity Reservoir outflow supplies water to the Trinity River and diversions to the Sacramento River Basin. The area between lines representing Trinity Reservoir outflow and flow at Lewiston represent an estimate of flow diverted to the Sacramento River Basin.

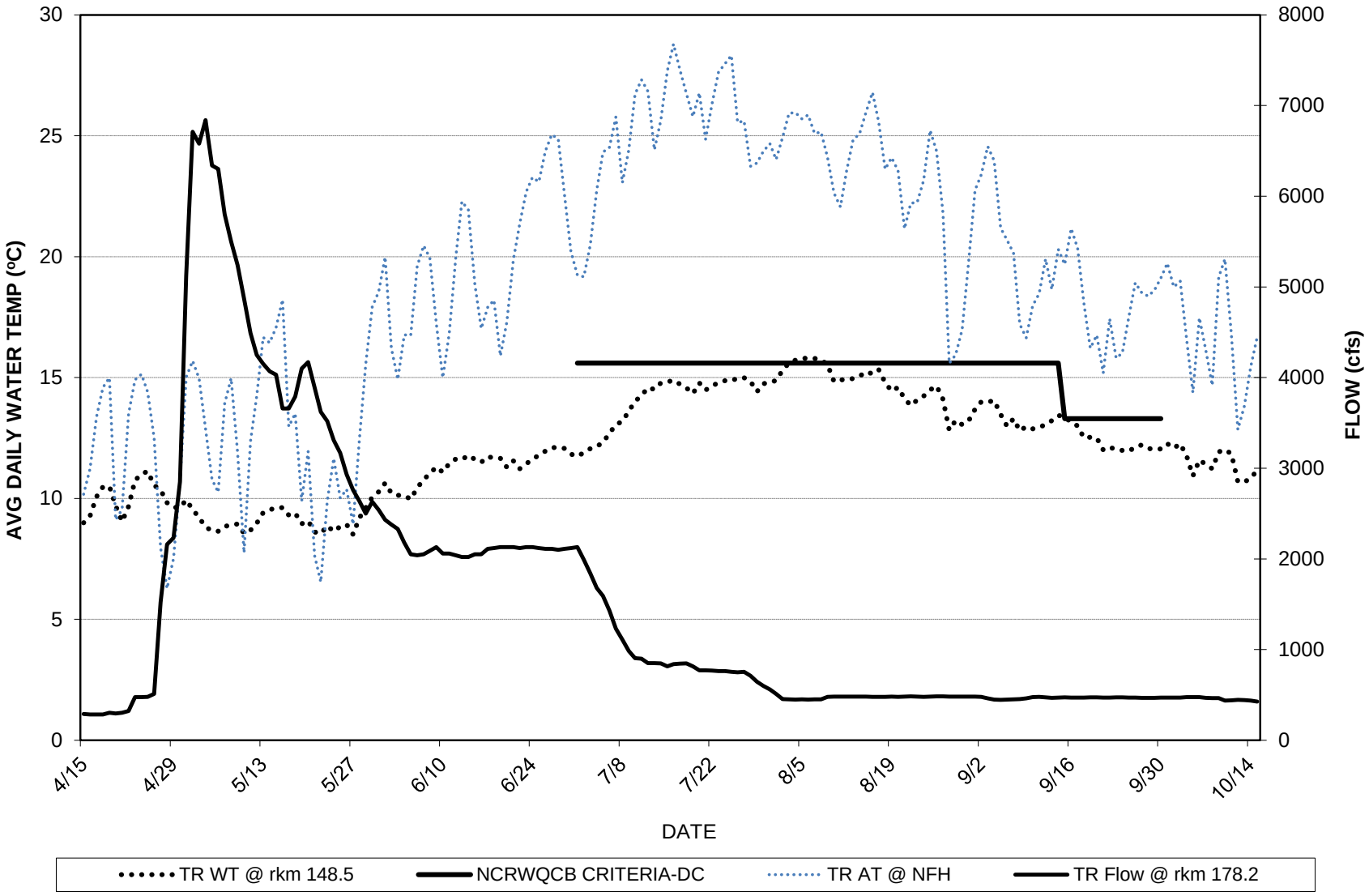

Figure 5. Comparison of average daily water temperatures (WT) of the Trinity River (TR) at Douglas City gauge (rkm 148.5) in 2010 and the water temperature objective of the North Coast Regional Water Quality Control Board (NCRWQCB Criteria-DC). Air temperature (AT) data are from the North Fork at Helena site.

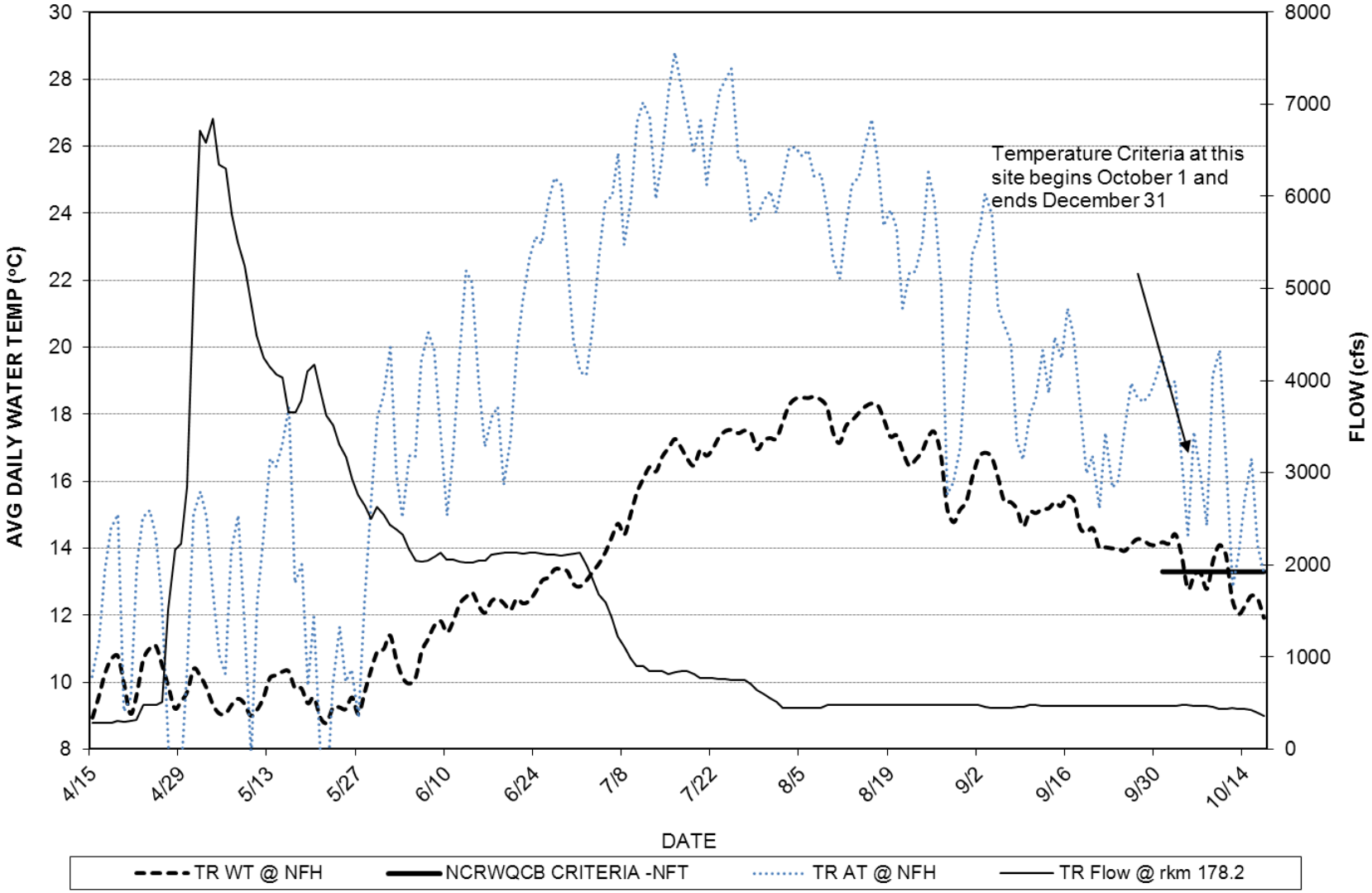

Figure 6. Comparisons of average daily water temperatures (WT) of the Trinity River (TR)above the confluence of the North Fork Trinity River (rkm 117.6) in 2010 and the water temperature objective of the North Coast Regional Water Quality Control Board (NCRWQCB-NFT). Air temperature (AT) data are from the North Fork at Helena site.

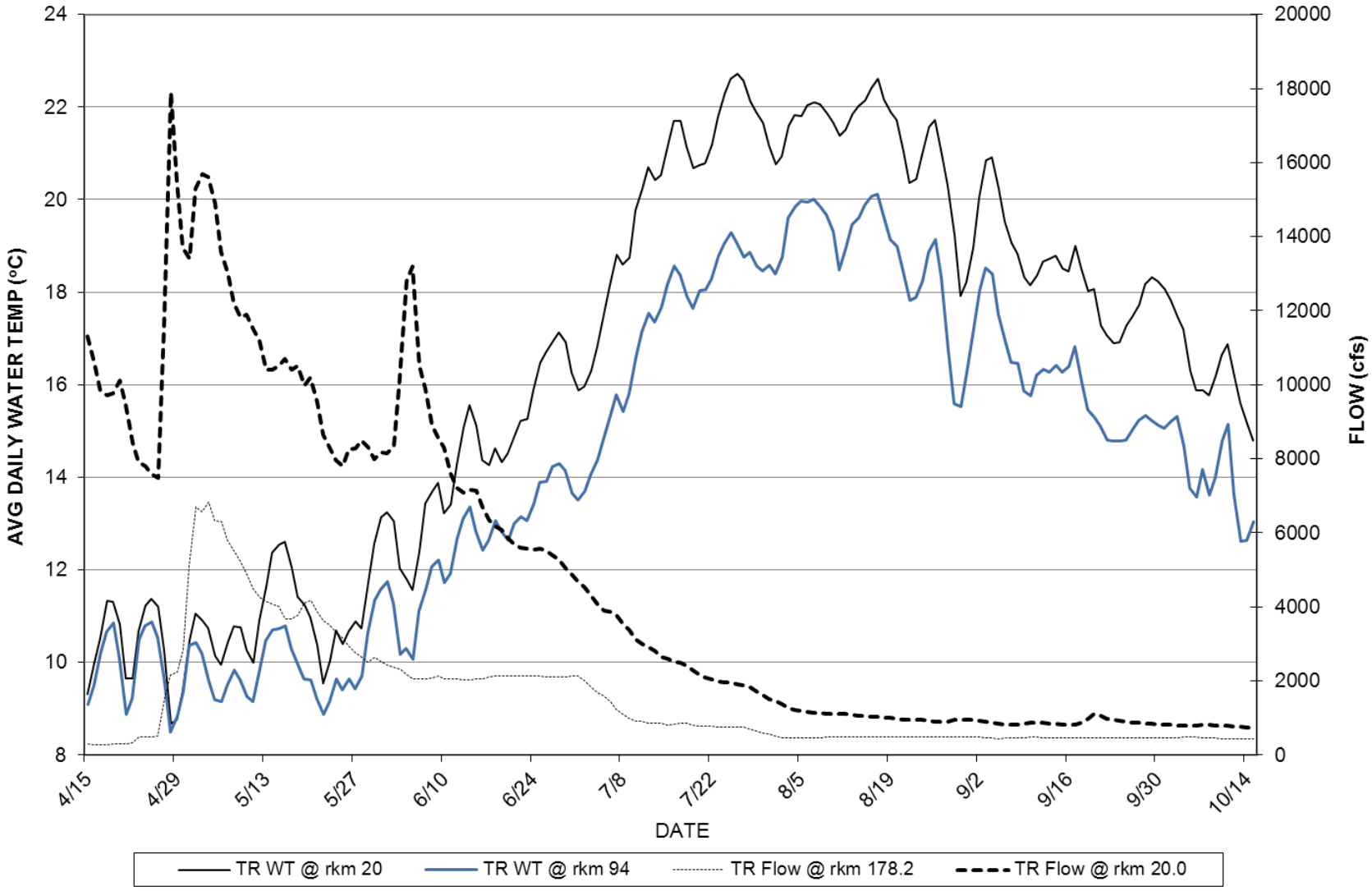

Figure 7. Comparisons of average daily water temperatures of the Trinity River (TR) above Big French Creek (rkm 94) and the Hoopa Gage (rkm 20.0) and flow at Lewiston (rkm 178.2) and Hoopa (rkm 20.0) in 2010.

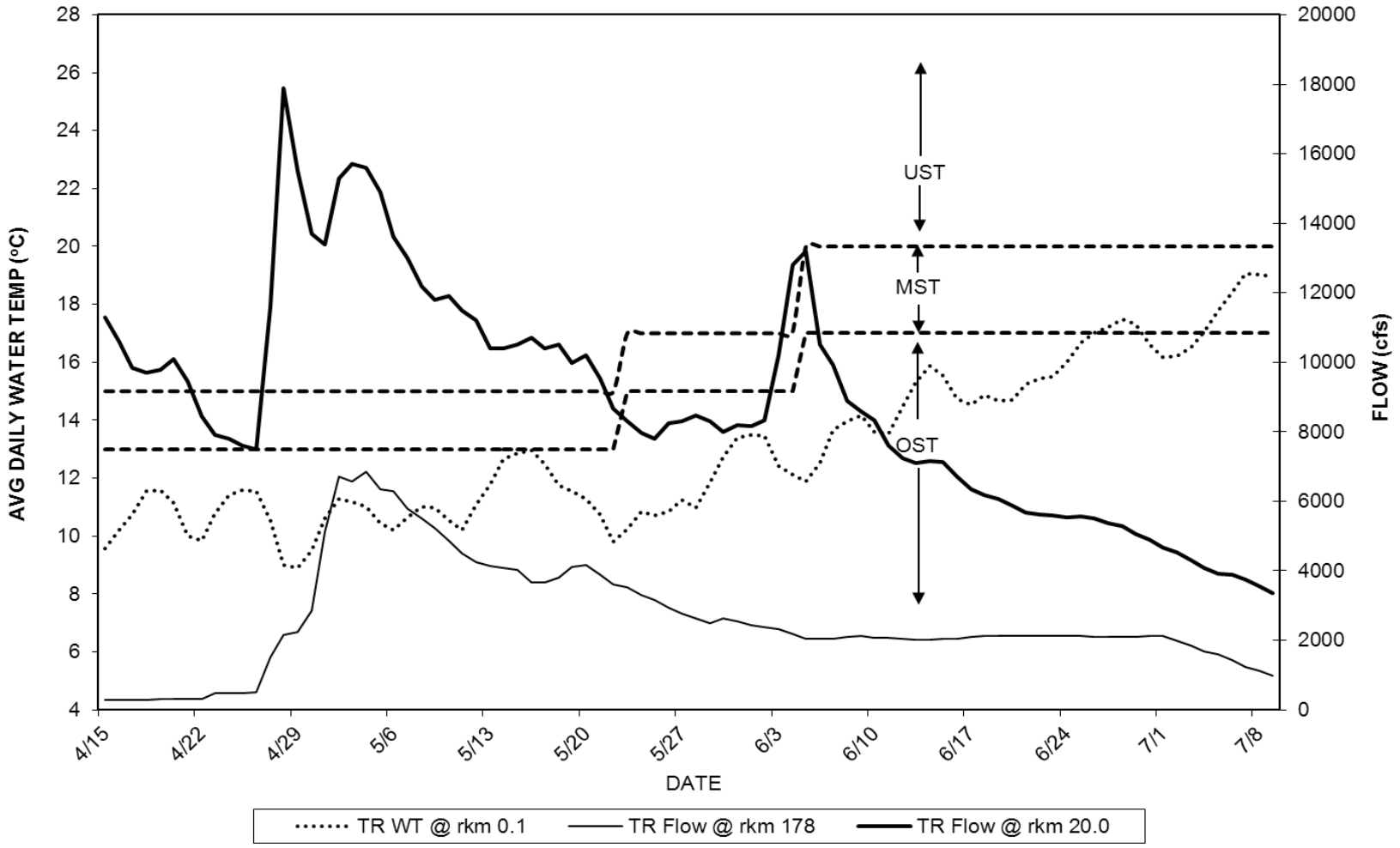

Figure 8. Average daily water temperatures (WT) of the Trinity River (TR) at Weitchpec in 2010 and how they compare to the spring-time temperature objectives established by the Record of Decision (USDOI 2000 and USFWS et al., 2000). Smolt objectives: UST = unsuitable smolt temperatures; MST = marginal smolt temperatures, OST = optimal smolt temperatures. Optimal smolt temperatures were sought from April 22 to July 9 in 2010.

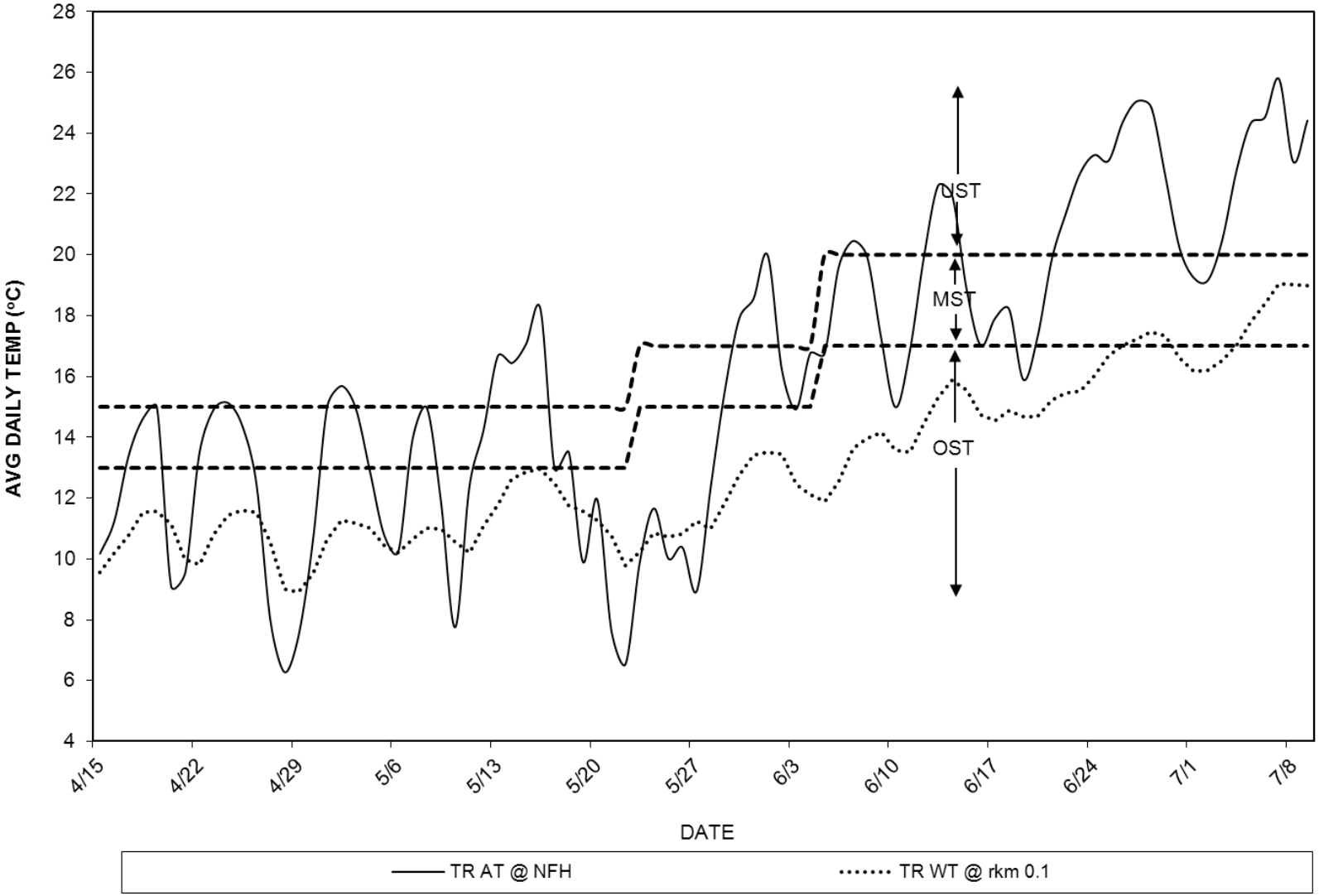

Figure 9. Air temperature (AT) and its influence on water temperature (WT) of the Trinity River (TR) at Weitchpec from April 22 to July 9, 2010. Smolt criteria: UST = Unsuitable temperatures; MST = Marginally suitable temperatures; OST = Optimally suitable temperatures.

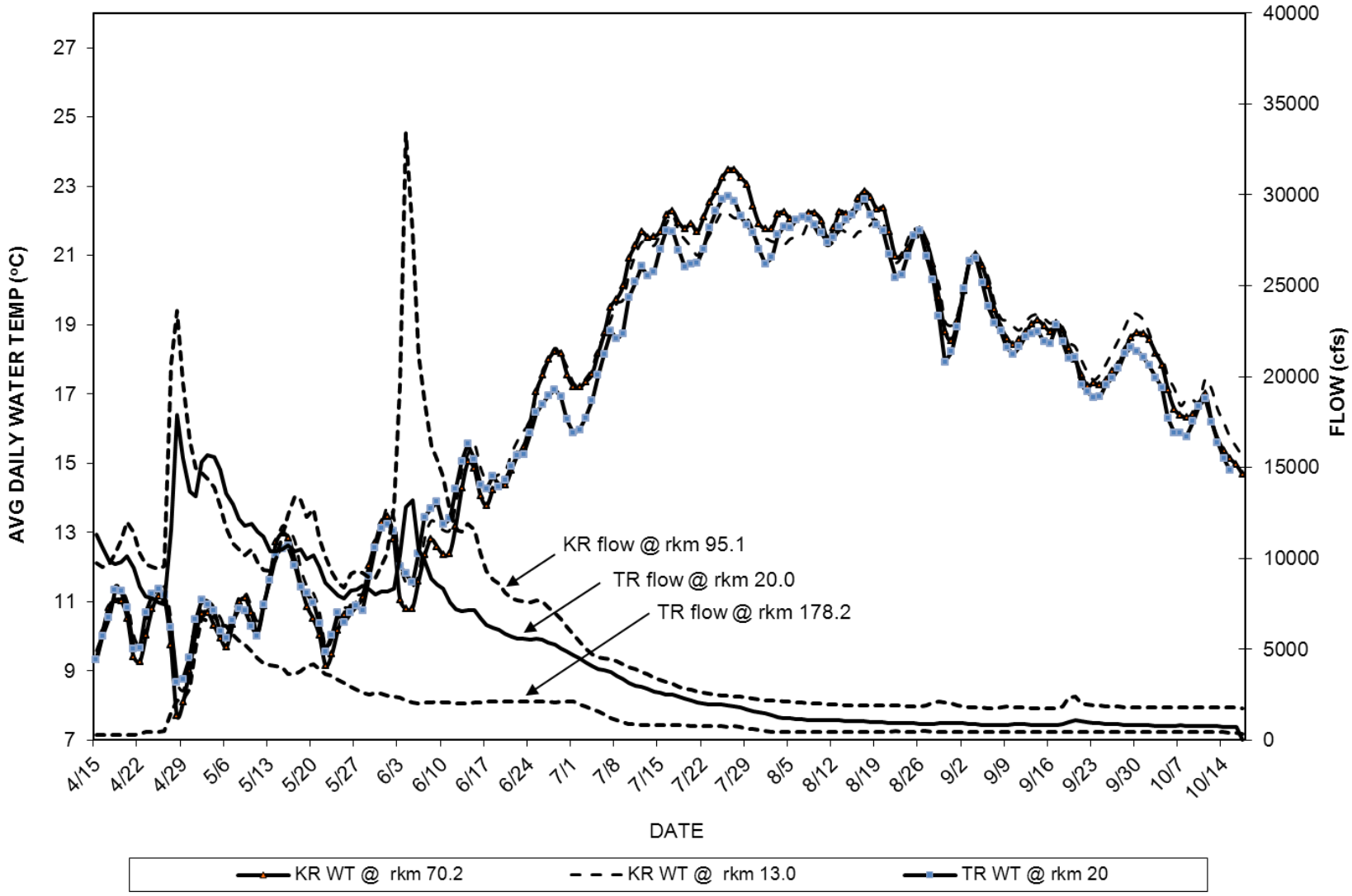

Figure 10. Comparison of water temperatures (WT) of the Trinity River (TR) at Hoopa (rkm 20) and the Klamath River (KR) above (rkm 70.2) and below (rkm 13.0)) the confluence of the Trinity River relative to stream flow in 2010. See Appendix A for daily information.

Appendix A. Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2010. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer

Date	Flow (CFS)							Average Daily Water Temperatures (°C)				Differences in Water Temps (°C) of the Klamath R. at RKm 70.2 and:		
	Trinity R.		Klamath R.			Contributions of Flow to the Klamath Gage (%)[b]		Trinity R.	Klamath R.			Trinity R.	Klamath R.	
	Lewiston (rkm 178.6)	Hoopa (rkm 20.0)	Iron Gate (rkm 305.5)	Orleans (rkm 95.1)	Klamath (rkm 13.0)	Lewiston Dam (rkm 178.6)	Iron Gate Dam (rkm 305.5)	TR (rkm 20.0)	WE (rkm 70.2)	KBW (rkm 68.7)	KAT (rkm 13.0)	TR (rkm 20.0)	KBW (rkm 68.7)	KAT (rkm 13.0)
04/15/10	290	11300	1340	9750	26100	1	5	9.3	9.3	9.3	9.6	0.0	0.0	-0.3
04/16/10	285	10600	1340	9510	25200	1	5	10.0	10.1	9.8	10.1	0.1	0.4	0.0
04/17/10	284	9850	1330	9700	24200	1	5	10.5	10.8	10.3	10.8	0.3	0.6	0.1
04/18/10	284	9710	1330	10300	24200	1	5	11.3	11.0	10.7	11.4	-0.3	0.3	-0.4
04/19/10	302	9780	1330	11000	24600	1	5	11.3	11.0	10.9	11.4	-0.3	0.1	-0.3
04/20/10	296	10100	1340	12000	25900	1	5	10.8	10.5	10.8	11.0	-0.3	-0.3	-0.5
04/21/10	302	9460	1340	11400	25800	1	5	9.6	9.4	10.1	10.0	-0.2	-0.7	-0.6
04/22/10	321	8440	1340	10300	23100	1	6	9.7	9.3	9.7	9.7	-0.4	-0.4	-0.5
04/23/10	475	7910	1340	9670	21300	2	6	10.7	10.0	10.1	10.4	-0.6	0.0	-0.4
04/24/10	476	7800	1340	9540	20500	2	7	11.2	10.8	10.6	11.1	-0.4	0.2	-0.3
04/25/10	477	7600	1340	9420	20100	2	7	11.4	11.2	10.9	11.5	-0.2	0.2	-0.3
04/26/10	510	7490	1340	9570	19800	3	7	11.2	11.1	11.1	11.4	-0.1	-0.1	-0.3
04/27/10	1520	11600	1390	20700	34000	4	4	10.3	9.8	10.7	10.5	-0.5	-0.9	-0.8
04/28/10	2160	17900	1370	23600	57500	4	2	8.7	7.7	8.9	8.7	-1.0	-1.2	-0.9
04/29/10	2230	15500	1360	19700	50000	4	3	8.8	8.1	8.4	8.4	-0.7	-0.3	-0.3
04/30/10	2850	13700	1350	16500	41000	7	3	9.4	9.0	9.2	9.3	-0.4	-0.2	-0.2
05/01/10	5120	13400	1330	15000	36700	14	4	10.5	10.1	10.2	10.1	-0.4	-0.2	0.0
05/02/10	6710	15300	1510	14700	37000	18	4	11.0	10.7	10.9	11.0	-0.4	-0.3	-0.4
05/03/10	6580	15700	1370	14400	37100	18	4	10.9	10.7	10.9	11.0	-0.2	-0.2	-0.3
05/04/10	6840	15600	1290	13900	36000	19	4	10.7	10.3	10.6	10.9	-0.4	-0.3	-0.5
05/05/10	6340	14900	1200	12900	33900	19	4	10.1	10.0	10.2	10.5	-0.2	-0.2	-0.6
05/06/10	6300	13600	1210	11700	30900	20	4	10.0	9.7	9.9	10.2	-0.3	-0.2	-0.5
05/07/10	5800	13000	1210	10800	28800	20	4	10.4	10.3	10.4	10.6	-0.1	-0.1	-0.2
05/08/10	5500	12200	1210	10500	27200	20	4	10.8	11.0	11.0	11.1	0.2	0.0	-0.1
05/09/10	5240	11800	1210	10200	26200	20	5	10.7	11.1	11.0	11.3	0.3	0.1	-0.2
05/10/10	4870	11900	1220	10500	26600	18	5	10.3	10.7	10.6	10.9	0.4	0.1	-0.2
05/11/10	4490	11500	1210	9810	26200	17	5	10.0	10.1	10.1	10.4	0.1	0.0	-0.3
05/12/10	4250	11200	1210	9380	23900	18	5	10.9	10.9	10.9	11.0	0.0	0.0	-0.1
05/13/10	4150	10400	1190	9340	23100	18	5	11.6	11.7	11.7	11.8	0.1	0.0	-0.1
05/14/10	4070	10400	1200	9990	23200	18	5	12.4	12.7	12.6	12.7	0.3	0.1	0.0
05/15/10	4030	10500	1200	11200	24400	17	5	12.5	13.0	12.9	13.2	0.4	0.1	-0.2
05/16/10	3660	10700	1200	12400	25800	14	5	12.6	12.8	12.9	13.1	0.2	-0.1	-0.2
05/17/10	3660	10400	1200	13400	26500	14	5	12.1	12.2	12.4	12.8	0.2	-0.1	-0.5
05/18/10	3790	10500	1200	13200	26900	14	4	11.4	11.5	11.6	12.0	0.1	-0.1	-0.5
05/19/10	4100	9980	1200	12300	25700	16	5	11.3	10.9	11.2	11.4	-0.4	-0.3	-0.6
05/20/10	4170	10200	1200	12700	26700	16	4	11.0	10.5	10.9	11.3	-0.5	-0.3	-0.7
05/21/10	3890	9520	1200	11100	24600	16	5	10.4	10.0	10.4	10.7	-0.3	-0.3	-0.7
05/22/10	3620	8660	1200	10100	23300	16	5	9.6	9.2	9.4	9.7	-0.4	-0.3	-0.5
05/23/10	3520	8290	1200	9210	21500	16	6	10.0	9.5	9.8	9.9	-0.6	-0.3	-0.4
05/24/10	3310	7960	1200	8680	20200	16	6	10.7	10.2	10.4	10.6	-0.5	-0.2	-0.4
05/25/10	3170	7800	1200	8410	19400	16	6	10.4	10.6	10.7	10.8	0.2	0.0	-0.2
05/26/10	2930	8250	1210	9130	20900	14	6	10.7	10.8	10.8	10.8	0.2	0.0	0.0
05/27/10	2760	8290	1210	9340	21700	13	6	10.9	10.9	11.1	11.2	0.0	-0.2	-0.3
05/28/10	2640	8480	1200	9230	22200	12	5	10.7	11.1	11.0	11.3	0.4	0.1	-0.1
05/29/10	2500	8310	1200	8930	21600	12	6	11.7	12.1	11.9	12.0	0.3	0.1	0.1
05/30/10	2630	8000	1200	8930	20700	13	6	12.6	12.7	12.7	12.7	0.1	0.0	0.0
05/31/10	2540	8180	1200	9580	20800	12	6	13.1	13.3	13.3	13.2	0.1	0.0	0.1
06/01/10	2430	8160	1090	10300	21600	11	5	13.2	13.5	13.5	13.8	0.2	0.0	-0.3

Appendix A. (Continued). Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2010. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer.

Date	Flow (CFS)							Average Daily Water Temperatures (°C)				Differences in Water Temps (°C) of the Klamath R. at RKm 70.2 and:		
	Trinity R.		Klamath R.			Contributions of Flow to the Klamath Gage (%)[b]		Trinity R.	Klamath R.			Trinity R.	Klamath R.	
	Lewiston (rkm 178.6)	Hoopa (rkm 20.0)	Iron Gate (rkm 305.5)	Orleans (rkm 95.1)	Klamath (rkm 13.0)	Lewiston Dam (rkm 178.6)	Iron Gate Dam (rkm 305.5)	TR (rkm 20.0)	WE (rkm 70.2)	KBW (rkm 68.7)	KAT (rkm 13.0)	TR (rkm 20.0)	KBW (rkm 68.7)	KAT (rkm 13.0)
06/02/10	2380	8340	1050	12900	23400	10	4	13.0	12.8	13.1	13.4	-0.2	-0.3	-0.6
06/03/10	2330	10200	1050	19500	36600	6	3	12.0	11.1	11.6	12.1	-1.0	-0.5	-1.0
06/04/10	2180	12800	1060	33400	52900	4	2	11.8	10.8	11.3	11.5	-1.0	-0.5	-0.7
06/05/10	2050	13200	1060	27900	57900	4	2	11.6	10.8	11.4	11.4	-0.8	-0.6	-0.6
06/06/10	2040	10500	1060	21200	41900	5	3	12.4	11.6	11.5	11.8	-0.8	0.0	-0.2
06/07/10	2050	9910	1060	18700	36400	6	3	13.4	12.3	12.7	12.8	-1.1	-0.4	-0.5
06/08/10	2090	8900	1060	16200	31900	7	3	13.7	12.8	13.2	13.3	-0.9	-0.4	-0.5
06/09/10	2130	8580	1060	15400	29500	7	4	13.9	12.6	13.1	13.2	-1.3	-0.5	-0.6
06/10/10	2060	8320	1060	14500	28900	7	4	13.2	12.4	12.8	13.1	-0.9	-0.4	-0.7
06/11/10	2060	7600	1060	12600	25600	8	4	13.4	12.4	12.8	13.1	-1.0	-0.4	-0.7
06/12/10	2040	7230	1050	11600	23100	9	5	14.3	13.2	13.6	13.8	-1.1	-0.4	-0.6
06/13/10	2020	7090	1040	11500	22200	9	5	15.1	14.3	14.6	14.8	-0.8	-0.3	-0.5
06/14/10	2020	7160	1040	11900	22100	9	5	15.6	15.0	15.3	15.3	-0.5	-0.3	-0.2
06/15/10	2050	7140	1040	11600	22100	9	5	15.1	14.8	15.1	15.6	-0.3	-0.3	-0.7
06/16/10	2050	6710	1050	10300	20300	10	5	14.4	14.1	14.3	14.9	-0.3	-0.3	-0.8
06/17/10	2110	6350	1040	9320	18600	11	6	14.3	13.8	14.1	14.5	-0.5	-0.3	-0.7
06/18/10	2120	6190	1040	8830	17600	12	6	14.6	14.2	14.4	14.6	-0.4	-0.2	-0.4
06/19/10	2130	6070	1040	8600	17100	12	6	14.3	14.4	14.5	14.7	0.0	-0.1	-0.3
06/20/10	2130	5860	1040	8140	16500	13	6	14.5	14.4	14.4	14.8	-0.1	0.0	-0.4
06/21/10	2130	5670	1040	7790	15800	13	7	14.9	14.8	14.8	15.3	-0.1	0.0	-0.5
06/22/10	2120	5610	1040	7700	15400	14	7	15.2	15.2	15.1	15.7	0.0	0.1	-0.4
06/23/10	2130	5580	1040	7640	15300	14	7	15.3	15.5	15.3	15.9	0.2	0.2	-0.5
06/24/10	2130	5540	1040	7580	15100	14	7	15.9	16.2	15.7	16.2	0.3	0.5	-0.1
06/25/10	2120	5570	1050	7690	15100	14	7	16.5	17.1	16.4	17.0	0.6	0.7	0.1
06/26/10	2110	5510	1050	7620	15100	14	7	16.7	17.5	16.8	17.7	0.8	0.8	-0.1
06/27/10	2110	5380	1050	7300	14600	14	7	16.9	18.0	17.1	18.0	1.1	0.9	0.0
06/28/10	2100	5270	1050	7000	14200	15	7	17.1	18.2	17.3	18.3	1.1	0.9	-0.1
06/29/10	2110	5050	1050	6680	13600	16	8	16.9	18.2	17.3	18.1	1.2	0.8	0.0
06/30/10	2120	4890	1050	6240	13000	16	8	16.3	17.6	17.0	17.8	1.3	0.6	-0.2
07/01/10	2130	4680	945	5820	12400	17	8	15.9	17.2	16.6	17.3	1.3	0.6	-0.1
07/02/10	1990	4530	843	5440	11900	17	7	16.0	17.2	16.5	17.2	1.2	0.7	0.0
07/03/10	1840	4310	818	5020	11200	16	7	16.3	17.4	16.6	17.5	1.1	0.8	-0.1
07/04/10	1680	4090	817	4700	10600	16	8	16.8	17.6	16.8	17.7	0.8	0.8	-0.2
07/05/10	1590	3910	814	4550	10200	16	8	17.5	18.2	17.2	18.3	0.6	0.9	-0.1
07/06/10	1430	3880	814	4490	9980	14	8	18.1	18.8	17.7	18.7	0.6	1.0	0.0
07/07/10	1230	3760	813	4460	9880	12	8	18.8	19.5	18.3	19.1	0.7	1.2	0.4
07/08/10	1110	3550	811	4320	9540	12	9	18.6	19.7	18.7	19.6	1.2	1.1	0.1
07/09/10	985	3360	816	4170	9240	11	9	18.7	20.1	18.7	19.7	1.4	1.4	0.4
07/10/10	905	3140	817	4010	8820	10	9	19.8	20.9	19.4	20.5	1.1	1.5	0.4
07/11/10	898	3000	816	3900	8490	11	10	20.2	21.3	19.9	21.0	1.1	1.4	0.3
07/12/10	850	2920	815	3760	8240	10	10	20.7	21.7	20.3	21.4	1.0	1.4	0.3
07/13/10	849	2810	814	3620	7980	11	10	20.4	21.5	20.4	21.4	1.1	1.1	0.2
07/14/10	847	2650	815	3420	7650	11	11	20.5	21.5	21.1	21.3	1.0	0.4	0.3
07/15/10	814	2590	816	3310	7340	11	11	21.2	21.7	21.7	21.6	0.5	0.0	0.1
07/16/10	838	2520	816	3200	7170	12	11	21.7	22.2	22.2	21.9	0.5	0.0	0.2
07/17/10	845	2490	816	3100	6980	12	12	21.7	22.3	22.3	22.2	0.6	0.0	0.1
07/18/10	846	2400	815	2950	6770	12	12	21.2	22.0	21.9	21.7	0.8	0.1	0.3
07/19/10	814	2290	817	2830	6510	13	13	20.7	21.8	21.6	21.5	1.1	0.2	0.3

Appendix A. (Continued). Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2010. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer.

Date	Flow (CFS)							Average Daily Water Temperatures (°C)				Differences in Water Temps (°C) of the Klamath R. at RKm 70.2 and:		
	Trinity R.		Klamath R.			Contributions of Flow to the Klamath Gage (%)[b]		Trinity R.	Klamath R.			Trinity R.	Klamath R.	
	Lewiston (rkm 178.6)	Hoopa (rkm 20.0)	Iron Gate (rkm 305.5)	Orleans (rkm 95.1)	Klamath (rkm 13.0)	Lewiston Dam (rkm 178.6)	Iron Gate Dam (rkm 305.5)	TR (rkm 20.0)	WE (rkm 70.2)	KBW (rkm 68.7)	KAT (rkm 13.0)	TR (rkm 20.0)	KBW (rkm 68.7)	KAT (rkm 13.0)
07/20/10	770	2180	818	2760	6270	12	13	20.7	21.9	21.6	21.3	1.2	0.3	0.7
07/21/10	770	2090	817	2690	6070	13	13	20.8	21.7	21.5	21.0	0.9	0.2	0.7
07/22/10	767	2030	818	2610	5920	13	14	21.2	22.1	21.9	21.3	0.9	0.2	0.8
07/23/10	763	1990	818	2550	5730	13	14	21.8	22.5	22.4	21.6	0.7	0.1	0.9
07/24/10	763	1970	819	2510	5630	14	15	22.3	22.8	22.8	21.9	0.6	0.1	0.9
07/25/10	755	1950	822	2470	5540	14	15	22.6	23.2	23.2	22.3	0.6	0.1	1.0
07/26/10	750	1900	822	2440	5410	14	15	22.7	23.5	23.3	22.2	0.8	0.2	1.3
07/27/10	753	1880	822	2410	5350	14	15	22.6	23.5	23.2	22.1	0.9	0.3	1.4
07/28/10	711	1820	823	2390	5280	13	16	22.1	23.2	23.0	22.1	1.1	0.3	1.1
07/29/10	644	1720	830	2340	5140	13	16	21.9	23.0	22.8	22.1	1.1	0.2	1.0
07/30/10	599	1610	832	2280	4950	12	17	21.7	22.4	22.3	21.7	0.8	0.1	0.7
07/31/10	560	1510	844	2240	4760	12	18	21.2	21.9	21.8	21.2	0.7	0.1	0.7
08/01/10	512	1460	906	2210	4670	11	19	20.8	21.8	21.6	21.5	1.0	0.2	0.3
08/02/10	452	1370	905	2190	4520	10	20	20.9	21.8	21.7	21.4	0.8	0.1	0.4
08/03/10	451	1270	905	2190	4450	10	20	21.6	22.2	22.1	21.4	0.6	0.1	0.8
08/04/10	449	1220	904	2150	4310	10	21	21.8	22.2	22.2	21.3	0.4	0.1	0.9
08/05/10	450	1190	906	2120	4210	11	22	21.8	22.0	22.1	21.5	0.2	0.0	0.6
08/06/10	449	1170	906	2100	4140	11	22	22.0	22.0	22.1	21.5	0.0	-0.1	0.5
08/07/10	451	1150	905	2070	4090	11	22	22.1	22.1	22.2	21.6	0.0	-0.1	0.5
08/08/10	451	1130	905	2040	4010	11	23	22.1	22.2	22.3	22.0	0.2	-0.1	0.3
08/09/10	479	1120	906	2020	3960	12	23	21.9	22.2	22.2	21.8	0.4	0.0	0.4
08/10/10	481	1110	907	2000	3900	12	23	21.7	22.0	22.0	21.5	0.3	0.0	0.5
08/11/10	482	1120	905	1990	3880	12	23	21.4	21.5	21.6	21.3	0.1	-0.1	0.2
08/12/10	482	1110	904	1980	3860	12	23	21.5	21.8	21.8	21.4	0.3	0.0	0.4
08/13/10	481	1090	905	1960	3810	13	24	21.8	22.3	22.3	21.7	0.4	0.0	0.5
08/14/10	480	1070	907	1940	3740	13	24	22.0	22.2	22.2	21.7	0.2	0.0	0.5
08/15/10	480	1050	916	1930	3680	13	25	22.2	22.2	22.2	21.5	0.1	0.0	0.7
08/16/10	479	1040	1020	1910	3640	13	28	22.4	22.6	22.6	21.7	0.2	0.1	1.0
08/17/10	478	1030	1020	1930	3600	13	28	22.6	22.9	22.8	21.7	0.3	0.1	1.2
08/18/10	479	1010	1020	1940	3650	13	28	22.2	22.7	22.6	21.9	0.5	0.1	0.8
08/19/10	481	994	1020	1930	3620	13	28	21.9	22.3	22.3	22.0	0.4	0.0	0.3
08/20/10	479	978	1020	1910	3560	13	29	21.7	22.4	22.3	22.0	0.7	0.1	0.4
08/21/10	482	961	1020	1890	3490	14	29	21.0	21.7	21.6	21.0	0.6	0.1	0.7
08/22/10	484	955	1020	1900	3480	14	29	20.4	21.0	20.9	20.8	0.6	0.1	0.2
08/23/10	480	956	1030	1890	3490	14	30	20.5	21.0	20.9	21.0	0.6	0.1	0.1
08/24/10	479	948	1020	1880	3460	14	29	21.0	21.2	21.3	21.5	0.2	-0.1	-0.3
08/25/10	480	930	1020	1870	3420	14	30	21.6	21.6	21.8	21.8	0.0	-0.2	-0.2
08/26/10	483	907	1300	1850	3360	14	39	21.7	21.8	21.9	21.4	0.0	-0.2	0.4
08/27/10	484	892	1410	1890	3290	15	43	21.0	21.4	21.5	21.4	0.4	0.0	0.0
08/28/10	482	900	1400	2080	3530	14	40	20.3	20.7	20.8	20.6	0.4	0.0	0.2
08/29/10	481	939	1290	2110	3730	13	35	19.2	19.8	19.9	20.1	0.5	-0.1	-0.4
08/30/10	480	960	1170	2070	3790	13	31	17.9	18.8	18.8	19.1	0.9	0.0	-0.3
08/31/10	480	958	1080	2030	3750	13	29	18.2	18.5	18.5	19.0	0.3	0.0	-0.4
09/01/10	480	951	1030	1940	3650	13	28	18.9	19.1	19.2	19.3	0.2	-0.1	-0.2
09/02/10	478	932	1030	1870	3470	14	30	20.0	20.0	20.1	20.1	0.0	-0.1	-0.1
09/03/10	462	906	1030	1830	3340	14	31	20.8	20.8	21.0	20.8	0.0	-0.1	0.0
09/04/10	449	880	1030	1810	3260	14	32	20.9	21.0	21.2	20.8	0.1	-0.1	0.2
09/05/10	446	834	1030	1790	3190	14	32	20.2	20.7	20.7	20.8	0.5	0.0	-0.1

Appendix A. (Continued). Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2010. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer.

Date	Flow (CFS)							Average Daily Water Temperatures (°C)				Differences in Water Temps (°C) of the Klamath R. at RKm 70.2 and:		
	Trinity R.		Klamath R.			Contributions of Flow to the Klamath Gage (%)[b]		Trinity R.	Klamath R.			Trinity R.	Klamath R.	
	Lewiston (rkm 178.6)	Hoopa (rkm 20.0)	Iron Gate (rkm 305.5)	Orleans (rkm 95.1)	Klamath (rkm 13.0)	Lewiston Dam (rkm 178.6)	Iron Gate Dam (rkm 305.5)	TR (rkm 20.0)	WE (rkm 70.2)	KBW (rkm 68.7)	KAT (rkm 13.0)	TR (rkm 20.0)	KBW (rkm 68.7)	KAT (rkm 13.0)
09/06/10	448	820	1030	1770	3120	14	33	19.5	20.1	20.2	20.3	0.6	-0.1	-0.2
09/07/10	451	816	1030	1770	3100	15	33	19.1	19.4	19.6	19.6	0.4	-0.2	-0.2
09/08/10	454	828	1030	1800	3160	14	33	18.8	18.9	19.3	19.2	0.1	-0.3	-0.2
09/09/10	462	848	1030	1840	3260	14	32	18.3	18.6	18.8	19.1	0.3	-0.2	-0.5
09/10/10	476	867	1030	1830	3280	15	31	18.2	18.4	18.6	19.0	0.3	-0.2	-0.5
09/11/10	477	883	1030	1810	3260	15	32	18.4	18.6	18.7	18.8	0.2	-0.1	-0.3
09/12/10	472	873	1020	1800	3230	15	32	18.7	18.8	19.0	19.1	0.2	-0.2	-0.3
09/13/10	466	854	1020	1770	3170	15	32	18.7	19.0	19.2	19.3	0.3	-0.2	-0.2
09/14/10	469	832	1030	1760	3110	15	33	18.8	19.1	19.2	19.3	0.3	-0.1	-0.2
09/15/10	472	819	1030	1770	3100	15	33	18.5	19.0	19.1	19.2	0.5	-0.1	-0.2
09/16/10	471	820	1020	1760	3090	15	33	18.4	18.8	18.9	19.0	0.4	-0.1	-0.2
09/17/10	471	827	1020	1770	3110	15	33	19.0	19.0	19.2	19.1	0.0	-0.2	-0.1
09/18/10	471	864	1020	1850	3320	14	31	18.5	18.8	19.0	18.9	0.3	-0.2	0.0
09/19/10	472	990	1020	2340	4410	11	23	18.0	18.3	18.5	18.5	0.3	-0.1	-0.2
09/20/10	472	1110	1020	2400	4920	10	21	18.1	18.0	18.3	18.4	-0.1	-0.2	-0.4
09/21/10	471	1060	1030	2040	4280	11	24	17.3	17.5	17.8	18.0	0.3	-0.3	-0.4
09/22/10	471	981	1030	1950	3800	12	27	17.1	17.2	17.4	17.6	0.2	-0.1	-0.4
09/23/10	472	947	1030	1920	3640	13	28	16.9	17.3	17.4	17.4	0.4	-0.1	-0.1
09/24/10	472	915	1030	1890	3540	13	29	16.9	17.3	17.4	17.6	0.3	-0.1	-0.3
09/25/10	469	897	1030	1870	3450	14	30	17.3	17.4	17.5	17.9	0.1	-0.1	-0.5
09/26/10	469	879	1030	1860	3390	14	30	17.5	17.7	17.8	18.2	0.2	-0.2	-0.6
09/27/10	467	861	1030	1840	3330	14	31	17.7	17.9	18.0	18.6	0.1	-0.2	-0.7
09/28/10	467	848	1030	1830	3290	14	31	18.2	18.3	18.4	18.9	0.1	-0.2	-0.6
09/29/10	468	833	1030	1820	3250	14	32	18.3	18.6	18.8	19.3	0.3	-0.2	-0.7
09/30/10	471	822	1030	1800	3190	15	32	18.2	18.8	18.9	19.3	0.5	-0.1	-0.5
10/01/10	469	812	1030	1790	3140	15	33	18.1	18.7	18.8	19.1	0.7	-0.1	-0.4
10/02/10	470	807	1030	1790	3110	15	33	17.8	18.6	18.6	18.7	0.7	-0.1	-0.2
10/03/10	469	799	1030	1810	3120	15	33	17.5	18.2	18.3	18.2	0.7	-0.1	0.0
10/04/10	476	791	1030	1800	3140	15	33	17.2	17.8	17.9	18.1	0.6	-0.1	-0.2
10/05/10	475	796	1030	1800	3110	15	33	16.3	17.1	17.3	17.5	0.8	-0.2	-0.4
10/06/10	474	804	1030	1800	3120	15	33	15.9	16.6	16.7	17.2	0.7	-0.1	-0.6
10/07/10	467	809	1030	1810	3130	15	33	15.9	16.4	16.6	16.7	0.5	-0.3	-0.3
10/08/10	464	806	1030	1810	3140	15	33	15.8	16.3	16.5	16.9	0.5	-0.2	-0.6
10/09/10	463	802	1030	1810	3140	15	33	16.2	16.4	16.5	16.8	0.2	-0.1	-0.4
10/10/10	436	799	1030	1820	3150	14	33	16.7	16.7	16.9	16.8	0.0	-0.2	-0.1
10/11/10	440	779	1030	1820	3160	14	33	16.9	17.0	17.2	17.4	0.1	-0.2	-0.4
10/12/10	446	759	1040	1800	3110	14	33	16.2	16.2	16.5	17.1	0.1	-0.3	-0.9
10/13/10	442	759	1030	1800	3060	14	34	15.6	15.7	16.0	16.6	0.1	-0.3	-0.9
10/14/10	436	751	1030	1790	3040	14	34	15.1	15.4	15.7	16.2	0.2	-0.3	-0.8
10/15/10	427	742	1030	1790	3030	14	34	14.8	15.1	15.4	15.8	0.3	-0.3	-0.6